FACULTY OF LAW, ECONOMICS AND FINANCE

CREA
Discussion
Paper
2016-25

Management

Centre for Research in Economics and Management
University of Luxembourg

Implications of Uncertain Patent Rights for German Start-ups' Commercialization Activities and Access to External Capital

available online : http://wwwfr.uni.lu/recherche/fdef/crea/publications2/discussion_papers

Diana Heger, HIS Economics in Frankfurt, Germany
Katrin Hussinger, CREA, University of Luxembourg

December, 2016

For editorial correspondence, please contact: crea@uni.lu
University of Luxembourg
Faculty of Law, Economics and Finance
162A, avenue de la Faïencerie
L-1511 Luxembourg

Implications of Uncertain Patent Rights for German Start-ups' Commercialization Activities and Access to External Capital

This paper is forthcoming in *Industry & Innovation*

December 2017

Diana Heger and Katrin Hussinger

Abstract

Start-ups may benefit in two ways from patenting their inventions: from the appropriation value and the certification effect of patents which reveals the ventures' "quality" to investors. As long as the patent office's grant decision is pending both benefits may not realize. We confirm for a data set of German start-ups that pending patent applications decrease the likelihood of market launch for new ventures. Regarding the certification effect, we find that pending patent applications attract risk-seeking investors, while more cautious investors do not react upon pending patent applications.

Keywords: start-ups, patents, pending patent applications, access to finance, new product launch

JEL: L26, O31, O34

Acknowledgements: We thank Antonio Della Malva, Adam Jaffe and Francesco Lissoni for helpful comments. We further thank Thorsten Doherr and Daniel Hoewer for data support.

Contact:
Diana Heger, IHS Economics, Bleichstrasse 1, 60313 Frankfurt, Tel. +352 46 66 44 6404 Fax: +352 46 66 44 6341, E-mail: dianaheger@gmail.com
Katrin Hussinger, University of Luxembourg, Center for Research in Economics and Management, 162 Avenue de la Faïencerie, 1511 Luxembourg, Luxembourg, phone: +352 46 66 44 6404, fax: +352 46 66 44 6341, e-mail: katrin.hussinger@uni.lu

1. Introduction

“An effective patent system offers protection for new entrants to the market, who do not have the distribution networks or reputation that can in some ways protect inventions. Their main strategic defense is intellectual property.” Thus, an effective patent system is a crucial pre-requisites and factor of success for innovative start-ups (Guellec and Sachwald, 2008). In reality, patent systems are, however, not always effective. Increasing durations of granting procedures causing augmented pendencies (Harhoff and Wagner, 2009, Czarnitzki et al., 2015), patent rights for marginal inventions (Jaffe and Lerner, 2004) and probabilistic patent rights (Lemley and Shapiro, 2005) are some of the downsides of current patent legislations.

This paper investigates the implications of patent pendencies for start-up companies, and, in particular, the consequences for their commercialization activities and access to external capital. The importance of patents for innovative start-ups arises from two features: one is related to technology certification and the other to the protection of a specific product market segment. First, patents strengthen the venture’s ability to appropriate the returns on research and development (R&D) investments in the product market (Arora and Ceccagnoli, 2006, Cohen et al., 2000, Dechenaux et al., 2008). This protective effect of a patent stems from the right to exclude others from producing, using or selling the invention (see e.g. 35 U.S.C. §154), hence, a monopoly right to exclusively sell a specific product (family) for a limited period in time. Patents foster the commercialization of new discoveries by shielding investments in complementary assets which are required for transferring inventions into marketable products (Teece, 1986).

Due to the monopoly right granted by patents they can further increase the startups' collateral value (Conti et al., 2013) as a granted patent can be sold to a competitor.

Second, patents certify technical feasibility and industrial applicability of an invention (see e.g. Art. 52(1) of the European Patent Convention) helping start-ups to attract external funds (Hsu and Ziedonis, 2008, Haeussler et al., 2008, 2014, Conti et al., 2013). External capital is often essential for new ventures that lack internal funds to finance R&D for growth and innovation (Stinchcombe, 1965). At the same time, attracting investors is difficult for new ventures since their quality is unknown and their prospective success is difficult to predict (Stuart et al., 1999). Patents can be used as "quality" certification which may reduce uncertainty with regards to the ventures' technological capabilities and its growth and market potential (Conti et al., 2013, Hsu and Ziedonis, 2008, Haeussler et al., 2008, 2014, Amit et al., 1990).

If patents are pending they induce uncertainties regarding the grant decision, the grant date and the patent scope as well as the strategic value of the invention (Lemley and Shapiro, 2005, Gans et al., 2008). Patent applicants may respond by postponing follow-up investments required for transferring the technical invention into a marketable product (Cohen et al., 2000, Dechenaux et al., 2008, Teece, 1986) with potentially serious consequences for young ventures' profitability, growth and survival prospects. Further, pending patent applications might negatively impact start-ups access to external capital. We focus on the two most important sources of capital for innovative start-ups in terms of occurrence and funding amount (Gude et al., 2008): Venture capitalists (VCs) as a risk-loving investor and banks as a benchmark for a cautious source of capital. Pending

patent applications can attract VCs because the patent application may serve as proof of concept (Haeussler et al., 2008, 2014, Conti et al., 2013). Banks, in contrast, relying on collateralization presumably do not attribute value to pending patent applications. They are generally expected to be reluctant to invest in innovative ventures because of the small collateral value they can provide (especially compared to their financing needs) and their inability to supply regular interest payments to pay back the loan.

Our results for a large sample of German start-up companies across different industries show that patent pendencies significantly lower the likelihood of new product launches suggesting that entrepreneurs postpone commercialization if they are confronted with uncertain IPR. With regards to ventures' access to finance, we find that pending patent applications attract venture capital financing. Bank financing, in contrast, is not related to pending patent applications. This suggests that an inefficient patent system deter commercialization activities by new ventures, but does not necessarily (further) restrict their access to external finance.

This study contributes to two strands of literature: First, the empirical evidence on inefficiencies induced by the patent systems. While prior studies analyzed implication of pending patents on licensing activities (Gans et al., 2008) and R&D collaboration (Czarnitzki et al., 2015), we focus on the effects on new ventures' product launch decision and access to finance. Second, this study contributes to the literature on the importance of patents for access to external financing for new ventures (Baum and Silverman, 2004, Hsu and Ziedonis, 2008, Haeussler et al., 2008, 2014). These prior studies often focus exclusively on risk-taking VCs as sources of external funds for new

ventures. Our study uses ventures' ability to access banks loans as a benchmark. Therewith, the major contribution of our study is to be the first to test the implications of patent pendencies on exploitation of the underlying knowledge and access to external finance at the same time. Prior studies focus on either effect of pending patent applications using different samples for different industries. We show that prior results hold in a multi-equation system. The results from our simultaneous assessment of the different implications highlight strongly the dilemma that the entrepreneur faces when confronted with the decision to patent and how to respond to patent pendencies.

The remainder of the paper is organized as follows. The next section reviews the related literature. Section 3 introduces our data set before and shows descriptive statistics. In section 4, we present our empirical results and the last section concludes.

2. Theoretical Considerations

2.1 The Product Market Dimension of Patents

The main function of patent systems is to grant property rights on technical inventions in order to increase incentives to innovate in the economy. Firms tend to under-invest in R&D as their R&D can be subject to expropriation (Arrow, 1962). Like public goods, inventions are non-rival in use in that the results of innovative efforts can be used by more than one party at the same time without restricting the use of the same invention for others. In addition, knowledge is non-excludable so that it is quasi impossible to exclude third parties from using an invention. Inventions are, hence, costly to develop while they can be copied at relatively low costs (Mansfield et al., 1977). Furthermore, the outcome

of innovation projects and the returns to R&D investments are highly uncertain compared to investments in tangible assets. As a consequence, investment into R&D in the private sector is lower than socially desirable. The patent system provides incentives to innovate by helping inventors appropriating the returns to their R&D investment (Arrow, 1962).[1]

Patent applications are usually filed at an intermediate stage of the innovation process: They are applied for after a research project led to results, but before a new product is developed and introduced into the market. Commercialization requires investments into complementary assets which are substantial and difficult to redeploy (Teece, 1986). Patents help safeguarding follow-up investments since they guarantee that third parties cannot use the respective invention without permission of the patent right holder (Cohen et al., 2000, Dechenaux et al., 2008).

The positive effects of patents as a means to safeguard R&D investments and complementary investments by limiting the threat of imitation can realize if the patent system works as designed in theory. In practice, patent systems are characterized by various types of uncertainty which can affect patent applicants' commercialization decision (Lemley and Shapiro, 2005, Gans et al., 2008). Uncertainty about the grant decision is only fully resolved once the final decision (grant/reject) about the patent application is reached. Patent scope uncertainty stems from the fact that examiners may require the applicant to abandon specific claims or to change the specification of claims in the course of the examination. The final scope of patent protection is only fully

[1] Note that there are also very critical assessments of IPR systems (Boldrin and Levine, 2008).

revealed once the patent is granted. Furthermore, uncertainty about the economic and strategic value of the invention exists since the value of the underlying invention may only become apparent to the applicant, competitors, potential investors and licensees once the patent is granted. Lastly, there is pendency uncertainty which corresponds to the duration of the patent examination. Pendency periods vary substantially across technological areas, patent and applicant characteristics (Harhoff and Wagner, 2009, Popp et al., 2004, Regibeau and Rockett, 2007). Only after the pendency time elapsed patent applicants have full information about the grant decision, the patent scope and get a better idea of the strategic value of the patent.[2] Under the assumption of patents providing complete protection we would expect a positive effect of IPR on commercialization efforts which is reduced by the uncertainties that are surrounding patent pendencies. This leads us to the hypothesis:

Hypothesis 1: Uncertainties about IPR decrease the likelihood of new product launch by start-ups.

2.2 The Certification Function of Patents

It is a well-documented fact that innovative start-up companies often face financial constraints (e.g. Himmelberg and Peterson, 1994, Hall, 2002, Czarnitzki and Hottenrott, 2011, Schneider and Veugelers, 2010). For start-up companies, internal financing is important, but often not sufficient for financing innovation because new ventures do not

[2] Let us clarify that pending patents can still have a positive value. They can have for instance a positive option value or a positive value due to the fact that they increase uncertainty for competitors (Henkell and Jell, 2010).

possess a portfolio of sales generating products providing regular cash flow which can be used for financing innovation activities and new product development. Additionally, the attraction of external funds is difficult for young innovative companies (Leland and Pyle, 1977, Bhattacharya and Ritter, 1983, Himmelberg and Petersen, 1994, Hall, 2002, Harhoff, 1998) because the "quality" of start-up firms is not directly observable for external investors. The relationship between investors and young ventures is characterized by a substantial degree of asymmetric information (Spence, 1973). Investors search for information that reduces uncertainty about the quality of new ventures (Amit et al., 1990, Hall and Hofer, 1993). Quality revealing information can come from different sources like the characteristics of the entrepreneur herself such as her educational background and working track record (Eisenhardt and Schoonhoven 1990, Burton et al. 2002, Shane and Stuart 2002, Dick et al., 2013) and the ventures' inter-organizational networks (Stuart et al., 1999). In case of R&D intensive start-ups, quality assessment is especially difficult because R&D incorporates technological uncertainty and market risk which add to the typical risks surrounding start-up companies (Hall, 2002, 2005, Arrow, 1962, Lessat et al., 1999). The uncertainty associated with R&D translates into highly skewed returns on investments (Cassar, 2004, Moore, 1994). Patents may serve as quality certification for the ventures' technologies and technological capabilities (Hsu and Ziedonis, 2008, Haeussler et al., 2008, 2014).

In light of patents as a well-defined, enforceable protection of an invention, previous literature has shown that patents are an important criterion for VCs' investment decision. Baum and Silverman (2004), Engel and Keilbach (2007), Cao and Hsu (2011) and Conti

et al., (2013) show that patents have a positive impact on the likelihood and the amount of venture capital funding. Hsu and Ziedonis (2008) find a positive effect of patents on investors' perception of the company's value for a sample of venture capital financed U.S. semiconductor start-ups. Ventures holding patents, further, attract more prominent VCs (Hsu and Ziedonis, 2008).

Baum and Silverman (2004) and Haeussler et al. (2008, 2014) distinguish between the patent application and the patent grant as signals for VC investors. Baum and Silverman (2004) find a strong effect of patent applications and a weaker effect of patent grants for their U.S. sample. Focusing on a sample of German and U.K. start-ups and their European patent records, Haeussler et al. (2014) find that firms with patent applications attract venture capital funding earlier than others. They also show that information learnt during the patent examination process and accessible to both the applicant and potential investors add information which was not anticipated at filing and which increases the likelihood to receive VC funding.[3] Hence, prior findings suggest that VC investors value patent applications more strongly than granted patents. One reason is that VCs may be able to add more value by providing monitoring, managerial and technical support in addition to financial means (Gompers and Lerner, 1998, Hellmann and Puri, 2000). Often VCs are not only motivated by financial returns, but also by knowledge appropriation (Dushnitsky and Lenox, 2005).

[3] It is noteworthy that Haeussler et al. (2008) find evidence that other milestones in the patent application process at the EPO seem to reduce uncertainty for external VCs. Patent oppositions, for instance, lead to earlier VC financing for new ventures.

Previous studies typically consider the certification effect of patents for VCs in isolation. Theoretical literature predicts that start-ups with a relatively small collateral value (Holmstrom and Tirole, 1997, Ueda, 2004), high growth (Ueda, 2004, De Bettignies, 2008), high risk (Berger and Udell, 1998, Ueda, 2004) and potentially high profitability (Ueda, 2004) have a higher probability to receive venture capital than funds from more cautious capital suppliers like banks. These theoretical predictions are supported by empirical evidence (e.g. Storey, 1993, Audretsch and Lehman, 2004) which suggests that small and innovative firms are more likely to be financed by VCs than by banks (Hellmann and Puri, 2000, Audretsch and Lehman, 2004, Brown et al., 2012, for the U.S.).

Given the characteristics of high-tech ventures, cautious investors like banks are in general more reluctant to provide funding. If the start-up is successful and generates high profits their return is bounded to the fixed interest rate, while they bear the full risk in case of failure (Carpenter and Petersen, 2002). Bank loans represent debt and require regular interest payments and collateral value. During the very early stages, start-ups do usually not generate enough returns to be able to pay regular interests (Hall, 2002, Gompers, 1995) and cannot provide sufficient collateral for banks (Berger and Udell, 1998, Carpenter and Petersen, 2002) - independent of having filed for or owning granted patents. [4]

[4] There is recent evidence that this is changing and that patents start to have collateral value, at least in the U.S. (see Hochberg et al., 2014).

VCs, in contrast, are specialized in financing risky and potentially highly rewarded opportunities purchasing an equity stake and providing management support (see e.g. Sahlman, 1990). Other than banks, who also provide small loans, VCs have a relatively high minimum amount of capital that they would like to invest. For the founder, VC investments represent equity rather than debt as in case of bank financing. In further contrast to banks, VCs provide monitoring, managerial and technical support for the ventures in addition to financial means (Gompers and Lerner, 1998, Hellmann and Puri, 2000). As they learn more about the firm in the course of their involvement and active guidance the ventures' technologies described in patent applications may be of value for VCs. This is not at least because VCs are not entirely motivated by financial returns, but also by knowledge appropriation (Dushnitsky and Lenox, 2005). The technical expertise of VCs and their possibility to behave opportunistically, hence, creates a double-moral hazard problem in the sense that not only the venture's effort is needed to attain successful outcomes, but also the VC's support and loyalty. In contrast to banks, VCs can credibly commit to take over the venture (Landier, 2001, Ueda, 2004, De Bettignies and Brander, 2007). In fact, VCs often replace the founders of new ventures by a new management team, even if the founders are performing well (Wasserman, 2003, Heger and Tykvova, 2009).

Entrepreneurs only favor VC investors over bank financing if VCs managerial support is expected to be beneficial for the venture. In case the VC investor is passive entrepreneurs would always prefer bank financing (De Bettignies and Brander, 2007). This hands-on support is especially important when patent applications are pending. During the

pendency period, ventures face a significant degree of strategic uncertainty (Gans et al., 2008).

The involvement of VCs and their knowledge appropriating motivation create a special role for IPR in the relationship between VC and venture. IPR protect ventures against expropriation by VCs (Ueda, 2004), but uncertain IPR can encourage VCs to invest in ventures if they aim at learning and expropriation (Dushnitsky and Lenox, 2005). Not least, VCs can use their expertise to manage the strategic uncertainty of uncertain IPRs and might be even able to turn the strategic uncertainty for the venture into strategic uncertainty for competitors. Banks have no such interests and serve as a benchmark case for a cautious investor.

Hypothesis 2: Uncertain IPR attracts VCs (while do not impact cautious investors like banks).

3. Data, Variables' Definitions and Descriptive Statistics

3.1 Data

The empirical analysis is based on the KfW/ZEW Start-up Panel (SuP), a large sample of start-up firms located in Germany. This data set provides comprehensive information on German entrepreneurial firms. Started in 2008, the SuP is a joint project of the Centre for European Economic Research (ZEW) in Mannheim, the "Kreditanstalt für Wiederaufbau" (KfW) Bankengruppe, Germany's largest state-owned promotional bank, and Creditreform, the largest credit rating agency in Germany, and was initiated in 2008.

The SuP focuses on legally independent firms excluding de-mergers and subsidiaries.[5] The survey is conducted using computer-assisted telephone interviews.

The aim of the SuP is to provide a complete track record for entrepreneurial start-ups with respect to specific firm characteristics (e.g. sales, number of employees), strategic decisions (e.g. composition of the management team, product market entry strategy) and financial sources. Firms drop out of the sample if they reach an age of eight years.[6] The assigned foundation year corresponds to the year in which a firm starts its regular business activities.

The SuP is a stratified random sample. The population is taken from the database of Creditreform which provides a comprehensive database for German firms.[7] Stratification criteria are the year of firm foundation, industry sector[8] and promotion of the venture by the KfW Bankengruppe. Stratification according to industry is based on ten industry clusters, four of which are high-technology industries. Altogether, technology-oriented firms represent half of the surveyed firms. Since the annual number of new firm formations in high-technology manufacturing is rather small (Metzger et al., 2008) each year's random draw includes entrepreneurial firms which have been founded within the

[5] Note that it is not required that the ventures applied for or received funding from the KfW.

[6] In other international surveys on start-up firms, the maximum firm age varies between two and eight years depending inter alia on the technology intensity of the respective industries (Van Praag, 2003, Brüderl et al., 2007, Agarwal and Audretsch, 2001, Prantl, 2001).

[7] Startups are identified as new entries to the data set. Using a computer assisted search algorithm we identify double entries and new entries from de-mergers and subsidiaries. These are dropped from the population sample of the SuP. Information on the firm's name, address, legal form, industry classification and information regarding insolvency procedures is included (see Almus et al., 2000, for a detailed description of Creditreform data).

[8] The industry sectors agriculture, mining and quarrying, electricity, gas and water supply, health care, and the public sector are excluded from the sample.

last three years. For a more detailed description of the sample design we refer to Fryges et al. (2009). For a distribution of our ventures across different broadly defined industry categories we refer to Table 6 in the Appendix.

In order to identify pending patent applications we linked the SuP to the data base of the German Patent and Trademark Office (GPTO) using a computer-based matching algorithm.[9] The link between both databases was conducted based on firms' and founders' names and addresses in the SuP and the names and addresses of patent applicants as listed in the patent records of the GPTO. Each match suggested by the algorithm was checked manually. It is important to note that we do not only match patent applications to company applicants, i.e. the ventures, but also to the entrepreneurs. This is important because ventures may be established only after a technical invention by the founder has been granted patent protection. In our sample, 91% of the patents are owned

[9] We used the Search Engine developed by Thorsten Doherr at the Centre for European Economic Research (ZEW). The algorithm works as follows: In a first step, this tool creates a kind of dictionary, containing all words of company names and other search criteria such as the company address along with an occurrence counter for every entry. This counter is the base for the heuristics of the matching algorithm. The occurrence reflects the identification potential of the word. A relatively low occurrence has a high potential to identify the company, because the resulting list of potential hits is small. Each list represents a percentage of the whole identity of a beneficiary company. This percentage is inversely proportional to the size of the list. By combining all potential hit lists, starting with the smallest, it is possible to rank the combined hits by the summarized percentage of the lists they are part of.
The main advantage of this algorithm is its potential to ignore non-identifying filler words and different positions of the words. The algorithm automatically adjusts itself to the specific combination of words of a beneficiary company name. If a company name consists of a few words with a high identification potential among some words with a low potential, the algorithm ignores the lesser important words. If all words are equally important, the algorithm is more restrictive and ignoring words is not an option.
Because the algorithm is word based, it could be very prone to typing errors that can transform a common word into a very unique word or into a word that is not represented by the dictionary. This problem is circumvented by introducing n-grams to the algorithm.
The main problem of heuristic matches is false positives, resulting from matches with a relative high identification. There is a trade-off between getting the most correct hits and getting too many false hits. Only the user knows the context of the search and sometimes the first result page has no matching entry. This means that manual control of the matches is required to distinguish between correct and false positives.

by the founder and not by the venture.[10] This is in line with Conti et al. (2013) who find that venture formation follows the filing of patent applications and not vice versa.

Our sample includes ventures that have been founded in the years 2005 and 2006 in Germany. In total, our sample includes 1,780 venture year observations. Since most of our start-up companies are only observed once, this figure corresponds to 1,190 ventures.

3.2 Variables' Definition and Descriptive Statistics

This section defines and describes the variables used in the empirical analysis. Table 1 shows the descriptive statistics for our variables, Table 2 the correlation matrix.

3.2.1 Dependent Variables

We define three different dependent variables. The first variable indicates whether a new product has been launched which allows us to test whether new product introductions are influenced by patent pendencies. Almost half of the observations indicate a new product launch within the last two years (about 43%).

In order to test whether pending patent applications impact the access to external financing we focus on VCs and banks as potential suppliers of external funds. We define two dummy variables indicating whether the venture had access to funds from these sources. Most observations in our sample rely on internal financing of their activities as is suggested by the previous literature (e.g. Himmelberg and Petersen, 1994): Only 3%

[10] It is noteworthy to mention that we cannot be sure that individual patents are essential for the venture's business. Such information can only be gathered by conducting interviews with each founder.

received venture capital and only 12% received loans from banks. We use dummy variables because we do not observe the amount of funding the companies received.

Table 1 about here

Table 2 about here

3.2.2 Pending Patent Applications

With respect to the patenting activities of our sampled ventures we find a small numbers of ventures with patent applications. Although 31% of the venture observations report that they conduct R&D in-house the number of patent applications per firm and founders is quite small with an average patent application stock of 0.02 per employee per venture observation. The most active venture in terms of patenting has a patent stock of three patent applications per employee.

We make use of the GPTO information in order to identify the ventures' pending patent applications. Pending applications are defined as filings that are still under review at the GPTO in the year of interest. We normalize the number of pending patents by the venture's patent application stock. For our ventures, on average, 2% of their patent application stock is still pending. For some ventures, all patent applications are still awaiting a decision. Note that the patent variables are lagged by one year in order to avoid endogeneity issues.

3.2.3 Control Variables

In addition to the variables of main interest, we use a number of control variables. We control for firm size in terms of employment since size is likely to be correlated with the

innovation capabilities of the venture. External investors may use this information as an indication for high market potential. We use the logarithm of the number of employees in order to account for the skewness of the venture size distribution. In order to control for venture performance, we use the empirical price cost margin which is on average 7%. This variable further indicates whether a firm already sells products in the markets so that it generates returns. In this sense, it also captures the availability of internal funds. Another variable that proxies the availability of funds is whether the firm is a company with limited liabilities. Companies with limited liabilities are more risk-prone and conduct more R&D than others (Czarnitzki and Kraft, 2000) so that they might be able to attract VCs more easily whereas they may have more difficulties in persuading banks to provide them with funds.

A variable that controls for the innovation capacity but also for the riskiness of the venture is a dummy variable that equals one if the venture conducts R&D in-house. We further control for the share of high skilled employees, those with a university degree, as opposed to the share of workers without training. The share of high skilled workers is low with about 1%. In contrast, more than 45% of the ventures' employees had no training.

Moreover, we account for the presence of a corporate investor. Ventures with the financial and non-financial backing of a corporation have been found to be more successful in terms of radical innovation than a control group of independent ventures (Czarnitzki et al., 2010). The presence of a corporate investor can impact the likelihood to receive funding from other sources as well as the likelihood to introduce a new product

to the market because, similar to VCs, corporate investors often supply managerial guidance in addition to the financial investment.

We further control for a number of characteristics of the founder or the founding team. First of all, 35% of the ventures have been founded by a team. With respect to the educational background and experience of the founders, it turns out that almost half of the observations have at least one founder holding a university degree. 28% of the observations correspond to ventures founded by at least one person with a business background, while 50% of the observations are founded by a team or an individual entrepreneur with a technical background. At least one of the founders of 74% of the observations has experience in managing a firm. The most experienced team member has worked, on average, for 14 years within the same industry. We use the logarithm of this variable to account for the skewness of its distribution. Lastly, it should be noted that a relatively large share of the venture observations (42%) has been founded by a re-starter. Re-starters might, on the one hand, have advantages for managing the new venture due to their past experience. Moreover, they might be discriminated by banks and VCs because of their past failure. The educational, employment and self-employment experience of the founder can act as a signal to potential investors (Eisenhardt and Schoonhoven, 1990, Burton et al., 2002, Shane and Stuart, 2002).

We further use control variables for the stratification criteria used to create the firm sample: industry dummies, year of firm foundation and KfW involvement as this was one of the stratification criteria. Finally, we include a dummy for the year of observation to

control for possible differences in cyclical patterns. These variables are included in all regressions, but not reported.

4. Estimation Approach and Empirical Findings

We hypothesize that pending patent applications affect a firm's decision to launch new products and their access to external financing. Since the access to external funds is likely to impact new product launches we are interested in estimating the following equations:

$$bank\ financing_i = \alpha\ pending\ patent\ applications_i + \delta X_i + u_i \quad (1)$$

$$VC\ financing_i = \alpha\ pending\ patent\ applications_i + \delta X_i + v_i \quad (2)$$

$$product\ launch_i = \alpha\ pending\ patent\ applications_i + \beta\ bank\ financing_i + \gamma\ VC\ financing_i + \delta X_i + w_i \quad (3)$$

where X depict our control variables for venture i and u, v and w the error terms respectively.

4.1 Recursive Model

The system of equations presented above can be interpreted as a hierarchical recursive model (Maddala 1983, Greene 1998, 2003) because the financing variables enter the equation for new product launch as regressors. This renders the sources of external finance potentially endogenous regressors in the product launch equation. We apply a multivariate probit model to estimate the equation system above allowing for correlated error terms. This equation system is identified as long as there is enough variation in the exogenous regressors (Wilde, 2000). The results are presented in Table 3. The

correlations between the equations turn out to be not significantly different from zero. This suggests that we can apply standard probit estimation to the individual equations.

Table 3 about here

4.2 Probit Models

The results of the ordinary probit models are presented in Table 4, the marginal effects in Table 5. Focusing on the product launch equation, it appears that pending patent applications have a negative impact indicating that with uncertain IPR ventures are reluctant to commercialize technologies. This supports hypothesis 1. The likelihood that the ventures introduce a new product decreases by 27% if the pending patents variable increases by one unit. This is a significant economic effect.

With regards to the control variables, new product launches are more likely to occur for large ventures, for ventures that conduct R&D and for venture capital backed companies. The latter result suggests that VCs supply non-monetary support in addition to capital. The price cost margin shows a negative effect suggesting that ventures with a better performance figure and those that already launched at least one product tend to be less prone to new product launch. This finding is expected for our sample of young and rather small ventures. After their first market launch ventures may concentrate on developing and improving the market positioning and features of this product and its production. At

this stage, the ventures most likely lack the capacity to develop and launch further products.[11]

Regarding the financing equations, Table 5 shows that there is a significant positive effect of pending patent applications on the probability of receiving venture capital funds. Hence, hypothesis 2 receives support. A one unit change of pending patent applications over the patent application stock increases the likelihood to receive venture capital by 4%. Although significant in a statistical sense, the economic impact of the certification effect of pending patent applications on the venture capital markets is rather small for our ventures. The effect of the patent application stock is of similar size. Since the pending patent variable has to be interpreted as a premium to the patent stock variable this indicates that pending patent applications are twice as attractive as the total patent application stock. The result is in line with the findings by Haeussler et al. (2008, 2014). They find venture capital investment to happen after the patent application date rather than after the patent grant date.

With respect to bank financing there is no significant effect of the patent variables. These results suggest that banks do not rely on patent applications, pending or not, as quality indicators for ventures. Banks also do not discriminate innovative ventures because they are presumably riskier which good news for these ventures is. The results are in line with hypothesis 2. Overall, the results suggest that risk-taking VCs prefer to invest in start-ups

[11] The industry dummies are mostly insignificant. Only the industry dummies for ventures in high tech and the software industry exhibit positive and significant signs in both the recursive model and the probit model. The results are available upon request.

which already have a proof of concept and are passing on to the product development and market launch stage, while banks as more cautious investors do not attribute value to patent applications, but not discriminate against them either. The result is in line with Conti et al. (2013) and Haeussler et al. (2008, 2014). Our results suggest that in particular pending patent applications matter for VCs while neither patent applications nor pending patent applications impact the likelihood of bank financing.

With respect to the control variables, we find that VCs have a preference for team foundations and capital companies. The latter effect can be explained by the fact that companies with limited liability are more prone to innovation (Czarnitzki and Kraft, 2000). Ventures with technically educated founders are discriminated against the benchmark of having neither a business nor a technical education. Also, founders with industry experience are less likely to receive venture capital. This may indicate that VCs seek greater influence on technological or commercialization decisions. Banks, in contrast, seem to invest in the better risks which are large ventures and they are less interested in funding re-starters.

Table 4 about here

Table 5 about here

4.3 Robustness Check: Instrumental Variables

Although the results from the multivariate probit model indicate that there is no endogeneity issue with regards to the funding sources in the product launch equation, we test whether this result is supported if we use an alternative methodology. A second way

of dealing with endogenous regressors in our context is to apply instrumental variables techniques. Bank financing and venture capital financing are treated as potentially endogenous regressors in the product launch equation.

As instrument for venture capital financing we use the share of venture capital backed ventures on the NUTS 3 regional level.[12] The availability of venture capital in a specific region should be indicative for the likelihood of receiving venture capital funding for the individual venture in our sample while the regional venture capital supply should not impact the likelihood that the individual venture launches a new product.

As an instrument for bank financing we use a measure for the concentration of public banks on the NUTS 3 regional level. We define the market shares of public banks in the region and calculate a Herfindahl concentration index. The measure takes values between zero and one and reaches it maximum if a region is dominated by a particular bank. We focus on public banks for several reasons. First, entrepreneurs typically first approach their house bank for a credit before moving to alternative banks and most people in Germany have their private bank accounts with public banks. Second, public banks fulfill a public mandate to foster small businesses and regional development. Finally, public banks do not have return on investment targets so that they may be more involved in the support of entrepreneurs. The concentration measure depicts the degree of dominance of public banks in a region. If there is a strong concentration of public banks in a region the

[12] NUTS stands for Nomenclature of Territorial Units for Statistics and is a geocode standard for classifying regions. The NUTS 3 level corresponds to the German county ("Kreis") level.

individual ventures' likelihood to receive bank financing should be higher because the bank can be assumed to have a balanced risk portfolio. The concentration measure is not expected to influence new product launches by the venture.

In the first step, we test whether the proposed instruments are relevant, i.e. the instrumental variables have to show a high partial correlation with the potentially endogenous variable. We run ordinary least squares (OLS) regressions for equations (1) and (2) and include the respective instrumental variable as an additional regressor. According to Staiger and Stock (1997) and Stock et al. (2002), a partial F-statistic for the instrumental variable which exceeds a critical value of 8.96 for our case indicates that the instruments are relevant. Our instruments for both equations turn out to be relevant. The share of venture capital backed ventures show an F-statistic of 20.32 in the venture capital financing equation and the Herfindahl index for public banks shows an F-statistic of 9.83 in the bank financing equation.

Having shown that our instruments are relevant, we test in the next step whether venture capital and bank financing are endogenous regressors in the product launch equation. This could be for instance the case if both venture capital financing and the likelihood of a product launch would be correlated with the unobserved quality of the venture. We apply Smith and Blundell (1986) tests and find that the test statistic does not reject exogeneity for both potentially endogenous variables.[13] This confirms our result from the

[13] In order to do so, we run OLS regressions for equations (1) and (2) and include the respective instrumental variable as an additional regressor and obtain the residuals from these regressions. We estimate the probit model for the product

multivariate model by indicating that endogeneity is not a concern for our application. Hence, our ordinary probit results presented in the previous subsection display unbiased results.

4.4 Endogeneity of Pending Patent Applications

A remaining issue is the potential endogeneity of pending patent applications. Patent applicants at the GPTO have the possibility to ask for examination of their patent application for up to seven years after the application date. Henkel and Jell (2010) document that more than 50% of the patent applications at the GPTO experience an applicant-induced examination delay. The reasons for these delays are that applicants aim at creating uncertainty for competitors and that they want to gain time for evaluation (Henkel and Jell, 2010). This could render the pending patents variable endogenous in our regressions. Our analysis so far dealt with the potential endogeneity of pending patents by using all patent variables with a one-year lag. Although we suspect that strategic delays are not useful for start-up companies that, in contrast to industry incumbents, benefit from the certification effect of patents, we test whether pending patent applications are subject to endogeneity in the product launch equation. We use the average pendency time for our start-up companies at the industry level as instrument. This measure depicts whether ventures induce strategic delays at the patent office due to industry specificities. It is, hence, likely to correlate with the patent strategy of individual

---

launch equation, but now also include the residuals obtained in step 1. The standard t-statistic of the coefficient of the included residuals is a valid test on endogeneity of the financing variables.

ventures in the same industry, but unlikely to correlate with the likelihood of the individual start-up's product launch. The instrument passes the Staiger and Stock (1997) test for relevance with a partial F-statistic of 13.23. A Smith and Blundell (1986) test does not reject the null hypothesis of exogeneity of pending patents. This is in line with our expectation that young ventures do not strategically delay the patenting progress because they can substantially benefit from the certification effect of patents.

5. Discussion

Patents can provide two important features for young ventures. On the one hand, they grant temporary monopoly rights on inventions protecting a specific technology from imitations and safeguarding complementary investments needed to develop an idea into a marketable product (Teece, 1986). As such, patents may foster the market launch of new products. On the other hand, patents can serve as a quality certificate for potential external investors (Hsu and Ziedonis, 2008, Haeussler et al., 2008, 2014).

The predicted positive effects of patenting for new ventures are based on the assumption that the patent system works efficiently. In practice, this is not always the case. In this study, we focus on the effect of pending patent applications on commercialization activities and access to external funding focusing on the two most important private investors for innovative start-ups: VCs and banks.

We postulate that if patent applications are pending at the patent office the desirable effects of patents for new ventures may be substantially reduced: In particular uncertainties about the extent of protection on the product market persist, whereas the

technology certification effect may be less at risk since the patent application contains technological information which can be reviewed by interested third parties. While the latter may be more important for risk-loving investors like VCs, the first may impact the firms' decision to launch the product based on the innovative idea. We conjecture that start-ups with pendencies are more reluctant to commercialize new products. We further hypothesize that patent pendencies positively affect the start-ups' access to VC capital.

Our results for a sample of German ventures support our hypotheses. We show that ventures are reluctant to launch new products when patent applications are pending. The reason is that if product launch is not protected by a patent competitors will try to enter the market with an imitation and thereby substantially reducing the innovative firm's return on R&D investment. As a consequence, the innovative firm can postpone market launch.

With regards to access to external funds, we find that patent pendencies increase the likelihood to receive venture capital financing and are even more attractive to VCs than granted patents. A possible explanation is that VCs are not entirely interested in financial returns, but also in knowledge appropriation (Dushnitsky and Lenox, 2005). Moreover, VCs add value to their ventures by providing monitoring, managerial and technical support beyond the financial investment (Gompers and Lerner, 1998, Hellmann and Puri, 2000) so that they might be interested in joining a venture at an early stage of technological development in order to be able to shape the venture's future.

Our result is in line with Haeussler et al. (2008, 2014) who find that patent applications increase the probability of receiving VC funding and that information released by the

patent office during the granting process further increase the probability pointing at the fact that not the full potential of an invention is anticipated at filing. In contrast, our results further show that banks' decision to provide loans to innovative start-ups is not impacted by patenting activities as we only find insignificant effects for pending and granted patents.

The German VC market is relatively small compared to its US and British counterparts (EVCA, 2009) so that bank financing represents a larger share in start-up financing so that bank financing represents a larger share in start-up financing (Metzger, 2015). Consequently, our result that uncertain IPR may delay market launch may be specific for Germany. This impact is most likely smaller in economies with an advanced venture capital market.

Our results have implications for several stakeholders: entrepreneurs, policy makers and patent offices. The implications of our findings for entrepreneurs are that patents if pending do not alleviate uncertainties with regards to protection against imitation and increasing pending periods may even aggravate the situation. Entrepreneurs typically need a substantial amount of money to finance follow-up investment in market launch activities so that they are hesitant to proceed when the patent decision is pending. This renders the decision to file for a patent or not a strategic one. Once submitted to the patent office, the patent application will become accessible by the public so that competitors can learn about the technology. Incumbent companies could use the advantage of deep pockets and proceed with reengineering and commercialization activities. If the entrepreneur would chose secrecy over a patent application she would

gain time to develop and commercialize the product as incumbent competitors only learn about the technology later. The entrepreneur's dilemma regarding the patent decision becomes severe when taking the fact that pending patents can attract VC financing.

Policy makers should be aware that delayed product launch activities induced by prolonged patent pending periods can have detrimental consequences for ventures' profitability, growth and survival. For young firms survival often depends crucially on a short time to market of the first product. Policy makers can take means such as subsidizing a fast track search and examination process at patent offices for start-up companies (see EPO, 2015, (Part E, Chapter VII, section 3) for a description of the Program for Accelerated Prosecution of European Patent Applications at the EPO). More general, policy makers should encourage patent offices to avoid patent pendencies. Patent pendencies can be reduced – while keeping the quality of the examination constant - by hiring of additional patent examiners. It should be investigated whether additional hirings are possible through budget reallocations within patent offices.

Our analysis has some caveats which have to be taken into account when interpreting our results. First, our ventures are very young and exist for a maximum of three years. It would be interesting to investigate whether the effects of pending patent applications sustain for more mature ventures. Second, it would be interesting to investigate the selection process into venture capital and bank financing from the ventures' perspective in more detail and the selection process of ventures by the VCs respectively. However, this data is highly subjective and therefore difficult to collect.

6. References

Agarwal, R. and D.B. Audretsch (2001). Doe entry size matter? The impact of the life cycle and technology on firm survival, *Journal of Industrial Economics* 49, 21-43.

Almus, M., D. Engel and S. Prantl (2000). *The "Mannheim Foundation Panels" of the Centre for European Economic Research (ZEW),* ZEW Documentation 00-02, Mannheim.

Amit, R., L., Glosten and E. Muller (1990). Entrepreneurial Ability, Venture Investments, and Risk Sharing. *Management Science* 36, 1232-1245

Arora, A. and M. Ceccagnoli (2006). Patent Protection, Complementary Assets, and Firms' Incentives for Technology Licensing. *Management Science* 52(2), 293-308.

Arrow, K.J. (1962), Economic Welfare and the Allocation of Resources for Invention, in: R.R. Nelson (ed.), *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton, N.J., 609–625.

Audretsch, D.B. and E.E. Lehman (2004). Financing High-Tech Growth: The Role of Banks and Venture Capitalists. *Schmalenbach Business Review* 56, 340-357.

Baum, J.A.C. and B.S. Silverman (2004). Picking Winners or Building Them? Alliance, Intellectual and Human Capital as Selection Criteria in Venture Financing and Performance of Biotechnology Start-ups. *Journal of Business Venturing* 19, 411-436.

Berger, A. and G. Udell (1998). The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle. Journal of Banking & Finance, 22 , 613-673.

Bhattacharya, S. and J. Ritter (1983). Innovation and communication: Signalling withpartial disclosure. *Review of Economic Studies* 50, 331-346.

Boldrin, M. and D.K. Levine (2008). *Against Intellectual Monopoly*. Cambridge University Press. Cambridge, M.A.

Brown, M., H. Degryse, D. Hoewer and M.F. Penas (2012), *How do Banks Screen Innovative Firms? Evidence from Start-up Panel Data*, ZEW Discussion Paper No. 12-032, Mannheim.

Brüderl, J., P. Preisendörfer and R. Ziegler (2007). *Der Erfolg neu gegründeter Betriebe. Eine empirische Studie zu den Chancen und Risiken von Unternehmensgründungen*, 3rd edition, Duncker & Humblot, Berlin.

Burton, M.D., J. Sorensen and C. Beckman (2002). Coming from Good Stock: Career Histories and New Venture Formation. *Research in the Sociology of Organizations* 19, 229-262.

Cao, J., Hsu, P.-H. (2011). The Role of Patents in Venture Capital Financing. *Working paper*, SSRN eLibrary.

Carpenter, R. and Petersen, B. (2002). Capital Market Imperfections, Hightech Investment, and New Equity Financing. *The Economic Journal* 112, F54-F72.

Cassar, G. (2004). The financing of business start-ups. *Journal of Business Venturing*,19, 261-283.

Cohen, W.M., R.R. Nelson and J.P Walsh (2000*). Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)*. NBER Working Paper Nr. 7552.

Conti, A., J. Thursby and M.C. Thursby (2013). *Patents as Signals for Startup Financing*. NBER Working Paper 19191, Cambridge MA.

Czarnitzki, D., J.M.H. Dick and K. Hussinger (2010). *The Contribution of Corporate Entrepreneurship to Radical Innovation*, ZEW Discussion Paper No. 10-060, Mannheim.

Czarnitzki, D. and H. Hottenrott (2011). R&D Investment and Financing Constraints of Small and Medium-Sized Firms, *Small Business Economics* 36(1), 65-83.

Czarnitzki, D., K. Hussinger and C. Schneider (2015). R&D Collaboration with Uncertain Intellectual Property Rights, *Review of Industrial Organization* 46(2), 183-204.

Czarnitzki, D. and K. Kraft (2000). Haftungsregeln und Innovation. Jahrbuecher fuer Nationaloekonomie und Statistik 220(5), 513-526.

De Bettignies, J.-E. (2008). Financing the Entrepreneurial Venture. *Management Science* 54(1), 151-166.

De Bettignies, J.-E. and J.A. Brander (2007). Financing Entrepreneurship: Bank Finance Versus Venture Capital. *Journal of Business Venturing* 22, 808-832.

Dechenaux, E. B. Goldfarb, S. Shane and M. Thursby (2008). Appropriability and Commercialization: Evidence from MIT Inventions. *Management Science* 54, 893-906.

Dick, J.M.H., K. Hussinger, B. Blumberg and J. Hagedoorn (2013). Is Success Hereditary? Evidence on the Performance of Spawned Ventures. *Small Business Economics* 40, 911-931.

Dushnitsky, G. and M.J. Lenox (2005). When Do Firms Undertake R&D by Investing in New Venture? *Strategic Management Journal* 26, 947-965.

Eisenhardt, K.M. and C.B. Schoonhoven (1990). Organizational Growth: Linking Founding Team, Strategy, Environment, and Growth among U.S. Semiconductor Ventures, 1978-1988. *Administrative Science Quarterly* 35, 504-529.

Engel, D. and M. Keilbach (2007). Firm-level Implications of Early Stage Venture Capital Investment -- An Empirical Investigation. *Journal of Empirical Finance* 14(2), 150-167.

EPO (2015). Guidelines for Examination in the European Patent Office. http://www.epo.org/law-practice/legal-texts/guidelines.html

EVCA (2009). 2009 EVCA Yearbook. Pan-European Private Equity & Venture Capital Activity Report. European Private Equity and Venture Capital Association (EVCA). http://www.apcri.pt/sites/default/files/YB%202009.pdf

Fryges, H., S. Gottschalk and K. Kohn (2009). *The KfW/ZEW start-up panel: Design and research potential*, ZEW Discussion Paper No. 09-053, Mannheim.

Gans, J.S., D.H. Hsu and S. Stern (2008). The Impact of Uncertain Intellectual Property Rights on the Market for Ideas: Evidence from Patent Grant Delays. *Management Science* 54(5), 982-997.

Gompers, P.A. (1995). Optimal Investment, Monitoring and the Staging of Venture Capital. *Journal of Finance* 50, 1461-1489.

Gompers, P.A. and J. Lerner (1998). *The Determinants of Corporate Venture Capital Success: Organizational Structure, Incentives, and Complementarities*, NBER Working Paper No. 6725, Cambridge MA.

Greene, W.H. (1998). Gender Economics Cources in Liberal Arts Colleges: Further Results. *Journal of Economic Education* 29, 291-300.

Greene, W.H. (2003). *Econometric Analysis 5th ed.*. Upper Saddle River, New Jersey: Prentice Hall.

Gude, H., K. Kohn, H. Spengler, S. Gottschalk, S. Kanzen, G. Licht, K. Schopen and M. Niefert (2008), *KfW/ZEW-Gründungspanel für Deutschland, Beschäftigung, Finanzierung und Markteintrittsstrategien junger Unternehmen - Resultate der ersten Befragungswelle*, October 2008 , Mannheim.

Guellec, D. and F. Sachwald (2008). *Research and entrepreneurship: A new innovation strategy for Europe,* Knowledge intensive growth: European strategies in the global economy, Conference of the French Presidency of the European Union, Toulouse, 7-9 July 2008.

Haeussler, C., D. Harhoff and E. Mueller (2014), How patenting informs VC investors – The case of biotechnology, *Research Policy* 43, 1286-1298.

Haeussler, C., D. Harhoff and E. Mueller (2008). The Role of Patents for VC Financing, *Frontiers of Entrepreneurship Research 2008 (FER)*, Babson College, Massachusetts, USA, 78-93.

Hall, B.H.H. (2002). *The financing of research and development.* NBER Working Paper No. 8773.

Hall, B.H.H. (2005). The financing of innovation. In: S. Shane (Ed.), *Blackwell Handbook of Technology and Innovation Management*, Blackwell Publishers, Oxford.

Hall, J. and C. Hofer (1993). Venture Capitalists' Decision Criteria in New Venture Evaluation. J*ournal of Business Venturing* 8, 25-42.

Harhoff, D. (1998). Are there financing constraints for R&D and investment in German manufacturing firms? *Annales d'Economie et de Statistique*, 49/50 , 421-456.

Harhoff, D. and S. Wagner (2009). The Duration of Patent Examination at the European Patent Office. *Management Science* 55(12), 1969-1984.

Heger, D. and T. Tykvova (2009). Do Venture Capitalists Give Founders Their Walking Papers?, *Journal of Corporate Finance* 15(5), 613-625.

Hellmann, T. and M. Puri (2000). The Interaction between Product Market and Financing Strategy : The Role of Venture Capital. *The Review of Financial Studies* 13(4), 959-984.

Henkel, J. and F. Jell (2010). *Patent Pending – Why Faster Isn't always Better*. Mimeo, TU Munich.

Himmbelberg, C. and B. Petersen (1994). R&D and Internal Finance: A Panel Study of Small Firms in High-Tech Industries, *Review of Economics and Statistics* 76, 38-51.

Hochberg, Y.V., C.J. Serrano and R.H. Ziedonis (2014). Patent Collateral, Investor Commitment, and the Market for Venture Lending. NBER Working Paper 20587. Cambridge, MA.

Holmstrom, B. and J. Tirole (1997). Financial Intermediation, Loanable Funds, and the Real Sector, *Quarterly Journal of Economics* 112, 663-691.

Hsu, D. and R.H. Ziedonis (2008). Patents as Quality Signals for Entrepreneurial Ventures. *Academy of Management Best Paper Proceedings*.

Jaffe, A. and J. Lerner (2004). *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About it*. Princeton University Press, Princeton, NJ.

Metzger, G. (2015). Germany's Private Equity Market Lacks Venture Capital. KfW Research, Focus on Economics No 98. KfW. Frankfurt.

Landier, A. (2001). *Start-up Financing: Banks Vs. Venture Capital*. Working Paper, MIT.

Leland, H. E. and D.H. Pyle (1977). Information Asymmetries, Financial Structure, and Financial Intermediation. *Journal of Finance* 32 (2), 371-387.

Lemley, M.A. and C. Shapiro (2005). Probabilistic Patents. *Journal of Economic Perspectives* 19(2), 75-98.

Lessat, V., M. Kulicke, J. Hemer, T. Eckerle, G. Licht and E. Nerlinger (1999). *Beteiligungskapital und technologieorientierte Unternehmensgründungen. Markt – Finanzierung – Rahmenbedingungen.* Gabler-Verlag, Wiesbaden.

Maddala, G.S. (1983) *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge University Press, Cambridge.

Mansfield, E., R. John, R. Anthony, W. Samuel and B. George, (1977). Social and private rates of return from industrial innovations. *The Quarterly Journal of Economics* 91 2: 221–240.

Metzger, G., M. Niefert and G. Licht (2008). *High-Tech-Gründungen in Deutschland: Trends, Strukturen, Potenziale*, Research Report, Zentrum für Europäische Wirtschaftsforschung, Mannheim.

Moore, B. (1994). Financial constraints to the growth and development of small high technology firms. In: A. Hughes & D. Storey (Eds.), *Finance and the small firm*, Routledge, London.

Popp, D., T. Juhl and D.N.K. Johnson (2004). Time in Purgatory: Examining the Grant Lag for U.S. Patent Applications. *Topics in Economic Analysis & Policy* 4(1), article 29.

Prantl, S. (2001). *Bankruptcy, Subsidized Loans, and Exit Decisions of Start-up Firms,* dissertation, University of Mannheim.

Régibeau, P. and K. Rockett (2007). *Are More Important Patents Approved More Slowly and Should They Be?, CEPR* Discussion Paper 6178.

Sahlman, W.A. (1990). The structure and governance of venture capital organizations. *Journal of Financial Economics*, 27, 473-521.

Schneider, C. and R. Veugelers (2010). On Young Highly Innovative Companies – Why They Matter and How (not) to Policy Support Them, *Industrial and Corporate Change*, (2010), 19(4), 969-1007.

Shane, S. and T. Stuart (2002). Organizational Endowments and the Performance of University Start-ups. *Management Science* 48, 154-170.

Smith, R. and R. Blundell (1986). An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply. *Econometrica* 54, 679-685.

Spence, M. (1973). Job Market Signaling. *Quarterly Journal of Economics* 87, 355-374.

Staiger, D. and J.H. Stock (1997). Instrumental Variables Regression with Weak Instruments. *Econometrica* 65, 557-586.

Stinchcombe, A.L. (1965). Social Structure and Organizations. In: J.G. March (ed), *Handbook of Organizations*. Rand McNally: Chicago, 142-193.

Stock, J.H., J.H. Wright and M. Yogo (2002). A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments. Journal of Business & Economic Studies 20(4), 518-529.

Storey, D. (1993). New Firm Growth and Bank Financing. *Small Business Economics* 6, 139-150.

Stuart, T. E., H. Hoang, and R.C. Hybels (1999). Inter-organizational Endorsements and the Performance of Entrepreneurial Ventures. *Administrative Science Quarterly* 44, 315-349.

Teece, D. (1986). Profiting from Technological Innovation, *Research Policy* 15(6), 285-305.

Ueda, M. (2004). Banks Versus Venture Capital, Project Evaluation, Screening, and Expropriation. *Journal of Finance* Vol. LIX No.2, 601-621.

Van Praag, C. M. (2003). Business Survival and Success of Young Small Business Owners, *Small Business Economics* 21, 1-17.

Wasserman, N. (2003). Founder-CEO Succession and the Paradox of Entrepreneurial Success. *Organization Science* 14(2), 149-172.

Wilde, J. (2000). Identification of Multiple Equation Probit Models with Endogeneous Dummy Regressors. *Economic Letters* 69, 309-312.

7. Appendix

Table 4 about here

8. Tables

Table 1: Descriptive Statistics

variable	mean	standard deviation
product launch	0.42	0.24
VC financing	0.03	0.03
bank financing	0.12	0.11
pending patents/patent stock	0.02	0.02
patent stock/employment	0.02	0.02
R&D	0.31	0.46
Log(employment)	1.15	0.41
team foundation	0.35	0.23
university degree	0.48	0.25
business education	0.28	0.20
technical education	0.50	0.25
leadership experience	0.74	0.19
log(work experience in the same field)	2.66	0.42
Restarter	0.42	0.24
capital company	0.45	0.25
price cost margin	0.07	0.07
corporate investor	0.04	0.18
% employees with university degree	0.01	0.03
% employees without training	0.45	0.90

Table 2: Correlation Table

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	product launch	1.00																	
2	VC financing	0.10	1.00																
3	bank financing	0.03	0.04	1.00															
4	pending patents/patent stock	0.00	0.22	0.02	1.00														
5	patent stock/employment	0.02	0.19	-0.02	0.55	1.00													
6	R&D	0.14	0.12	0.13	0.06	-0.03	1.00												
7	Log(employment)	0.06	0.13	0.00	0.10	0.08	0.12	1.00											
8	team foundation	0.12	0.08	-0.08	0.09	0.07	0.02	0.27	1.00										
9	university degree	0.03	0.05	-0.01	-0.01	0.00	0.06	0.24	0.12	1.00									
10	business education	0.00	-0.01	0.04	0.05	0.01	0.01	0.13	0.20	-0.24	1.00								
11	technical education	0.13	0.07	0.01	0.06	0.06	0.18	0.25	0.24	0.08	0.10	1.00							
12	leadership experience	-0.02	-0.04	0.03	-0.02	0.01	0.07	0.07	0.00	-0.12	0.14	0.22	1.00						
13	log(work experience in the same field)	0.11	0.07	-0.10	0.07	0.10	0.08	0.30	0.20	0.09	0.01	0.50	0.05	1.00					
14	Restarter	0.15	0.15	-0.01	0.13	0.10	0.29	0.38	0.32	0.15	0.07	0.31	0.09	0.29	1.00				
15	capital company	-0.10	-0.08	-0.05	-0.14	-0.08	-0.09	-0.12	-0.06	-0.04	0.02	-0.03	0.04	-0.04	-0.22	1.00			
16	price cost margin	-0.05	-0.01	-0.04	-0.02	-0.02	-0.02	-0.02	-0.01	-0.04	-0.03	-0.04	0.04	-0.01	-0.11	0.14	1.00		
17	corporate investor	0.07	0.10	-0.01	0.01	0.03	0.07	0.15	0.08	0.12	0.01	0.09	0.00	0.10	0.15	-0.04	-0.01	1.00	
18	% employees with university degree	0.12	0.23	-0.01	0.05	0.02	0.36	0.15	0.27	0.07	0.07	0.13	0.00	0.12	0.29	-0.04	-0.02	0.16	1.00
19	% employees without training	-0.07	-0.06	-0.02	-0.04	0.00	-0.21	-0.07	-0.12	-0.07	-0.04	-0.09	-0.09	-0.04	-0.14	0.05	-0.01	-0.06	-0.16

Table 3: Multivariate Probit Model (#1780)

	VC financing	Bank financing	Product launch
	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)
pending patents/patent stock	0.76**	0.34	-0.75**
	(0.35)	(0.36)	(0.31)
patent stock/employment	0.56**	-0.48	0.06
	(0.28)	(0.53)	(0.25)
R&D	0.10	0.05	0.66***
	(0.17)	(0.10)	(0.07)
Log(employment)	0.21	0.26***	0.21***
	(0.13)	(0.07)	(0.06)
team foundation	0.47***	0.03	-0.09
	(0.17)	(0.10)	(0.08)
university degree	-0.12	-0.15	0.15**
	(0.19)	(0.10)	(0.08)
business education	0.00	0.04	0.01
	(0.17)	(0.10)	(0.08)
technical education	-0.26	0.18*	-0.08
	(0.17)	(0.09)	(0.07)
leadership experience	0.24	0.14	0.16*
	(0.27)	(0.11)	(0.09)
log(work experience in the same field)	-0.28**	0.05	-0.07
	(0.12)	(0.07)	(0.05)
Restart	-0.17	-0.32***	0.04
	(0.18)	(0.10)	(0.08)
capital company	0.50**	-0.07	-0.02
	(0.23)	(0.10)	(0.08)
price cost margin	-0.36	-0.13	-0.28**
	(0.28)	(0.16)	(0.13)
price cost margin missing	0.32**	-0.11	-0.15**
	(0.16)	(0.09)	(0.07)
founded in 2005	0.09	-0.11	-0.08
	(0.15)	(0.08)	(0.06)
corporate investor	0.26	0.10	0.25
	(0.26)	(0.23)	(0.17)
% employees with university degree	4.67***	-0.82	-0.72
	(0.39)	(1.66)	(1.30)
% employees without training	-0.21	0.01	-0.02
	(0.17)	(0.05)	(0.04)
VC financing			0.45*
			(0.26)
bank financing			0.05***
			(0.19)
constant			-2.50***
			(0.50)
$\rho_{2.1}$ = 0.4 (s.e. = 0.08)	$\rho_{3.1}$ = 0.05 (s.e. = 0.07)		$\rho_{3.2}$ = -0.00 (s.e. = 0.09)
LL	-1846.69		
Wald Chi	2439.96		

***.**.* indicate statistical significance at the 1%. 5%. 10% level.
5 industry dummies. 1 year dummy and 1 stratification dummy are included but not reported.

Table 4: Probit Model (#1780)

	VC financing	Bank financing	Product launch
	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)
pending patents/patent stock	0.75**	0.34	-0.77**
	(0.37)	(0.41)	(0.33)
patent stock/employment	0.56**	-0.48	0.05
	(0.28)	(0.47)	(0.23)
R&D	0.10	0.05	0.66***
	(0.15)	(0.10)	(0.08)
Log(employment)	0.22	0.26***	0.21***
	(0.14)	(0.08)	(0.06)
team foundation	0.47***	0.03	-0.09
	(0.18)	(0.11)	(0.08)
university degree	-0.12	-0.15	0.15*
	(0.18)	(0.11)	(0.08)
business education	-0.01	0.04	0.01
	(0.17)	(0.11)	(0.08)
technical education	-0.27*	0.18*	-0.07
	(0.15)	(0.10)	(0.07)
leadership experience	0.25	0.14	0.16*
	(0.23)	(0.12)	(0.09)
log(work experience in the same field)	-0.28**	0.05	-0.07
	(0.12)	(0.07)	(0.05)
restart	-0.16	-0.32***	0.04
	(0.17)	(0.11)	(0.08)
capital company	0.50**	-0.07	-0.02
	(0.21)	(0.11)	(0.08)
price cost margin	-0.37	-0.13	-0.28**
	(0.29)	(0.16)	(0.13)
price cost margin missing	0.31**	-0.11	-0.16**
	(0.13)	(0.09)	(0.07)
founded in 2005	0.08	-0.11	-0.08
	(0.15)	(0.09)	(0.07)
corporate investor	0.26	0.09	0.24
	(0.27)	(0.23)	(0.19)
% employees with university degree	4.62**	-0.81	-0.82
	(1.88)	(2.04)	(1.28)
% employees without training	-0.21	0.01	-0.02
	(0.16)	(0.05)	(0.04)
VC financing			0.55**
			(0.22)
bank financing			0.05
			(0.10)
constant	-2.49***	-1.55***	-0.50***
	(0.45)	(0.25)	(0.19)
LL	-163.30	-596.73	-1087.02
Pseudo-R2	0.28	0.10	0.10

***.**.* indicate statistical significance at the 1%. 5%. 10% level. 5 industry dummies. 1 year dummy and 1 stratification dummy are included but not reported.

Table 5: Marginal Effects

	VC financing	Bank financing	Product launch
	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)
pending patents/patent stock	0.04**	0.06	-0.27**
	(0.02)	(0.08)	(0.12)
patent stock/employment	0.03**	-0.09	0.02
	(0.01)	(0.09)	(0.08)
R&D	0.00	0.01	0.23***
	(0.01)	(0.02)	(0.02)
Log(employment)	0.01	0.05***	0.07***
	(0.01)	(0.01)	(0.02)
team foundation	0.02***	0.01	-0.03
	(0.01)	(0.02)	(0.03)
university degree	-0.01	-0.03	0.05*
	(0.01)	(0.02)	(0.03)
business education	-0.00	0.01	0.00
	(0.01)	(0.02)	(0.03)
technical education	-0.01*	0.03*	-0.03
	(0.01)	(0.02)	(0.03)
leadership experience	0.01	0.03	0.05*
	(0.01)	(0.02)	(0.03)
log(work experience in the same field)	-0.01**	0.01	-0.02
	(0.01)	(0.01)	(0.02)
restart	-0.01	-0.06***	0.01
	(0.01)	(0.02)	(0.03)
capital company	0.02**	-0.01	-0.01
	(0.01)	(0.02)	(0.03)
price cost margin	-0.02	-0.02	-0.10**
	(0.01)	(0.03)	(0.04)
price cost margin missing	0.01**	-0.02	-0.05**
	(0.01)	(0.02)	(0.02)
founded in 2005	0.00	-0.02	-0.03
	(0.01)	(0.02)	(0.02)
corporate investor	0.01	0.02	0.08
	(0.01)	(0.04)	(0.07)
% employees with university degree	0.22**	-0.15	-0.29
	(0.09)	(0.37)	(0.45)
% employees without training	-0.01	0.00	-0.01
	(0.01)	(0.01)	(0.01)
VC financing			0.19**
			(0.08)
bank financing			0.02
			(0.04)

***.**.* indicate statistical significance at the 1%. 5%. 10% level.
5 industry dummies. 1 year dummy and 1 stratification dummy are included but not reported.

Table 6: Industries

industry	#
Super high tech	218
High tech	176
High tech services	447
software	213
Non-tech manufacturing	402
Knowledge intense services	168
Other services	156
total	1780