TECHNISCHE UNIVERSITÄT MÜNCHEN

Dr. Theo Schöller-Stiftungslehrstuhl für Technologie- und Innovationsmanagement

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The Role of Patents in Venture Capital Financing – an Empirical Analysis from Different Perspectives

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Vollständiger Abdruck der von der Fakultät für Wirtschaftswissenschaften der Technischen Universität München zur Erlangung des akademischen Grades eines

Doktors der Wirtschaftswissenschaften (Dr. rer. pol.)

genehmigten Dissertation.

Vorsitzender: Univ.-Prof. Dr. C. Kaserer

Prüfer der Dissertation: 1. Univ.-Prof. Dr. J. Henkel

2. Univ.-Prof. Dr. Dr. H. Patzelt

Die Dissertation wurde am 17.07.2012 bei der Technischen Universität München eingereicht und durch die Fakultät für Wirtschaftswissenschaften am 15.10.2012 angenommen.

Preface

While working on this dissertation, I have received support from many people. I would like to take this opportunity to warmly thank all those who have assisted me during this time.

First of all, I am grateful to my advisor Prof. Dr. Joachim Henkel for his continuous support throughout my entire Ph.D. studies, his valuable advice regarding my research, and for providing me with a fully-fledged academic experience. I would also like to thank him for co-authoring the papers that underlie the fourth and fifth chapter of this dissertation. Furthermore, I am thankful to my second advisor Prof. Dr. Dr. Holger Patzelt and to Prof. Dr. Christoph Kaserer for chairing my Ph.D. committee.

The empirical studies in this dissertation would not have been possible without the venture capitalists and entrepreneurs who offered their time to answer my interview questions or take part in one of my surveys. I am very grateful for their invaluable input.

Moreover, I owe a big thanks to Annika Bock, Jörn Block, Rainer Filitz, Timo Fischer, Florian Jell, Robert Lüttke, Anja Schön, Frank Spiegel, Josef Waltl, Evelin Winands, and Hans Zischka for creating a very cooperative, inspiring, and fun working environment at the Schöller Chair in Technology and Innovation Management. In particular, I am thankful to Timo Fischer for his suggestions and advice regarding the concept and methods of my research.

Additionally, I would like to thank the TUM students Ferdinand von Bennigsen, Stephanie Conrad, Jan König, Max Pfaffenzeller, and Leonhard Sachsenhauser. This thesis has benefitted greatly from their research support.

Finally, I am deeply indebted to my parents, my brother and my wife, Anna, for their continuous encouragement and unconditional support throughout my academic career and beyond.

Daniel Hoenig

July 2012

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List of Abbreviations

AME	Average marginal effect
ARIPO	African Regional Intellectual Property Organization
Avg.	Average
B	Billion
Biotech	Biotechnology
BVK	Bundesverband Deutscher Kapitalbeteiligungsgesellschaften
CEO	Chief executive officer
Cleantech	Clean technologies
Coeff.	Coefficient
CTO	Chief technology officer
CVC	Corporate venture capitalist
EPO	European Patent Office
ET	Equally good technologies
EVCA	European Private Equity and Venture Capital Association
GER	Germany
GDP	Gross domestic product
High-tech	High technology
ICT	Information and communication technologies
iia	Independence of irrelevant alternatives
i.e.	Id est
IP	Intellectual property
IPO	Initial public offering
IT	Information technology
KMO	Kaiser-Meyer-Olkin
LR	Likelihood ratio
M	Million
Mgmt.	Management
Ob.	Observations
OLS	Ordinary least squares
PATSTAT	EPO Worldwide Patent Statistical Database
Prob.	Probability

PVC	Public venture capitalist
R&D	Research and development
SE	Standard error
Std. Dev.	Standard deviation
TRIPS	(Agreement on) Trade Related Aspects of Intellectual Property Rights
TU	Technologies unknown
U.S.	United States
UK	United Kingdom
USP	Unique selling proposition
USPTO	U.S. Patent and Trademark Office
VC	Venture capitalist
VC-funded	Entrepreneurs who received funding from venture capitalists
Vs.	Versus
WIPO	World Intellectual Property Organization

Abstract

Recent empirical studies suggest that patents are an important investment criterion for venture capitalists (VCs). A start-up's patent stock has been found to be related to both its likelihood of receiving equity funding and the amount of venture capital it receives. However, a detailed understanding of exactly how patents influence VCs' decision making is still missing. The purpose of this dissertation is to address this gap. By analyzing data from interviews, surveys, and patent databases, I provide new empirical evidence regarding the role of patents in venture capital financing. In sum, this dissertation features five studies, each of which examines the research topic from a different perspective.

In the first study, I investigate the relative importance of patents and other start-up resources as venture capital selection criteria in an international context. By analyzing data from a conjoint survey among 102 VCs investing in Germany and 85 VCs from the United States, I find that alliances are considered the most important criterion followed by patent protection in both regions. A comparison of the value contribution of individual resources between the two samples reveals that VCs in Germany attach a significantly higher importance to granted patents than U.S. VCs. International differences in the patent system and legal practice may explain this higher evaluation of patents in Germany than in the U.S.

The second study compares the decision making of venture capitalists between three high technology industries, a topic that so far has been neglected by entrepreneurship scholars. My industry-specific calculations show that VCs' selection criteria differ considerably between industries. As expected, in the biotech industry, patent protection represents the most important criterion whereas in the cleantech and ICT sector, alliances have the strongest impact on VCs' decisions. In assessing the value contributions of individual attribute levels, similar differences between discrete and complex industries come to light. A granted patent and a research alliance agreement are perceived significantly more valuable by VCs in biotech than in the two complex industries. A written sales alliance, on the contrary, appears to be much more useful in raising venture capital in the cleantech and ICT industry than in biotech.

In the third study, I take on a functional perspective. The role of start-up resources in venture capital financing is twofold; they can have a productive and a signaling function. Patents, for instance, not only carry value in their original function as property rights, but can possibly also serve as signals of the unobservable quality of a venture's technology. Existing studies in this field are based on firm-level transaction data, which does not allow the disentanglement of the signaling effect of start-up resources from their productive effect. I address this gap by means of a scenario-based conjoint survey among German and U.S. VCs. My results show that VCs mainly rely on existing research alliances as indicators of technological quality. Patents appear to have a strong impact on venture capital decision making as well, but only in their property rights function and not as quality signals.

The fourth study analyzes VCs' attitude towards patents from a human capital perspective. Patents not only provide start-ups with benefits but also incorporate a number of drawbacks. Thus, VCs' opinions on patents owned by start-ups may vary. Since some recent studies find that VCs' human capital, i.e. education and experience, can explain differences in the decision making of individual investors, I apply this contingency approach to VCs' attitude towards patents. My multivariate regressions reveal that several types of human capital have a significant effect on VCs' appreciation of patents. VCs who claim to know a great deal about intellectual property attach a higher value to patents than VCs without such specific knowledge. On the other hand, VCs who have experienced a patent lawsuit or hold a law degree appreciate patents much less than their peers. Industry-specific human capital gained from technical education is negatively related to VCs' attitude towards patents as well.

In the fifth study, I examine patents' role from the perspective of entrepreneurs. Using data from a survey with 91 high-tech entrepreneurs in Germany, I perform two types of analyses. In the first analysis, I explore to what extent entrepreneurs understand the decision making of venture capitalists. A direct comparison of my conjoint experiment among VCs with same conjoint experiment among entrepreneurs shows that entrepreneurs apparently comprehend VCs' usage of selection criteria quite well. In the second step, I analyze the patenting activity of my sample of entrepreneurs and test whether different levels of patenting experience affect entrepreneurs' attitudes towards patents. For that purpose, the survey data is complemented with patent data from a patent database. I observe that patenting is positively related to venture capital financing; however, I cannot identify any influence of an entrepreneur's own patenting experience on his/her attitude towards patents.

In conclusion, even though patents in general play an important role as selection criterion in venture capital financing, their value contribution is in some respects clearly limited. For practitioners and academics alike this dissertation provides many novel insights on how the importance of patents differs between regions, industries, and functions as well as from the perspective of individual investors and entrepreneurs.

Zusammenfassung

Aktuelle empirische Studien deuten darauf hin, dass Patenten eine hohe Bedeutung als Investitionskriterium für Venture-Capital-Investoren (VCs) zukommt. So belegen diese Untersuchungen einen positiven Zusammenhang zwischen der Anzahl der Patente, welche ein Start-up besitzt, und dessen Finanzierungswahrscheinlichkeit. Es fehlt allerdings weiterhin ein genaues Verständnis dafür, wie genau und in Abhängigkeit welcher äußeren Umstände Patente das Entscheidungsverhalten von VCs beeinflussen.

Ziel dieser Dissertation ist es, diese Forschungslücke zu schließen. Basierend auf Analysen von Daten aus Interviews, Umfragen und Patentdatenbanken, werden neue empirische Erkenntnise zur Rolle von Patenten in der Venture-Capital-Finanzierung vorgestellt. Insgesamt enthält diese Dissertation fünf Studien, die sich dem Untersuchungsgegenstand jeweils aus einer unterschiedlichen Perspektive nähern.

Die erste Studie untersucht die relative Bedeutung von Patenten und anderen Start-up-Ressourcen als Auswahlkriterien bei der Venture-Capital-Finanzierung in einem internationalen Rahmen. Zu diesem Zweck werden Daten aus einer Conjoint-Umfrage mit 102 deutschen und 85 US-amerikanischen VCs analysiert. Es stellt sich heraus, dass Patentschutz in beiden Regionen nach Allianzen das zweitwichtigste Entscheidungskriterium darstellt. Ein Vergleich der Wertbeiträge einzelner Ressourcen zwischen den beiden Stichproben ergibt, dass VCs in Deutschland einem erteilten Patent eine deutlich höhere Bedeutung zusprechen als US-amerikanische VCs. Internationale Unterschiede im Patentsystem wie auch in der Rechtsprechung dürften für diese höhere Wertschätzung von Patenten in Deutschland ausschlaggebend sein.

Die zweite Untersuchung vergleicht das Entscheidungsverhalten von VCs in drei verschiedenen Hochtechnologie-Industrien, eine Fragestellung die bis dato in der Forschung vernachlässigt wurde. Branchenspezifische Berechnungen zeigen, dass sich die Auswahlkriterien der VCs zwischen den einzelnen Industrien deutlich unterscheiden. Wie erwartet stellt sich in der Biotech-Branche vorhandener Patentschutz als das wichtigste Kriterium heraus, wohingegen sowohl im Cleantech-Segment wie auch im Bereich der Informations- und Kommunikationstechnologie (IKT) bestehende Allianzen den stärksten Einfluss auf die Entscheidungen der Investoren haben. Bei einer genauen Analyse der Wertbeiträge einzelner Ressourcen lassen sich ähnliche

Unterschiede zwischen diskreten und komplexen Industriebranchen erkennen. Ein erteiltes Patent und eine vereinbarte Forschungsallianz sind in der Wahrnehmung der VCs in der Biotech-Branche deutlich wertvoller als in den beiden komplexen Industrien. Im Gegensatz dazu erscheint eine schriftlich festgehaltene Vertriebsallianz für die Gewinnung von Venture Capital in der Cleantech- und IKT-Branche deutlich nützlicher zu sein als im Biotech-Segment.

Die dritte Studie befasst sich mit einer funktionalen Perspektive. Start-up-Ressourcen nehmen eine doppelte Rolle im Rahmen der Venture-Capital-Finanzierung ein: Sie können sowohl eine produktive Funktion als auch eine Signalfunktion ausfüllen. Beispielsweise tragen Patente einen Wert in ihrer eigentlichen Funktion als Eigentumsrechte, können darüber hinaus allerdings auch als Signale für die nicht beobachtbare Qualität der Technologie eines Start-ups dienen. Bestehende Untersuchungen in diesem Bereich basieren auf Transaktionsdaten und können daher den Signaleffekt von Start-up-Ressourcen nicht von ihrem produktiven Effekt trennen. Genau diese Forschungslücke wird mit Hilfe einer szenariobasierten Conjoint-Umfrage unter deutschen und US-amerikanischen VCs geschlossen. Die Ergebnisse zeigen, dass sich VCs hauptsächlich auf bestehende Forschungsallianzen als Indikatoren für technologische Qualität verlassen. Patente haben ebenfalls einen starken Einfluss auf die Auswahlentscheidungen von Venture-Capital-Investoren, allerdings ausschließlich in ihrer Funktion als Eigentumsrechte und nicht als Qualitätssignale.

Die vierte Studie analysiert die Einstellung von VCs gegenüber Patenten aus einer Humankapital-Perspektive. Patente bieten für Start-ups nicht nur Vorteile, sondern bringen u.a. aufgrund der Verfahrensgebühren auch einige Nachteile mit sich. Daher dürften sich die Meinungen einzelner Investoren in Bezug auf Start-up-Patente unterscheiden. Da aktuelle Studien herausgefunden haben, dass durch das Humankapital von VCs, d.h. ihre Ausbildung und Erfahrung, Unterschiede in deren Entscheidungsverhalten erklärt werden können, wird dieser Kontingenz-Ansatz auch auf die vorliegende Untersuchung der Einstellung gegenüber Patenten angewandt. Es stellt sich heraus, dass verschiedene Arten von Humankapital einen signifikanten Einfluss auf die Werteinschätzung von Patenten durch VCs haben. VCs, die angeben sich gut mit Themen rund um geistiges Eigentum auszukennen, weisen Patenten einen deutlich höheren Wert zu als Investoren ohne dieses spezifische Wissen. Andererseits schätzen jene VCs, die bereits einmal in einen Patentrechtsstreit verwickelt waren oder eine juristische Ausbildung durchlaufen haben, Patente deutlich geringer ein als ihre Kollegen. Industriespezifisches Humankapital, welches durch eine technische Ausbildung erlangt wurde, scheint sich ebenfalls negativ auf die Einstellung von VCs gegenüber Patenten auszuwirken.

In der fünften Studie wird die Rolle von Patenten aus der Sicht von Unternehmern erforscht. Unter Verwendung der Daten einer Umfrage mit 91 Technologie-Unternehmern in Deutschland werden zwei Analysen durchgeführt. Die erste Analyse verfolgt das Ziel zu bestimmen, inwieweit Unternehmer den Entscheidungsprozess von Venture-Capital-Investoren verstehen. Ein direkter Vergleich der Umfrageergebnisse von VCs und Unternehmern zeigt, dass Unternehmer recht gut einschätzen können, welche Bedeutung VCs Patenten und anderen Start-up-Ressourcen bei der Bewertung von Business-Plänen beimessen. Im zweiten Schritt wird das Patentierungsverhalten der teilnehmenden Unternehmer analysiert und mit deren Einstellung gegenüber Patenten in Verbindung gebracht. Die Umfragedaten werden dazu mit Patentdaten aus entsprechenden Datenbanken erweitert. Statistische Berechnungen belegen zwar, dass aktives Patentieren in einem positiven Zusammenhang mit dem Erhalt einer Venture-Capital-Finanzierung steht, allerdings lässt sich kein signifikanter Einfluss der Patentierungserfahrung eines Unternehmers auf dessen Einstellung gegenüber Patenten erkennen.

Zusammenfassend lässt sich sagen, dass Patente zwar generell als Auswahlkriterium in der Venture-Capital-Finanzierung eine wichtige Rolle spielen, ihr Wertbeitrag in mancherlei Hinsicht allerdings deutlich eingeschränkt ist. Praktikern wie Wissenschaftlern bietet diese Dissertation viele neue Erkenntnisse darüber, wie sich der Stellenwert von Patenten zwischen Regionen, Branchen und Funktionen sowie aus der Sicht einzelner Investoren und Unternehmer unterscheidet.

1 Introduction

1.1 Motivation

The business world's interest in intellectual property (IP) rights, in particular patents, has strongly increased in the last two decades. The number of yearly patent applications worldwide doubled from 1990 to 2010 and even tripled in some major economies, e.g., the United States. (USPTO 2012a, WIPO 2011). Furthermore, some industries have recently experienced a boom in patent litigation activities (Bessen and Meurer 2005). Through current news reports, we can follow how major technology players acquire other firms mainly to get a hold of their patent portfolios (Economist 2011), and how corporations in the mobile communications market continuously battle each other in court on the basis of their property rights (e.g., Economist 2010). Some studies argue that nowadays intangible assets account on average for 80% of firms' market value—compared to 32% 25 years ago—with a large part of that value being represented by intellectual property rights (e.g., Ocean Tomo 2011). As a result, many technology firms have started to invest in their IP management capabilities by hiring dedicated IP professionals (e.g., Reitzig 2004, Rivette and Kline 2000).

The increased importance of IP rights is not only relevant for large technology firms, but also for new and small ventures. For start-ups built upon an innovative technology patents might be especially valuable as they typically do not own many other assets yet (e.g. Hall 2007, Häussler et al. 2010). The context of venture capital financing represents an interesting area to investigate the role of patents owned by new firms for two main reasons. First, many technology start-ups are in need for external financing to enable further development and thus have to master the challenging task of raising venture capital (e.g., Achleitner and Nathusius 2004, Gompers and Lerner 2001). Based on the fact that it is commonly very difficult to obtain venture capital, it is interesting to know whether the presence of patents has an influence on the investment decisions of venture capitalists (VCs). Furthermore, in selecting their investment targets, VCs are said to have a very good sense for identifying particularly promising start-ups (e.g., Baum and Silverman 2004). VCs are thus expected to know what kind of resources start-ups need to eventually become successful.

Recent statements from VCs and empirical findings suggest that patents' role in venture capital financing is indeed gaining importance. Asked for his main investment criteria when evaluating start-ups from the clean technologies (cleantech) industry, German VC Christian Wexlberger states in a recent interview with "Venture Capital Magazin" (2011), "First of all, it must be an innovative product which can be defended. That means the idea needs to be protected against imitators, usually through patents." Even if patents are not necessarily considered as the No. 1 investment criterion by all VCs, many other venture capital firms clearly communicate on their websites that patent protection is one crucial element they look for when evaluating start-up business plans.[1]

This anecdotal evidence is supported by results from recent empirical studies. Analyzing firm-level transaction data entrepreneurship scholars have found that a start-up's patent stock is positively related to both its likelihood of raising funding and the amount of venture capital it receives (e.g., Baum and Silverman 2004, Hsu and Ziedonis 2011, Mann and Sager 2007). Patents appear to have a positive impact on VCs' decision making not only in discrete product industries, e.g., biotechnology (biotech), but also in more complex product markets such as the semiconductors or information technology (IT) sector (e.g., Baum and Silverman 2004, Conti et al. 2011, Häussler et al. 2010, Hsu and Ziedonis 2011). Researchers commonly argue that these findings are due to the twofold function patents fulfill in this context; they carry value in their original function as property rights and may additionally serve as signals of start-up qualities which cannot be directly observed (e.g., Conti et al. 2011, Long 2002).

While the above mentioned studies have managed to shed some light on the role of patents in venture capital financing, several questions remain unanswered. In the following section, I will explain what these open issues are and how I aim to address them in this dissertation.

[1] See for example http://www.whebpartners.com/our-approach/investment-criteria (accessed 11.11. 2011) or http://www.wellington-partners.com/wp/whatwelookfor_home_ls.html (accessed 11.11. 2011).

1.2 Research Objectives

The purpose of this thesis is to provide a detailed investigation on the role of patents in venture capital financing. More precisely, in analyzing the influence of patents on VCs' decision making, I pursue four research objectives. First, I aim to determine to what extent start-up resources, in particular patent applications and grants, affect VCs' decision making across various regions and industries. In a second step, I aim to clarify patents' functional role by disentangling their signaling effect from their productive effect. Third, I aim to find out whether VCs' attitude towards patents can be explained by their human capital. Fourth, I aim to shed more light on the role of patents by investigating it from the perspective of entrepreneurs.

Research objective 1: *Assess how start-up resources, in particular patent applications and grants, influence the decision making of venture capitalists across various regions and high-tech industries.*

Patents have long been recognized as a relevant but not very important venture capital selection criterion (e.g. MacMillan 1987). Only recently the attention towards patents has increased due to a number of studies based on transaction data finding a positive correlation between start-ups' patenting activity and venture capital financing variables (e.g., Baum and Silverman 2004, Hsu and Ziedonis 2011, Mann and Sager 2007). Empirical evidence regarding the importance of patents during VCs' screening of business plans, however, is still scarce. The screening of business plans represents the first step of the venture capital decision making process and is of particular relevance as only 20% of all start-ups applying pass this initial test (e.g., Roberts 1991). Since there is only very little time for screening each start-up, VCs will use a limited set of the most objective and trustworthy start-up characteristics as their selection criteria (e.g., Hall and Hofer 1993). Fulfilling these requirements a start-up's patents as well as other resources, e.g., team members and alliances, and are thus expected to have a strong impact on VCs' screening decisions.

Besides analyzing the relative importance of start-up resources in general, a further interesting path of research is to investigate how their impact is moderated by external circumstances. The existing literature, for instance, hardly offers any evidence on how VCs' usage of selection criteria differs between regions. Patents provide an especially interesting case for such a comparison, since due to regional differences in the patent and legal systems (e.g., Harhoff et al. 2009, Jaffe and Lerner 2004, Ohly 2008) the value of patents to VCs may certainly vary between two countries.[2] Furthermore, the importance of certain selection criteria may also differ from one start-up industry to another industry. For example, patents are known to be more effective in discrete industries than in complex industries (e.g., Cohen et al. 2000, Levin et al. 1987). By testing whether VCs incorporate this fact into their evaluation of start-ups from various industries, I aim to address another gap in the venture capital literature.

I investigate the importance of start-up resources as venture capital screening criteria in three high-technology industries by conducting a conjoint survey with VCs investing in Germany and the United States. This method not only allows me to identify trade-offs between the different decision criteria but also to determine the value contribution of individual levels of these variables, for example patent applications and grants. Furthermore, by comparing the results from my two regional samples I am able to study differences in the value that German and U.S. VCs attribute to patents and the other start-up resources. Moreover, when splitting each sample by industry, I can provide industry-specific results and test whether the relative importance of certain screening criteria differs between industries.

Research objective 2: *Clarify patents' functional role by disentangling their signaling effect from their productive effect.*

In recent studies, patents have been shown to be positively related to a start-up's ability to attract venture capital financing (e.g., Baum and Silverman 2004, Häussler et al. 2010, Hsu and Ziedonis 2011, Mann and Sager 2007). The role of patents in this context is twofold; they can have a productive and a signaling function. Regarding their productive function as property rights, patents help appropriate returns from investment in research and development (R&D) and facilitate the commercialization of new technologies (Cohen et al. 2000, Hall and Ziedonis 2001, Levin et al. 1987, Teece 1986). Regarding the signaling function, patents hold informational value and may serve as a quality signal in the presence of information asymmetry (Long 2002). In line with Spence's (1973) definition of a signal, patents, being differentially costly to obtain,

2 I analyze VCs investing in Germany and the United States.

may be regarded as an observable proxy for the unobservable quality of a start-up's technology (e.g., Conti et al. 2011). Existing studies in this field are based on firm-level transaction data, which does not allow the disentanglement of the signaling effect of start-up resources from their productive effect. Among others, Mann and Sager (2007, p. 200) call for more research on this issue by stating that "the patent serves as a proxy for both the innovation and the legal protection," two effects that patent scholars so far cannot untangle.

I address this research gap by means of a scenario-based conjoint experiment with VCs from Germany and the United States. Analyzing data collected from hypothetical screening decisions, I can determine the value contribution of each start-up resource in VCs' decision making. To disentangle the signaling effect of these resources from their productive effect, I conducted the experiment under two scenarios featuring different levels of information asymmetry. This advancement of a traditional conjoint survey allows me—to the best of my knowledge for the first time—to isolate and quantify the signaling effect of patents and other start-up resources in venture capital financing.

Research objective 3: *Examine how VCs' human capital characteristics explain differences in their attitudes towards patents.*

Due to the numerous benefits they involve, patents owned by technology start-ups appear to be highly appreciated by VCs (e.g., Baum and Silverman 2004, Häussler et al. 2010). However, patents may also incorporate some downsides, especially for young ventures (e.g., Graham and Sichelman 2008). Hence, the assumption arises that the high value associated with patents does not likely reflect the opinions of all VCs. Even though the VC community is often considered as a fairly homogenous group with regard to their decision making, recent studies prove that considerable differences between individual VCs do exist and are worth further exploring (e.g., Dimov and Shepherd 2005, Zarutskie 2010). It is often the human capital of individuals, i.e. their education and experience, that serves as a differentiator in this context (e.g., Dimov et al. 2007, Patzelt et al. 2009). Thus, VCs' human capital may also be capable of explaining a fair share of their differing attitudes towards patents.

I examine this issue by means of a survey with VCs investing in Germany. Using data collected in a conjoint analysis as well as a traditional questionnaire, I am able to measure and analyze VCs' attitude towards patents in two different ways. I use standard regression models to show how various types of education and experience influence VCs' appreciation of patents.

Research objective 4: *Investigate entrepreneurs' perception of the role of patents in venture capital financing.*

For a holistic investigation of the role of patents in venture capital financing, not only the views of capital providers need to be considered but also those of capital receivers. I present and investigate two situations, in which the perceptions of entrepreneurs are of particular interest.

First, numerous articles have explained the investment process of VCs and in particular the selection criteria they employ at the different stages of that process (e.g., Hall and Hofer 1993, Tyebjee and Bruno 1984). However, no scientific study has ever directly examined whether entrepreneurs understand VCs' decision making. Thus, I aim to fill this gap by comparing the results of a conjoint survey among entrepreneurs with the results of the same survey among venture capitalists. Based on this analysis I am able to specify to what extent entrepreneurs understand VCs' usage of patents and other start-up resources as selection criteria.

Second, the patenting behavior and underlying motives of large technology firms have been analyzed by innovation scholars for many years (e.g., Arundel 2001, Blind et al. 2006, Cohen et al. 2000). While some recent studies have started investigating what the managers of small and young firms think about patents (e.g., Graham et al. 2009, Veer and Jell 2011), we still lack an understanding of the drivers of entrepreneurs' attitude towards patents. In particular, it would be interesting to know whether an entrepreneur's own experience in filing patents alters his/her perception of the usefulness of patents. In order to address this question, I investigate entrepreneurs' patenting activity and their attitude towards patents with data from my own survey and a patent database. More specifically, I examine to what extent entrepreneurs' appreciation of patents can be explained by their human capital, especially their own patenting experience.

1.3 Structure of this Dissertation

In order to address the above described research objectives I examine the role of patents from several perspectives. These different perspectives serve as structure of this dissertation. In total, this work comprises eight chapters.

After this introductory chapter, *Chapter 2* lays the theoretical foundations for all following empirical investigations. First of all, I introduce the main working mechanisms of the patent system and the concept of venture capital financing. I then review the existing literature on the role of patents in this context. Furthermore, I present qualitative evidence I gained from interviews with VCs at an early research stage.

Chapter 3 offers an *international perspective* on venture capitalists' decision making. Together with the next chapter it addresses *research objective 1*. I investigate the importance of patents and other start-up resources as selection criteria in the screening of business plans. Analyzing survey data from two samples of VCs, German and U.S., I present regional results as well as an international comparison.

In *Chapter 4*, I take on an *industry perspective*. After discussing differences in the effectiveness of patents and alliances between industries, I develop several hypotheses on industry-related variations in VCs' decision making. My empirical analyses provide an overview of VCs' usage of start-up resources as selection criteria in three high-tech industries and demonstrate by how much the importance of individual criteria differs between industries.

Chapter 5 discusses the role of patents from a *functional perspective*. In order to address *research objective 2*, I investigate the extent to which start-up resources function as signals of technological quality. I analyze data from a scenario-based conjoint survey with VCs that was specifically designed to allow for separating the signaling effect of start-up resources from their productive effect.

A *human capital perspective* is applied in *Chapter 6*. In this study, I establish the link between VCs' human capital and their attitude towards patents (*research objective 3*). Examining various types of data from a survey among German VCs I identify personal characteristics that determine whether VCs appreciate patents more or less.

In *Chapter 7*, I switch from a VC's to an *entrepreneur's perspective*. Addressing *research objective 4*, two independent analyses based on a survey with German high-tech entrepreneurs are presented. First, I investigate to what degree entrepreneurs understand VCs' decision making. In the second study, I examine how human capital characteristics, in particular personal patenting experience, determine entrepreneurs' attitudes towards patents.

Chapter 8 concludes this thesis by summarizing key findings, highlighting implications for theory and practice, and suggesting avenues for future research.

2 Theoretical Foundations and Qualitative Evidence

2.1 Intellectual Property Rights in the Form of Patents

2.1.1 Characteristics of patents

Intellectual property (IP), such as discoveries, inventions, designs, and specific know-how, is nowadays considered one of the most valuable assets of a firm, especially if the firm is small and new (e.g., Corrado et al. 2009, Sandner and Block 2011, Teece 1998). To protect these intangible assets a variety of intellectual property rights have been established by legislative authorities in most economies. Patents, copyrights, trademarks, design rights, and trade secrets, are the most common IP rights, which each cover a specific type of intangible asset.[3] For many technological inventions, the primary form of IP protection comes from patents.

A patent is a legal document that is issued by a government authority and grants the holder the right to exclude others from using or producing the underlying invention (e.g., Griliches 1990). Patents are typically valid for up to 20 years, with the exception of pharmaceutical patents that can be extended for an additional five years. The granting of patent rights is subject to an examination by a patent office, which checks whether the submitted invention fulfils the requirements of being novel, non-obvious, and industrially useful (e.g., Granstrand 1999).[4] Thanks to the establishment of the World Intellectual Property Organization (WIPO) and the adoption of the TRIPS[5] agreement, the process of granting is now approximately the same everywhere and only varies slightly between the world's main jurisdictions (Hall and Harhoff 2012). The review by the patent office, however, often takes several years and the scope of the invention covered by the patent may change substantially during that time (Harhoff and Wagner 2009). Prosecuting a patent from application to approval is quite expensive for the

[3] For an overview of the different types of IP rights see for example Granstand (1999).

[4] U.S. patent law distinguishes between "design", "plant" and "utility" patents. In this thesis, the term "patent" refers to the American "utility" patent.

[5] Agreement on Trade Related Aspects of Intellectual Property Rights

patentee as it typically not only involves paying filing fees to the patent office but also hiring attorneys. At the U.S. Patent and Trademark Office (USPTO) total costs for filing a patent range from $10,000 to $30,000 per patent (Lemley 2001), while an application at the European Patent Office (EPO) is on average even more expensive with approximate costs of €21,500 (Harhoff and Reitzig 2004).[6]

The standard of novelty and utility imposed on the granting of patent rights de facto varies across nations and over time and is commonly considered not very high (e.g., Griliches 1990, Lemley 2001). In the 1970s, granting success rates, i.e. the percentage of patent applications that eventually get approved, fluctuated around 65% in the U.S. (Griliches 1990). For the same time period, patent offices in France, the U.K., and Germany reported approval rates of 90%, 80%, and 35% respectively. Nowadays, patent approval rates have assimilated internationally and range between 40-50%[7] (EPO 2011, USPTO 2012a).

A patent right is typically only effective within the borders of the jurisdiction that has granted it. Hence, to attain international patent coverage for their invention, patentees need to file applications with multiple patent offices. Important exceptions of this rule are the European Patent Office and the African Regional Intellectual Property Organization (ARIPO), where an inventor can file a patent application that will, subject to approval, become a set of national patents within the respective region or a part of it (e.g., Hall and Harhoff 2012).

Patents are valuable as exclusion rights only if they can be enforced. If patent holders observe that their exclusion rights are infringed upon by other parties, they need to enforce their patents in court. Patent lawsuits, however, are notoriously expensive, which may prevent patent owners from taking defensive action (Lemley 2001). In this case, the patent right essentially becomes worthless. Especially young and small firms with little financial resources are often reluctant to defend their patent rights against financially potent competitors. In order to maintain its property right and actually be able to bring a patent to court, the patent owner must pay a yearly renewal fee (e.g.

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6 Both estimations include all application and filing fees paid to the patent office as well as attorney's fees. Patent renewal fees are not considered.

7 Approval rate = (# of patents granted) / (# of patent applications incl. withdrawals).

Harhoff et al. 2009). Even though these maintenance fees[8] are relatively low compared to the filing costs, a surprisingly large number of patents are already abandoned before their term is over (Lemley 2001).

2.1.2 Economic functions of patents

Patent rights were originally introduced to promote the diffusion of ideas and stimulate innovation by providing incentives for investing in research and development activities (e.g., Hall 2007). In return for making his/her invention public instead of keeping it secret, the innovator receives an exclusive right for a limited period of time. Society effectively pays for the idea disclosure by accepting the social costs related to this potential short-term monopoly. In reality, however, it is not that simple.

The benefits and drawbacks of the patent system have been intensively discussed in the scientific literature from the 1950s until today. Thorough overviews of theoretical and empirical studies addressing the ambiguous role of the patent system can be found in Hall (2007), Lanjouw and Lerner (2000), Machlup (1958), Penrose (1951), and Scherer (1980). A review of the patent literature suggests that the patent system has become not only quite complex but also quite influential on the global economy. Numerous economic effects can be observed that go well beyond the originally intended effects. Harhoff and Hall (2011) provide a summary of the most recent findings and present a framework that reflects the benefits and disadvantages of patents with regard to two dimensions, innovation and competition.

As to innovation, the short-term right to exclude others from using an invention provides individuals with the opportunity to earn higher returns from innovation than those they would earn if direct imitation were allowed. The provided incentives may even lead to “too much innovation” (e.g., Reinganum 1989). On the other hand, taking into account the often cumulative (or sequential) nature of invention and fragmented ownership of patents, patent protection may actually have negative effects on innovation

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8 Yearly renewal fees at the EPO range from €445 to 1,495 depending on the patent’s age (EPO 2012b); maintenance fees at the USPTO are due after 3.5, 7.5 and 11.5 years and range from $565 to $4,730 depending on the patent’s age and the size of the patent holding entity (USPTO 2012b).

(Bessen and Maskin 2009, Heller and Eisenberg 1998). In both cases, patents may increase transaction costs and thus impede the combination of new ideas and inventions.

Concerning competition, the patent system involves costs to society as patents award the opportunity to build short-term monopolies, which may become long-term in network industries (Mazzoleni and Nelson 1998). On the other hand, patents may also facilitate competition by helping small firms with limited assets to enter new markets (Hall 2007). Another advantage is that patents can transform intangible ideas into tradable assets and thus facilitate the development of technology markets (Gans and Stern 2010).

In sum, the patent system triggers a multitude of partially opposing economic effects. Due to the variety of arguments in favor or against patents, the debate whether the patent system is effective or not has not yet reached a consensus. However, despite constant suggestions for reforming the patent system (e.g., Heller 2008, Jaffe and Lerner 2004), most scholars and policy makers today still agree with Machlup's (1958, p.80) basic conclusion that once introduced there is no better alternative to the patent system and "[...] it would be irresponsible [...] to recommend abolishing it."[9] It can thus be assumed that the patent system, while being repeatedly reformed, will stay in place for the foreseeable future. Technology firms will have to accept this fact and try to use the patent system to their own advantage.

The overall relevance of patents in high-technology industries has strongly increased in recent years. Patent offices around the world experience an explosion in patent applications (Hall 2005, WIPO 2011) as firms in many technology-driven industries engage in patent portfolio races (e.g., Hall and Ziedonis 2001, Jell and Henkel 2010). In complex product industries, where one product can incorporate several thousand patents that are owned by various parties, patents have essentially become a form of currency and facilitate cooperation. However, patents are also increasingly used as weapons; the number of patent lawsuits has strongly risen during the last decade (Bessen and Meurer 2005). One prominent example is the information and communication technologies (ICT) sector, where the largest players nowadays

[9] Note that Machlup (1958, p.80) at the same time concludes, "If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one."

constantly sue each other for patent infringement (Economist 2011). Additionally, so called patent trolls (or sharks) have entered the scene. These non-practicing entities aim to generate payments from inadvertent infringements of the patents in their portfolio (e.g., Henkel and Reitzig 2008). All these recent developments have led to a higher attention of business executives towards the strategic management of patents and other IP rights.

Many large technology corporations invest heavily in their patent portfolio and patent management expertise to gain competitive advantage or at least not get left behind (Edvinsson and Sullivan 1996, Reitzig 2004, Rivette and Kline 2000). Young technology firms need to deal with patents as well. The benefits and downsides of patents from the perspective of young technology firms will be discussed in the following section.

2.1.3 Benefits and drawbacks of patenting inventions for start-ups

Many start-ups that are built upon a technical invention face the question whether to patent their core technology or not. Several arguments in favor and against patenting provide the basis for this decision.

A start-up can derive five key benefits from holding a patent.[10] First and foremost, a patent protects the start-up's intellectual property from imitation and thus serves as a value appropriation mechanism (e.g., Dechenaux 2008, Levin et al. 1987, Shane 2001, Teece 1986). The right to prevent others from making, using, or selling the invention allows the start-up to sell its innovative product exclusively and generate greater-than-average returns. In case the start-up decides to not commercialize the patented technology itself, it can ask for licensing royalties from other parties that want to use it or even sell the patent right. The effectiveness of patents as a value appropriation mechanism varies between industries depending on whether the predominant product design is discrete or complex (e.g. Cohen et al. 2000, Levin et al. 1987). Discrete products, as common in the biotech or chemical industry, consist of only very few separately patentable elements. Since one or a few core patents are sufficient to prevent imitation, patents are usually considered very effective for these

[10] See Graham and Sichelman (2008) for a comprehensive overview of start-ups' patent filing motives.

types of products. The opposite is true for complex product industries, such as electronics, where one product usually contains numerous separately patentable elements. In these industries, patents are commonly rated as less effective as a means of appropriating returns from innovation (e.g. Cohen et al. 2000, Levin et al. 1987).

Second, since patents form ideas into "tangible" assets they facilitate cooperation with external business partners (Arora et al. 2001). Start-ups may consequently benefit from holding patents in that they help facilitate the establishment of alliances with other entities. Third, young ventures may also file patents for defensive reasons. Instead of actively stopping others from making or selling their products, in this case patent applications are supposed to secure a firm's freedom to operate by creating prior art (De Rassenfosse 2010, Henkel and Pangerl 2008). Fourth, start-ups can use patents as marketing instruments. A patent can help the owner to distinguish him/herself from competitors and define his/her unique selling proposition. In advertising campaigns patents may be used to signal uniqueness or quality to consumers (Graham and Sichelman 2008). Fifth, patents are known to be positively evaluated by external investors (e.g., Baum and Silverman 2004, Hsu and Ziedonis 2011, Mann 2005). Therefore, patent ownership may increase a start-up's likelihood of sourcing venture capital funding, of being acquired, or of achieving an initial public offering (IPO). The association between a start-up's patenting activity and its success in raising venture capital is one of my key research interests and will be discussed in more detail throughout this thesis.

Due to the benefits related to patents, it is not surprising that empirical studies find patent ownership to be positively related to firm performance. For instance, Hall et al. (2007) observe a positive association between patent ownership and stock market valuation. Furthermore, patent ownership correlates with the business performance of start-ups in terms of asset growth (Helmers and Rogers, 2011), short time to initial public offering (IPO) (Stuart et al., 1999), and an increased likelihood of survival after IPO (Wagner and Cockburn, 2010).

Despite the obvious benefits, there are also a number of disadvantages related to patents, which start-ups may regard as reasons not to patent a technical invention. First, as described above, the initial costs of filing a patent are quite high. Thus, new ventures might simply not be able to afford a patent, especially at early stages. But even if a start-up has enough financial resources to prosecute a patent, the limited effectiveness of patents as appropriability mechanism in certain industries might prevent it from spending the money. The notoriously high enforcement costs may be an additional reason for not patenting. Third, 18 months after filing, every patent application is disclosed. In order to keep their innovative technology secret from competitors, start-ups may thus refrain from patenting it and instead rely on other appropriability mechanisms when commercializing it (e.g., Cohen et al. 2000, Horstmann et al. 1985).

In the end, each start-up will have to decide on an individual bases whether the benefits of patenting outweigh the drawbacks. Amongst other factors this decision will depend on the firm's business model, product design, competitive environment, and financial resources.

2.2 Financing of Technology Start-ups through Venture Capital

Building up a new firm requires financial resources. Especially high-technology start-ups are often already at early development stages in need of external financing (Achleitner and Nathusius 2004). Early-stage firms, however, typically cannot offer many securities and face a very high risk of failure, which rules out many classical sources of financing, such as bank loans, bonds, or other types of debt financing (e.g., Franke et al. 2004). Nevertheless, a few financing options exist: first, many start-ups are able to collect cash from friends, family members, or business angels, which, however, typically involves only small amounts (e.g., Elitzur and Gavious 2003, Roberts 1991). Furthermore, they can apply for funding from government programs, which is offered by many countries but often also limited in size (Brettel et al. 2000). Finally, start-ups can approach venture capital funds, which are specialized in financing new ventures. Since venture capital is commonly regarded as the most suitable form of high-technology start-up financing (Colombo and Grilli 2010, Gompers and Lerner 2001), I will now discuss its characteristics in more detail.

2.2.1 Characteristics of venture capital

Venture capital is a high-risk form of equity investment into innovative start-ups with a high growth potential (Alisch et al. 2005). Georges Doriot, founder of the first venture capital firm in the U.S., describes the strategy of his firm as "to invest in things nobody has dared try before" (Haislip 2011, p.1). In more general terms, venture capital can be described by the following six characteristics.

High risk: Venture capital is normally invested in new firms, which have very little performance history (Tyebjee and Bruno 1984). VCs compensate this risk by carefully selecting the start-ups they expect to have the highest growth potential.

Equity capital financing: In venture capital financing, the investor usually receives a share of the start-up's equity in exchange for the working capital that he/she provides. Venture capital is thus a sub-category of private equity. The start-ups benefit from the fact that in contrast to debt financing, it does not commit to any interest payments, which would increase its insolvency risk (Schefczyk 2006). The VC, on the other hand, has the opportunity to directly participate from an increase in firm value but at the same time faces the risk of losing his/her entire capital invested in case the venture goes bankrupt (Freiling 2006).

Minority shareholding: VCs typically only hold minority shares in their portfolio firms[11] (Weitnauer 2007). Consequently, the founding team is still the majority shareholder and remains strongly committed.

Temporary investment: Venture capital investments are temporary. After five to ten years, VCs are determined to sell their equity shares in order to realize a return on their investment (Fischer 1987). Trade sales and IPOs are VCs' preferred exit scenarios (Haislip 2011).

Control rights: In exchange for the capital provided, VCs typically ask for a substantial amount of control and voting rights that often exceed their actual share of ownership (e.g., Welpe 2004). Through these co-determination rights VCs can exert a strong influence on the start-up's strategic decisions and make sure the financial resources are used appropriately (Fried and Hisrich 1994). In essence, VCs employ

[11] New ventures in which VCs invest are called portfolio firms because these start-ups form the investment portfolio of the VC (Fitza et al. 2009).

control rights to protect themselves from hold-up by the entrepreneurs (Hellmann 1998).

Management function: VCs do not only provide their portfolio firms with financial capital but often also with strategic advice, which is why venture capital is sometimes referred to as "smart capital" (e.g., Sørensen 2007). While the degree of direct involvement differs considerably between venture capital firms, start-ups have been found to benefit in their performance when VCs actively bring in their entrepreneurial and industrial expertise (e.g., Bottazzi et al. 2008).

Technically speaking, venture capital firms act as intermediaries between institutional investors and young firms. They collect money from large investors, such as insurance companies or pension funds, and invest it into start-up firms (Bottazzi and Da Rin 2002). Institutional investors, hence, entrust VCs with the selection and supervision of appropriate start-ups.

The amount of venture capital that is invested depends on the maturity of the respective start-up. In accordance to the typical lifecycle of a new venture, scholars distinguish between four financing phases: *seed*, *start-up*, *expansion*, and *later-stage* (e.g., Haislip 2011, Schefczyk 2006). *Seed* financing commonly refers to a rather small amount of funding (ca. $100,000) that allows entrepreneurs to test the feasibility of their business idea and develop an appropriate business model (Bottazzi and Da Rin 2002, Jungwirth 2006). In the *start-up* phase, the venture begins to market its product and to build up necessary complementary assets. The financial funding required is higher (up to $1,000,000) than in the *seed* phase, while the investment risk is already substantially lower (Nathusius 2001). During the *expansion* phase, start-ups often already operate profitably but may need further financing to grow their production facilities, hire new employees or enter new markets (Bruno and Tyebjee 1985). In the last phase, *later-stage* financing may be used to unleash a firm's earning potential or to prepare it for a trade sale or IPO (Bottazzi and Da Rin 2002). The first two financing phases, *seed* and *start-up*, are often referred to as *early-stage* (e.g., Drukarczyk 2008). It is important to note that most VCs focus on *early-stage* investments in order to benefit from the high growth during the subsequent phases (Achleitner and Nathusius 2004). However, it is not uncommon for a start-up to receive several rounds of venture capital, sometimes from various venture capital firms (Florin 2005).

Despite its comparatively short history, the venture capital industry today plays a major role in fostering innovation and economic growth (e.g., Kortum and Lerner 2000, Timmons and Bygrave 1986). In the U.S., where the world's first venture capital firm was founded in 1946, the national venture capital market has by now reached a volume of about $22 billion in yearly investments (Weitnauer 2007, BVK 2011b). The German venture capital industry was initiated 20 years later and has since then grown to a yearly investment volume of about €650 million (Weitnauer 2007, BVK 2011a).[12] In addition to the original "private" venture capital firms, a few other types of funds have developed, that differ mainly in their funding sources. Corporate venture capitalists (CVCs) are subsidiaries of large technology firms and are financed by their mother company (Chesbrough 2002). Public venture capitalists (PVCs) are initiated by national or regional governments and are mainly financed by state money (Lerner 2002). Bank-affiliated funds are investment vehicles installed by financial banks and receive a major part of their funding from the respective bank (Gompers and Lerner 2004). All types of venture capital funds apply essentially the same business model. If at all, only CVCs might differ in their investment approach by not only pursuing financial but also strategic objectives (Dushnitsky and Lennox 2005, Hellmann 2002).

2.2.2 Benefits and challenges of venture capital funding for start-ups

When considering venture capital as a potential source of capital for their start-up, entrepreneurs need to reflect on the pros and cons related to this type of financing.

The benefits of a venture capital deal are obvious. The start-up receives an infusion of money, which it can use in many different ways. Depending on the specifications in the venture capital agreement, the provided capital may be spent on product development, patenting activities, marketing campaigns, or hiring new team members (e.g., Gompers and Lerner 2004, Schefzcyk 2006, Weitnauer 2007). Venture capital funding is not necessarily a one-time occurrence; VCs are highly committed to their portfolio companies and thus often willing to invest in further financing rounds if necessary (Cooper and Carleton 1979). In addition to financial resources, start-ups also

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[12] Further differences between the German and U.S. venture capital market are discussed in Chapter 3. Moreover, an analysis of regional differences in VCs' decision making is presented.

receive managerial support from their VCs. VCs often have a track record of being successful entrepreneurs or managers themselves, which may help start-ups in two ways (e.g., Gompers and Lerner 2001a, Timmons and Bygrave 1986). First, the founding team can ask their VC for strategic advice and rely on his/her entrepreneurial and industrial know-how in making decisions. Furthermore, start-ups can benefit from accessing VCs' network of contacts to other start-ups, large industry players, and financial investors.

Numerous empirical studies provide evidence that venture capital funding may have a positive influence on firm performance in several dimensions. For instance, with regard to innovative performance, start-ups funded with venture capital develop more patents than non-funded firms (Bertoni et al. 2010, Kortum and Lerner 2000). Furthermore, venture capital is associated with the professionalization of portfolio firms (Hellman and Puri 2002). As a consequence, Davila et al. (2003) find that venture capital is positively related to start-ups' growth. Concerning financial performance measures, scholars observe a positive correlation of venture capital with changes in start-up valuation (e.g., Fitza et al. 2009). Moreover, start-ups financed with venture capital have a higher likelihood of achieving an IPO and raise more capital in an IPO than non-funded ventures (Hsu and Ziedonis 2011, Gulati and Higgins 2003). While a positive development of start-ups subsequent to venture capital funding can be widely observed, it remains, however, unclear to what extent these performance gains are attributable to the three potential explanations. First, as demonstrated above the influx of financial capital may drive start-ups' performance. Second, it may be the VCs' management support that helps start-ups excel. Third, the fact that VC-backed firms perform better than non-VC-backed firms may simply be due to VCs' capability of "scouting" promising ventures in the first place (e.g., Baum and Silverman 2004).

Besides the above outlined benefits of venture capital, start-ups also face a number of drawbacks when deciding to apply for this type of funding. First, venture capital is difficult to obtain. Start-ups need to be aware that the venture capital application and selection process consumes a lot of time and resources, while the chances of eventually receiving funding are very low (Brettel 2002, Roberts 1991). Furthermore, VCs require a lot of information, such as technical and commercial details, before deciding to invest or not. Start-ups may thus fear the expropriation of their ideas by potential investors and refrain from approaching VCs (Dushnitsky and

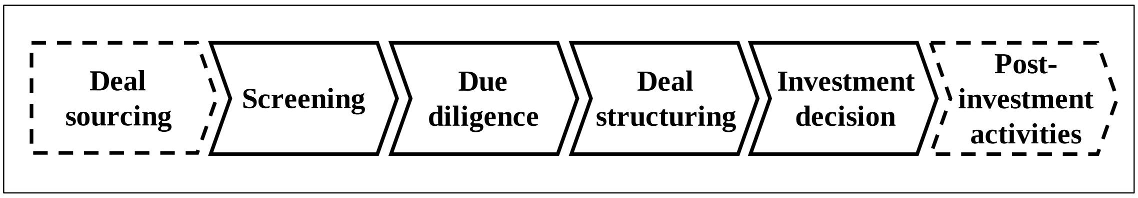
Shaver 2009, Siegel et al. 1988). Third, in case a VC actually offers funding, the entrepreneurial team will have to sacrifice its sovereignty in exchange. Not only must the start-up team give up a share of ownership in the firm, but also it will have to accept continuous interference and monitoring by the VC. VCs' co-determination may create further problems as the objectives of entrepreneurs and VCs often diverge; VCs aim for the highest possible return on their investment, which is often achieved through an IPO, whereas most entrepreneurs would rather not sell their start-up and stay independent (Weitnauer 2007).

In sum, even though there are considerable drawbacks related to venture capital financing, there is no doubt that it helps start-ups to develop faster. In fact, the acquisition of venture capital is often a crucial step for high technology entrepreneurs in building a successful business. It is thus important to understand how start-ups are able to source venture capital, which is explained in the next section.

2.2.3 The venture capital decision making process

The investment activities of venture capitalists can be described as a process of several sequential steps (Tyebjee and Bruno 1984, Wells 1974). Figure 1 displays the six phases of this process. The solid lines indicate the actual selection process that starts at the screening stage and ends with the final investment decision.

Figure 1: The venture capital decision making process[13]



The *deal sourcing* phase[14] describes how VCs aim to identify potential investment candidates. This step involves marketing measures to attract start-ups'

[13] Based on Hall and Hofer 1993, Tyebjee and Bruno 1984, Wells 1974.

applications as well as continuous networking discussions with entrepreneurs, investors, and intermediaries that might bring VCs and start-ups with cash needs together (Wells 1974). The actual selection process begins with the *screening* phase.[15] At this stage, all incoming investment proposals, mostly in the form of written business plans, are evaluated for the first time (Kirsch et al. 2009). Due to the high number of applications[16], VCs screen each business plan briefly and make a decision within a few minutes (Hall and Hofer 1993). The *screening* phase is of particular importance as it is the first big hurdle that start-ups have to master on their way to eventually receiving venture capital. Only the business plans that meet the VC's screening criteria are selected for further evaluation. Studies show that about 20% of all investment proposals pass this initial test, while the majority is rejected outright (Roberts 1991). Due to their high practical relevance I put a particular focus on VCs' screening decisions in this thesis.

In the subsequent *due diligence* phase, which is also called *evaluation* phase, the selected start-up is examined in detail. VCs typically arrange a meeting with the entrepreneurial team, test the start-up's technology, and check whether all specifications from the business plan are valid (Silver 1985). Once a start-up has passed the *due diligence*, it enters the *deal structuring* phase, during which the VC and the entrepreneurial team negotiate the financial terms. The deal will be consummated only if both parties agree on a price and a set of financial arrangements that are featured in the venture capital investment agreement (Tyebjee and Bruno 1984).[17] The last step of the venture capital decision making process is the *investment decision* which describes the signing of the contract and the provision of the financial capital by the VC. *Post-investment activities* of VCs include monitoring, consulting, and eventually preparing the venture for an appropriate exit (Weitnauer 2007).

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[14] The deal sourcing phase is sometimes referred to as "deal generation phase" or "deal origination phase."

[15] The screening phase is sometimes referred to as "initial screening" or "selection phase".

[16] A typical small venture capital firm is estimated to receive around 2,000 business plans per year (e.g., Sahlmann 1997).

[17] As a matter of fact, the contracts between VCs and entrepreneurs are often very complex and include numerous clauses, which determine, for example, how VCs' control and liquidation rights decrease with firm performance (Kaplan and Strömberg 2003).

Many technology start-ups are in need of venture capital to ensure their further development. The criteria that VCs use in their selection process are thus a key research topic for entrepreneurship scholars. Extant research has identified five groups of criteria that are commonly employed throughout this process: start-up characteristics related to the management team, market, product, financial potential, and portfolio fit (e.g., Petty and Gruber 2011, Riquelme and Rickards 1992, Zarachakis and Meyer 2000). In Chapter 3.1, I provide a detailed overview of existing studies on VCs' evaluation criteria and highlight some important results and research gaps.

2.3 The Role of Patents in Venture Capital Financing

Patents can play a prominent role in the context of venture capital financing in several respects. VCs may use them as a screening criterion and as a value driver in the financial evaluation of start-ups (e.g., Baum and Silverman 2004, Lemley 2000, MacMillan et al. 1985). Furthermore, patents may be of importance in the structuring of venture capital agreements. Despite the fact that patent ownership (founder vs. firm) often needs to be clarified, patents represent tradable assets and can as such be used as collateral (Bigus 2006, Fischer and De Rassenfosse 2011). Moreover, patents can be taken as a measure of innovative activity in milestone planning. Finally, a well-defined patent strategy may have a positive influence on VCs' exit in a trade sale or IPO (e.g., Heeley et al. 2007). For the purpose of this thesis, I focus my research on the role of patents as investment criterion in VCs' evaluation and selection of business proposals.

2.3.1 Patents as venture capital investment criterion

This section deals with the question how patents influence the investment decisions of VCs. The role of patents in this context is twofold; they can have a productive and a signaling function. Regarding its productive function as a property right, a patent constitutes a legal right to exclude others from using an invention. As such, patents support the appropriation of returns from innovative activities and facilitate cooperation and bargaining with business partners (e.g. Cohen et al., 2000;

Hall and Ziedonis, 2001). Consequently, empirical studies have found a positive association between start-ups' patent ownership and business performance.[18] Additional value to both entrepreneurs and VCs may result from the possibility of selling patent rights to third parties (e.g., Levin et al 1987).

Concerning its signaling function, a patent can represent a valuable signal of start-up qualities which cannot be directly observed (Long 2002).[19] VCs may, for instance, in the assessment of business plans rely on patents as indicators for the unobservable quality of a start-up's technology (Conti et al. 2011). While the patent office approval serves as a certification for granted patents as quality signals, even pending patent applications may be regarded as proxies for technological quality (e.g., Baum and Silverman 2004, Häussler et al. 2010).

A number of scholars have investigated the importance of patents as venture capital investment criterion. Table 1 provides an overview of relevant empirical studies in this field and specifies whether the respective study examines the usage of patents as selection criterion or as criterion in the financial evaluation (see column "Focus of analysis"). Studies focusing on VCs' selection behavior provide evidence on how patent ownership increases a start-up's likelihood of receiving venture capital funding, while studies concerned with VCs' financial evaluation test whether a start-up's patent stock increases the amount of funding it receives. Furthermore, the column "patent type" indicates whether the reported results are based on granted patents or patent applications.

[18] More details on the productive benefits that start-ups may draw from patents and their positive influence on firm performance can be found in Chapter 2.1.3.

[19] An introduction to signaling theory and its application in entrepreneurial finance is given in Chapter 5.2.2.

Table 1: Previous research on patents as venture capital investment criterion

Study	Sample (location)	Method	Stage	Industry	Focus of analysis	Patent type	Patent-related results
MacMillan et al. (1987)	67 VC firms (US)	Questionnaire survey	Screening	Not specified	Selection	Grants	"Protection of product" with comparatively low importance
Riquelme and Rickards (1992)	6 VCs (UK)	Conjoint survey	Across all stages	Not specified	Selection	Grants	One of most important criteria in due diligence phase
Brettel (2002)	55 VC firms (Germany)	Questionnaire survey	Screening, Due Diligence	Not specified	Selection	Grants	"Patent protection" with low importance
Baum and Silverman (2004)	204 biotech start-ups (Canada)	Transaction data	Investment decision	Biotech	Financial evaluation	Applications & grants	Patents show highly significant influence on financial evaluation
Baeyens et al. (2006)	16 VCs from 16 VC firms (Belgium)	Interviews, questionnaire survey	Across all stages	Biotech vs. other technologies	Selection	Grants	Patents regarded as important signaling mechanism
Engel and Keilbach (2007)	21,517 start-ups (Germany)	Firm-level data on patenting and VC-funding	Investment decision	Not specified	Selection	Applications	VC-selected ventures have significantly higher patent application stocks
Mann and Sager (2007)	1,089 start-ups (US)	Transaction data	Investment decision	Software & biotech	Financial evaluation	Applications & grants	Patenting positively correlated with investment amounts received
Häussler et al. (2010)*	190 biotech firms (D & UK)	Transaction data	Investment decision	Biotech	Selection	Applications & grants	Start-ups with patents are likely to receive venture capital earlier
Knockaert et al. (2010)	68 VCs (Europe)	Conjoint survey	Not specified	"High technologies"	Selection	Grants	Criterion "Protection" with low to medium importance
Cao and Hsu (2011)*	>20,000 VC-backed firms (US)	Transaction data	Investment decision	Various	Financial evaluation	Applications	Patent filings correlated with larger venture capital funding
Conti et al. (2011)*	117 start-ups (US)	Transaction data	Investment decision	Mostly IT	Selection & financial evaluation	Applications	Positive impact on likelihood of funding and financial evaluation
Greenberg (2011)*	188 start-ups (Israel)	Transaction data	Investment decision	Not specified	Financial evaluation	Applications & grants	Positive association of patents with firm value
Hsu and Ziedonis (2011)*	370 start-ups (US)	Transaction data	Investment decision	Semiconductors	Financial evaluation	Applications	Significant influence on financial evaluation, especially in early rounds

* Working paper

Early surveys demonstrate that patents have long been recognized as a relevant but not very important selection criterion (e.g., Brettel 2002, MacMillan et al. 1987, Riquelme and Rickards 1992). Interest in patents has only increased recently with a number of studies based on transaction data finding a positive correlation between start-ups' patent stocks and venture capital financing variables. Patent ownership appears to not only increase start-ups' chances of receiving funding but also the amount of financial capital offered for a given equity share (e.g., Baum and Silverman 2004, Mann and Sager 2007, Hsu and Ziedonis 2011). The positive impact of patents has been found both in discrete product industries, e.g., biotech, and in more complex product markets such as the semiconductors or information technology sector (e.g., Baum and Silverman 2004, Conti et al. 2011, Häussler et al. 2010, Hsu and Ziedonis 2011). In transaction data based studies, the reported effects are mainly based on patent applications. An additional impact of granted patents cannot be consistently observed and often applies only to a subgroup of the sample, such as very young firms and early financing rounds (e.g., Greenberg 2011, Häussler et al. 2010). Existing research focuses on the world's most developed venture capital markets, namely North America, Europe, and Israel. Emerging markets such as Asia or South America have not been covered yet.

On the basis of the above literature review, a number of research gaps can be identified. First, even though previous research covers various industry sectors, a direct comparison of the importance of patents between several industries in one comprehensive study is still missing. The same is true for regional comparisons, e.g., between European and North American markets. Moreover, existing empirical studies are not able to explain what portion of patents' positive effect on venture capital financing is due to their productive function versus their signaling function. In the following section, I state how I aim to address these questions.

2.3.2 Different perspectives on the role of patents

Recent studies have shown that patents play an increasingly important role in venture capital financing. In this thesis, I aim to investigate this phenomenon in more detail by applying several perspectives.

International perspective: According to existing studies patents may be regarded as a relevant venture capital selection criterion. As mentioned above, however, differences in the importance of start-up patents between regions have not been empirically tested yet. Due to international differences in the patent system and legal practice, patents may be seen as more valuable by VCs from one region compared to VCs from another region. I investigate this issue in *Chapter 3*.

Industry perspective: Previous research describes that patents have a significant influence on VCs' decisions in many start-up industries. Differences in the strength of this effect between industries, however, have not been researched yet. According to value appropriation literature, the effectiveness of patents as a means for appropriating value from R&D varies strongly from one industry to another (e.g., Arora et al. 2008, Cohen et al. 2000, Teece 1986). This leads to the assumption that the importance of patents as venture capital selection criterion may also differ between start-up industries. This question is investigated in *Chapter 4*.

Functional perspective: In the context of venture capital financing, patents may fulfill a productive as well as a signaling function (e.g., Long 2002). Based on these two functions, recent empirical studies find that a start-up's patent stock increases its likelihood of sourcing venture capital financing (e.g., Baum and Silverman 2004, Conti et al. 2011, Häussler et al. 2010). However, the use of firm-level transaction data in these studies does not allow the disentanglement of the signaling effect of patents from their productive effect. I address this research gap in *Chapter 5*.

Human capital perspective: Every VC has a different opinion on patents. Variations in VCs' decision making can be attributed to their human capital characteristics, i.e. their education and experience (e.g., Dimov et al. 2005, Patzelt et al. 2009). In *Chapter 6*, I relate VCs' human capital to their attitude towards patents and identify personal characteristics that determine whether VCs appreciate patents more or less.

Entrepreneurial perspective: Most studies analyze the role of patents in venture capital financing from a VCs' point of view. In *Chapter 7* of this thesis, I take on the perspective of entrepreneurs. First, I examine to what extent high-technology entrepreneurs understand VCs' decision making. Then, I investigate how human capital characteristics, in particular patenting experience, determine entrepreneurs' attitude towards patents.

Before addressing each perspective through quantitative analyses, I will present qualitative evidence on some of the issues raised above in the next section.

2.4 Qualitative Evidence on the Role of Patents in Venture Capital Financing

As a first step to better understand the role of patents in venture capital financing I conducted interviews with both VCs and entrepreneurs. When talking to practitioners I was not only able to learn more about the different aspects of patent protection in the venture capital context but also had the chance to discuss more general issues in financing young ventures that are currently on the top of people's agendas. The following section summarizes the findings of my interviews with active VCs. It provides a first look at the overall topic of this dissertation and constitutes a qualitative foundation for the subsequent chapters, in which some of the most relevant research questions are empirically addressed.

2.4.1 Data and methods

Conducting interviews with practitioners is a common approach to initially become acquainted with a research field. Analyzing data from interviews is a qualitative research method (e.g., Flick 2010). Qualitative research methods have several benefits that make them especially suitable for the early stages of a research project. First, they enable the researcher to quickly build up knowledge about the latest dynamics and most important challenges in the respective industry (Bortz and Döring 2002). Furthermore, the practical relevance of theory-grounded research questions for future quantitative studies can be tested (e.g., Stier 1999). Last but not least, based on the collected qualitative data, common patterns can be identified and general propositions can be deduced (Miles and Huberman 1994).

Interviews are typically conducted as face-to-face conversations or via telephone. A researcher can choose between three forms of interviews depending on the state and the goal of the research: explorative interviews, semi-structured interviews, or standardized interviews (Schnell et al. 2005). I conducted semi-structured interviews, as this form is suitable for both exploration and proposition building (Lamnek 2005). Unlike standardized interviews, semi-structured interviews are not entirely based on a set of standardized questions but rather rely on an interview guide that serves as a framework for the discussion. This approach implies a certain flexibility, which allows the researcher and the interviewee to focus on the most important topics but also to discuss new issues that emerge within the conversation. At the same time, the interview guide ensures that at the end of the discussion all relevant topics are covered and that the findings are comparable between interviews (Flick 2010). Interviews are generally documented by taking notes during the discussion and/or fully recording the conversation (Mayring 2002).

In order to understand the way the venture capital industry works in general and deals with patents in particular, I conducted interviews with German-speaking venture capital investors. The unit of analysis is thus the individual venture capital investment decision maker. I interviewed six VCs from different venture capital firms to incorporate a variety of cases in my research design (Yin 2003). The sample consists of typical cases, including investment professionals from different locations working for a range of small to large funds, which invest into various high-tech industries. Table 2 provides an overview of the interviews conducted.

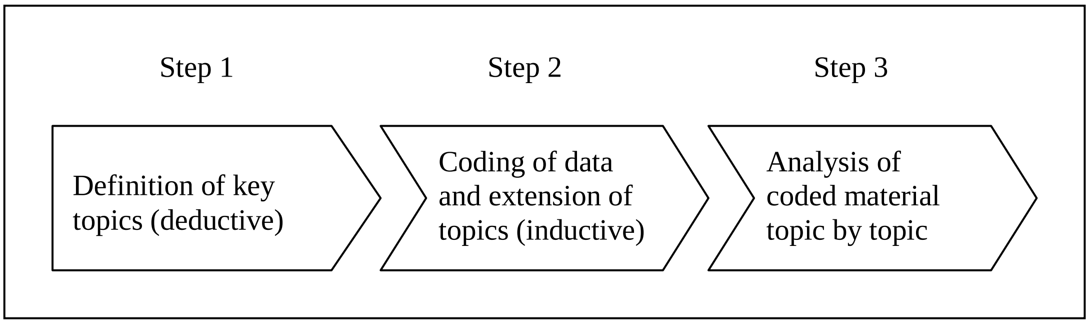
Table 2: Overview of interviews conducted

Investor	Type of VC firm	Investment focus	Location	Fund size	Date of interview	Duration
VC 1	Independent	Cleantech	Munich	Medium	04.08.10	45 min
VC 2	Independent	Cleantech	Munich	Small	09.08.10	60 min
VC 3	Independent	Cleantech	Zurich	Medium	03.09.10	40 min
VC 4	Corporate	Technology	Munich	Large	07.09.10	50 min
VC 5	Independent	ICT	Hamburg	Small	15.09.10	50 min
VC 6	Independent	ICT	Zug	Large	27.09.10	35 min

All interviews were held in a semi-structured form, one face-to-face and five via telephone. A one-pager with relevant discussion questions was sent to the interviewees before the interview (see Appendix A.1). This interview guide allowed participants to prepare for the interview and also served as a guideline during the interview to keep it focused and effective. Some questions were aimed to test and verify existing beliefs others were rather explorative. Most questions had an open form and triggered a lively discussion. In order to summarize and draw conclusions from thematic blocks of the interviews, I asked the VCs for rankings or trade-offs between certain arguments when suitable. Four interviews were fully recorded electronically and transcribed thereafter, for the remaining two interviews written notes were taken during and after the interview. Further information in the form of handouts, brochures and company webpage content was additionally collected.

The analysis of the documented material followed a structured approach as suggested by Miles and Huberman (1994). I used QSR's Nvivo 7 software to analyze the collected data. Figure 2 illustrates the procedure of the qualitative data analysis. The first step was to define the key topics for investigation based on the interview guide and literature review. In the second step, I evaluated the documented material step by step and coded the text modules that were relevant for one of the predefined topics and modified and extended the initial list of key topics to adapt it to the "real world". The result of the second step was a database of relevant text modules sorted by topic. In the last step, I analyzed all text modules topic by topic and developed my findings based on the documented material.

Figure 2: Procedure of qualitative data analysis



2.4.2 Results

2.4.2.1 Venture capital investment criteria

As described in Chapter 2.2.3 VCs employ a limited set of criteria when making their investment decisions. The management skills of the founding team are commonly reported as the most important selection criterion for venture capital investors (for an overview see Franke et al. 2008). The practitioners I interviewed widely share this view. VC 5, for instance, states that "*first and foremost it is about the team itself, the management, the people, their experience.*" On the same note, VC 1 claims that the management team is essentially even more important than the business idea. Even though it seems that a good team is crucial, my interviewees make clear that other criteria also play an important role in the investment decision. Among the most frequently mentioned criteria is the size of the market and the financial potential, as well as the viability of the start-up's business model and the extent to which it has yet been established. Alliance agreements are also considered valuable, as they serve as reference for customer interest and technological quality, and thus help determine if the new venture will be able to earn money. Overall, when asked to name their most important investment criterion, four out of six VCs emphasized the importance of the founding team (Table 3). VC 4 explains that investing money into a start-up is a matter of "*partnership and trust*", which is why the "*chemistry between the VC and the entrepreneurial team must just feel right.*"

Table 3: Most important investment criterion for VCs

Investor	**Top criterion**
VC 1	Team
VC 2	Market & financials
VC 3	Total package (no ranking)
VC 4	Team
VC 5	Team
VC 6	Team

A number of academic studies (refer to Chapter 2.3.1) suggest that intellectual capital – for technology start-ups mostly in the form of patents – has received increased recognition from VCs in recent years. The findings from my interviews support this proposition. VC 3, for example, states that "*[…] depending on the technology, patents generally are relevant in the investment decision.*" Another investor (VC 2) regarded patents as a "*[…] very relevant element in venture evaluation*" and as proof shared a copy of an excel evaluation form with me that indicated "business protection" as one of his six key investment criteria. As a matter of fact, quite a few venture capital firms provide a list of investment criteria on their webpage, and on most of them patents or intellectual property rights are prominently featured (see Footnote 1).

When discussing investment decision making with VCs it becomes clear that trade-offs (substitutive relationships) between selection criteria only apply to some extent. VC 5 mentioned a case he experienced in which a start-up held a patent on a unique packaging form, which made it an interesting target. However, despite a clear unique selling proposition (USP) and positive market outlook the VC did eventually not invest in the start-up because he did not believe in the team. This case provides a good example for the fact that the team skills are often regarded as a knock-out criterion, meaning a poor team will prevent any financial investment and cannot be made up for. In contrast, the lack of intellectual property rights is a downside that can be compensated for by other positive start-up characteristics.

In sum, my interview data emphasizes the dominant importance of the entrepreneurial team as selection criterion in the final investment decision. However, it also shows that at the end of the day it is not only one criterion but the "*whole package*" that matters to VCs; and patents can certainly be considered as one part of that package.

2.4.2.2 The different functions of a patent

Having confirmed that a start-up's patents can play an important role in the venture capital investment decision, I will now examine how the different functions[20] of a patent are perceived by VCs and how much value is attributed to them. In the following analysis, I distinguish between a patent's property rights (productive) function and its signaling function.

In its original function a patent serves as a legal right to protect a person's or firms's intellectual property. It provides exclusionary rights for the inventors of a new technology and therefore can help them appropriate returns from their inventions. In current times, intellectual property rights are of increasing importance for established companies in defining and pursuing their innovation strategies. For young ventures property rights can be equally important despite a few limitations (compare Chapter 2.1.3). Every VC I interviewed appreciates any existing form of protection (patents or

[20] For a detailed discussion of different patent functions please refer to Chapter 2.3.1.

other means) for a start-up's core technology. They like to see patents or at least patent applications in place even though they regard the productive value of patent rights as limited for young firms. One reason for a limited value they mention is the lack of financial resources to defend the respective patent in case it is infringed upon by a competitor. VC 4 points out that in the case of infringement the start-up management will have to "*think twice if they can actually afford it to go to court.*" According to him, in most cases legal action does not happen. A second reason for limited value is brought up by VC 5, who says, "*Patent rights are in reality difficult to enforce, especially with regard to high-tech or software*." The majority of the VCs interviewed are aware of the limitations associated with patent rights, but at the same time reiterate the necessity of patents as a protection mechanism for high-tech start-ups.

Despite their limitations regarding enforcement, intellectual property rights can be valuable assets even if the start-up does not succeed in commercializing its proprietary technology. Like most of his colleagues, VC 6 attributes a trade value to patents, explaining that in case the start-up is liquidated a patent constitutes an asset that can be sold to third parties and partly reimburse the VC for its investment write-off. VC 2 even experienced a case where after an acquisition a venture was able to increase its book value by activating the acquired patent as an asset in the balance sheet.

Apart from its property rights function a patent can serve as a quality signal to VCs. When evaluating start-ups, VCs told me they always look for a USP, such as a new business model, a best-in-class production process or a unique technology. For the latter, a patent may serve as the relevant observable proxy and as such indicate a technology-based USP. VC 4 brings the signaling function of a patent to the point: "*I want to see something, but I don't want to understand yet what is really behind it. However, I want to see that they have thought deeply about it and that it is a unique technology and that it is somewhat protected. […] I want to see one, two patents on a certain process and that's our USP, done!*" The credibility gained through the external validation by the patent office is an additional factor that underlines the value of patents as signals: "*If you can read somewhere that the process is patented and serves as a USP; that conveys a certain amount of credibility*" (VC 3). According to VC 5, entrepreneurs sometimes use patents to prove that their start-up has gained a know-how edge on competitors.

For some VCs a filed or granted patent additionally works as a signal of the team's professionalism and indicates their commitment to their business venture. According to VC 6, "*It is a good sign that the inventor or founder believes in his idea and was willing to spend some money on it. He has really tried to protect his idea*." Positive signaling effects from an existing patent on the team's expertise are also acknowledged by VC 3: "*It is a good signal, as the guys know at least for the technological part pretty precisely what they are doing*." Overall, however, opinions on the signaling effect of patents regarding the team's quality are mixed, and for some VCs (e.g., VC 5) it simply does not exist.

An informational function is sometimes mentioned in the literature as a third function a patent can have in the context of venture capital financing. It is based on the assumption that investors are able to extract additional information from patent documents that would otherwise be much more difficult for them to obtain (Long 2002). The VCs in my sample do not regard the actual patent documents as a source of additional information. Those VCs who have experience in reading patents claim that the language used in patent documents is typically very technical and thus difficult to interpret and that the entrepreneurial team is expected to explain the underlying technology in a more comprehendible manner anyway. Other VCs state they hardly ever take a detailed enough look at start-ups' patents before investing, hence ruling them out as an additional source of information.

The analysis of the interview text modules confirms that patents do fulfill productive and signaling functions from the perspective of VCs. After having discussed the different patent functions, I asked all interviewees to roughly rank them by importance. Table 4 summarizes the rankings provided by each VC. A score of 1 stands for "most important function" while a score of 4 was given to the least important function or to several functions that were declared as not important at all. The aggregated rankings indicate that overall the signaling function for the technology is seen as most important, followed by the protective function. The signaling effect regarding the founding team takes third place, whereas patents' trade value is considered as least important.

Table 4: Ranking of patent functions*

	Signal		Property right	
Investor	**Technology**	**Team**	**Protection**	**Trade value**
VC 1	1	2	3	4
VC 2	4	4	2	1
VC 3	2	3	1	4
VC 4	1	2	3	4
VC 5	1	4	2	4
VC 6	1	2	4	3
∑ Rankings	**10 (1.)**	**17 (3.)**	**15 (2.)**	**20 (4.)**

* 1 = most important, 4 = least important

2.4.2.3 Moderating factors on patent importance

A number of factors influence the importance of patents in the venture capital investment decision. First of all, a distinction needs to be made between patent applications and granted patents. Even though a patent application can fulfill all patent functions discussed above by providing a signal and serving as a basis for claiming property rights, it holds less value to most VCs than a granted patent. VC 2 quantifies the value of a patent application at about 40% of a patent granted, others simply state that a patent application is less valuable due to the higher potential risk of a rejection. With regard to signaling functions, VCs' opinions differ in the sense that some see no difference between an application and a granted patent (VC 1) while others would rather rely on granted patents as a reliable signal (VC 5).

It can furthermore be assumed that the type of product and the industry the start-up operates in may have a significant influence on the importance that VCs attribute to patents. There is a strong consensus among the VCs I interviewed that across all industries patent protection is a lot more important in hardware than in service applications. For example in the medical technologies industry (medtech), according to VC 6, the invention of a new surgical tool (hardware) needs to be protected by patents in order to not get "*stolen*" immediately. For medtech services, in contrast, patents are practically irrelevant and successful commercialization is rather based on "*protecting the customer to not move to a different service provider.*" Similar differences can be observed between product-based and process-based inventions. While patents are considered a necessary protection mechanism for hardware products, it is often considered unnecessary to patent process know-how since it is mostly difficult to copy. VC 4 explains, "*if the start-up team can make us believe that the respective process is so far unique and difficult to imitate, we are happy even if it is not patented or even patentable*" (VC 4).

Regarding differences in the importance of patents between industries, the statements of the VCs interviewed can be summarized as follows. Patents reach their highest importance in the biotech and medtech industry, especially due to their property rights function. For cleantech start-ups, patents can also be of considerable importance, whereas in the ICT industry, patents only play a minor role. In the software and e-commerce sector, patents are considered not important at all. In fact, a start-up that strongly advertises its patents in one of these industries will be rather investigated suspiciously (VC 5).

Finally, the development stage of the venture may influence the importance of patents for investors. There seems to be a consensus among the participating VCs that patents play a bigger role in assessing early-stage than later-stage ventures. The following statement by VC 1 can thus be taken as a general rule: "*The younger the companies, the more important the patents.*" VC 2 explains that young companies in early-stage financing rounds lack a positive track record and can therefore benefit from the early existence of a patent to at least have something to show. According to VC 3, at that stage the patent "*[…] is a signal that the company indeed has something that's new.*" On the contrary, when assessing more established companies, the VCs in my sample mainly rely on other criteria such as a strong market position, good customer relationships and positive profit margins. Under these circumstances the existence of intellectual property rights plays a minor role or at least can be more easily compensated for.

2.4.3 Summary and Discussion

I use interviews with VCs as a first step in investigating the role of patents in venture capital financing. By applying methods of qualitative data analysis I find interesting results on venture capital decision making in general and the role of patents in particular. These findings lay the foundation for my subsequent quantitative studies on the most relevant issues.

While team characteristics still appear to be the No.1 investment criterion for most VCs, I observe that a start-up's patents have gained importance and now are featured on the criteria list of almost every high-tech VC. Due to the qualitative research design it is difficult to make general statements about the relative importance of patents compared to other venture capital decision criteria. However, it becomes clear in the interviews that the importance VCs attribute to patents is moderated by several factors: First, a patent only really matters for a start-up based on a technical product (hardware) and not on a service offering. Second, it seems to make a difference if a start-up has "only" filed a patent or if the patent has already been granted. Third, patents appear to be more important in research-intense discrete industries, such as biotech or medtech, than in complex industries, such as software or e-commerce. Fourth, VCs put a higher emphasis on patents if they are held by early-stage ventures compared to more established firms. When discussing the different functions a patent may have, the VCs interviewed support the recent notion that besides its productive value as property right a patent can also be a valuable quality signal (compare e.g., Long 2002, Hsu and Ziedonis 2011). In comparing different signaling effects my analysis shows that a patent is regarded mostly as an indicator for the quality of a start-up's technology and less for the professionalism of the team.

As with any qualitative study, a few limitations apply when interpreting the results. This research is based on a rather small sample of six interviews with different VCs which limits the generalizability of my findings. Furthermore, since the data analysis is based on qualitative statements, I can only quantify the observed effects to a limited extent. To overcome these limitations and investigate the most relevant of the above mentioned issues in more detail I conducted a large-scale survey with VCs. Results with regard to the relative importance of patent protection compared to other selection criteria – including a differentiation between filed and granted patents as well as between various regions and industries – can be found in Chapters 3 and 4 of this dissertation. Findings regarding the two-fold role of patents as property rights and quality signals are discussed in Chapter 5.

3 International Perspective: Patents as Venture Capital Screening Criterion in Two Major Economies

3.1 Introduction

Investigating venture capitalists’ decision making has been of continuous interest to entrepreneurship scholars for several decades (see Table 5 for an overview of relevant studies). Nevertheless, as the literature review below shows, several white spots remain. Two of them will be addressed in this chapter. First, I will analyze the role and importance of patents and alliances as screening criteria at the first stage of the venture capital decision making process. Second, regional differences in VCs’ decision making will be investigated.

Extant literature has gained valuable insights on the criteria that VCs use in assessing business proposals. These selection criteria can be clustered into five groups: start-up characteristics related to the (1) management team, (2) product, (3) market, (4) industry/portfolio fit, and (5) financial potential (e.g. Riquelme and Rickards 1992, Zarachakis and Meyer 2000). Even though there is considerable debate on the importance and trade-offs between these criteria, some universal conclusions can be drawn from previous research. VCs prefer start-up teams with a strong sense of leadership, a high amount of industry expertise and if possible entrepreneurial experience (e.g., Hisrich and Jankowitz 1990, Dixon 1991, Muzyka et al. 1996, Franke et al. 2008). In terms of the start-up's product or service offering, VCs look for criteria such as innovativeness, proprietary protection, proven functionality, and scalability (e.g., MacMillan et al. 1987, Brettel 2002, Baum and Silverman 2004, Petty and Gruber 2011). Regarding the venture’s target market, VCs are attracted by big market sizes and high growth rates (e.g., Tyebjee and Bruno 1984, Hall and Hofer 1993). With respect to industry/portfolio fit, VCs normally only invest in start-ups that are active in an industry that is in line with the fund’s investment strategy (Petty and Gruber 2011). Considering the financial aspects, prior research emphasizes the importance of high expected returns in relation to the level of risk perceived (e.g., MacMillan et al. 1985, Baeyens et al. 2006).

It has been pointed out by Hall and Hofer (1993) amongst others that the criteria influencing VCs' decisions differ between the various phases of the venture capital decision making process.[21] Some—mostly qualitative studies with a small sample—address this issue and thoroughly investigate changes in decision making between the different phases (e.g., Baeyens et al. 2006, Petty and Gruber 2011) while others put the emphasis on one specific phase. Some survey based studies concentrate on the screening phase at the beginning of the venture capital decision making process (e.g., Hall and Hofer 1993, Franke et al. 2006), while others investigate the deal-structuring or the due diligence phase right before investment (e.g., Payne et al. 2009). Studies analyzing transaction data naturally focus on the actual investment decisions and subsequent business performance (Baum and Silverman 2004, Engel and Keilbach 2007). Quite a few studies are kept rather general and do not specify the phase their results refer to. Acknowledging the distinctiveness of the various phases I focus my research on the screening phase, which is of particular interest as it is the first big hurdle that entrepreneurs have to master on their way to eventually receiving venture capital. As a matter of fact only a very small share (20%) of all business plans submitted pass this initial test, while the majority is rejected outright (Roberts 1991). With several hundreds of business plans submitted to them each year, venture capital firms spend a substantial share of their time screening these applications. The screening phase is special in the sense that it involves the highest amount of information asymmetry between the entrepreneur and potential investors. In many cases VCs will have never heard of the start-ups described in the business proposals on their desks, but have to make a first decision based on a very limited set of observable characteristics, after screening the presented information for a few minutes only (Hall and Hofer 1993). Based on this setting and under the assumption that VCs' basic requirements regarding portfolio fit and financial potential are fulfilled, I focus my research on the start-up resources VCs can observe. In particular, I investigate to what extent early-stage VCs employ these resources as selection criteria in the screening decision.

[21] For a detailed overview of the venture capital decision making process from deal generation via screening and due diligence to the actual investment decision see Chapter 2.2.3.

Table 5: Previous research on venture capital decision making

Study	Sample (location)	Method	Stage	Research focus	Industry-specific results	Role of patents	Role of alliances
Tyebjee and Bruno (1984)	46 VCs (US)	Interviews, survey	Across all stages (screening to investment decision)	VC decision process & criteria	None	--*	--
MacMillan et al. (1985)	102 VCs (US)	Questionnaire	Screening	Grouping of screening criteria	None	--	--
MacMillan et al. (1987)	67 VC firms (US)	Questionnaire	Screening	Criteria distinguishing successful from unsuccessful ventures	None	"Protection of product" with rather low importance	--
Sandberg et al. (1988)	1 VC firm (not stated)	Interviews	Screening	Contingency aspects influencing selection criteria used by VCs	None	--	--
Hisrich and Jankowitz (1990)	5 VCs (not stated)	Interviews	Screening	Influence of intuition on VC decision making	None	--	--
Dixon (1991)	30 VC firms (UK)	Interviews, questionnaire	Due Diligence	Factors used in business proposal evaluation	None	--	--
Riquelme and Rickards (1992)	6 VCs (UK)	Conjoint experiment	Across all stages	Application of conjoint methods to group VC decision criteria	None	One of most important criteria in due diligence phase	--
Hall and Hofer (1993)	4 VC firms (US)	Interviews, analysis of (16) actual protocols	Screening	Criteria used in various stages	None	--	--
Knight (1994)	379 VCs (US 100, Can. 31, Asia-Pac. 53, Europe 195)	Questionnaire, partially secondary data	Screening	International comparison, replicating MacMillan et al. (1985)	None	--	--
Muzyka et al. (1996)	73 VCs (Europe)	Conjoint experiment	Not specified	Grouping of VCs based on decision criteria, 35 characteristics	None	--	--
Shepherd (1999)	66 VCs (Australia)	Conjoint experiment	Not specified (focus on venture survival)	Influence of start-up attributes on expected venture survival	None	--	--

Study	Sample (location)	Method	Stage	Research focus	Industry-specific results	Role of patents	Role of alliances
Zacharakis and Meyer (2000)	53 VCs (US)	Conjoint experiment	Screening	Use of actuarial models as screening decision aids	None	--	--
Brettel (2002)	55 VC firms (Germany)	Questionnaire	Screening, Due Diligence	Decision criteria of German VCs	None	"Patent protection" with low importance	--
Shepherd et al. (2003)	66 VCs (Australia)	Questionnaire, Conjoint exp.	Investment decision	Impact of VC experience on decision making	None	--	--
Baum and Silverman (2004)	204 biotech start-ups (Canada)	(Actual) transaction data	Investment decision	Influence of start-up criteria on financial evaluation by VCs	Biotech	Highly significant and strong influence	Sign. influence of downstream, but not upstream alliances
Baeyens et al. (2006)	16 VCs from 16 VC firms (Belgium)	Interviews, questionnaire	Across all stages	Importance of biotech-specific characteristics in VC decisions across stages	Biotech vs. other technologies	Important signaling mechanism	--
Franke et al. (2006)	51 VCs (Europe)	Conjoint experiment	Screening	VC evaluation of start-up team characteristics, similarity bias	None	--	--
Engel and Keilbach (2007)	21,517 start-ups (Germany)	Firm-level data on patenting and VC-funding (1/0)	Investment decision	Comparison of VC-funded and non-VC-funded start-ups	None	VCs select ventures with high patent application stock	--
Dimov et al. (2007)	108 VC firms (US)	(Actual) transaction data	Investment decision	Impact of VC firm characteristics (expertise) on investment selection	Communication industry	--	--
Payne et al. (2009)	26 VCs (US)	Questionnaire	Deal structuring stage	Influence of investor confidence and potential control on VC funding	None	--	--
Knockaert et al. (2010)	68 VCs (Europe)	Conjoint experiment	Not specified	Grouping of VCs based on decision criteria	"High technologies"	"Protection" low to medium importance	--
Petty and Gruber (2011)	1 VC firm (Europe)	Qualitative analysis of archival data	Across all stages	Applied decision criteria over time, influence of VC specific criteria	"A specific high-tech growth industry"	--	--

Note: Only peer-reviewed papers displayed
* -- Not included or not investigated

One classic example of a venture capital selection criterion is the team's amount of relevant experience, which is a type of information that is easily observable in a business plan and presumably related to the future success of the start-up. Introducing additional criteria, I note that existing patents and written alliances also fulfill the characteristics of being directly observable for outsiders and possible indicators of success. Although neither patents nor alliances have received much attention as venture capital screening criteria yet (see Table 5, columns on the right), there are good reasons to believe that they can actually have a substantial influence on VCs' screening decisions. A number of recent studies have found that both a start-up's patents and its alliances are positively related to its financial evaluation by VCs (e.g. Baum and Silverman 2004, Hsu and Ziedonis 2011) and also to its likelihood of being selected and receiving funding at all (e.g., Engel and Keilbach 2007, Häussler et al. 2010). These results based on actual investment deals can serve as indication for the screening decision in the preceding stage. At the screening stage, it can even be assumed that the value of patents and alliances is particularly high as both characteristics may carry a productive *and* a signaling component. Considering patents for instance, they are appreciated by VCs in their original function as legal rights by protecting a start-up's intellectual property, but may also serve as signals of unobservable attributes, such as the quality of the start-up's technology (Long 2002). As quality signals, both start-up resources may be capable of reducing the information asymmetry between entrepreneur and investor.

My literature review also reveals that only very few studies have investigated regional differences in the decision making of VCs (e.g., Brettel 2002, Knight 1994). In particular, no researcher has ever performed an international comparison of venture capital selection criteria in one comprehensive study. However, since venture capital markets and legal systems differ substantially between countries, e.g., Germany and the United States (e.g., BVK 2011a and 2011b, Ohly 2008), differences in the usage of selection criteria by VCs from different regions seem quite plausible. While I aim to investigate this issue, one particular focus will be on the role of patents in this context.[22]

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[22] As such, this research responds to a call by Häussler et al. (2011) to investigate differences between European and U.S. VCs in evaluating start-up patents.

Based on arguments related to differences in national jurisdictions I propose that patents may be valued higher by German VCs than by U.S. VCs.

In order to investigate the importance of patents and alliances as venture capital screening criteria in an international context, I analyze data from my own survey with 102 German[23] VCs and 85 U.S. American VCs. Employing a choice-based conjoint approach, which is an advanced version of the traditional conjoint analysis, I can determine the individual value contributions of pending and granted patents and also of different types of alliances – the latter variable being typically difficult to observe for scholars due to confidentiality. Moreover, using the same survey in both countries allows me to empirically examine regional differences in the importance of the individual start-up resources. By providing country-specific results and overcoming the limitations of earlier questionnaire- or interview-based studies with a conjoint method, I aim to add a new level of detail and precision to existing research on VCs' selection criteria.

The remainder of this chapter is organized as follows. I first summarize the relevant literature on VCs' decision making and the potential role of start-up resources as screening criteria. I then discuss potential international differences regarding the importance of patents and state my research hypothesis. Thereafter, I explain the data and methods used for my analyses. A presentation of the results is followed by a discussion of theoretical and practical implications.

3.2 VCs' Decision Criteria in Screening Business Proposals

Securing capital for further development constitutes a key challenge for new ventures (Penrose, 1959). Venture capital is one potential source of funding available to start-up entrepreneurs but in general is difficult to obtain. Due to the high level of risk associated with the investment in start-ups, VCs choose their portfolio companies very carefully. In order to increase their chance of funding, start-up entrepreneurs need to understand how the venture capital decision making process functions and what the relevant decision criteria are, so that they can build up their own resources accordingly.

[23] To be precise, the "German sample" consists of 102 European VCs that all invest in German start-ups.

From a VC's perspective, assessing investment opportunities involves several dimensions of uncertainty. First, outsiders cannot easily judge the current performance and future potential of technology-based start-ups, which makes it difficult to evaluate them. Commonly used indicators such as a performance track record or even positive revenue streams are hardly available at this stage (Shane and Stuart 2002). Furthermore, young ventures face a high failure rate which inherently comes with the development of new technologies but is also attributable to many other obstacles they face on their development path—a phenomenon known as liability of newness (Stinchcombe 1965). Moreover, a probable information asymmetry between entrepreneurs and external evaluators may aggravate an assessment by potential investors. The limited amount of reliable information is especially apparent in the first stage of the venture capital decision making process, which is generally referred to as initial screening.[24] At this stage VCs see themselves confronted with hundreds of written business proposals per year and have to quickly select which opportunities to pursue further and which ones to immediately discard. In most cases VCs make that first decision without talking to the entrepreneurs nor seeing the product. Therefore, compared to the actual investment decision later on, the screening phase incorporates a much higher degree of uncertainty regarding skills of the start-up team and the technological quality of their product.

Given these uncertainties, VCs search for any indicators of a start-up's quality or potential (Di Maggio and Powell 1983, Podolny 1993). As often the quality of young companies cannot be observed directly, investors will have to base their evaluation on other sources of information, e.g. on available observable resources of the respective start-up (Stuart et al. 1999). This is especially true for the screening phase; when there is only little time available for screening each start-up, VCs will eventually use a limited set of the most objective and reliable start-up characteristics as their decision criteria. Being aware of that, entrepreneurs who plan to apply for venture capital funding invest in observable characteristics to signal the commercial potential of their venture (Zott and Quy 2007). The resources and capabilities which start-up teams build up in early stages constitute the foundation for successful business activities (Brush et al. 2001, Davidson and Honig 2003, Parker and van Praag 2006) and may at the same time serve as signals aimed at external parties (Spence 1973). VCs are expected to pay attention to

[24] Some researchers have also used the term "selection" stage (e.g. Maxwell et al. 2011).

resources when screening business plans due to both of these functions. Prior research suggests three broad categories of observable resources affecting VCs' assessment of high-technology start-ups: entrepreneurial team, alliances, and intellectual property rights (e.g., Baum and Silverman 2004).

In the following paragraphs I will discuss the most important screening criteria in detail and conclude this section by stating my research aim.

3.2.1 Entrepreneurial team

Phrases such as "I invest in people, not ideas" or "we bet on the jockey, not the horse" are often heard from prominent VCs and show their emphasis on the entrepreneurial team when assessing business plans (Sahlmann 1997). The high importance of a start-up's human capital is supported by numerous empirical studies in which the management skills of the founding team have been reported as the most important selection criterion for VCs (see Franke et al. 2008 for an overview). Several observable team characteristics have been introduced as indicators for the team's management skills, ranging from educational background to work experience to different types of relationships of the team members. Besides the fact that VCs appreciate teams that are functionally diverse (e.g. Beckman et al. 2007), team attributes related to entrepreneurial and industry experience have shown the largest impact on start-up performance and thus also on VCs' decisions:

Concerning entrepreneurial experience, Gompers et al. (2006) report that founders with previous positive IPO experience have higher chances of achieving another IPO than first-time entrepreneurs due to learning effects. Furthermore, serial entrepreneurs can benefit from their existing social network when building up their teams, which materializes in higher financial evaluations by venture capitalists (Hsu 2007). Regarding relevant industry experience, entrepreneurs benefit from multiple advantages thanks to industry-specific skills and contacts. For instance, Chatterji (2009) finds a positive relationship between industry experience and start-up performance in the medical device industry due to nontechnical knowledge. Agarwal et al. (2004) demonstrate how a spin-off's probability of survival is positively influenced by knowledge and capability transfer from the incumbent to the spin-off. Moreover, Burton et al. (2002) find that entrepreneurs with prior career experience in prominent firms benefit from information and reputation advantages when securing external financing. Additionally, VCs might regard the high opportunity costs of experienced managers as signals, supposing that a start-up's quality must be good since the value of the next best alternative is high (Hsu and Ziedonis 2011). Indeed, when asked for trade-offs between different founder team characteristics, VCs value the amount of industry experience as most important of all team attributes (Franke et al. 2008). Furthermore, start-up managers' experience has been shown to have a considerable impact on VCs' financial evaluation of start-ups (e.g., Patzelt 2010).

Based on literature review and my personal interviews I assume that founder team experience is a highly relevant venture capital screening criterion across all start-up industries.

3.2.2 Alliances

The positive influence of strategic alliances on firm performance is a well-known phenomenon, which also extends to small technology-based ventures (Lee et al. 2001). Not only can collaborations with banks or investors have a substantial impact on the opportunities and constraints a new venture faces, but also affiliations with other productive organisations. For the purpose of this study I distinguish between upstream alliances, which are collaborations with organizations up the value chain in order to pursue research and development, and downstream alliances, which are agreements with organizations down the value chain such as potential sales partners (e.g. Baum et al. 2000).

Prior research shows that organizations benefit from collaboration within their network of alliances and are therefore likely to outperform others. Alliances, for example, may provide advantages associated with the access to complementary resources such as sales channels (Chung et al. 2000). Similarly, Liebeskind et al. (1996) show that upstream alliances, e.g., with universities or other research organisations, secure valuable access to knowledge and other assets. Moreover, companies gain valuable information through their alliance network, which can help them discover and exploit business opportunities (Cohen and Levinthal 1990). These general benefits also hold true for young and small companies. While Baum et al. (2000) found evidence that biotechnology start-ups that are able to quickly establish both upstream and downstream alliances deliver significant performance improvements during their early years of business, similar positive effects can be assumed for start-ups from other industries. However, when interacting with alliance partners, entrepreneurs need to be aware of the risks of information leakage (Hellmann 2002) and negative returns for a high level of alliance activity (Deeds and Hill 1996).

In theory financial investors should also appreciate the existence of alliance agreements in a start-up business plan. Besides the above-explained productive functions, which directly influence new ventures' performances, alliances may also serve as quality signals to external parties. According to Miner et al. (1990) and Baum and Oliver (1991), alliances can be regarded as legitimation for the new venture and consequently facilitate the acquisition of other resources such as venture capital. This holds particularly true for upstream relationships with research partners that serve as quality indicators for a start-up's technology development capabilities (Baum and Silverman 2004). Furthermore, Stuart et al. (1999) argue that third parties rely on the prominence of the affiliates of new ventures to make judgments about their quality, and start-ups endorsed by prominent exchange partners will perform better than otherwise comparable ventures that lack prominent associates.

As a selection criterion for venture capital investors, non-financial start-up alliances have been obviously neglected in previous studies (Table 5). In one exception, Baum and Silverman (2004) investigate the role of alliances in start-up evaluation and show that the amount of downstream alliances, but not upstream alliances, a start-up possesses is positively related to the amount of venture capital financing it receives. The limited attention towards alliances in existing venture capital research is somewhat surprising as the productive benefits for start-ups are well proven and their importance as external references was commonly mentioned in my interviews with VCs and entrepreneurs. In sum I conclude that, especially during the screening phase, a start-up's alliances may positively influence VCs' assessments by implying access to resources, knowledge, and sales channels as well as serving as quality certifications from external evaluators. I thus expect to find this positive effect for both upstream and downstream alliance agreements in all start-up markets.

3.2.3 Intellectual property rights

Patents are a further observable resource that entrepreneurs increasingly emphasize when promoting their venture to investors (Graham et al. 2009). There are several advantages technology start-ups can draw from when patenting their technological inventions. First, property rights in the form of patents are a means to protect a company's intellectual capital from imitation. Patents offer to their owner the exclusion right to commercialize or licence the underlying technology and can thus assure a start-up's unique selling proposition while differentiating itself from established competitors. In this function as exclusionary rights, patents help start-ups appropriate returns from investment in research and development by facilitating the commercialization of new technologies (Teece 1986, Hall and Ziedonis 2001). When dealing with external organisations patents can, on the one hand, facilitate cooperation with business partners, and on the other hand, be used as a defense mechanism against industry rivals (Arora et al. 2001, Cohen et al. 2000). Furthermore, patents incorporate a trade value, as intellectual property rights have become tradable assets on the market for technology (e.g. Arora et al. 2001, Gans et al. 2008). In addition to the above-described productive functions, a patent may also serve as a quality signal to third parties (Long 2002). In the presence of uncertainty, for instance in the screening stage, investors may appreciate patents as indicators for unobservable characteristics, such as the quality of a start-up's technology or the management capabilities of the start-up team (e.g. Häussler et al. 2010, Lemley 2001). The independent examination by the patent office thereby substantiates the credibility of the patent as a signal.

Despite the monetary and time-related expenses required to file a patent, VCs can be assumed to appreciate start-ups' investment in patents as they are aware of the advantages associated with them. There is evidence from recent studies focused on the investment stage indicating a positive influence of existing patents on the venture capital evaluation of start-ups (Baum and Silverman 2004, Hsu and Ziedonis 2011, Mann and Sager 2007) and their likelihood of receiving venture capital (Engel and Keilbach 2007, Häussler et al. 2010). As in the screening stage the uncertainty surrounding VCs' decisions is even higher and the availability of other reliable selection criteria certainly lower compared to the investment stage, it can be assumed that patents will at least play an evenly important role in the screening of business plans as in the final investment decision.

When discussing the importance of patents as investment criterion for VCs, one needs to distinguish between granted patents and patent applications. Due to time constraints—the patenting process from application to grant takes about four years in Germany—many start-ups applying for the first round of venture capital have not been granted a patent yet (Häussler et al. 2010). Evidence from previous research on the importance of patent applications versus patent grants as venture capital selection criteria is scarce and inconclusive, and my interviews support this observation. While one one of my interviewees rates the value of a patent application at only 40% of the value of a granted patent, others do not regard grants as much more valuable than applications due to the generally high approval rates of patent application. As a matter of fact, 40-50% of patent applications at the EPO are eventually approved[25] (EPO 2011). From a signaling perspective, patent applications can work just well as a proxy for technological quality than granted patents (Baum and Silvermann 2004, Hsu and Ziedonis 2011). However, regarding the asset value of a patent, a granted patent should pose much higher benefits for a VC than a mere application, as the latter one still implicates a lot of uncertainty.

All three described types of observable start-up resources – team experience, alliances, and intellectual property – constitute viable selection criteria for VCs during the screening phase. As a first goal of this study I would like to better understand to what extend these criteria matter and what the trade-offs in attribute levels are.

Explorative research aim: *Investigate in detail how observable start-up resources influence VCs in the screening of business plans.*

[25] The remainder is rejected by the patent office or withdrawn by the applicant.

3.3 Regional Differences between German and U.S. VCs

The venture capital industry has its seeds in the United States of America, where the first venture capital firm was founded in the 1940s (Weitnauer 2007). Nowadays, active venture capital funds can be found in all major economies. Even though the general business model of venture capital firms is the same around the world, a few regional differences do exist. Compared to the German VC community, the U.S. venture capital industry is not only older but also larger. In 2010, €15.9 billion of venture capital were invested in the U.S. while in Germany VCs' investments only add up to €0.7 billion (BVK 2011a and 2011b). Even on a relative scale, dividing total venture capital investment volume by national GDP, the U.S. venture capital market is about five times larger than the German venture capital market (VC-GDP ratios: U.S. 0.15%, Germany 0.03%)[26]. In terms of investment stages, German VCs allocate a larger share of their total funding volume (56%) to early-stage ventures than U.S. VCs (32%), who to some extent prefer later-stage investments. When comparing portfolio industries only slight differences can be found. While high-tech industries and the e-commerce sector account for the majority of investments on both sides of the ocean, German venture capital firms hold a higher share of retail and consumer goods start-ups than their U.S. peers (BVK 2011a and 2011b).

Due to the general differences described above, an investigation of differences in decision making between U.S.-based and Germany-based VCs seems interesting. Surprisingly only very few studies have ever compared the decision criteria used by VCs from the two different regions. Relying on a list of criteria developed by MacMillan (1985) based on a sample of U.S. VCs, Knight (1994) conducted a comparative study by collecting data from Canadian, Asian-Pacific and European VCs. Brettel (2002) added further insights to this research by investigating the decision making of German VCs with a similar questionnaire. Comparing the results of all three studies, VCs across all continents appear to employ roughly the same decision criteria with only a few exceptions. For instance, VCs from the U.S. seem to put a higher emphasis on the characteristics of the entrepreneurial team, e.g. their background and

[26] Data for the calculation was taken from Bundesverband Deutscher Kapitalbeteiligungsgesellschaften (BVK 2011a) and Bureau of Economic Analysis (2011). An exchange rate of $1 = €0.723 was used.

experience, than their international peers. Also, U.S. VCs appear to require a higher level of patent protection of the intended product than German VCs (Brettel 2002).[27]

By using a more advanced method, conjoint analysis, instead of the Likert-scale questionnaires used in previous studies, I attempt to provide a more precise comparison of international venture capital decision making behavior. One particular focus will be on the role of patents as venture capital selection criterion. In contrast to other classic selection criteria such as team experience or alliances, potential regional differences in the attitudes towards patents can actually be reasonably argued. There are two arguments suggesting a higher importance of patent protection as selection criterion for German VCs than for U.S. VCs. The first argument refers to patents' value as quality signals. The costs of applying for a patent in the U.S. are much lower than in Europe (Harhoff et al. 2009, van Pottelsberghe 2006), and the technical requirements for patenting are also comparatively low in the U.S. These two conditions have led to a flood of low quality patents in the United States (Jaffe and Lerner 2004). This phenomenon in turn implies that the mere existence of a patent hardly works as a signaling mechanism for good qualities in the U.S. In Germany, on the contrary, being more difficult to obtain, patents might be a better differentiator. The second, and probably more powerful, argument relates to patents' protective value. In Germany, a patent infringement constitutes a sufficient condition to obtain an interlocutory injunction (Bodewig 2005). In the U.S., however, a patent infringement alone is not enough to claim an injunction. The plaintiff rather needs to prove that the additional conditions of the so-called "four factors test", e.g., having suffered an irreparable injury, are fulfilled (Ohly 2008). A patent can thus in Germany be regarded as a more powerful weapon to fight off competitors than in America. The sum of both arguments leads me to conclude that German VCs may attach a higher importance to patent protection in screening business plans than U.S. VCs. Note that the according hypothesis stated below challenges the findings of earlier studies (Brettel 2002).

[27] A direct comparison of the mean values between the different regional samples leads to the observation that U.S. VCs attach a higher importance to almost any decision criterion. In the light of a potential importance inflation bias it may thus be regarded questionable to conclude regional differences for selected investment criteria.

Hypothesis 1: *Patent protection will have a larger impact on a start-up's likelihood of receiving venture capital in Germany than in the United States.*

3.4 Data and Methods

3.4.1 Conjoint analysis

In order to investigate the importance of observable start-up resources for venture capital funding, I conducted choice-based conjoint experiments[28] with early-stage VCs. A conjoint analysis offers clear advantages compared to post-hoc methodologies, especially for investigating VCs' decision policies, for the following three reasons (Shepherd and Zacharakis 1999). First, several shortcomings of traditional likert scale surveys, such as inflation of importance or biases due to individual response styles, are avoided (e.g. Stening and Everet 1984). In fact, a choice-based conjoint analysis allows me to capture nonlinear effects and trade-offs between individual start-up characteristics. A second advantage of my research design is that choice experiments with bundled "products" come very close to real-life decision situations and help not only to increase the validity but also the response rate of scientific surveys. Third, this experimental approach implicates advantages over the analysis of real transaction data in that all independent variables are clearly defined and can be unambiguously interpreted while an omitted variable bias is excluded by construction.[29]

In a choice experiment respondents are repeatedly (six times in this case) presented with a set of hypothetical alternatives and asked to pick the one they prefer most (and/or least). In this study, participants are shown three start-ups at a time, which differ in a limited number of attributes as explained below, while all other characteristics are set equal. By analyzing the revealed preferences I can draw

[28] Choice-based conjoint experiments are also known as discrete choice experiments. In contrast to completely ranking a high number of stimuli in a traditional conjoint analysis, respondents are asked to repeatedly select their preferred option out of a set of only few stimuli (Elrod et al. 1992).

[29] All other potential selection criteria (independent variables) are defined to be at "comparable levels" and thus cannot influence VCs' decisions making in this conjoint experiment. Moderating effects of external variables, however, are still possible and will be investigated in Chapter 4.

conclusions about the importance that participants attach to the different attributes when screening investment proposals.

It is important to make choice experiments as realistic as possible. At the same time they should be easy to understand and manageable for all respondents in terms of timing and complexity. At first the setting of the experiment needs to be defined precisely and relevant variables need to be selected accordingly. As explained earlier I decided to focus my research on the screening stage, which is a well suited setting for a conjoint experiment since evaluating conjoint cards is very similar to evaluating executive summaries of business proposals in real life (Franke et al. 2008). The decision to focus on this stage has direct implications for the experimental design, in particular for the choice and specification of potential variables. For screening decisions based on written business plans it is only reasonable to incorporate directly observable start-up attributes. While the actual management skills of the start-up team cannot be observed on paper, the team members' amount of management experience is clearly quantifiable and commonly stated in business plans. Furthermore, VCs who are evaluating investment applications will rather rely on tangible and objective characteristics, e.g., written alliance agreements, as opposed to more subjective and ambiguous attributes, such as "a large number of potential customers". Estimated market figures and expected growth rates or returns are necessary items in any business plan; however, as my research interest lies with the reliable resources of new ventures, I exclude any financial criteria from the conjoint analysis.

Prior research, as outlined earlier, implies that VCs rely on three types of start-up resources in the screening process: team characteristics, alliances, and intellectual property. To make sure I only use variables that are relevant in practice I conducted a pilot study which included the analysis of the relevant academic and practice-oriented literature, business plan competition guidelines, and interviews with venture capital experts, among them eight active VCs, three entrepreneurs and nine venture capital scholars. The discussions with industry experts not only helped me select the most relevant screening criteria but also determine the realistic levels of these attributes. I eventually selected three observable start-up resources for this analysis: start-up team's experience, patent protection, and alliance agreements. And for each of these attributes I included three different attribute levels (Table 6) that are used in the experiment to describe the setup of different start-ups at a specific point in time.

Table 6: Start-up attributes and levels

Attribute	Levels	Description
Patent Protection	• None (reference) • Patent applied for • Patent granted	Patent protection for the start-up's core technology, covering all relevant regions and territories
Team's relevant management experience	• 2 years (reference) • 5 years • 10 years	Average years of experience per team member working in a management position at a company in the respective industry
Alliances	• Set of verbal agreements (reference) • One written research agreement • One written sales agreement	Established relationships with reputable business partners, based on a research agreement (e.g. with universities, research institutions) or sales agreement (e.g. with pilot customers, sales partners)

To be able to interpret the results correctly, I needed to make sure that all respondents had a common reference setting in mind when doing the experiment. In the introduction of the survey, I therefore provided a short description of the overall screening situation and the type of start-up to be assessed. This introduction had been extensively refined and validated in a pre-test with industry experts (Wason et al. 2002). Figure 3 depicts the reference setting used to introduce respondents to the situation in which they were supposed to act.

Figure 3: Reference setting as presented to participants

Several technology start-ups present their business plan to you in order to apply for venture capital funding. They all have the same background as described below:

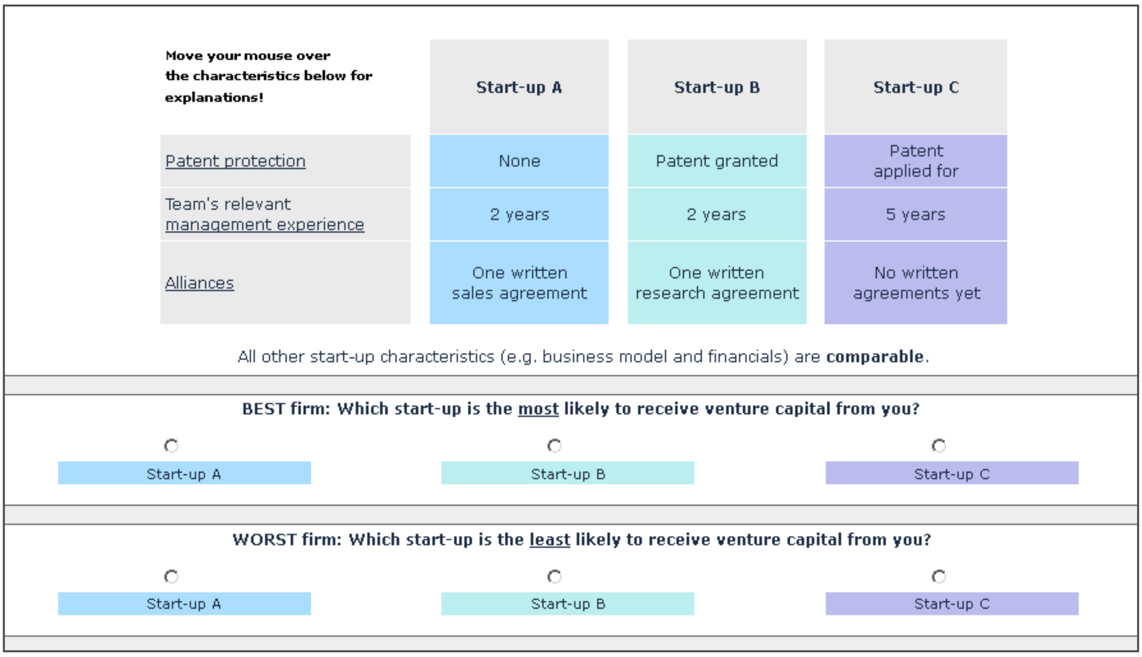
- Venture based on a technical invention
- Industry*: Biotechnology or Clean technology or ICT
- Clearly visible value proposition
- Potential users: Industrial firms
- A working prototype exists
- Applying for early stage financing

You are not familiar with the presented start-ups and do not possess any information on the quality of their technology.

* Every participant was presented with the industry of his/her main expertise.

For the construction of the conjoint choice sets I relied on an efficient fractional-factorial design generated by computerized search (Yu et al. 2009)[30] and was thus able to reduce the full fractional design of $3^3=27$ possible combinations to a manageable number of six choice sets. In each of the six choice sets respondents were presented with three hypothetical start-ups each and asked to select the one they would most likely and least likely, respectively, fund with venture capital. An extensive pre-test confirmed that the experimental setting including its variables was understandable, realistic, and manageable within the suggested time frame. Figure 4 depicts a choice set as presented to the survey participants. I sent out six different versions of the survey, which varied in the order of choice sets and start-up characteristics and were randomly assigned to survey participants in order to avoid biases. At the very end of the survey participants were asked for open comments on the role of patents and alliances in venture capital financing.

Figure 4: Choice set as presented to participants



30 The design was generated using the software package NGene 1.0 by ChoiceMetrics, Ltd.

3.4.2 Samples

I analyze two distinct samples in this study, a German sample and a U.S. sample. The German sample consists of 102 individual venture capitalists from 80 different venture capital firms, who took part in my survey during the first quarter of 2011. The relevant population comprises all VCs who invest in German high-technology start-ups from one the industries biotech, cleantech or ICT.[31] In preparation of the survey potential respondents had been identified by searching industry associations (BVK, EVCA), press releases, and venture capital fund websites, while making sure the population was currently active and invested in high-tech start-ups at early stages. Following these criteria I identified 148 venture capital firms, which virtually represent the entire VC community investing in Germany that is relevant for this study. Per venture capital firm I randomly selected one investment professional from each relevant industry department, collected their contact information and created a database of 233 potential individual participants.

When conducting the survey, I took several measures to achieve a high response rate, which is considered very difficult in surveys among VCs (Muzyka et al. 1996). First, being aware of VCs' busy schedule, I tried to design this survey as convenient and interesting as possible by making it available online, asking for relevant demographic information only, and providing a straightforward but entertaining choice experiment.[32] Second, I went through the effort of first contacting the relevant VCs by phone before sending them the link to the online survey by e-mail. By speaking to the majority of the target group in person, I was able to establish a personal relationship and explain the purpose and mechanics of the conjoint experiment. Third, in case of no direct response a friendly reminder was sent 2-3 weeks after the initial contact. In total I received answers from 110 participants, of which 102 completed the entire survey. The sample features a fairly even distribution of the target industries with 29 VCs specialized in biotech, 34 in cleantech, and 39 in the ICT sector. Checking for non-response bias I could not find any demographic differences between participating and non-participating VCs, neither in terms of fund size, hierarchical position, nor industry focus. With a high direct response

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[31] More information on the three focus industries is provided in Chapter 4.

[32] Indeed I received much positive feedback not only on the research topic but also on the survey design. Respondents spent on average less than 15 minutes completing the entire survey.

rate of 40%[33] and answers stemming from 80 different venture capital firms my sample should thus be representative of the Germany-oriented VC market. Descriptive information on the sample, split by industry, is shown in Table 7.

The U.S. sample consists of 85 individual investors, who took part in my survey during the third quarter of 2011. All participants fulfill the same basic requirements as the above described German sample: they are currently active, invest in high-technology start-ups, and specialize in early-stage investments. Relevant venture capital firms were identified based on a list of members of the U.S. National Venture Capital Association. Thereafter, from each venture capital firm, one appropriate VC per target industry was selected by searching firm websites. Through this selection I generated a list of 285 individual VCs, who were then invited to take part in the survey. The invitation process followed the same steps as the previous survey. All potential respondents were first contacted by phone and right afterwards received an e-mail with a link to the online survey. They were given the option to forward the survey link to colleagues or other VCs in their network. A friendly reminder was sent 2-3 weeks after the initial contact. All in all, I received complete answers from 85 VCs stemming from 67 different venture capital firms. The direct response rate is 20%.[34] Descriptive statistics on the U.S. sample are displayed in Table 8.

Out of the 85 participants, 42 specialize in ICT, 27 in biotech, and 16 in the cleantech industry. In terms of their general characteristics, the participating U.S. VCs are very similar to the German sample. The share of senior and junior positions is roughly equal in both samples, while the U.S. VCs are on average slightly more experienced. The educational background is also very similar, for instance both samples show similarly high shares of scientists in the biotech industry. There are some differences in venture capital firm types and fund sizes, which are due to the underlying structure of the industry. The vast majority of the U.S. VCs are private VCs, as there are simply hardly any public venture capital funds in the U.S. Furthermore, venture capital funds are commonly larger in the U.S. than in Germany, which is also reflected in my

[33] Out of 233 VCs invited, 94 responded directly (= 40%). 16 participants received the link from a colleague or other contact.

[34] Out of 285 VCs invited, 56 responded directly (= 20%). 29 participants received the link from a colleague or other contact.

sample. All in all, my U.S. sample can be regarded as representative of the relevant VC population in the U.S. and well suited for a comparison with the German sample.

Table 7: Descriptive statistics on German sample

Variable	Biotech	Cleantech	ICT
Number	29	34	39
VC experience (median)			
Number of start-ups funded	8	5	10
Position (percent)			
Partner	0.41	0.32	0.33
Principal	0.21	0.21	0.23
Associate	0.14	0.26	0.15
Senior advisor	0.03	0.12	0.08
Other	0.17	0.09	0.18
No answer	0.03	0.00	0.03
Education / degree* (percent)			
Business	0.55	0.68	0.85
Engineering	0.14	0.47	0.26
Science	0.52	0.21	0.05
Law	0.03	0.03	0.03
Other	0.17	0.03	0.00
Type of VC (percent)			
Private	0.66	0.74	0.67
Corporate	0.10	0.15	0.10
Public	0.14	0.06	0.21
Business angel	0.00	0.00	0.00
Other	0.10	0.06	0.03
VC fund size in € (percent)			
<25 mio	0.14	0.12	0.21
26 - 50 mio	0.17	0.09	0.13
51-100 mio	0.21	0.21	0.13
101-250 mio	0.14	0.26	0.31
251-500 mio	0.03	0.26	0.10
501 mio -1 bn	0.21	0.00	0.03
>1 bn	0.03	0.00	0.00
No answer	0.07	0.06	0.10

* Multiple answers possible

Table 8: Descriptive statistics on U.S. sample

Variable	Biotech	Cleantech	ICT
Number	27	16	42
VC experience (median)			
Number of start-ups funded	8	4	6.5
Position (percent)			
Partner	0.44	0.19	0.43
Principal	0.19	0.38	0.19
Associate	0.33	0.44	0.36
Senior advisor	0.00	0.00	0.00
Other	0.04	0.00	0.02
No answer	0.00	0.00	0.00
Education / degree* (percent)			
Business	0.63	0.75	0.76
Engineering	0.26	0.13	0.31
Science	0.59	0.25	0.14
Law	0.00	0.00	0.00
Other	0.00	0.00	0.00
Type of VC (percent)			
Private	0.93	0.94	0.95
Corporate	0.00	0.06	0.02
Public	0.07	0.00	0.00
Business angel	0.00	0.00	0.02
Other	0.00	0.00	0.00
VC fund size in € (percent)			
<25 mio	0.04	0.06	0.10
26 - 50 mio	0.07	0.06	0.02
51-100 mio	0.04	0.00	0.10
101-250 mio	0.19	0.19	0.17
251-500 mio	0.22	0.38	0.24
501 mio -1 bn	0.22	0.19	0.26
>1 bn	0.22	0.06	0.12
No answer	0.00	0.06	0.00

* Multiple answers possible

3.4.3 Estimation

Since I asked respondents in each choice set for the start-up they would most likely fund and the one they would least likely fund, they provided me with a complete ranking of the ventures in each choice set. Beggs et al. (1981) and Chapman and Staelin (1982) were the first to present a method to analyze that kind of rank-ordered data by exploding it. More precisely, the ranking of three alternatives is decomposed into two choices: first choosing one out of three alternatives and then choosing the better of the two remaining alternatives. Applying this method to my experimental setting, every respondent makes 12 choices, 6 times selecting the best out of three available start-ups and 6 times picking the better of the remaining two start-ups.

The decomposed data could then be fitted with McFadden's (1974) conditional logit model. However, estimating a conditional logit model based on (decomposed) repeated choice data is questionable in light of the assumption of independence of irrelevant alternatives (iia) underlying this model. According to the iia assumption the error terms of each respondent's choice of alternatives would have to be independently and identically distributed. This assumption, however, is likely violated with data from choice experiments, as respondents' preferences will influence the error terms in their various choice decisions in a similar way (Hausman and Wise 1978, Layton 2000). Mixed logit a.k.a. random coefficient models are extensions of conditional logit models that do not require the iia assumption (Revelt and Train 1998; McFadden and Train 2000). Hence I rely on a rank-ordered mixed logit estimator for the analysis of the collected VC choice data.

Following the approach of Revelt and Train (1998), Hole (2007), and Fischer and Henkel (2012b), I model the utility of alternative *j* in choice set *t* for respondent *n* as a linear additive function of the alternative's characteristics, which are described by the vector x_{njt}. $ß_n$ is a vector of participant-specific coefficients. The error terms ε_{njt} are assumed to be independently and identically distributed and to follow an extreme value distribution.

$$U_{njt} = \beta_n' x_{njt} + \varepsilon_{njt}$$

Conditional on the participant-specific coefficient vector $ß_n$ the probability that respondent *n* selects alternative *i* from choice set *t* can be expressed by:

$$L_{nit}(\beta_n) = \frac{exp[\beta_n' x_{nit}]^{35}}{\sum_{j=1}^{J} exp[\beta_n' x_{njt}]}$$

The probability of the sequence of 12 choices made conditional on $ß_n$ is then given by:

$$S_n(\beta_n) = \prod_{t=1}^{T} L_{ni(n,t)t}(\beta_n)$$

where *i(n,t)* indicates the alternative chosen by respondent *n* in choice *t*. As a last step I integrate the conditional probability over the distribution of *ß* in order to derive the unconditional probability of the sequence of choices made. $f\,(\beta|\theta)$ describes the density of *ß*, while θ specifies the parameters of the distribution:

$$P_n(\theta) = \int S_n(\beta)\, f(\beta|\theta) d\beta$$

As the log-likelihood function $LL(\theta) = \sum_{n=1}^{N} \ln P_n\,(\theta)$ to be maximized in a mixed logit model does not have a closed form solution, Revelt and Train (1998) proposed a procedure for maximizing the likelihood function by simulation. This was implemented in Hole's (2007) STATA mixlogit command, which I use for my estimations. Since all start-up attributes are described by three levels, I code each attribute into two dummy variables that indicate the deviation from the reference value. For ease of interpretation I use the level with the presumably lowest benefit contribution per attribute as reference value: no patents, two years of experience, no written alliance agreements yet (see Table 6).

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[35] *ß'* denotes the transposed vector; *ß'x* = vector product.

3.4.4 Group comparisons

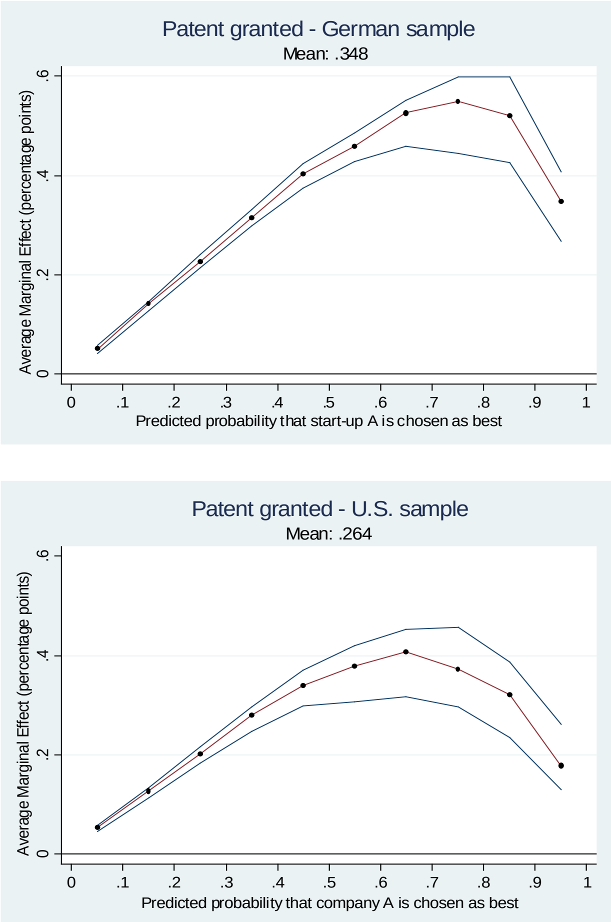
In order to investigate differences between German and U.S. VCs, I estimate separate models, one for each national sample, and then test for group differences. Estimating separate equations per group is preferable to using an interaction term for group comparisons unless differences in unobservable variation can be ruled out (Hoetker 2007). To simply test for the equality of the coefficients across the different groups, however, is not an appropriate approach since I estimate nonlinear models and the amount of residual variation between the models is expected to differ (Allison 1999). Since potential solutions to test for equality of residual variation between the models (Allison 1999) or compare ratios of coefficients across models (Hoetker 2007) are not applicable in this case, I employ an alternative approach proposed by Long (2009), which was recently implemented by Fischer and Henkel (2012a). Following this approach I analyze group differences by comparing predicted probabilities, which is suitable as predicted probabilities are not scaled by unobserved heterogeneity. Predicted probabilities, however, depend on all variables jointly, which requires testing differences between groups with respect to a focal variable for various levels of all other variables.

Concentrating on one particular dummy variable at a time, I first determine its marginal effect for each group separately. A variable's marginal effect is defined as the difference in predicted probabilities that a hypothetical start-up A in a given choice set is chosen as best when the dummy variable is switched from 0 to 1 (e.g. Hoetker 2007), for instance from "no patent" to "patent applied for". The size of the marginal effect depends on both the other attributes of start-up A and all attribute levels of the two competing start-ups in the choice set. I thus calculate the marginal effect per focal variable for all possible combinations of start-up A and the two competing start-ups.[36] This results in $3^2 \times 3^3 \times 3^3 = 6{,}561$ marginal effect values per dummy variable. Figure 5 illustrates the marginal effect of a "patent granted" in two different countries, Germany in the upper graph and the U.S. in the lower graph. For each graph the 6,561 marginal effects are sorted into ten "probability ranges" (0-10%, 10-20%, etc.) by the probability

[36] Alternatively, one could calculate the marginal effect of the focal variable while setting all other variables (of the focal start-up and of the two competing start-ups) to their respective sample mean. However, this approach makes little sense in this setting since, first, all variables are dummy variables, and second, each characteristic of each firm is coded by two variables which cannot simultaneously take on the value of one.

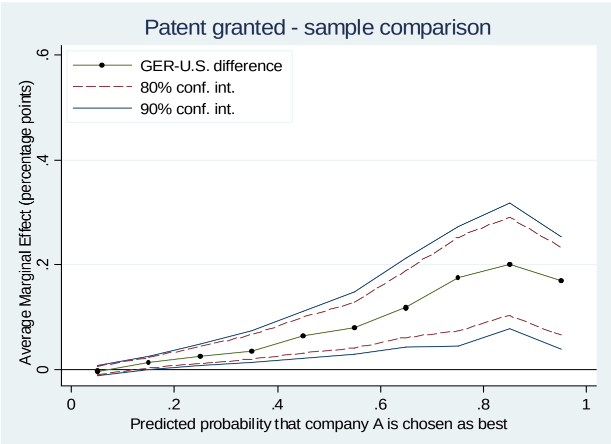
that start-up A is chosen as best when the dummy variable equals 1 (is turned on). The points of the solid line depict the average marginal effect for each range.

Figure 5: Average marginal effects of "patent granted" by group



After calculating marginal effects for all dummy variables in each group, I check to see whether the differences between the groups are significantly different from zero. To that end, I employ a simulation approach to measure the variance of marginal effects (King et al. 2000, Zelner 2009). Based on the results of the rank-ordered mixed logit estimations, I make 100 random draws from the joint distribution of all coefficients and repeat the calculation of the marginal effect for each simulated coefficient vector to determine confidence intervals (cf. Fischer and Henkel 2012a). I measure the significance of a difference of an average marginal effect between two groups in a specific probability range by calculating differences in average marginal effects for each simulated coefficient vector in both groups. Figure 6 illustrates the difference in average marginal effects between the two groups, German and U.S. sample, and the according confidence intervals for all probability ranges. I included 90% and 80% confidence intervals for the illustrated two-sided tests, because for directed one-sided tests they can be interpreted as 95% and 90% confidence intervals, respectively.[37]

Figure 6: Group differences in average marginal effects of "patent granted"



3.5 Results

I analyze VCs' screening decisions in three steps. I start by presenting a model that takes into account the choices made by all VCs from the German sample. Then, I discuss the estimation results generated from the choice data of the U.S. VCs. In the third step, I compare the screening decisions of German and U.S. VCs by looking at each selection criterion individually.

Regarding the German sample, Table 9 summarizes the results of my mixed-logit estimation, displaying estimated coefficients, robust standard errors, and average marginal effects (AME) for all six dummy variables. According to the coefficient and standard error values, all included start-up characteristics come out to have a highly significant influence on VCs' screening decisions. Their relative importance can be

[37] Note that my hypothesis is directed: I expect a higher value contribution of granted patents in Germany than in the U.S.

assessed by comparing their average marginal effects. As commonly done in conjoint analyses I define the importance of a start-up attribute by the difference between the highest average marginal effect of one of its levels and the attribute level with the lowest AME (Franke et al. 2008). The marginal effect of the least important attribute level, which I call the reference level, is zero by construction. Hence, I can use the highest AME of the two remaining attribute levels as the attribute's measure of importance[38]. These respective importance values are then normalized by dividing each by the sum of all three values. To illustrate the calculation consider the attribute "alliances". The attribute level "research alliance" has an average marginal effect of 0.167, while the AME of a "sales alliance" equals 0.350 and is thus higher. Dividing 0.350 by the sum of all most preferred attribute levels (0.348 + 0.233 + 0.350 = 0.931) results in a relative importance of 38% for alliances. Accordingly, patent protection receives an overall importance rating of 37%, while the start-up team's experience accounts for 25%. As a first answer to my explorative research question, the overall model indicates that patent protection and alliances have a comparatively high importance in VCs' screening decisions, whereas the amount of management experience appears to be of lower importance.

By taking a look at the individual attribute levels I find that VCs perceive granted patents (AME=0.348) as about twice as valuable as patent applications (AME=0.198). Similarly, a written sales agreement is regarded as twice as valuable as an R&D alliance agreement. One entrepreneur I interviewed stated, "*VCs always want to see downstream references, like pilot customers, as a proof that there is demand for your product.*" A number of trade-offs can be identified, for instance a team's lack of high experience can be made up for by the existence of a written alliance or a patent application.

[38] The importance of an attribute strongly depends on its individual levels and thus needs to be interpreted with the respective reference levels in mind. Refer to Table 6 for my choice of realistic attribute levels.

Table 9: Estimation results – German sample

	Model 1: Overall model GER		
Model specification	Rank-ordered mixed logit		
Dependent variable: firm ranking	**Coeff.**	**SE**	**AME**
Patent applied for	2.618***	0.327	0.198
Patent granted	4.304***	0.393	0.348
Experience 5 years	1.963***	0.273	0.153
Experience 10 years	2.878***	0.349	0.233
Research alliance	2.175***	0.312	0.167
Sales alliance	4.370***	0.422	0.350
Obs/Persons	1224	102	
LR Chi-squared (6)	250.37		
Prob > Chi-squared	0.000		
Log likelihood	-731.170		

* p < 0.1; ** p < 0.01; *** p < 0.001; robust standard errors (SE) reported

In order to analyze the U.S. survey data, choices made by all participating U.S. VCs are entered into an overall model. The results of the mixed logit estimation are shown in Table 10. Based on their coefficient and standard error values all dummy variables have a highly significant influence on VCs' screening decisions. Again, the relative importance of the individual attributes can be inferred from the average marginal effects of their highest attribute levels. I observe that alliances rank first with a normalized importance of 39.7%[39], patent protection is second (31.2%), and the team's experience ranks last with 29.2%. This ranking order is the same as in the German overall model and thus confirms the above reported findings. Written alliance agreements appear to be the most important start-up resource in the screening of business plans in both regional markets. Some differences in the magnitude of the respective AMEs between the two national samples are already notable and will be discussed in the next paragraph.

[39] 0.336 / (0.264+0.247+0.336) = 0.397

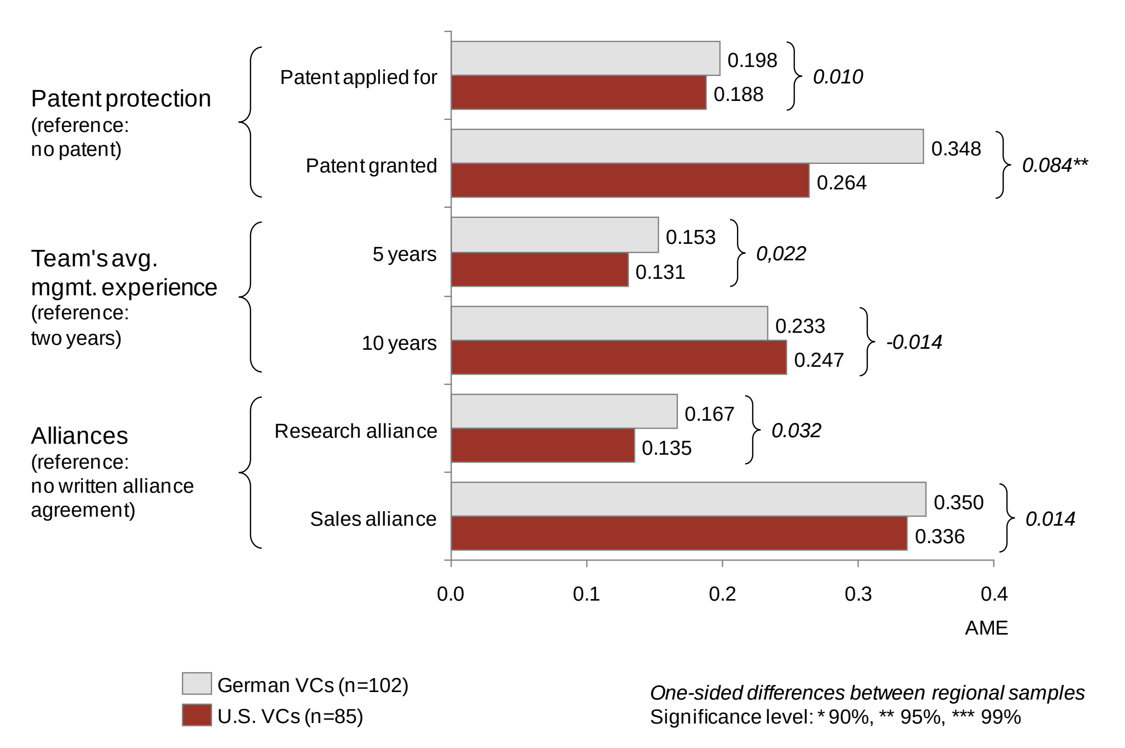
Table 10: Estimation results – U.S. sample

	Model 2: Overall model U.S.		
Model specification	Rank-ordered mixed logit		
Dependent variable: firm ranking	**Coeff.**	**SE**	**AME**
Patent applied for	2.215***	0.329	0.188
Patent granted	3.035***	0.342	0.264
Experience 5 years	1.534***	0.289	0.131
Experience 10 years	2.783***	0.375	0.247
Research alliance	1.595***	0.314	0.135
Sales alliance	3.940***	0.454	0.336
Obs/Persons	2550	85	
LR chi2(6)	256.73		
Prob > chi2	0.000		
Log likelihood	-639.9532		

* $p < 0.1$; ** $p < 0.01$; *** $p < 0.001$; robust standard errors reported

I will now focus on the differences between U.S. and German VCs concerning the screening criteria they use. Figure 7 illustrates the estimation results of both samples in comparison, juxtaposing the data of Model 1 and Model 2. While most dummy variables' differences in AMEs are minor and thus of no statistical significance, I find one important exception. The variable "patent granted" reaches a much higher contribution to passing the VC screening in the German sample than in the U.S. sample (AME 0.384 vs. 0.264). Figure 6 in the methods section shows that this difference is statistically significant at the 95% level (one-sided). *Hypothesis 1*, which states that patent protection has a larger impact on a start-up's likelihood of receiving venture capital in Germany than in the United States, is thus clearly supported. Since this difference could be caused by an unequal representation of industries in the two samples, I also compare the responses of U.S. and German VCs within each industry group. It turns out that the finding that German VCs appreciate granted patents more than U.S. VCs holds true in all three industries. This regional difference in AMEs is largest in the ICT sector and smallest in biotech (see Appendix A.2).

Figure 7: Differences in AMEs between German and U.S. sample



3.6 Discussion and Conclusion

By analyzing the decision behavior of venture capital investors when screening business plans, I investigate the importance of observable start-up resources as venture capital selection criteria. I report new insights on the role of patents and different types of alliances and how their influence on VCs' decisions differs between Germany and the United States.

Overall, I observe that both patents and alliances constitute important advertising mechanisms for start-ups in order to secure venture capital funding across both national markets. The high relative importance of both characteristics I find in analyzing screening decisions extends the results from transaction data based studies that report a significant influence of patent and alliance variables on venture capital funding figures (e.g. Baum and Silverman 2004, Hsu and Ziedonis 2011). My findings even suggest that an existing alliance agreement and/or patent grant could have a stronger impact in the screening stage than in the actual investment decision later on. The screening phase potentially favors the weight of objective and tangible characteristics such as patents and alliance agreements, whereas at later stages in the decision making process VCs become more acquainted with the start-up's team and technology and other more subjective investment criteria gain importance. The screening setting could hence be one reason for the comparatively low importance of the team variable in this study.[40] Even though team characteristics are commonly referred to as the prime investment criterion of VCs, this might well be different for the first screening of business proposals. At that point in time, entrepreneurs can only report their previous experience on paper, whereas at later stages after personal contact and team presentations, VCs are better able to assess the quality of the team and will make that a more important criterion in their decision making.

The comparatively strong impact of the attribute "patent protection" in both regions may seem surprising at first but can be explained by several reasons. First, this study was exclusively directed to VCs investing in technology-based start-ups from high-tech industries, in which patent protection is known to be most effective. Changing dynamics in the venture capital market could pose a further argument of higher patent importance compared to earlier studies (e.g. MacMillan 1987, Brettel 2002). Nowadays, VCs already consider future exit scenarios in their screening decisions, which strengthens the value of patents in two ways. On the one hand, in a negative exit scenario of the start-up going bankrupt, its intellectual property rights can be sold on the increasingly efficient markets for technology (e.g. Arora et al. 2001, Serrano 2006); see the case of Kodak for a recent example.[41] In other words a salvage value can be recovered from the start-up's patents. With regard to positive venture capital exits, on the other hand, trade sales are becoming increasingly popular in comparison to IPOs (Giot and Schwienbacher 2007). When large corporations acquire technology firms, patent rights may represent a major valuation driver. In the case that a start-up has filed a patent on its core technology but has not passed the examination yet, I find that to a VC a patent application is worth about half as much as a granted patent. The grant

[40] Furthermore, note that I used a reference level of "2 years" for the attribute "team experience," which might have already been regarded as relatively high by the survey respondents. A reference level of "0 years" of experience instead of "2 years" would not have been realistic in combination with a granted patent or existing alliance, but would have yielded higher importance values for the attribute "team experience."

[41] See for example http://www.bbc.co.uk/news/technology-18413173, accessed 08 July 2012.

decision by the patent office thus adds further value to the start-up, as it reinforces the patent's productive function and reduces uncertainty about the scope of the IP rights (Greenberg 2011).

Alliances appear to have an even stronger impact than patents as venture capital screening criterion, especially in the U.S. This result does come as a surprise in light of limited evidence on alliances as selection criterion, but may be plausibly explained. When discussing the influence of existing alliances on VCs' screening decisions I need to emphasize that my findings are based on written alliance agreements. The distinction between written agreements (as featured in this experiment) and non-confirmed agreements is crucial in the assessment of business plans. One interviewee explains, "Basically every start-up mentions to be in advanced discussions with some kind of business partner or about to sign an agreement, but to actually have a written agreement makes a big difference." This could contribute to the high overall importance of alliances in this analysis. In any case, the strong impact of alliance agreements in this study is especially noteworthy since the role of alliances as venture capital selection criterion has yet to be thoroughly explored. Hardly surprising from a practitioner's perspective this importance is to a large extent driven by downstream alliances. An agreement with a downstream partner, such as a letter of intent, serves as a proxy for market access and commercial viability of the technology, which is of crucial importance to every VC I talked to. Upstream alliances play a different role; they indicate access to know-how and technology development capabilities and are thus associated with the quality of the start-up's technology (Baum and Silverman 2004). As such their value contribution appears to be in general lower than sales agreements', but, as I will discuss later, it strongly increases with the research intensity of the start-up industry.

Analyzing two independent samples of VCs from Germany and the U.S. provides two important benefits. First, since I find the same ranking of start-up resources as venture capital selection criteria in both countries, the above reported results may be regarded robust. Second, my data allows me to compare the value of certain resources internationally. This comparison reveals one interesting regional difference concerning the start-up resource patent protection; German VCs attribute a significantly higher value to granted patents in business plans than U.S. VCs. Even though this finding stands in contrast to the results of a study by Brettel (2002) it may be reasonably explained. To begin with, patents are arguably easier and cheaper to obtain in America than in Europe (e.g., Jaffe and Lerner 2004), which limits their discriminatory function for U.S. VCs. Furthermore, with respect to their property rights function, patents may be regarded more valuable by German VCs, because a patent infringement, unlike in the U.S., already constitutes a sufficient condition to claim an injunction against a competitor (Ohly 2008).

This study provides two main contributions to entrepreneurship literature. First, I present detailed results on the role of observable start-up resources as venture capital screening criteria and thus extend the literature on VCs' decision making (e.g., Tyebjee and Bruno 1984, MacMillan et al. 1985, Hall and Hofer 1993, Shepherd et al. 2003). By focusing on the initial screening stage I add new insights to existing research on the value of patents and alliances in start-up financing, which has so far been centered around the investment decision stage (e.g. Baum and Silverman 2004, Engel and Keilbach 2007, Hsu and Ziedonis 2011, Häussler et al. 2010). Particularly alliance agreements are surprisingly underexplored as screening criteria, potentially due to operationalization and confidentiality issues, even though their relevance seems to be obvious from a practitioner's perspective. Due to my conjoint setup I can add a new level of detail by clearly defining the research variables and consequently determining the individual value contribution of different attribute levels, for instance pending and granted patents or up- and downstream alliances.

Second, this investigation adds to existing research on international differences in venture capital selection criteria (Knight 1994, Brettel 2002) by comparing self-collected survey data from a U.S. and a German sample. My finding that start-up patents are appreciated more by German VCs than by U.S. VCs also adds a new dimension to the recent debate on the role of patents in venture capital financing (e.g., Baum and Silverman 2004, Häussler et al. 2010, Hsu and Ziedonis 2011). Apparently regional considerations do matter in discussing the value of patents for technology start-ups.

A few limitations of this study need to be pointed out. First, conjoint experiments may over simplify real-world decision making by not representing the full complexity of the actual task (e.g., Gustaffson et al. 2001, Petty and Gruber 2011). When designing this study I had to select a limited number of screening criteria to be included. Since I decided to focus on observable start-up resources, I excluded other potential selection criteria such as expected market return or estimated market size from the experiment. However, since all excluded variables are set equal by construction, my estimation models do not suffer from an omitted variable bias.

Although I report in detail the value contribution of different levels of patent protection and alliance agreements, there are limits regarding the interpretation of my results. My analyses are based on the plain existence of start-up resources and do not account for different qualities of these resources. Even though VCs typically screen business plans quickly and do not assess each resource in great detail at this stage, some quality considerations could still play a role for patents, e.g., regarding the number of citations, and for alliances, e.g., regarding the reputation of the actual alliance partner. I did not vary these quality aspects in the experimental setting and therefore cannot test for them. Moreover, the influence of observable resources on VCs' decisions may not only differ between regions, but also between start-up industries. As there are good reasons to believe that the impact of certain resources, for example patents, may vary between discrete and complex industries, I will investigate this issue in Chapter 4. Furthermore, the strong impact of patents and alliances on the likelihood of venture capital funding can be attributed to both productive and signaling effects of the observable start-up characteristics. To disentangle these two effects and determine the signaling value of patents for instance could be a promising avenue of future research (e.g. Long 2002) which I aim to address in Chapter 5 of this thesis.

Interesting practical implications for both entrepreneurs and VCs can be derived from this study. Entrepreneurs seeking funding are well advised to inform themselves about the resources that VCs value in their respective national market before submitting a business plan. Especially for inexperienced founders, investing time and money into an observable asset such as a patent application or sales agreement can pay off. However, relying solely on one particular type of start-up resources, be it through building up a patent thicket or a large alliance network, will not be the most promising strategy. One VC makes clear that, *"Patents are almost always necessary - but never sufficient,"* and another investor adds, *"Eventually, even at first screen it's the whole package that matters."* Venture capitalists may use the results of this study to reflect on their own decision making in comparison with peers from their own or a different region.

4 Industry Perspective: Patents as Screening Criterion in Various Industries

4.1 Introduction

In-depth knowledge about the criteria that VCs use in evaluating start-up business plans is highly relevant for entrepreneurs in search of funding. Entrepreneurs can find orientation in existing academic studies which have done a good job at identifying and describing the most important venture capital selection criteria in general (see Table 5 in Chapter 3 for an overview). Nevertheless, there is still need for providing a more accurate picture of VCs' decision making in some respects.

Dimov et al. 2007, for instance, point out that most extant studies on VCs' decision making have focused on finding a common set of selection criteria and thereby have identified a stereotypical decision making behavior, in which the potential influence of moderating effects is neglected.[42] However, in the light of a recent debate on contingencies in the resource-based view theory, external factors should be taken into account when assessing the importance of organizational resources (e.g., Brush and Artz 1999, Aragón Correa and Sharma 2003). From a contingency perspective the overall business environment can have a substantial impact on the investment criteria applied by VCs. The industry sector a start-up operates in is the most prominent moderating factor to potentially influence how each selection criterion is weighted (Sandberg et al. 1988). Industry-related differences may be particularly relevant when assessing the importance of start-ups' resources, such as patents and alliances, as venture capital selection criteria since the usefulness of resources often differs between industries (e.g., Cohen et al. 2000, Levin et al. 1987). To my knowledge, industry differences in VCs' decision making, especially in the screening of high-tech start-ups, have not yet been investigated in detail. While most recent transaction-data based studies focus on one specific venture industry, i.e. biotechnology or semiconductors, most experimental studies do not specify the industrial setting at all and only control for some industry-related VC characteristics in their analyses (see Table 5). Only Mann and

[42] A few recent studies go into more detail. Knockaert et al. (2010), for instance, have shown that high-tech VCs can be grouped by the decision criteria they appreciate most in assessing start-ups.

Sager (2007) compare their results of venture capital investments in software start-ups to a biotech sample.

The purpose of this study is to address this gap and consequently also to extend the results reported in Chapter 3. In order to compare the importance of patents and other resources as selection criteria between various high technology industries, I analyze data from my own survey with 102 German VCs and 85 U.S. VCs. By varying the start-up industry setting based on respondents' expertise, this survey was designed to specifically test for industry differences in venture capital screening criteria. In providing both industry-specific results and cross-industry comparisons regarding the value of individual selection criteria, I aim to add a new level of detail to existing research on VCs' decision making.

4.2 Industry-related Differences in the Importance of Start-up Resources

Start-ups' resources, such as patents and alliances, have been shown to play an important role as venture capital selection criteria (see Chapter 3). To understand their impact in more detail I would like to point out the potential influence of contingency effects in this context. According to contingency theory, superior organizational performance can be achieved through aligning the organizational setup with the environmental circumstances that the organization has to deal with (Burns and Stalker 1961). These environmental circumstances should thus be taken into account when formulating strategic advice. With most research on VCs' decision making being focused on defining "one size fits all" solutions, the concept of contingency effects has only recently found its way into entrepreneurial studies. Gruber (2007) for instance shows that the value of planning activities for start-ups depends on the business environment being dynamic or less dynamic. Applying a contingency perspective to the investigation of VCs' screening criteria leads to the assumption that the contribution of observable characteristics to securing financial funding may also depend on external moderating factors. As a matter of fact Sandberg et al. (1988) already identified the start-up's industry sector as one influential external factor on VCs' selection criteria, but did not provide any quantitative evidence. I follow up on this issue and focus specifically on the question how a start-up's industry affiliation influences the importance VCs attach to observable start-up resources. In the following, I develop hypotheses on industry differences with regard to the two most important resources, alliances and patents.

4.2.1 Alliances

A start-up's existing alliances can constitute a highly relevant selection criterion for VCs. First of all, they entail productive benefits in providing start-ups with access to information, knowledge, and complementary resources (e.g., Cohen and Levinthal 1990, Chung et al. 2000, Liebeskind et al. 1996). Second, alliance agreements may serve as quality signals and help VCs to assess start-ups before investment (e.g., Baum and Oliver 1991, Stuart et al. 1999). In this context, alliances can refer to partnerships in research and development (upstream alliance) as well as to collaborations with sales partners (downstream alliance) (e.g., Baum et al. 2000).

With regard to contingency effects, I mentioned earlier that the industry sector in which a start-up is active in might play a crucial role when discussing the resources it needs to succeed in the market place. Considering the build-up of resources, there are some universal differences between industries; for instance technology development standards and lead times are generally higher in the biotech industry than in the ICT or cleantech sector. A high level of research intensity, a common attribute of the biotech industry, drives the need for R&D alliances and the potential benefits that result from them (Rothaermel and Deeds 2004). Partnerships with research institutions could thus be a more important prerequisite of success for biotech companies than for companies from other industries, particularly in the early years of business. On the other hand, downstream alliances might be of higher relevance in industries where not technology leadership but rather market access acts as a key differentiator. A written sales agreement can serve as an external acknowledgement of a start-up's product offering and proves its marketability. As such it might constitute a more important asset in industries where time-to-market is crucial, such as ICT or cleantech, compared to research-driven industries with products built around technological advantage.

Being experts in their portfolio segments, it can be assumed that VCs understand the differences in determinants of business success in the underlying industries and alter their selection behavior and criteria accordingly. Hence, I expect to see industry-related differences in the observable characteristics that VCs use to evaluate start-ups.

Hypothesis 1a: *An upstream alliance agreement will have a larger impact on a start-up's likelihood of receiving venture capital in the biotech industry than in the ICT or cleantech industries.*

Hypothesis 1b: *A downstream alliance agreement will have a larger impact on a start-up's likelihood of receiving venture capital in the ICT or cleantech industries than in the biotech industry.*

4.2.2 Patents

A considerable impact of start-ups' patents on VCs' decision making has been suggested by a number of recent academic studies (e.g., Baum and Silverman 2004, Hsu and Ziedonis 2011, Mann and Sager 2007) and also results from my own research (see Chapter 3). When discussing the role of patent in venture capital financing, contingency effects need to be considered as well since the value of intellectual property rights varies between industries (e.g., Levin et al. 1987). In discrete industries, such as biotech, intellectual property rights are considered highly effective, whereas in more complex industries, such as the clean technology sector, it is easier to invent around a protected technology (Cohen et al. 2000). Subsequently the high importance of patent protection in the biotech sector is a commonly mentioned phenomenon, as patented compounds are especially difficult to bypass (e.g., Lerner 1994a). In contrast to most other industries, in biotech patents are the primary instrument for appropriating returns from innovations (Cohen et al. 2000). Companies in the ICT sector rather use patent rights as strategic instruments for bargaining and blocking purposes as can be seen in the recent battle between the major players in the mobile phone market (Economist 2011). Based on the presented arguments I assume that patent rights constitute valuable resources for new ventures across all industries. Nevertheless, I hypothesize that patents' value is higher for start-ups from discrete industries compared to start-ups from complex industries due to differences in patents' effectiveness as appropriability mechanisms.

As in the case of alliances, VCs should understand how industry differences affect the benefits of patent protection and thus use this knowledge in evaluating a start-up's ownership of a patent. Prior research has not paid much attention to this issue yet but provides an indication of industry moderating effects. When investigating a sample of VC-funded startups, Mann and Sager (2007) find a higher share of start-ups owning patents in the biotech group than in the software group. In a qualitative study by Baeyens et al. (2006) VCs emphasized patents as a selection criterion for biotech start-ups more than for start-ups from other industries. Based on the presented theoretical arguments and qualitative findings I expect patent protection to have a stronger impact on the likelihood of receiving venture capital funding for biotech start-ups than for start-ups from the cleantech or ICT industries.

Hypothesis 2a: *A patent application will have a larger impact on a start-up's likelihood of receiving venture capital in the biotech industry than in the ICT or cleantech industries.*

Hypothesis 2b: *A granted patent will have a larger impact on a start-up's likelihood of receiving venture capital in the biotech industry than in the ICT or cleantech industries.*

4.3 Data and Methods

The analysis of industry-related differences in VCs' decision making is based on the same survey as described in Chapter 3.4.1. In a number of choice experiments, participating VCs were asked to rank hypothetical start-ups based on a description of the start-ups' configuration of resources (see Figure 4 for an example). Before the choice experiments, I provided respondents with a short description of the overall screening situation in order to introduce them to the situation in which they were supposed to act. Figure 3 depicts the reference setting I used. The only varying item in the provided description was the industrial sector that all start-ups are active in, since its potential moderating effect is one of my research interests. At the beginning of the survey, respondents were asked for their industrial preference based on expertise and subsequently presented with a reference setting featuring the respective industry.

In this regard, I chose to focus this study on three high-tech industries—biotechnology, cleantech hardware, and ICT hardware—which were picked for three main reasons. First, a general relevance of the chosen selection criteria is given in all three selected industries, which thus requires respondents to actually make trade-off decisions. This would, for example, not be true in the e-commerce or software sector, where patent protection is considered to be only of minor effectiveness and thus of only minor importance as a selection criterion (Cohen et al. 2000, Mann and Sager 2007). Second, the three high-tech industries represent a major share of the German venture capital market with investments into these sectors totaling ~€200M (out of ~€500M) according to a recent VC panel (Fleischhauer et al. 2010). This was confirmed by my own review of German VC portfolios and published deals, which additionally brought to my attention the recent surge in cleantech investments in Germany. The third argument applies specifically to including the biotech sector, which has been the underlying setting for a number of previous studies on venture capital investment criteria (e.g. Baeyans et al. 2006, Baum and Silverman 2004, Häussler et al. 2010), and can therefore serve as reference for validating and comparing my results.

The conjoint survey was conducted with VCs investing in Germany and the United States. A description of the survey procedure and the two independent samples can be found in Chapter 3.4.2. In analyzing the collected choice data I use the same methods as explained in Chapter 3.4.3 and 3.4.4. I rely on rank-ordered mixed-logit regressions to determine the value contribution of each dummy variable. In order to investigate differences between the three industries, I estimate separate models, one for each industry. Group differences are analyzed pair-wise between two industries at a time by comparing average marginal effects of each dummy variable. To test these differences for significance, I employ a simulation approach and determine significance levels based on the corresponding graphs (see Figure 6 as an example).

4.4 Results

After presenting the overall estimation models in Chapter 3, I will in this chapter concentrate directly on industry-specific results. Starting with the German sample, Table 11 shows three separate estimation models, each one fitted exclusively with data from VC choices within the respective start-up industry. The comparatively small sub-samples are not an issue here due to the high number of data points collected in the experiments. While all independent variables have a highly significant influence on VCs' decisions in all industries, one can clearly see differences in their relative importance between industries. Within the biotech sector, patent protection shows the highest relative importance of all selection criteria with a value of 45%[43], whereas alliances and management experience account for 29% and 26%, respectively. One VC explained, "*Good IP is a conditio sine qua non in biotech venture investing.*" In the cleantech industry, alliances (43%) are the most important screening criterion, patent protection (34%) ranks second and management experience (23%) third. With regard to ICT start-ups, VCs mostly look for alliances (40%) then for patent protection (33%) and less for an experienced management team (26%). Especially a written downstream alliance appears to be a key start-up asset in the ICT environment, since it indicates market interest in the technology. One ICT investor explained,*"The critical issue with my investments was usually the marketability and salability of the product."*

[43] Importance values are calculated based on average marginal effects: 0.435/(0.435+0.254+0.286) = 45%

Table 11: Estimation results – industry models German sample

	Model 1: Biotech			**Model 2: Cleantech**			**Model 3: ICT**		
Model specification	Rank-ordered mixed logit			Rank-ordered mixed logit			Rank-ordered mixed logit		
Dependent variable: firm ranking	**Coeff.**	**SE**	**AME**	**Coeff.**	**SE**	**AME**	**Coeff.**	**SE**	**AME**
Patent applied for	3.096***	0.765	0.190	3.277***	0.761	0.227	2.067***	0.470	0.167
Patent granted	6.115***	0.949	0.435	4.101***	0.806	0.285	3.629***	0.520	0.317
Experience 5 years	3.206***	0.693	0.207	1.616***	0.518	0.117	1.714***	0.406	0.140
Experience 10 years	3.815***	0.752	0.254	2.690***	0.783	0.195	2.880***	0.521	0.253
Research alliance	3.604***	0.793	0.234	1.526***	0.557	0.106	2.027***	0.475	0.164
Sales alliance	4.317***	0.827	0.286	4.849***	0.875	0.355	4.538***	0.637	0.385
Obs/Persons	870	29		1020	34		1170	39	
LR Chi-squared (6)	52.49			83.53			87.73		
Prob > Chi-squared	0.000			0.000			0.000		
Log likelihood	-181.46			-250.84			-275.37		

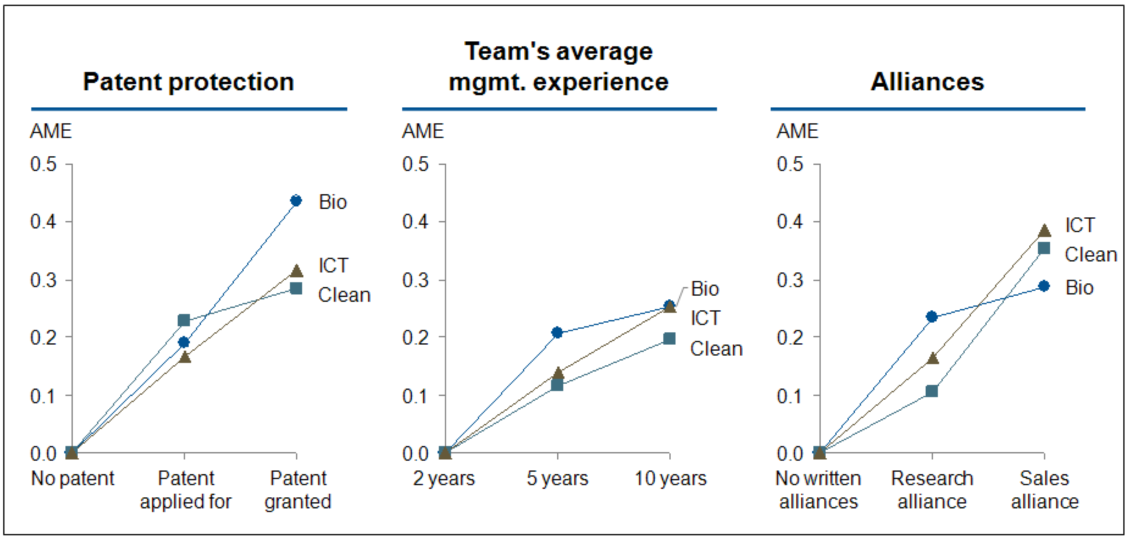
* p < 0.1; ** p < 0.01; *** p < 0.001; robust standard errors reported

When evaluating the importance of one particular start-up resource across industries, one needs to compare its respective average marginal effects. For ease of interpretation Figure 8 illustrates the average marginal effects of each attribute and its levels in the different start-up industries. Focusing first on the importance of patent protection I find that a granted patent, as expected, has a much higher influence on VCs' screening decisions in the biotech industry than in the other two sectors. One investor makes it explicit by stating that compared to other industries, *"in biotech patents are a must have and not just another criterion."* The value contribution of a patent application owned by a start-up is at similar levels in all three industries. Interestingly, it can be seen that while in biotech and ICT a granted patent is worth about double as much as a patent application, in the cleantech sector the value added by a granted patent compared to a filed patent is only 25%. One cleantech VC mentions that in the screening decision, "*There is no big difference between a filed and a granted patent. A patent application can even be more interesting since the information is secret if the application is not made public yet.*"

Turning to alliances I observe that VCs appreciate an upstream (i.e. research) alliance more in biotech than in the ICT or cleantech sectors. The opposite is true for downstream (sales) alliances; VCs attach more importance to downstream alliances in the ICT and cleantech industries than in biotech. When comparing the different types of alliances within each industry, both a research and a sales agreement seem to have a similarly strong impact on VCs' decision making in biotech, whereas in the ICT and cleantech industry an existing sales alliance clearly outperforms an upstream alliance. The latter phenomenon reflects the notion of the VCs interviewed that a start-up's eventual success in these industries is rather driven by time-to-market, indicated by a downstream alliance, than superior technological quality, indicated by an upstream alliance.

With respect to the start-up team's management experience I find that its overall importance is roughly equal across industries, but to have at least a medium level (five years) of experience is more important in biotech than in the other two sectors. I furthermore note that in both the ICT and cleantech industry the value contribution of experience as screening criterion appears to be a linear function of its levels. On the contrary, for biotech start-ups the incremental benefit from five years to ten years of management experience is rather small.

Figure 8: Average marginal effects of start-up characteristics in three industries



To statistically verify the reported industry differences, I performed pair-wise significance tests using simulations as explained in the methods section. Table 12 summarizes the differences in AMEs between the three start-up industries and indicates to what extent they are statistically significant. The according graphs featuring confidence intervals for all probability ranges can be found in Appendix A.3. Regarding the variable “research alliance”, the AME in biotech is significantly different from the AME in cleantech and ICT (difference of 0.128 and 0.070, respectively) which supports *Hypothesis 1a* by proving that an upstream alliance is perceived more important by VCs in the biotech industry than in the other two industries. Even though I find some indicative evidence that a downstream alliance in the cleantech and ICT industries may impact a start-up’s likelihood of receiving venture capital more than in biotech, the reported AME differences are not statistically significant. Thus *Hypothesis 1b* cannot be fully confirmed. With respect to *Hypothesis 2a* on patent applications, there are no statistically significant industry differences for the dummy variable “patent applied for.” I do, however, find that granted patents affect VCs’ decisions significantly more in the biotech industry than in the ICT or cleantech sector, which is in line with my expectations stated in *Hypothesis 2b*.

Table 12: Differences in AMEs between industries – German sample

Dummy variable	Biotech - Cleantech	Biotech - ICT	Cleantech - ICT
Patent applied for	-0.037	0.023	0.060
Patent granted	0.150**	0.118**	-0.033
Experience 5 years	0.090**	0.067*	-0.023
Experience 10 years	0.059	0.001	-0.058
Research alliance	0.128**	0.070*	-0.058*
Sales alliance	-0.069	-0.099	-0.030

Level of significance (one-sided): * 0.90; ** 0.95; *** 0.99

As a robustness check, I will now analyze the U.S. sample by industry. Table 13 provides an overview of the three industry models. In biotech patent protection clearly shows the highest contribution to passing VCs’ initial screening, while team experience ranks second and alliance agreements third. For cleantech start-ups alliances are the most important resource, before team experience and patent protection. In the ICT industry I observe the same ranking, however with more pronounced differences between the attributes.

In comparing the AMEs of each attribute level across industries, I provide additional evidence regarding my hypotheses on industry differences. For the attribute level “sales alliance” I observe a significantly higher value contribution in the ICT industry (but not in cleantech) than in biotech, thus partially supporting *Hypothesis 1b*.

Industry differences in AMEs regarding the variable “research alliance” are not significant; resulting in no support for *Hypothesis 1a*. With regard to patent protection, I find, as expected, a significant difference between the biotech sector and the two complex product industries. Both “patent applied for” and “patent granted” show significantly higher effects in biotech; *Hypothesis 2a* and *Hypothesis 2b* are thus confirmed. Table 14 summarizes the differences in AMEs between the three start-up industries and indicates their significance levels.

Table 13: Estimation results – industry models U.S. sample

	Model 4: Biotech U.S.			**Model 5: Cleantech U.S.**			**Model 6: ICT U.S.**		
Model specification	Rank-ordered mixed logit			Rank-ordered mixed logit			Rank-ordered mixed logit		
Dependent variable firm ranking	**Coeff.**	**SE**	**AME**	**Coeff.**	**SE**	**AME**	**Coeff.**	**SE**	**AME**
Patent applied for	4.744***	0.951	0.279	1.072*	0.613	0.116	1.569**	0.499	0.135
Patent granted	6.632***	1.184	0.422	2.136***	0.629	0.241	1.927***	0.422	0.167
Experience 5 years	2.726***	0.768	0.173	1.501**	0.551	0.158	1.039*	0.433	0.088
Experience 10 years	4.492***	0.984	0.292	2.381***	0.700	0.270	2.342***	0.605	0.202
Research alliance	2.162***	0.700	0.139	1.525**	0.543	0.160	1.555**	0.497	0.125
Sales alliance	3.185***	0.671	0.211	3.150***	0.813	0.352	5.223***	0.857	0.407
Obs/Persons	810	27		480	16		1260	42	
LR Chi-squared (6)	62.45			22.01			149.54		
Prob > Chi-squared	0.000			0.001			0.000		
Log likelihood	-172.154			-132.139			-285.877		

* p < 0.1; ** p < 0.01; *** p < 0.001; robust standard errors reported

Table 14: Differences in AMEs between industries – U.S. sample

Dummy variable	**Biotech - Cleantech**	**Biotech - ICT**	**Cleantech - ICT**
Patent applied for	0.163**	0.144**	-0.019
Patent granted	0.181**	0.255**	0.074
Experience 5 years	0.015	0.085	0.070
Experience 10 years	0.022	0.090	0.068
Research alliance	-0.021	0.014	0.035
Sales alliance	-0.141	-0.196*	-0.055

Level of significance (one-sided): * 0.90; ** 0.95; *** 0.99

4.5 Discussion and Conclusion

By conducting a choice experiment in three different industries, I am able to investigate the moderating effect of industry affiliation on VCs' screening decisions. In analyzing data from two regional samples, I find that the importance of patents and alliances as screening criteria differs strongly between complex and discrete industries. As expected, granted patents show their strongest impact in the biotech industry, where the lack of patent protection can almost be considered a knock-out criterion for VCs. VCs appear to have incorporated in their selection behavior the tight appropriability regime present in this discrete industry (Teece 1986). The finding that patent protection actually constitutes the most important screening criterion in biotech connects well with a study by Baeyens et al. (2006), which reported that in the biotech industry technology criteria are more important than management team skills for early stage investors. My observation that research alliances have a stronger impact in the biotech sector than in other industries is mostly likely driven by the high R&D intensity in biotech compared to the ICT or cleantech industry. Subject to a constraint of money and time, biotech start-ups can benefit about evenly from building up either an upstream or a downstream alliance. Contrarily, in the ICT or cleantech industry, a written downstream alliance as part of the business proposal is more useful in raising venture capital than an upstream alliance. I conclude that it is rather commercial viability than outstanding technological quality that is important to VCs in these industries. Furthermore, I observe that biotech VCs strongly favor entrepreneurial teams with at least an average amount of five years of relevant experience compared to their cleantech or ICT colleagues. It might be that a medium level of experience is considered necessary to understand all regulatory requirements in the biotech sector, while in a rather young industry like cleantech, experience is less important since the market is changing quickly anyway.

This study provides an important contribution to entrepreneurship literature. I am, to the best of my knowledge, the first researcher to investigate industry-related contingency effects in VCs' screening decisions. By conducting the same survey with VCs investing in three different industries I find quantitative evidence that the relative importance of observable start-up characteristics differs significantly between these industries. While patent protection dominates VCs' decisions in the biotech industry, downstream alliances appear to be VCs' main selection criterion in complex product industries.

Being based on a conjoint analysis, this study is subject to the same limitations as the ones explained in Chapter 3.6. In addition, splitting each sample into the three industry groups naturally decreases the number of observations per estimation model. This may be the reason why some of the observed differences between industries turn out to not be statistically significant. Future research may overcome this limitation by investigating a larger sample of VCs from each industry.

With regard to practical implications, my analyses provide entrepreneurs with customized information about the relative importance of start-up resources in their respective industry. The findings may thus help entrepreneurs in different high-tech industries to decide, for instance, whether it is worth to apply for a patent or not. Venture capitalists may use the results of this study to reflect on their own decision making in comparison with peers from their own or different high-tech sectors. After all, this research can overcome some limitations of "one size fits all" studies on venture capital selection criteria and provide more specific results and advice to high-tech entrepreneurs and VCs.

5 Functional Perspective: Patents' Role as Productive Assets and Quality Signals[44]

5.1 Introduction

Venture capitalists specialize in financing young firms with a high growth potential. Such investments bear a high risk due to a lack of securities and a high level of uncertainty. In particular the start-up itself is subject to uncertainty, since for lack of a track record its quality is only imperfectly observable. Thus, in evaluating a young firm, external parties have to rely on attributes that are observable at the time of assessment and presumably correlated with further, unobserved determinants of the start-up's quality (Stuart et al. 1999). Hence, observable resources may, in addition to their intrinsic value as assets, serve as signals when the potential of young companies is being evaluated.

For high technology start-ups, patents are an important instance of such an observable resource. In their original function as property rights, patents help appropriate returns from investment in research and development and facilitate the commercialization of new technologies (Cohen et al. 2000, Hall and Ziedonis 2001, Levin et al. 1987, Teece 1986). In a second function, patents hold informational value and may serve as a quality signal in the presence of information asymmetry (Long 2002). In line with Spence's (1973) definition of a signal, patents, being differentially costly to obtain, may be regarded as an observable proxy for an unobservable characteristic, namely the quality of a start-up's technology (Conti et al. 2011). Indeed, they have long been recognized as a relevant selection criterion for venture capital investors (e.g., MacMillan et al. 1987). More recently, a number of studies have shown a positive relationship between the patent stock of a high technology start-up and the amount of funding received from VCs (e.g., Baum and Silverman 2004, Conti et al. 2011, Greenberg 2011, Häussler et al. 2010, Hsu and Ziedonis 2011, Mann and Sager 2007). The same reasoning applies to a start-up's alliances: they have a productive function related to the benefits of collaboration but may as well serve as a quality signal

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[44] This chapter is partly based on Hoenig and Henkel (2012b).

providing external acknowledgement for the start-up's technology (e.g., Stuart 2000). Accordingly, alliances have also been shown to be positively related to a start-up's ability to attract venture capital financing (e.g., Baum and Silverman 2004, Greenberg 2011, Hsu and Ziedonis 2011).

However, a detailed understanding of exactly how these resources support start-ups in attracting venture capital is missing. Most existing studies in the field are based on firm-level transaction data and relate patenting and alliance information to venture capital funding figures. This approach provides meaningful results, however it does not allow the disentanglement of the signaling effect of patents or alliances from their productive effect. Among others, Mann and Sager (2007, p. 200) call for more research on this issue by stating that "the patent serves as a proxy for both the innovation and the legal protection," two effects that patent scholars so far cannot untangle.

In this study, I address this gap. Drawing on value appropriation and signaling theory, I develop a conjoint approach to quantify the relative value of patents and alliances as productive assets and as signals of quality. I conducted a survey among 102 European VCs, all of whom invested in German high technology start-ups. Participants completed a set of choice-based conjoint experiments in which the importance of observable start-up characteristics—patents, alliances, and the team's experience—for securing venture capital funding was tested. To isolate the signaling effect of these resources, the experiment was conducted under two scenarios. In one scenario, participants were told that the technological quality of the start-ups under consideration was unknown to them. In the other scenario, they were briefed that the firms' technologies were known to them and equally good. With the collected choice data I estimate mixed-logit models to determine the value contribution of each start-up characteristic. Since no signaling regarding the start-ups' technologies is required in the latter scenario featuring equally good technologies, differences between the two scenarios can be interpreted as signaling effects of the respective characteristic.

My results are somewhat surprising. Although I find a comparatively high importance of patent protection for securing venture capital funding, I cannot identify a signaling effect of patents. In other words, VCs value patents highly, but only in their function as property rights, not as quality signals. Instead, VCs seem to rely on research alliances as signals of technological quality. These findings are rather unexpected in the light of conceptual studies on a patent's signaling value (compare e.g., Graham et al.

2009, Long 2002) and question received wisdom. On the other hand, by indicating the value of upstream alliances as technology signals, my results support the recent increasing attention toward the importance of open innovation as an effective approach to create technological innovations (e.g., Vanhaverbeke 2006).

This study makes three contributions. First, it adds to a recent stream of research on the role of patents and alliances in venture capital financing (Baum and Silverman 2004, Cao and Hsu 2011, Conti et al. 2011, Greenberg 2011, Hsu and Ziedonis 2011, Häussler et al. 2010, Mann and Sager 2007). To the best of my knowledge, this study is the first to isolate a resource's signaling effect from its productive asset function. Second, I contribute to the literature on venture capital selection criteria (e.g., Franke et al. 2008, Hall and Hofer 1993, MacMillan et al. 1985). Third, I extend the range of applications of conjoint analysis for managerial research (e.g., Fischer and Henkel 2012a, Shepherd and Zacharakis 1999) by combining it with a scenario approach.

5.2 Theoretical Background

5.2.1 VCs' decision making

Investing in young technology-based ventures is a high risk undertaking. On the one hand, new organizations are confronted with many challenges and therefore highly vulnerable, a phenomenon that Stinchcombe (1965) termed liability of newness. With their product offering still in the development phase, start-ups, especially high technology start-ups, face a high technical and commercial failure rate (Aldrich and Fiol 1994, Tushman and Rosenkopf 1992). On the other hand, start-ups are difficult for investors to evaluate, as their potential and quality cannot be assessed from outside. Reliable information, such as a performance track record or even existing revenue streams, is rarely available for young companies (Penrose 1959, Shane and Stuart 2002). Despite these risks, VCs provide start-ups with capital to finance further development, but are well aware of the high level of uncertainty that surrounds their investment decision. Hence, they very selectively choose their portfolio companies, making this type of funding very difficult for any start-up to obtain.

A considerable amount of research has been done to explain VCs' decision making and especially to identify the criteria VCs employ in their investment decisions. One of the basic requirements for any start-up is to fulfill investors' expectations about the financial potential, often determined by a large addressable market and high expected growth rates (e.g., Hall and Hofer 1993, Tyebjee and Bruno 1984). Furthermore, the start-up needs to be active in an industry in which the VC is actually interested, subject to its fund's investment strategy (e.g., Petty and Gruber 2011). When these basic requirements are fulfilled, VCs assess the potential of new ventures based on the existing resources they can observe.[45] The characteristics of the entrepreneurial team play a major role in this assessment and are commonly reported as the most important selection criterion for VCs (Zacharakis and Meyer 2000). A skilled and experienced team significantly increases a start-up's chances of receiving venture capital funding (e.g., Franke et al. 2008, Hsu 2007). Other resources, however, are also important. In particular, patents and alliances have recently been shown to be positively related to a start-up's ability to attract venture capital financing (e.g., Baum and Silverman 2004, Hsu and Ziedonis 2011). The latter two resources may even provide start-ups with two distinct benefits—a productive and a signaling value.

5.2.2 Signaling in entrepreneurial finance

New high technology ventures are often founded on the basis of a technical invention. When looking for external funding, the issue of information asymmetry arises, as the entrepreneurial team naturally possesses more information about the quality of the technology than any outside investor (Shane and Stuart 2002). This is especially true for the screening stage, when the VC looks at the start-up's business plan for the first time. Information asymmetry, in particular with regard to information about quality, can have strong effects on decision making (Stiglitz 2000). In the markets of entrepreneurial finance, information asymmetries often hinder the establishment of an investor/start-up relationship and thus need to be overcome (Leland and Pyle 1977).

[45] Especially in the screening stage, the available information about the applying start-up is scarce as it is limited to the resources stated in the business plan.

According to Spence’s (1973) signaling theory, the better informed party can send a signal of quality to the less informed party in order to reduce information asymmetries. Spence (1973) uses an example of the labor market, where job candidates obtain education to signal productive capabilities to potential employers. Signals provide a sorting mechanism in case of uncertainty or, in other words, help form opinions by serving as indicators for unobservable characteristics (Kirmani and Rao 2000). Connelly et al. (2011) explain that efficacious signals have two necessary characteristics, observability and cost. Signal observability describes the extent to which outsiders are able to notice the signal. Signal cost refers to the condition that the costs of signaling must be lower for parties of higher quality. For instance, it should be “cheaper” for a high quality manufacturing firm to obtain an ISO9000 certification than for a low quality manufacturer. Even though signals are often sent intentionally, parties may also send signals without being aware of it (Janney and Folta 2003, Spence 2002).

Signaling theory holds a prominent position in entrepreneurship literature and applies well to the context of venture capital financing (Connelly et al. 2011). Since the quality of a start-up often cannot be observed directly, VCs have to rely on other sources of information, in particular on observable characteristics of the new venture (Stuart et al. 1999). VCs spend a substantial amount of time and effort on seeking and assessing these signals of a start-up’s quality and potential (Amit et al. 1990, Hall and Hofer 1993). At the same time, entrepreneurs facing the challenge of securing resources for further development invest in observable characteristics to signal the quality of their venture (Zott and Huy 2007).

In this study, I investigate the function of observable start-up resources as signals of the unobservable quality of a start-up’s technology. In correspondence with Spence’s (1973) example of the labor market, my case start-ups build resources, such as patents and alliances, to signal the quality of their technologies to investors. In statistical terms, the quality of the technology represents the “hidden” or “latent variable,” while a start-up’s resource constitutes a “proxy” from which the value of the hidden variable can be inferred (e.g., Bartholomew and Knott 1999, Upton and Cook 2002).

5.2.3 The twofold role of patents

Up until the 2000s, intellectual property rights have been acknowledged as a relevant, but not very important, venture capital selection criterion (e.g., MacMillan et al. 1985). Only recently, the attention toward patents has increased with a number of studies, all based on transaction data, indicating a positive relationship between the existence of patents and venture capital financing of start-ups.[46] Baum and Silverman (2004) demonstrate that biotechnology start-ups in possession of patent applications or patent grants receive more venture capital financing than ventures without patent protection. A study by Hsu and Ziedonis (2007) in the semiconductor industry yields similar results in that the number of patent applications a start-up holds is shown to drive its financial evaluation by VCs, especially in early funding rounds. Examining a sample of mostly information technology start-ups from an incubator at Georgia Institute of Technology, Conti et al. (2011) find that patents filed have a positive impact on the likelihood of VC investment and the amount of funding received. For a U.S.-based sample of VC-backed firms from various industries, Cao and Hsu (2011) show that pre-VC patent filings are correlated with larger venture capital funding and lower likelihood of failure. Mann and Sager (2007) find positive correlations between patenting activity and several performance variables such as number of financing rounds or total investment for a sample of software start-ups. Analyzing a sample of German ventures, Engel and Keilbach (2007) notice that VC-funded firms hold a higher number of patent applications at pre-funding stage than non-VC-funded firms. Häussler et al. (2009) are able to prove that biotech start-ups are likely to receive venture capital earlier in cases of existing patent applications and particularly if these patents turn out to be of high quality. Finally, Greenberg (2011) finds a positive association of patent applications with firm valuation. This effect is more pronounced for granted than for pending patents, but only for the younger start-ups in her sample and during early financing rounds.

The above mentioned impact of patents on venture capital financing is explained with the two main functions of a patent for technology-based start-ups: property rights and quality signals. Regarding its productive function as a property right, a patent

[46] For an overview of relevant studies see also Table 1 in Chapter 2.3.1.

constitutes a legal right to exclude others from using an invention. As such, patents support the appropriation of returns from innovative activities and facilitate cooperation and bargaining with business partners (e.g., Cohen et al. 2000, Hall and Ziedonis 2001). Indeed, a positive correlation of patent ownership and stock market valuation can be observed (e.g., Hall et al. 2007). Furthermore, patent ownership correlates with the business performance of start-ups in terms of asset growth (Helmers and Rogers 2011), short time to initial public offering (IPO) (Stuart et al. 1999), and an increased likelihood of survival after IPO (Wagner and Cockburn 2010). Additional (trade) value to both entrepreneurs and VCs may result from the possibility of selling property rights to third parties.

As to its signal function, a patent can represent a valuable signal of the quality of a start-up’s technology. In line with the above presented notion of a signal, patents can be regarded as valid quality signals as they are differentially costly to obtain and directly observable by outsiders (Long 2002). I point out that, in contrast to some existing studies that use the term signaling more broadly in the sense of patents as indicators of future performance, I apply a narrower definition, in line with Spence (1973). I investigate the function of patents as a signal of the presently existing but unobservable quality of a start-up’s technology (as, e.g., Conti et al. 2011). Technology entrepreneurs are well aware of the signaling value a patent may have to VCs, and report to engage in patenting activities to increase their chances of securing investment (Graham and Sichelman 2008). The comprehensive examination by the patent office works as a certification mechanism and lends credibility to the granted patent as a signal (Häussler et al. 2010). But even before the patent office makes a decision, a patent application can work as a proxy for technological quality (Baum and Silverman 2004; Hsu and Ziedonis 2011). While most patent scholars ascribe a positive signaling value to patents, differing opinions exist. In analyzing the effect of patent filings on IPO underpricing in the United States, Heeley et al. (2007) conclude that patents in complex product industries fail to provide a signaling function to equity investors.

As there is little quantitative evidence yet on the twofold role of patents in venture capital financing, this research aims to determine the importance of the patent’s signaling effect compared to that of its property right function. Based on my literature review, I predict that patents constitute valuable signals of the quality of a start-up’s technology.

Hypothesis 1: *Patents, both filed and granted, serve as signals of the quality of a start-up's technology.*

5.2.4 The twofold role of alliances

Alliance agreements entered into by a start-up constitute another important investment criterion for VCs. Not only linkages with banks or investors, but also strategic alliances, i.e. affiliations with other industrial organizations, can have a substantial impact on the opportunities and constraints a new venture faces (Gulati and Higgins 2003). Studies based on venture capital transaction data show that the number of alliances a start-up possesses is positively related to the amount of venture capital it receives (e.g., Baum and Silverman 2004, Greenberg 2011). I distinguish between upstream alliances, to pursue R&D, and downstream alliances, agreements with organizations down the value chain such as sales partners (e.g., Baum et al. 2000). Just like patents, both types of alliances incorporate a productive as well as a signaling component.

Regarding the productive value, prior research shows that organizations with reputable networks of alliances benefit from collaboration and are therefore likely to outperform others. Alliances improve access to complementary resources (Chung et al. 2000). For example, a downstream agreement with a sales partner can help a start-up bring its innovative product to market. Similarly, Liebeskind et al. (1996) show that upstream alliances, e.g., with universities or other research institutes, secure valuable access to knowledge and other assets. Such assets can enable a new venture to develop technological knowledge that it could not have generated by itself (Santoro and Gopalakrishnan 2000). Furthermore, alliances provide access to information and can thus help firms discover and exploit business opportunities (Cohen and Levinthal 1990). Investigating the benefits of alliances for new ventures, Baum et al. (2000) find evidence that biotechnology start-ups that are able to quickly establish both upstream and downstream alliances achieve significant performance improvements during their early years of business.

With respect to the signaling function, alliances may also serve as legitimation for the new venture (Baum and Oliver 1991, Miner et al. 1990) and consequently facilitate the acquisition of other resources such as VC. In this context, downstream relationships with sales partners or pilot customers serve as external endorsements for a company's product or technology offering (Stuart 2000). Correspondingly, upstream alliances with reputable research institutions may constitute a reference for high quality technology development (Pisano 1991). In line with signaling theory, alliances involve costs as a differentiator in the sense that it is easier for a high quality start-up to gather alliance partners than it is for a low quality venture. Furthermore, alliances are observable for external parties as long as they are recorded in a written agreement. It can thus be argued that alliances are valid signals, and so third parties should refer to the affiliates of new ventures to make judgments about their quality whenever they cannot observe it directly (Stuart et al. 1999). In particular, if the quality of a start-up's technology is unknown, I propose that both upstream and downstream alliances come into consideration as quality signals.

Hypothesis 2: *Alliance agreements, both upstream and downstream, serve as signals of the quality of a start-up's technology.*

5.3 Data and Methods

5.3.1 Sample

For the purpose of this study, I analyze the same sample of venture capital investors as described in Chapter 3.4.2. It consists of 102 individual VCs from 80 different venture capital firms, all of which invest in German high technology start-ups. Table 15 provides an overview of the sample and shows that it contains VCs with a large variety in expertise, background, and funding history. An analysis of the U.S. sample will be provided as robustness check.

Table 15: Demographic sample information

VC individuals (n=102)	
VC experience (# of start-ups funded)	Range: 1- >20; Median: 8
Position	Partner: 36; Principal: 22; Associate: 19; Senior advisor: 8; Other: 15; No answer: 2
Education* (Type of degree)	Business: 72; Engineering: 30; Science: 24; Law: 3; Other: 6
Industry expertise**	Biotech: 29; Cleantech: 34; ICT: 39
Type of VC firm	Private: 70; Corporate: 12; Public: 14; Business angel: 0; Other: 6
VC fund size (in €)	<25 M: 16; 26-50 M: 13; 51-100 M: 18; 101-250 M: 25; 251-500 M: 14; 501-1 B: 7; >1B: 1; no answer: 8
Office location	Germany: 82; Switzerland: 9; Other Europe: 9, No answer: 2

* Multiple answers possible
** As selected for experiment

5.3.2 Scenario-based conjoint analysis

In order to shed more light on the role of signals in venture capital financing, I conducted choice-based conjoint experiments with VCs. As outlined in Chapter 3.4 a conjoint analysis is generally regarded as a very appropriate method for investigating VCs' decision making. However, there is one additional reason why I chose an experimental approach for this specific study. Conducting choice experiments I benefit from two advantages over the analysis of real transaction data. First, an omitted variable bias is excluded by construction[47], and second, the desired signaling effect can be isolated experimentally (e.g., Sprinkle 2003).

In conducting the survey I relied on the previously explained design of the conjoint experiments (see Chapter 3.4.1). Participating VCs were presented with the task of screening business plans of technology-based start-ups. I repeatedly offered them choice sets of three hypothetical start-ups which were described by different levels of start-up attributes. For each choice set, VCs were asked to select the most promising and least promising start-up. Analyzing the revealed preferences allows me to draw

[47] See Footnote 29 for details.

conclusions about the importance that participants attach to the different attributes when screening investment proposals. As attributes—and thus research variables—I used three observable start-up resources that VCs commonly employ as selection criteria: team's experience, patent protection, and alliance agreements. Please refer to Chapter 3.4.1 for a detailed description of the variables used (Table 6) and an example of a choice set (Figure 4).

To isolate the signaling effect of patents and alliances, I conducted the experiment under two different scenarios, each containing the same six choice sets in random order. This led to a total of twelve choice sets to be addressed by each respondent. The two scenarios differed only in one underlying assumption. In the scenario "technologies unknown" VCs were briefed that they were not familiar with the quality and uniqueness of the presented start-ups' technologies, whereas in the scenario "equally good technologies" the technologies of the presented start-ups were described as equally good and known to the investor.[48] Differences in attribute importance between the two scenarios can be interpreted as signaling effects of the firms' observable characteristics. For illustration, consider the variable "patent granted": When uncertain about the start-ups' technologies, respondents are assumed to value a start-up's patent both as a property right and as a signal of the unobservable technological quality. In contrast, in the case of "equally good technologies" VCs should value patents only for their productive function as property rights, since the technological quality of all alternatives is equal by assumption. The same reasoning applies to alliances and team experience. Thus, differences in value contribution of the focus variables can be interpreted as signaling effects with respect to the quality of a start-up's technology.

The use of controlled experiments involving the manipulation of available information is a well-established approach used across all kinds of scientific research fields to answer questions that otherwise might go unanswered (e.g., Sprinkle 2003). Scenario-based studies are one subgroup of experiments that are frequently employed to study managerial issues in, for instance, the areas of marketing and operations management (see Rungtusanatham et al. 2011 and Wason et al. 2002 for overviews). To introduce respondents to the hypothetical situation in which they are supposed to act,

[48] Please note that Chapters 3 and 4 of this dissertation are exclusively based on an analysis of the scenario "technologies unknown".

they are typically presented with a "scenario" (Wason et al. 2002).[49] By reproducing a real-life decision making situation, a well-constructed scenario enhances respondent involvement and increases the experiment's internal validity by bringing all participants onto the same page and focusing their attention on the main features of the research (Cavanagh and Fritzsche 1985, Fredrickson 1986). In most applications, different versions of the same basic scenario are designed by altering only one piece of information and then randomly allocating them to different respondents, thus allowing for investigating intergroup differences (Alexander and Becker 1978). Novel results from numerous studies in different managerial research fields show that when the scenarios are appropriately designed and validated, scenario-based experiments are an effective method for studying managerial decision making (Wason et al. 2002, Rungtusanatham et al. 2011).

For the purpose of this survey, an extensive pretest confirmed that the experimental setting including its variables and scenarios was understandable, realistic, and manageable within the suggested time frame. To ensure internal validity and increase respondents' attention, the two differing scenarios were each illustrated with a brief example and marked with a different color. To avoid biases, I created six different versions of the survey (see Table 16) that differed by the order of scenarios and start-up attributes, and randomly assigned one version to each participant.

For the analysis of the collected choice data I used the same methods as explained in Chapter 3.4.3 and 3.4.4. I rely on rank-ordered mixed-logit regressions to determine the value contribution of each dummy variable. In order to investigate differences between the two scenarios, I estimate separate models, one for each scenario. Scenario differences are analyzed by comparing average marginal effects of each dummy variable. To test these differences for significance, I employ a simulation approach and determine significance levels based on the corresponding graphs (see Figure 5 as an example).

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49 Some scholars refer to this short description of a person or social situation as a "vignette" (e.g., Alexander and Becker, 1978).

Table 16: Choice sets of different survey versions

	Type 1	Type 2	Type 3		Type 4	Type 5	Type 6
	A B C	A B C	A B C		A B C	A B C	A B C
Scenario TU:	1 Pat 0 2 1	Exp 0 1 2	All 0 1 2	Scenario ET:	7 Pat 2 1 0	Exp 1 2 0	All 1 2 0
technologies	Exp 0 0 1	All 1 0 2	5 Pat 0 2 0	equally good	Exp 0 1 0	All 0 2 1	11 Pat 2 0 0
unknown	All 2 1 0	4 Pat 1 1 1	Exp 2 0 0	technologies	All 1 0 2	10 Pat 1 1 1	Exp 0 0 2
	2 Pat 2 0 0	Exp 1 2 2	All 1 0 2		8 Pat 0 0 2	Exp 2 2 1	All 0 2 1
	Exp 1 2 1	All 1 2 0	4 Pat 1 1 1		Exp 2 1 1	All 2 0 1	10 Pat 1 1 1
	All 2 0 1	6 Pat 1 0 2	Exp 0 1 2		All 0 1 2	12 Pat 0 2 1	Exp 1 2 0
	3 Pat 2 1 2	Exp 0 0 1	All 2 0 1		9 Pat 1 2 2	Exp 0 1 0	All 0 1 2
	Exp 2 1 0	All 2 1 0	2 Pat 2 0 0		Exp 1 0 2	All 1 0 2	8 Pat 0 0 2
	All 0 2 1	1 Pat 0 2 1	Exp 1 2 1		All 2 1 0	7 Pat 2 1 0	Exp 2 1 1
	4 Pat 1 1 1	Exp 2 0 0	All 1 2 0		10 Pat 1 1 1	Exp 0 0 2	All 2 0 1
	Exp 0 1 2	All 0 1 2	6 Pat 1 0 2		Exp 1 2 0	All 1 2 0	12 Pat 0 2 1
	All 1 0 2	5 Pat 0 2 0	Exp 1 2 2		All 0 2 1	11 Pat 2 0 0	Exp 2 2 1
	5 Pat 0 2 0	Exp 2 1 0	All 2 1 0		11 Pat 2 0 0	Exp 1 0 2	All 1 0 2
	Exp 2 0 0	All 0 2 1	1 Pat 0 2 1		Exp 0 0 2	All 2 1 0	7 Pat 2 1 0
	All 0 1 2	3 Pat 2 1 2	Exp 0 0 1		All 1 2 0	9 Pat 1 2 2	Exp 0 1 0
	6 Pat 1 0 2	Exp 1 2 1	All 0 2 1		12 Pat 0 2 1	Exp 2 1 1	All 2 1 0
	Exp 1 2 2	All 2 0 1	3 Pat 2 1 2		Exp 2 2 1	All 0 1 2	9 Pat 1 2 2
	All 1 2 0	2 Pat 2 0 0	Exp 2 1 0		All 2 0 1	8 Pat 0 0 2	Exp 1 0 2
Scenario ET:	7 Pat 2 1 0	Exp 1 2 0	All 1 2 0	Scenario TU:	1 Pat 0 2 1	Exp 0 1 2	All 0 1 2
equally good	Exp 0 1 0	All 0 2 1	11 Pat 2 0 0	technologies	Exp 0 0 1	All 1 0 2	5 Pat 0 2 0
technologies	All 1 0 2	10 Pat 1 1 1	Exp 0 0 2	unknown	All 2 1 0	4 Pat 1 1 1	Exp 2 0 0
	8 Pat 0 0 2	Exp 2 2 1	All 0 2 1		2 Pat 2 0 0	Exp 1 2 2	All 1 0 2
	Exp 2 1 1	All 2 0 1	10 Pat 1 1 1		Exp 1 2 1	All 1 2 0	4 Pat 1 1 1
	All 0 1 2	12 Pat 0 2 1	Exp 1 2 0		All 2 0 1	6 Pat 1 0 2	Exp 0 1 2
	9 Pat 1 2 2	Exp 0 1 0	All 0 1 2		3 Pat 2 1 2	Exp 0 0 1	All 2 0 1
	Exp 1 0 2	All 1 0 2	8 Pat 0 0 2		Exp 2 1 0	All 2 1 0	2 Pat 2 0 0
	All 2 1 0	7 Pat 2 1 0	Exp 2 1 1		All 0 2 1	1 Pat 0 2 1	Exp 1 2 1
	10 Pat 1 1 1	Exp 0 0 2	All 2 0 1		4 Pat 1 1 1	Exp 2 0 0	All 1 2 0
	Exp 1 2 0	All 1 2 0	12 Pat 0 2 1		Exp 0 1 2	All 0 1 2	6 Pat 1 0 2
	All 0 2 1	11 Pat 2 0 0	Exp 2 2 1		All 1 0 2	5 Pat 0 2 0	Exp 1 2 2
	11 Pat 2 0 0	Exp 1 0 2	All 1 0 2		5 Pat 0 2 0	Exp 2 1 0	All 2 1 0
	Exp 0 0 2	All 2 1 0	7 Pat 2 1 0		Exp 2 0 0	All 0 2 1	1 Pat 0 2 1
	All 1 2 0	9 Pat 1 2 2	Exp 0 1 0		All 0 1 2	3 Pat 2 1 2	Exp 0 0 1
	12 Pat 0 2 1	Exp 2 1 1	All 2 1 0		6 Pat 1 0 2	Exp 1 2 1	All 0 2 1
	Exp 2 2 1	All 0 1 2	9 Pat 1 2 2		Exp 1 2 2	All 2 0 1	3 Pat 2 1 2
	All 2 0 1	8 Pat 0 0 2	Exp 1 0 2		All 1 2 0	2 Pat 2 0 0	Exp 2 1 0

5.4 Results

The results of my estimations are summarized in Table 17, displaying estimated coefficients, robust standard errors, and average marginal effects. Model 1 is based on the choices made under the scenario “technologies unknown” (TU), whereas Model 2 was fitted with choice data from the scenario “equally good technologies” (ET).

I first focus on the individual start-up characteristics and their relative importance in VCs’ screening decisions under both scenarios. The strength of the variables’ influence can be assessed by comparing their average marginal effects. I define the importance of a start-up attribute as the difference between the highest and the lowest AME across this attribute’s levels as commonly done in conjoint analyses (e.g., Franke et al. 2008). As the marginal effect of the least preferred attribute level is zero by construction, the highest AME of the two remaining attribute levels measures the attribute’s importance. These respective importance values are then normalized by dividing each by the sum of all three values.

As an example, consider Model 1 and the attribute “alliances.” A research alliance shows an average marginal effect of 0.167, while the average marginal effect of a sales alliance equals 0.350 and is thus higher. Dividing 0.350 by the sum of all attributes’ importance values (0.348 + 0.233 + 0.350 = 0.931) results in a relative importance of 38% for alliances. Patent protection comes out roughly equally important with a value of 37%, whereas the start-up team’s experience contributes only 25%. In the scenario of equally good technologies, I find a slightly higher importance value of alliances (40% vs. 38%) and of patent protection (41% vs. 37%), while team experience is less important (19% vs. 25%). In summary, my results indicate a comparatively high importance of patent protection in both scenarios, ranking at similar levels as the existence of written alliance agreements. Team experience, measured in average number of years in a management position in the respective industry, shows the lowest importance values in both settings.

Table 17: Estimation results

	Model 1: Technologies unknown			Model 2: Equally good technologies		
Model specification	Rank-ordered mixed logit			Rank-ordered mixed logit		
Dependent variable: firm ranking	**Coeff.**	**SE**	**AME**	**Coeff.**	**SE**	**AME**
Patent applied for	2.618***	0.327	0.198	3.184***	0.363	0.222
Patent granted	4.304***	0.393	0.348	4.901***	0.433	0.372
Experience 5 years	1.963***	0.273	0.153	1.462***	0.269	0.111
Experience 10 years	2.878***	0.349	0.233	2.259***	0.362	0.174
Research alliance	2.175***	0.312	0.167	1.474***	0.305	0.110
Sales alliance	4.370***	0.422	0.350	4.617***	0.432	0.359
Obs/Persons	1224	102		1224	102	
LR chi2(6)	250.37			276.97		
Prob > chi2	0.000			0.000		
Log likelihood	-731.170			-714.243		

* p < 0.1; ** p < 0.01; *** p < 0.001

Simulations for estimating coefficients and calculating predicted probabilities were done using 1,000 Halton draws. Simulations for calculating confidence intervals of average marginal effects were done using 100 random draws of coefficients. Robust standard errors reported.

Coming to the core of this study, I now concentrate on the differences in AMEs between the two scenarios. Figures 9, 10, and 11 allow me to investigate the differences in detail by 10% probability ranges for each dummy variable separately.[50] It can be clearly seen in Figure 9 on the right-hand side that the difference between the two scenarios in the contribution of “patent granted” to the probability of winning is minimal and not significantly different from zero for any probability range. The same is true for a “patent applied for,” as depicted in the graph on the left-hand side. This means that—surprisingly—VCs do not put a higher emphasis on patent protection in the case of unknown technological qualities compared with a situation in which they face start-ups with known and equally good technologies. In other words, I cannot identify a signaling effect of patents when comparing the two scenarios.

[50] See Chapter 3.4.4 for a detailed explanation of the AME graphs.

Figure 9: Patent protection – scenario differences in average marginal effects

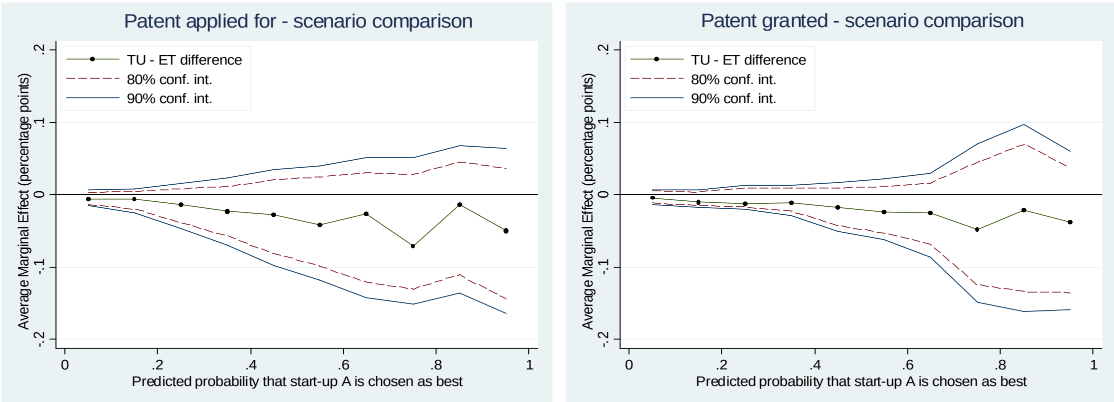


Figure 10: Team experience – scenario differences in average marginal effects

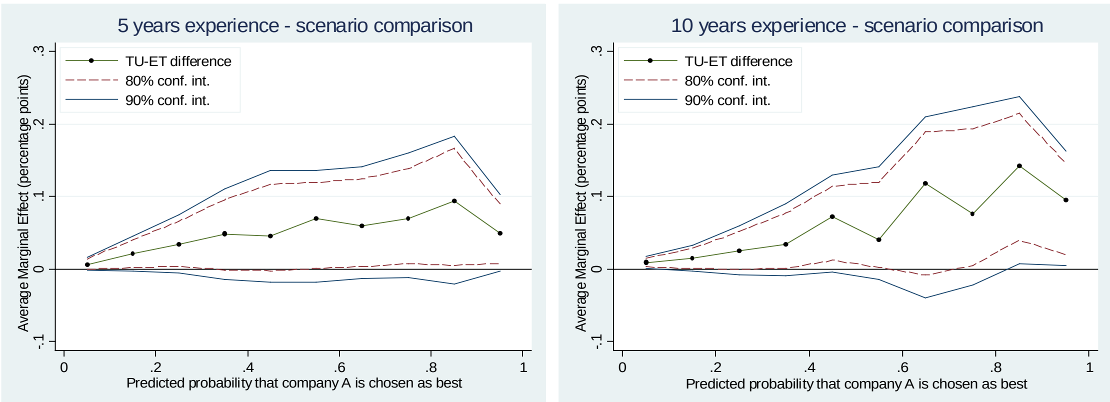
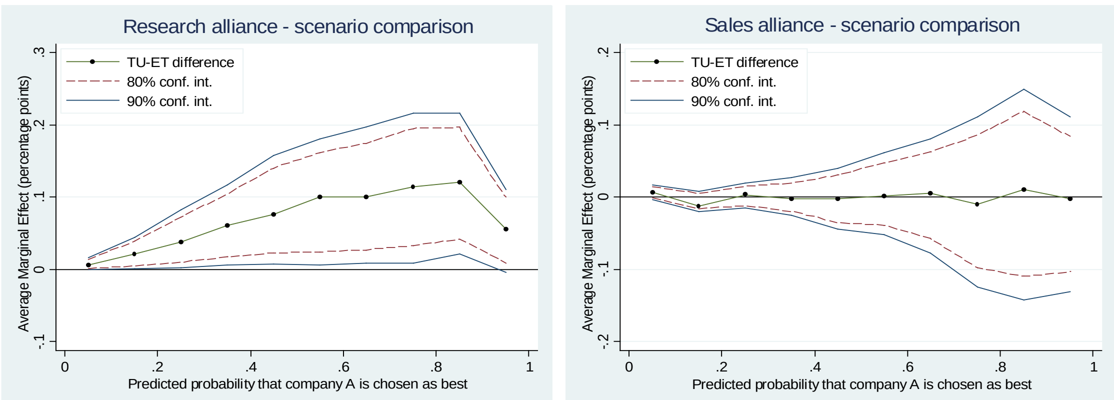


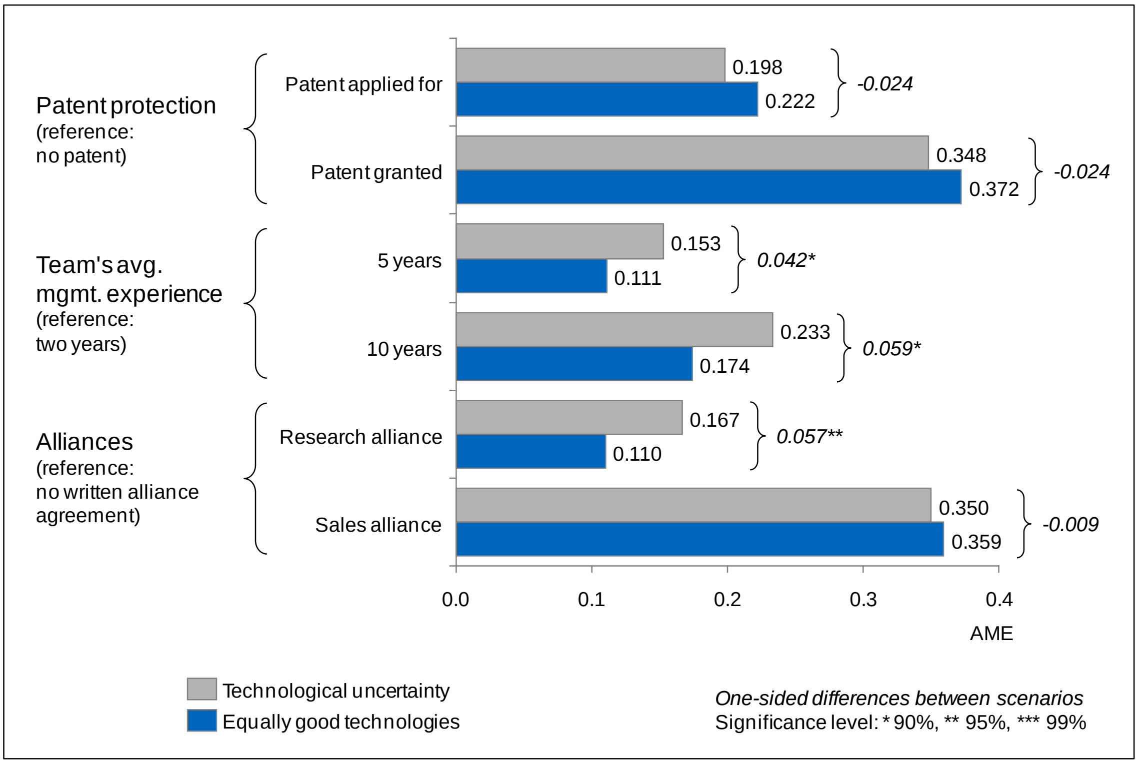
Figure 11: Alliances - scenario differences in average marginal effects



Interestingly, I do find differences between the two scenarios for the other variables. Figure 10 on the left shows that the contribution to the probability of winning of having a team with five rather than with two years of experience is slightly higher in the “technologies unknown” scenario. The difference is weakly significant (10%, one-sided test) for small and high probability ranges. Similarly, for the dummy variable “10 years experience” on the right of Figure 10 I see weakly significant (10%, one-sided) differences in AMEs between TU and ET for medium and high probability ranges. The largest differences, however, occur for the attribute “research alliance” (Figure 11, left). Its average marginal effect is significantly (5%, one-sided) higher under “technologies unknown” than in the scenario of equally good technologies across all probability ranges. When technologies are unknown, VCs appreciate existing research alliances much more; indeed, they seem to use them as signals of the unobservable quality of a start-up’s technology. On the other hand, the contribution of sales alliances to the probability of winning is identical in both scenarios. Figure 12 summarizes the average marginal effects of all variables for both models.[51]

[51] Note that the sum of the average marginal effects of the respective most preferred level of each characteristic is bounded (though in general smaller than 100%). Thus, what I measure is the signaling effect of a variable *relative* to that of other variables, and my analysis shows that the signaling effect of both “patent granted” and “patent applied for” is smaller than that of any other dummy variable. Thus, even though an absolute signaling effect of patents cannot be entirely ruled out, as long as other start-up resources are present the patent variables have, according to my findings, no signaling effect.

Figure 12: Comparison of average marginal effects between scenarios



I performed several robustness checks to substantiate my results. One point of criticism could be that respondents might have had difficulties internalizing the change from one scenario to the other. As a result, choices made in the second half of the survey might have been biased in such a way that they differ less from those in the first half than they would have if the respondent had only done the second half of the survey. To address this potential issue, I calculated two additional estimation models, taking into account only the choices made during the first scenario for each participant. I thus implicitly divide the sample into two groups, one that only saw the scenario "equally good technologies" (ET_1, n=53) and one that was only briefed to make decisions under "technologies unknown" (TU_1, n=49). The results of the two additional models in comparison to each other are shown in Figure 13 and confirm the previously reported findings. For the dummy variable "research alliance," I again see a significant difference (5% one-sided) between the two scenarios, which can be interpreted as its signaling effect (see Figure 14 for the respective significance tests for all variables with a positive signaling value). The scenario differences with regard to both team experience variables point in the same direction as in the main models, but are not statistically significant from zero due to the smaller number of observations. More importantly, I do not observe a signaling effect of neither patent applications nor granted patents, which is consistent with my earlier results. The value contribution attached to a granted patent hardly differs between the two scenarios, whereas patent applications even seem to have a negative signaling value. Thus overall, I indeed find indications of a bias of each respondent's choices in Scenario 2 toward his/her choices made in Scenario 1, since the differences between the two scenarios tend to be more pronounced in Figure 13 than in Figure 12. Thus, the findings of the main model are conservative estimates of the absolute size of the signaling effects.

Figure 13: Scenario comparison – only first scenario choices

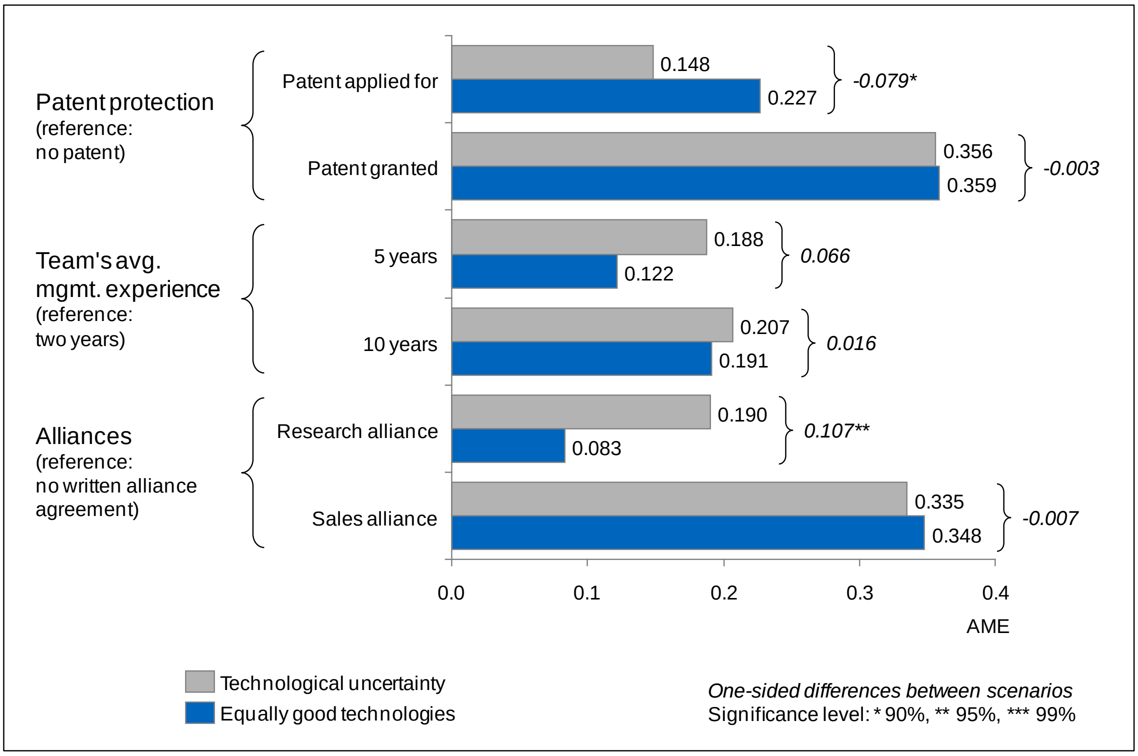
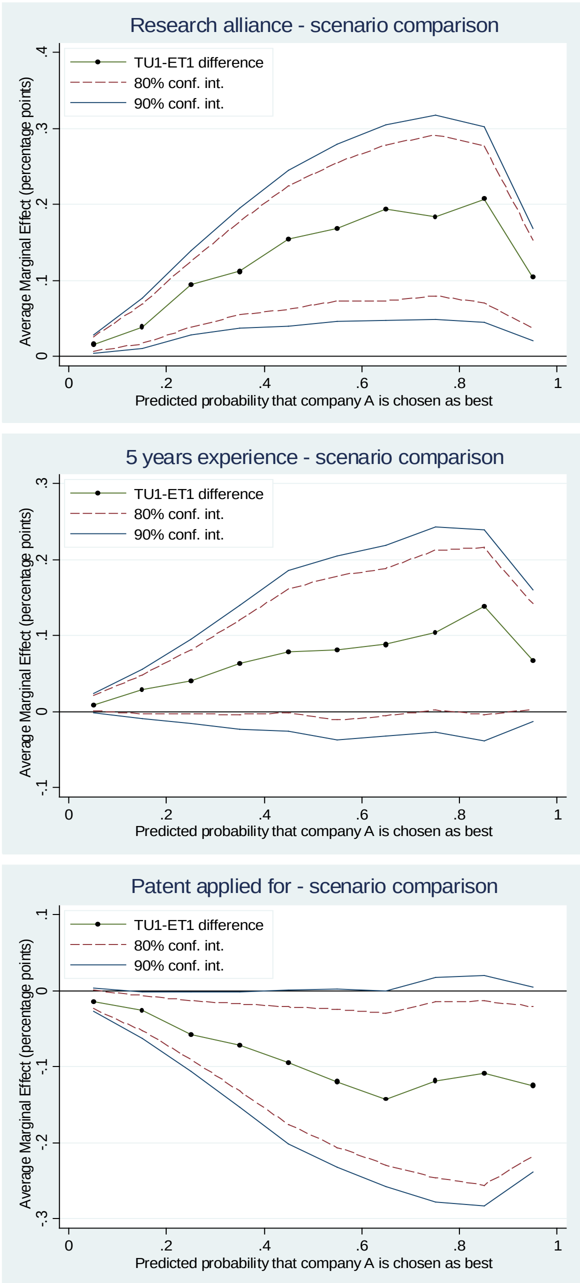


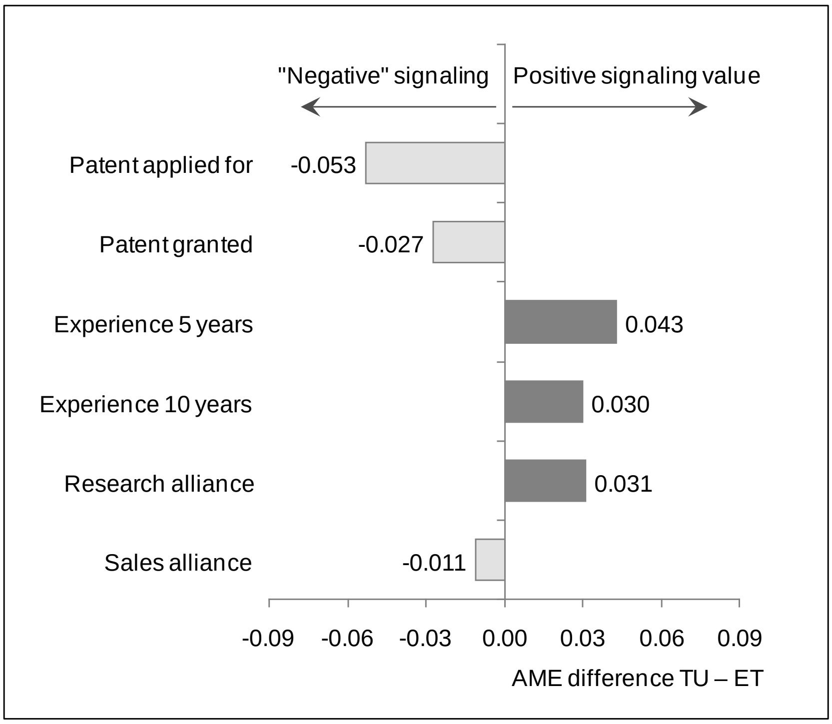
Figure 14: Scenario differences in average marginal effects – only first scenario choices



To further increase the validity of my results, I analyzed additional data from U.S.-based VCs. The same conjoint analysis as described above was sent to 285 high technology VCs in the United States during the third quarter of 2011. I received 85 complete answers in total and analyzed the data analogously to the German sample. For a detailed description of the U.S. VC sample please refer to Chapter 3.4.2. Focusing directly on the signaling effect of the research variables, Figure 15 illustrates the difference in AMEs between the two scenarios “technologies unknown” and “equally good technologies.” I again find a signaling effect for the dummy variable “research alliance,” showing a positive difference between the scenarios that, however, just fails to be significant. Similar signaling effects can be observed for both team experience variables. In contrast, and consistent with the previously reported results, patent applications and grants appear not to have any signaling value regarding the quality of a start-up’s technology. All in all, the analysis of U.S. VCs’ choice decisions further confirms my findings that VCs rely on R&D alliance agreements rather than on patent protection as signals of technological quality.

As an additional robustness check, I investigated the potential signaling value of patents restricted to each industry in both of the samples. While there are differences in the importance VCs attach to the key start-up characteristics depending on the venture’s industry (compare Chapter 4.4), these differences exist for both scenarios. For patents, both filed and granted, this means that while the intrinsic property rights value is higher in biotech than in the cleantech or the ICT sector, I do not observe a signaling effect of the patent variables in any industry.

Figure 15: Scenario differences in average marginal effects – U.S. VCs



5.5 Discussion and Conclusion

By analyzing choice decisions of VCs, I investigate the importance of observable start-up resources for acquiring venture capital. Focusing on the initial screening of written business proposals, I find remarkable results concerning patents and alliances.

Looking at the model for each scenario individually, I observe that existing patents under all conditions are an important selection criterion for VCs. This result supports and extends previous research in which the relevance of patent protection as a VC investment criterion has been mentioned (e.g., Riquelme and Rickards 1992) and patents have been shown to drive the VCs' evaluation of start-ups (e.g., Baum and Silverman 2004, Mann and Sager 2007). The high relative importance of patent protection compared to other start-up attributes seems somewhat surprising at first but might be explained by two reasons. First, this study is targeted at high tech VCs featuring an experimental setting of start-ups based on technical inventions in technology-driven industries. This is where patent protection is known to be most effective. Second, it can be argued that the screening stage favors the importance of patents, being tangible and reliable characteristics, compared to later stages of the investment process where VCs have gained better insight into the start-ups and other investment criteria come into play. This reasoning may also explain the comparatively low importance of team experience in this study.[52]

By comparing the two scenario models, I am able to disentangle a resource's signaling from its productive function. Surprisingly, no signaling effect of patents regarding the start-ups technology quality can be identified, neither of patent applications nor of granted patents. Instead, the presence of an R&D alliance does seem to work as a quality signal. To quantify this effect, I subtract the AME in the scenario ET (0.110) from its AME in the scenario TU (0.167) yielding a value of 0.057. Thus, about 33% of a research agreement's value contribution can be attributed to its signaling function, the remaining 67% to its productive function. I observe similar but smaller

[52] For a more detailed discussion on the rather low importance of the entrepreneurial team in this study refer to Chapter 3.6**Error! Reference source not found.**.

(and marginally significant) signaling effects for the entrepreneurial team's management experience (at medium and high levels).

The nonexistence of patent signaling in the venture capital financing context constitutes a new insight, challenging most extant theoretical and qualitative evidence regarding the twofold role of patents. One interpretation of my results could be that patent rights are relatively easy to obtain and therefore hardly proof of technological quality. A research alliance is likely more difficult to build and should therefore constitute a more reliable signal of the quality of a start-up's technology. The strong signaling effect of R&D alliances I observe fits nicely into a recent stream of literature on the importance of open innovation for developing and commercializing innovative technologies (e.g., Chesbrough 2003, Faems et al. 2010, Lichtenthaler 2011). An open approach to innovation, for instance in the form of research collaboration with alliance partners, provides benefits in technology development, especially for young firms (Stuart 2000, Vanhaverbeke 2006).

While my results reveal that patents do not act as signals of unobservable technological quality, I cannot control for other signaling functions. This means VCs might still draw implications from existing patents on other unobservable start-up characteristics, such as the professionalism or technical know-how of the entrepreneurial team. These other signaling effects, however, seem to be of minor importance as my interviews with VCs reveal that patents held by young ventures are first and foremost associated with technology development (see Chapter 2.4.2.2) and other scholars share this view (e.g., Conti et al. 2011).

From a theoretical perspective, this study makes several contributions. First, and most importantly, I add new insights to a recent stream of research on the role of patents in venture capital financing (Baum and Silverman 2004, Cao and Hsu 2011, Conti et al. 2011, Häussler et al. 2010, Hsu and Ziedonis 2011, Mann and Sager 2007). I present and implement—to the best of my knowledge for the first time—a method to isolate the signaling effect of patents in venture capital financing. By employing a scenario-based conjoint approach, I am able to disentangle a patent's property right from its signaling function and thereby address a limitation of transaction data based studies. My finding that patents fail to serve as quality signals is highly interesting in the light of existing studies on patents' signaling value and calls for further analysis.

Second, I add to the existing literature on VCs' decision making (e.g., Franke et al. 2008, Hall and Hofer 1993, MacMillan et al. 1985). More precisely, my results provide insights on the importance of the investigated start-up characteristics as venture capital selection criteria in the screening phase. The high value contribution of both research and sales alliances and patent protection in comparison to management experience is notable.

Third, I provide an example of how to extend the usage of choice experiments for managerial research (e.g., Fischer and Henkel 2012a, Shepherd and Zacharakis 1999). By changing scenarios between groups of choice sets, individual effects regarding the respective independent variables can be investigated. The size of these separated effects can be tested for significance by calculating group differences in marginal effects (Fischer and Henkel 2012a, King et al. 2000, Long 2009).

When interpreting the results of this study, certain limitations need to be kept in mind. First of all, conjoint experiments are always simplified models of real-world decision making. For instance, I had to select a limited number of venture capital selection criteria to be included in the choice sets and decided to focus on start-up resources. In the actual decision process, financial criteria such as expected growth rates or estimated market size will play a role. However, even though I focus on only three (objectively observable) start-up attributes, my analysis does not suffer from omitted variable bias as all excluded variables are set equal by construction. Another potential issue is that introducing a change in scenarios after half of the choice sets poses a challenge to participants. But since I do find sensible and significant differences between the two scenarios, the change from "technologies unknown" to "equally good technology" or vice versa seems to have been understood. If anything, I seem to underestimate the signaling effects: taking only the first scenario decisions of each participant into account confirms my findings, with an even larger signaling effect of "research alliances."

Moreover, the scenario setup of this study allows for the separation of only one effect, i.e. the strength to which patents (and alliances) signal technological quality. Serving as a proxy for technological quality is commonly considered to be the most important signaling function a patent can possess (e.g., Long 2002). To what extent patent applications and/or grants are taken and valued as signals of other unobservable start-up characteristics, such as team professionalism, is left to future research.

Correspondingly, besides acting as proxy for technological quality, research alliances could also have additional signaling functions. Thus, it could be an interesting avenue of research to investigate the signaling value of alliances for other unobservable qualities.

This study provides interesting insights for entrepreneurs and VCs alike. Patents constitute a very important advertising mechanism for high tech start-ups when applying for venture capital. Hence, it is advisable for founders to invest time and money into patenting activities before approaching potential investors. However, VCs seem to appreciate patents only in their productive functions as property rights, not as quality signals. Instead, they appear to rely on the existence of R&D alliances and management experience as signals of technological quality. Entrepreneurs in technology-driven industries need to be aware of that and should focus on building up their research network early. They can emphasize established research agreements in their business proposals to signal the technological quality of their firm to VCs, especially if the potential investor has never heard of the start-up before. VCs, on the other hand, may take my results as a benchmark and interpret them in comparison to their own decision making.

6 Human Capital Perspective: Determinants of VCs' Attitude towards Patents

6.1 Introduction

Venture capital constitutes an important source of financing for young companies. Especially new technology-based firms often have to rely on external funding at early stages and can benefit greatly in their development from an infusion of venture capital (e.g. Gompers and Lerner 2001, Colombo and Grilli 2010). With risks for investors being very high and many ventures applying for funding, venture capital is typically very difficult to obtain for any given start-up. Subsequently, in order to help start-up entrepreneurs and policy makers address this challenge, a substantial amount of research has been done on the dynamics of the venture capital industry. One stream of literature aims to explain the investment process of venture capital firms, in particular by investigating the criteria VCs employ in selecting their portfolio start-ups (e.g., Muzyka et al. 1996, Petty and Gruber 2011, Tyebjee and Bruno 1984). Criteria related to the quality of the management team, the market potential, the quality of the technology/product offering, and VC's expected financial return are commonly accepted as the most important decision drivers (e.g. Riquelme and Rickards 1992, Zacharakis and Meyer 2000).

One technology-related criterion that already plays an important role in the initial screening of business plans is the start-up's stock of patents (see Chapter 3). Attention towards patents as a valuable start-up resource has recently increased with a number of studies finding a positive relationship between a start-up's patents and its likelihood and/or amount of venture capital financing (e.g., Baum and Silverman 2004, Häussler et al. 2010). Due to their twofold function as productive assets and potential quality signals (Long 2002), patents appear to be highly appreciated by the high-tech VC community. However, patents may also incorporate some downsides from a VC's perspective, as they are usually difficult to interpret by non-experts, often not very effective as appropriability mechanisms, and difficult to enforce especially for small companies (e.g., Cohen et al. 2000, Gompers and Lerner 2001, Svensson 2007). Hence, the question arises whether the high value associated with patents in general conforms with the opinion of all VCs.

Even though the VC community has traditionally been considered as a fairly homogenous group with regard to their selection criteria, differences between individual investors do exist and can contribute to explaining their behavior. Recent studies found, for instance, that heterogeneity among VCs may not only affect fund performance (Dimov and Shepherd 2005, Zarutskie 2010), but also decision making (e.g., Elango et al. 1995, Knockaert et al. 2010). It is often the human capital of VCs, i.e their education and experience, that serves as a differentiator in this context (e.g., Dimov et al. 2007, Patzelt et al. 2009). For the purpose of my study, I apply this contingency perspective to one specific selection criterion, namely patents. In particular, I examine to what extent different types of human capital determine VCs' attitude towards patents in start-up business plans[53]. Besides investigating the influence of task-specific and industry-specific human capital I add a new dimension called intellectual property-specific human capital to my analysis. I use a unique dataset stemming from my own survey with 102 European VCs. By collecting information by means of a conjoint experiment as well as through a traditional questionnaire, I am able to measure and investigate VCs' appreciation of patents in two different ways.

My results show that human capital does have a significant influence on VCs' attitude towards patents. Examining various types of education and experience I find several significant effects going in both directions. These new insights contribute to the literature on how VCs' human capital characteristics affect their decision making and performance (e.g., Dimov and Shepherd 2005, Patzelt et al. 2009, Zarutski 2010) and as such provide further evidence that the VC community in itself is quite heterogeneous. Moreover, this article contributes to the literature on the role of patents in venture capital financing by illustrating that not only benefits but also drawbacks related to patents need to be considered. This chapter is structured as follows. I first discuss the relevant literature and develop my research hypotheses before describing the sample and methodology used. I then present the results, followed by a discussion of conclusions and implications.

[53] Note that a working paper by Knockeaert et al. (2011) addresses a similar research question by investigating the influence of general and specific human capital on VCs' attitude towards the variable "technology can be protected or not". I rely on the actual existence of patents as dependent variable.

6.2 Theoretical Background

6.2.1 Patent protection as venture capital selection criterion

Entrepreneurship scholars started to recognize the value of patent protection as venture capital selection criterion several decades ago (MacMillan et al. 1987, Riquelme and Rickards 1992), but only recently has the discussion around the role of patents in venture capital financing picked up considerably, based on evidence from large scale transaction-data-based studies. Besides the finding that technology-based start-ups holding patent applications or grants receive larger amounts of venture capital financing than start-ups without patents (e.g., Baum and Silverman 2004, Hsu and Ziedonis 2011, Mann and Sager 2007), the possession of patent rights has also been shown to increase the likelihood of a start-up to receive venture capital funding at all and thus serves as a selection criterion (e.g., Conti et al. 2011, Engel and Keilbach 2007, Häussler et al. 2011). VCs' appreciation of patents can be traced back to their productive benefits for young companies and their potential use as quality signals.

The productive benefits of patents can be inferred from their function as legal property rights that allow its owner to exclude others from an invention.[54] Based on this function patents are known to help firms appropriate returns from R&D investments activities and to promote the commercialization of new technologies (Teece 1986, Levin et al. 1987). Furthermore, patents can be a means for firms to differentiate themselves from competition, while at the same time facilitating cooperation and bargaining with business partners (e.g., Cohen et al. 2000, Hall and Ziedonis 2001). Subsequently, many scholars have observed a positive impact of patent ownership on the performance of both established and especially new firms (e.g., Stuart et al. 1999, Ernst 2001, Wagner and Cockburn 2010). Intellectual property rights in the form of patents can transform intangible ideas into assets which can then be licensed out or traded on the market for technologies (e.g., Gans and Stern 2010). From the perspective of the entrepreneur and VC, patents thus represent a marketable asset which can be sold to third parties in case the start-up fails. In addition to the productive benefits, patents may also carry value as quality signals in the sense that investors rely on patents as observable indicators for

[54] See Chapter 2.1 for more details on patent rights.

unobservable start-up qualities (Long 2002). Some researchers argue that patents' signaling value explains a substantial part of VCs' appreciation of patents (Baum and Silverman 2004, Conti et al. 2011, Hsu and Ziedonis 2011).

Despite these commonly accepted benefits, patents also incorporate several downsides which may eventually lower their value to VCs. First of all, filing a patent is not only a costly process (Harhoff and Reitzig 2004) but also requires the disclosure of technical information, which may attract direct competition (Horstmann et al. 1985, Mazzoleni and Nelson 1998). Second, the actual effectiveness of patent protection as appropriability mechanism is often limited (e.g., Arora et al. 2008, Cohen et al. 2000). Particularly in complex industries, where inventing around a protected technology is common, other appropriability mechanisms such as complementary assets are more important drivers for successful technology commercialization (Teece 1984). Moreover, the process of enforcing property rights in case of litigation is commonly very costly and especially for entrepreneurs with tight financial resources often not affordable (Lanjouw and Schankerman 2001, Agarwal et al. 2009). Hence, many patents end up being worthless or of trivial economic value (Scherer and Harhoff 2000). Fourth, the information revealed through patents is often noisy, which makes patents difficult to interpret, especially for non-technicians. Instead of reducing information asymmetries by acting as quality signals, patents may actually increase information asymmetries and agency risks (Gompers and Lerner 2001, Long 2002, Svensson 2007). Finally, the signaling value of patents may be limited, as a patent certificate is no guarantee for the underlying invention to be of high quality. In fact, a patent application can be filed without any prior technical inspection, and the threshold for getting a patent approved is quite low, in particular in the U.S. (Jaffe and Lerner 2004).[55] As signals of the technological quality of a start-up, VCs might rather count on other more revealing characteristics (Chapter 5.5).

With respect to the pros and cons associated with start-up patenting, I argue that a contingency approach will be suitable in order to investigate VCs' attitude towards patents in the screening of business plans. In the following, I lay out how a VC's appreciation of patents may be contingent on his/her human capital.

[55] The approval rate for patents filed at the European patent office lies around 50% (EPO 2011).

6.2.2 Human capital perspective

According to Hambrick and Mason's (1984) upper echelons theory, strategic choices of top managers can to a significant extent be explained by their human capital. Human capital refers to an individual's specific knowledge which is determined by his/her education and experience (Becker 1975). While most early studies have focused on the quantitative nature of human capital, Dimov and Shepherd (2005) have introduced qualitative aspects of human capital to a VC-specific context. They distinguish between general and specific human capital, with general human capital referring to the overall education and experience applicable in many managerial activities, and specific human capital relating to the education and experience that is only useful in a particular profession or context, such as the selection of ventures for investment (Becker 1975, Dimov and Shepherd 2005, Gimeno et al. 1997). To allow a higher level of detail in analyzing high-tech VCs' decisions, specific human capital should be further broken down (e.g., Patzelt et al. 2009). Zarutskie (2010) for instance differentiates between task-specific human capital, i.e. venture capital or entrepreneurial experience, and industry-specific human capital, e.g., gained through technical education.

For the purpose of examining VC's attitude towards patent protection as one specific selection criterion, I suggest to include an additional dimension of specific human capital, namely intellectual-property-specific (IP-specific) human capital. In the following, I discuss the three different dimensions of specific human capital (task-specific, industry-specific, IP-specific) and how they may affect VC's appreciation of patents. In particular, I argue how an individual's knowledge and experience around intellectual property rights can alter the value a VC attributes to patents in start-up business plans.

6.2.2.1 Task-specific human capital

Following Zarutskie (2010), task-specific human capital in this study relates to an individual's amount of experience as a venture capital investor. Prior research provides evidence that venture capital investment experience can have a substantial impact on VCs' selection behavior. In the related field of auditing, Bonner (1990) finds that task-specific knowledge gained from experience moderates the selection and weighting of auditing criteria. Shepherd et al. (2003) observe that up to a certain level an increase in experience improves VCs' decision making. Looking at investment selection, Dimov et al. (2007) show that venture capitalists with a large amount of finance experience hold a smaller share of early-stage companies in their portfolios than their less experienced colleagues. Franke et al. (2008) find that experienced VCs focus on different types of team characteristics than novice VCs when assessing business proposals.

Theory suggests that managers build up task-specific human capital from learning on the job, which helps them to eventually perform certain tasks better than others (Gibbons and Waldman 2004). This may also apply to VCs' assessment of a specific start-up characteristic, in this case patent rights. Experienced VCs may have developed own expertise in assessing patents over the years and/or may have built up a network of experts who help them evaluate patents (Knockaert 2011). Consequently, a high amount of task-specific human capital can provide respective VCs with an advantage in deriving informational content from patents (Hsu and Ziedonis 2011). Regarding their attitude towards patents, this could result in a positive or negative effect:

On the one hand, since they know how to assess patents, highly-experienced VCs may simply regard patents as a useful source of information and thus appreciate them in business plans. Novice VCs with little task-specific human capital may rather fear the potential agency risks related to patents and thus may be reluctant to invest in start-ups featuring patents (Knockaert 2011). On the other hand, assessing patents more closely may also lead to a negative bias. Applying a long-term perspective, experienced VCs may have seen many cases in which the actual value of an initially promising patent ended up being limited (e.g., Scherer and Harhoff 2000). From a third perspective, a direct influence of investment experience on VCs' attitude towards patents may even not exist at all. Investors may have built a network of experts not only capable of assessing patents but also other start-up resources, thus eliminating any preferences towards patents versus other investment criteria. Indeed, knowledge stemming from other forms of experience, e.g., closer related to intellectual property topics, may have a stronger impact on VCs' appreciation of patents than task-specific human capital. In any case it appears interesting to test for a potential influence of task-specific human capital on VCs’ appreciation of patents. As theoretical arguments are inconclusive, I state two opposing hypotheses:

Hypothesis 1a: *Task-specific human capital positively affects VCs’ attitude towards patents.*

Hypothesis 1b: *Task-specific human capital negatively affects VCs’ attitude towards patents.*

6.2.2.2 Industry-specific human capital

Industry-specific human capital in general describes a person’s knowledge and skills related to understanding the modus operandi in a particular industry, which are not firm-specific but applicable across a range of firms or tasks (Neal 1995). In line with Patzelt et al. (2009) and Zarutskie (2010), I refer to industry-specific human capital in the context of high-tech start-up financing as a VC’s technical education (in engineering or science). The impact of industry-specific human capital on VCs’ decision making rather comes from an investor’s skills acquired through prior technical education than from his/her expertise gained through investing into and managing start-ups (Zarutski 2010). On the one hand, technical knowledge may be beneficial when evaluating patents and thus lower investors’ risk perceptions with regard to patents in start-up business plans (Knockaert et al. 2011). VCs with industry-specific human capital could consequently have a positive attitude towards patents. On the other hand, I argue that technical knowledge gained through a technical degree may have opposing effects. Assessing the technology of a start-up is a crucial part of screening business plans in which technology experts may have an advantage. The mere existence of a patent is not necessarily a good signal of the quality of the underlying technology (compare Chapter 5). While VCs without a technical degree might put trust in patents in absence of other sources of information, technically educated investors do not have to rely on patents as quality signals. Based on their technical knowledge, they can better judge the technical viability and potential applications of a briefly presented technology, regardless if it is patent protected or not (Walske und Zacharakis 2009). Individuals with industry-specific human capital might also be more aware of the fact that patents often cover only a small part of a firm’s actual product and are thus limited in their value appropriating function (e.g. Cohen et al. 2000). As a consequence technically-educated VCs may appreciate patents in a business plan less than VCs with a non-technical background. Assuming that the latter arguments outweigh the potential positive effect discussed first leads me to the following hypothesis:

Hypothesis 2: *Industry-specific human capital negatively affects VCs' attitude towards patents.*

6.2.2.3 IP-specific human capital

The third dimension of specific human capital, which I call IP-specific human capital, refers to a person's knowledge of intellectual property topics overall and the patent system in particular. It has of all human capital dimensions the most direct connection to assessing start-up patents and is consequently assumed to substantially influence venture capitalists' attitude towards patents in business plans. Individuals tend to focus their attention on aspects of their environment where they have prior knowledge (Levinthal and March, 1993). They can benefit in their decision making from a thorough evaluation of the pros and cons associated with these aspects. With regard to patents, this implies that decision makers with specific know-how around IP rights tend to have a stronger opinion on the merits and demerits of patent protection (e.g., Granstrand 1999, Rivette and Kline 2000). To be more precise in discussing the effects of IP-specific human capital, I first describe the potential impact of IP-related knowledge in general before I distinguish between different types of knowledge with respect to its sources: education and experience.[56]

On the one hand, while investors with a technical background prefer to invest into technology-based ventures (Patzelt et al. 2009), VCs with large IP-specific human capital are expected to favor start-ups featuring a patent protected technology. Several arguments support this reasoning. First, unlike IP novices, IP knowledgeable VCs should not perceive a risk increase due to patents in business plans but rather benefit from a reduction in information asymmetry, as they know how to interpret and evaluate

[56] As explained in the literature dealing with entrepreneurial learning, knowledge can be build up through education or experience (e.g., Politis 2005)

patents (Hsu and Ziedonis 2011, Knockaert et al. 2011). Second, investors with experience in defining and implementing a proper IP strategy can actively bring in their expertise and support a start-up in establishing the right organizational structures to make the most out of its intellectual property (Reitzig 2004). They should thus be pleased to see a first patent not only as a resource to be exploited but also as an opportunity to personally influence the start-up's future development. As managers generally prefer to have influence and control (e.g., Simons 1990), IP knowledgeable VCs may subsequently appreciate patents in start-up business plans.[57] Furthermore, IP savvy VCs may—already at the screening stage—have in mind that patent protected start-ups reach higher valuations at IPOs and thus improve a VC's exit opportunities (e.g., Mann and Sager 2007, Hsu and Ziedonis 2011). Finally, VCs with experience in monetizing IP rights might value a patent in a business plan more, since they know how to sell it for high prices and thus regard it as a fall-back security in case the start-up fails (Levin et al. 1987).

On the other hand, while being more aware of all the benefits, IP experts should also be more aware of all the downsides and limitations related to patents compared to less IP informed VCs, which subsequently implicates a lower appreciation of patents. In sum, however, I expect the positive arguments to prevail. Only VCs with a high amount of IP-specific human capital are assumed to recognize and appreciate the entire productive value of a patent. Furthermore, they may regard patents as an asset they can work with and through which they can personally influence a start-up's future. VCs without IP-related knowledge might rather overlook the commercial potential of patents and thus attach a lower value to them as a start-up resource. I thus hypothesize:

Hypothesis 3: *IP-specific human capital in general positively affects VCs' attitude towards patents.*

IP-specific human capital typically stems from various sources, therefore involves various types of knowledge that eventually may influence a person's attitude towards patents in various ways. One important aspect in the management of

[57] For a detailed discussion, based on social identity and attribution theory, on how exercising control may affect managers' perceptions see Fischer and Henkel (2012a).

intellectual property is dealing with the legal and regulatory framework of the patent system (e.g., Eisenberg 1989, Besen and Raskind 1991). This requires know-how on patenting conditions, terms of protection and territorial extension, and perhaps most importantly patent enforcement in case of violations (e.g., Granstrand 1999). As these topics are commonly part of law school curriculum, a venture capitalist holding a law degree should be familiar with the legal aspects surrounding patents (Fishman 2010), which may lead to a favorable view on patents in start-up business plans. Legally trained VCs may attach a high value to patents as they may believe more strongly in the power of the patent system and thus in patents' functionality as protective mechanisms. Moreover, a VC with a law background may focus his/her attention on patents when screening start-ups, as it will be likely his/her task to evaluate them in the subsequent due diligence phase. Contrarily, investors with a law background may just as well have a negative view on start-up patents, because they are well informed about the difficulties and costs involved with obtaining, renewing, and enforcing patent rights (e.g., Lemley 2001). Furthermore, a lawyer might be less aware or less convinced of all the commercial benefits a patent entails than a business man with IP experience.

With valid theoretical arguments for both a high and low appreciation of patents by VCs with a law background, I state two opposing hypotheses:

Hypothesis 4a: *Legal training positively affects VCs' attitude towards patents.*

Hypothesis 4b: *Legal training negatively affects VCs' attitude towards patents.*

Experience constitutes an important part of an individual's human capital (Becker 1975). Compared to education, experience is often more influential in building up knowledge and shaping opinion (Politis 2005) and thus can have a strong influence on decision making (e.g., Dimov et al. 2005). One specific type of experience, particularly important in investigating VCs' attitude towards patents, is personal experience in patenting an invention. Going through the process of filing a patent and strategically using the property right after patent office approval provides patent holders with specific knowledge on the economics of the patent system (e.g., Granstrand 1999). Individuals experienced in patenting should not only be aware of the benefits and disadvantages a patent entails, but also should know how to effectively use them as a company asset. Accordingly, I expect patenting-experienced VCs to be in favor of start-ups that are built upon a patent protected technology. Compared to their inexperienced colleagues, patenting-experienced investors are expected to have an advantage in assessing and interpreting patents in start-up business plans, which reduces potential agency risks (Gompers and Lerner 2001, Svensson 2007). Moreover, similarity effects could come into play. Comparable with the phenomenon that VCs like to invest in start-up teams that have professional experience similar to their own (Franke et al. 2006), VCs experienced in patenting might favor start-ups that possess a patent. In sum, I assume that patenting-experienced VCs attach a higher importance to patents in start-up business plans than investors without this type of IP-specific human capital. The corresponding hypothesis predicts:

Hypothesis 5: *Patenting experience positively affects VCs' attitude towards patents.*

A further sort of experience that may influence VCs' attitude towards patents is the participation in a patent lawsuit. Such an event may represent a critical incident which induces changes in an individual's opinion. Patent lawsuits are triggered when one party infringes on the patent of another party who then decides to enforce its property right by suing the infringer. Young technology based start-ups face a high risk of patent infringements by large incumbent firms (Lanjouw and Schankerman 2004, Bessen and Meurer 2005). Enforcing their patent rights, however, is often associated with a negative outcome. Filing a lawsuit against patent infringers is notoriously expensive in terms of both time and money, especially in the U.S. (Lemley 2001). As start-ups' financial resources are comparatively tight, even when supported by a VC, many entrepreneurs refrain from going to court (Graham 2009). Even if a start-up decides to pursue a litigation lawsuit, a verdict in favor of a single patent holder against an incumbent's large patent portfolio is highly unlikely (Lanjouw and Schankerman 2004). Small firms are thus disadvantaged in protecting their patent rights, and their asset values of patents are arguably much lower than for large corporations (Bessen 2008).

Venture capitalists who have at some time in their career, either as an entrepreneur or as a VC supporting a portfolio firm, been involved in a patent lawsuit are expected to be aware of these disadvantages. Remembering the patent lawsuit as a negative experience for the small firm, they may attach less value to start-up-owned patents than VCs without a similar experience. In more general terms, a patent lawsuit may be the critical incident which makes VCs realize that patents are often de facto less effective than they commonly appear. Accordingly, I hypothesize:

Hypothesis 6: *Prior experience of a patent lawsuit negatively affects VCs' attitude towards patents.*

6.3 Data and Methods

6.3.1 Sample and data collection

I chose the early-stage high-tech venture VC as the target population of this study. More precisely, I decided to focus on venture capitalists invested in German start-ups, who are active in the industries of biotech, cleantech, or ICT hardware. In preparation for the survey, potential participants were identified by searching industry associations (BVK, EVCA), press releases and venture capital fund websites, while making sure they were currently active and met the aforementioned criteria. 233 potential participants from 148 venture capital firms were invited to take part in this survey during the first quarter of 2011. A number of measures were taken to achieve a high response rate, among them personal invitations by telephone, friendly reminders, the option to receive survey results, a prize lottery, and above all a short-paced survey around an interesting topic. In total I received responses from 110 participants. After throwing out incomplete responses, my final sample consists of 102 individual VCs from 80 different venture capital firms. For more detailed information on the sample and survey procedures please refer to Chapter 3.4.2 of this thesis.

6.3.2 Measures

6.3.2.1 Dependent variables

I measure a VC's attitude towards patents in two ways: (1) through a *patent utility value* revealed in a choice experiment and (2) through a *patent importance score* based on traditional Likert-scale questions.

Regarding the first measure, *patent utility value*, I conducted a choice-based conjoint analysis with the entire sample of VCs. A conjoint approach is particularly suitable for investigating VCs' selection behavior, as it comes relatively close to their actual decision tasks, and many limitations of other survey methods can be overcome (Shepherd and Zacharakis 1999, Franke et al. 2008). As described in Chapter 3.4.1, participating VCs were asked to evaluate technology start-ups in an initial screening of business plans. Respondents were repeatedly shown choice sets consisting of three hypothetical start-ups each, which were described by different levels of three observable characteristics: experience of the team, alliances, and patent protection. The attribute "patent protection", for instance, was used to portray the patenting status of the start-up's core technology and featured the levels "no patent", "patent applied for" or "patent granted". For each choice set respondents were asked to select the venture they would most and least likely fund with venture capital. I analyze these choice decisions by estimating a rank-ordered mixed logit model. With this approach, I can determine the value contribution of each attribute to the odds of being chosen as most preferred venture. The participant-specific coefficients of each attribute level incorporated in the estimation are well suited for an individual-level examination of the population (Revelt and Train 2000, Train 2009). I use the investor-specific coefficient of the attribute level "patent granted" as my variable of interest.[58] It can be interpreted as the utility a VC derives from a patent held by a start-up. While attribute utility values can theoretically be negative, all participants in the sample show positive values regarding "patent granted", which means that a patent owned by a start-up in general has a positive effect on VC investment decisions. Still, the attitude towards patents in the sample varies

[58] After estimating a rank-ordered mixed logit model in STATA with Hole's (2007) mixlogit command, individual-level parameters are derived by applying the "mixlbeta" option.

strongly with values of the variable *patent utility value* ranging from 1.23 to 6.68 and a standard deviation of 1.31 (average 4.30).

Considering the second measure, *patent importance score*, I asked respondents (after the choice experiment) for their rating of different patent functions in the context of venture capital financing of technology start-ups. More precisely, VCs had to judge the importance of patents as (a) a legal right to protect a unique technology, (b) a legal right to generate revenues from licensing or selling the patent, (c) a signal of the quality of a start-up's technology, and (d) a signal of the start-up team's professionalism, each on a five-point Likert scale (1 = not important at all, 5 = very important). Every VC's four answer values were added up to a *patent importance score*, which I use as a proxy for his/her appreciation of patents.[59] The average value of this second dependent variable is 15.2, with a minimum of 10 and a maximum of 20.

6.3.2.2 Independent variables

Task-specific human capital is operationalized as the number of years a respondent has worked as venture capitalists (*experience_years*). The investment experience of my sample ranges from 1 year to >15 years, with a median of 5 years.

Industry-specific human capital is defined by a participant's technical education (Patzelt et al. 2009). The dummy variable *edu_tech* takes on the value of 1 if a VC holds a university degree in either engineering or science. Exactly half the investors in the sample have a technical background by this definition.

IP-specific human capital is measured by four different variables that are all related to an individual's knowledge of intellectual property topics. The variable *ip_knowhow* describes a VC's IP-specific human capital in general based on his/her own assessment. To this end, I asked participating VCs to rate their "knowledge on topics related to intellectual property" on a five-point Likert scale ranging from 1 = "IP novice" to 5 = "IP expert". All levels of *ip_knowhow* are represented in the sample, while the average value is 3.3. The variable *edu_law* refers to a respondent's legal training. As a dummy variable it takes on the value of 1 if an investor is in possession of

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[59] I also performed a factor analysis to condense these four variables into one factor. The outcome of this analysis will be discussed in the results section.

a law degree. Three investors in the sample have undergone legal training (among other degrees). Moreover, the dummy variable *patent_received* reflects a VC's personal patenting experience. A value of 1 indicates that a participant has at some time in his/her career filed and received a patent, which is the case for 23% of VCs in this sample. Finally, the variable *patent_lawsuit* describes whether a VCs has during his/her prior career been actively involved in a patent lawsuit or not. In my sample 24% of respondents possess IP-specific human capital from this type of experience. Experience in both patenting and a lawsuit applies to only 8 out of 102 participating VCs.

6.3.2.3 Control variables

Accounting for the results of previous research I include a number of control variables in my estimations. As VCs' operational involvement has been shown to influence their decision making and portfolio management (e.g., Casson and Martin 2007, Bottazzi et al. 2008), I incorporate a variable called *operational_involve* based on a 5-point Likert scale ranging from "active investor" to "passive investor". The investment strategy of a VC, whether to finance ventures at early stages or rather at later stages may also effect his/her use of selection criteria (e.g., Elango et al. 1995). To control for these effects I thus use two dummy variables, *seed_funding* and *laterstage_funding*, indicating whether or not a particular VC normally invests into ventures at these stages.[60] Differences between portfolio industries may further alter VC investment decisions, especially with respect to patents as selection criterion (e.g., Sandberg et al. 1988, Mann and Sager 2007; see also Chapter 4). Hence I include two industry-related variables in my models: a *biotech_dummy* and an *ICT_dummy*, indicating whether an investor predominantly deals with biotech or ICT start-ups, respectively. The cleantech industry serves as reference category. Furthermore, I account for the potential influence of the size of the venture capital firm by constructing a *fundsize* variable that divides the sample into seven groups from <50 M€ to >1 B€ (Gupta and Sapienza 1992, Hall and Tu 2003). Moreover, to control for potential regional effects, I add a dummy variable to describe if a VC is based in Germany[61] or a

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[60] VCs only investing at the "start-up stage" represent the reference category.

[61] Germany-based VCs constitute the majority (82%) in my sample.

different European country (e.g., Elango et al. 1995). Finally, I take potential strategic differences between venture capital organizations into account (e.g., Dushnitsky and Shaver 2009) and introduce a dummy variable for corporate VCs (*type_cvc*) and public VCs (*type_pvc*) while noting that the majority of the sample are independent VCs.

Descriptive statistics and correlations between all variables can be found in Table 18. As all correlations are below a value of 0.40 and the variance inflation factors do not surpass the value of 2.0, I assume that multicollinearity is not an issue in my dataset (e.g., Hair et al. 2010).

Table 18: Descriptive statistics and correlations

No.	Variable	Mean	S.E.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	patent utility value	4.30	0.13	1.00																
2	patent importance score	15.21	0.23	0.33	1.00															
3	experience_years	6.56	0.45	-0.02	-0.04	1.00														
4	edu_tech	0.51	0.05	0.02	-0.01	0.02	1.00													
5	ip_knowhow	3.27	0.09	0.33	0.19	0.06	0.33	1.00												
6	edu_law	0.03	0.02	-0.15	-0.09	-0.04	-0.16	0.08	1.00											
7	patent_received	0.23	0.04	0.14	0.05	-0.08	0.31	0.29	-0.09	1.00										
8	patent_lawsuit	0.24	0.04	-0.14	0.10	0.08	0.11	0.23	0.18	0.16	1.00									
9	operational_involve	4.07	0.10	0.09	0.19	0.02	0.40	0.31	0.10	0.15	0.27	1.00								
10	seed_funding	0.44	0.05	0.04	0.12	0.09	0.14	0.24	0.18	0.16	0.00	0.19	1.00							
11	laterstage_funding	0.25	0.04	0.15	0.07	-0.09	0.02	-0.09	-0.09	-0.08	-0.09	-0.10	-0.21	1.00						
12	biotech_dummy	0.28	0.04	0.26	0.27	-0.03	0.10	0.02	0.02	0.06	-0.05	0.05	0.18	0.02	1.00					
13	ict_dummy	0.38	0.05	-0.05	-0.25	0.17	-0.27	0.05	-0.02	-0.17	-0.10	-0.19	-0.08	-0.04	-0.50	1.00				
14	fundsize	3.09	0.17	0.18	0.01	0.20	0.21	0.03	-0.13	-0.06	-0.01	0.09	-0.03	0.29	0.09	-0.17	1.00			
15	country_D	0.80	0.04	-0.10	-0.07	0.07	-0.16	0.08	0.08	0.07	0.02	-0.05	0.00	-0.07	-0.06	0.22	-0.19	1.00		
16	type_cvc	0.12	0.03	-0.03	-0.06	-0.28	0.07	0.07	0.12	0.04	-0.04	-0.18	-0.14	0.15	-0.03	-0.03	-0.11	0.01	1.00	
17	type_pvc	0.14	0.03	-0.11	-0.18	0.22	-0.21	-0.10	0.08	-0.22	-0.17	-0.37	0.27	-0.18	0.06	0.13	-0.01	0.14	-0.15	1.00

Note: All correlations with absolute value above 0.19 are significant ($p<0.05$), n=102

6.4 Results

In the following, I present the results of my multivariate analyses that investigate the human capital determinants of VCs' attitude towards patents. I first show the main regression results regarding the two dependent variables and relate them to my hypotheses. Subsequently I display further findings concerning the role of patents from the perspective of venture capitalists.

6.4.1 Main results

I use the standard ordinary least squares (OLS) estimation method for my regression analyses and perform two separate estimations for the two dependent variables, *patent utility value* and *patent importance score*. For each dependent variable, I construct three different models, in which (a) the dependent variable is regressed against the control variables, (b) human capital variables are added and (c) irrelevant control variables are removed from the analysis.

Table 19 displays the results concerning the dependent variable *patent utility value*. Model 1a, which contains the control variables only, comes out to be statistically significant ($F=2.27$, $p<0.05$, adjusted $R^2=0.05$), but is of relatively low explanatory value. When adding the human capital variables (Model 1b), the estimation model improves strongly ($F=5.05$, $p<0.01$, adjusted $R^2=0.20$). Finally, for Model 1c, I streamline the estimation by taking out irrelevant control variables. Testing for joint significance ($F=1.38$, $p=0.24$) proves that these control variables are jointly insignificant.

Focusing now on Model 1c, I find that industry-specific human capital based on technical education[62] has a significant negative influence on VCs' attitude towards patents, while task-specific human capital shows no significant effects. With regard to IP-specific human capital, I observe that general IP know-how has a strong positive influence (99% significance level) and patent lawsuit experience a strong negative

[62] When introducing two dummy variables, engineering education and science education, instead of technical education, to the model, the same significant negative effect can be observed for both variables.

influence (95% significance level) on the dependent variable. For legal training and patenting experience, no significant effects are found.

Table 19: Estimation results – patent utility value

Dependent variable: Patent utility value		Model 1a		Model 1b		Model 1c	
		Coeff.	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**
Task-specific human capital							
	experience_years			-0.015	0.027	-0.003	0.027
Industry-specific human capital							
	edu_tech			-0.624**	0.310	-0.509*	0.294
IP-specific human capital							
	ip_knowhow			0.625***	0.146	0.625***	0.143
	edu_law			-1.071	0.889	-1.315	0.867
	patent_received			0.347	0.309	0.153	0.306
	patent_lawsuit			-0.589**	0.288	-0.619**	0.274
Controls							
	operational_involve	0.060	0.173	0.076	0.176		
	seed_funding	0.110	0.310	-0.053	0.268		
	laterstage_funding	0.298	0.334	0.303	0.334		
	biotech_dummy	0.921***	0.307	0.748***	0.287	0.730**	0.284
	ict_dummy	0.483	0.347	0.211	0.304	0.051	0.302
	fundsize	0.106	0.077	0.103	0.072		
	country_D	-0.245	0.333	-0.400	0.328		
	type_cvc	-0.016	0.340	-0.134	0.391		
	type_pvc	-0.384	0.521	-0.242	0.472	-0.465	0.345
Constant		3.412***	0.792	2.165***	0.769	2.524***	0.549
	Regression	OLS		OLS		OLS	
	F-value	2.27**		5.05***		4.63***	
	R^2	0.14		0.32		0.27	
	Adjusted R^2	0.05		0.20		0.20	

Note: *** p<0.01, ** p<0.05, * p<0.1, n=102, Robust standard errors reported

Model 2 uses the *patent importance score*, derived from the Likert-scale rankings of patent functions, as the dependent variable. Estimation results are displayed in Table 20. Following the same procedure as in Model 1, I first regress the *patent importance score* against the control variables (Model 2a: F=2.03, p<0.05, adjusted R^2=0.06), then I add the human capital variables (Model 2b: F=2.66, p<0.01, adjusted R^2=0.11), and finally I leave out insignificant control variables (Model 2c: F=3.38, p<0.01, adjusted R^2=0.13).[63] The main findings in Model 2c are similar to the results in Model 1c. Task-specific human capital does not appear to have an influence on the *patent importance score*, whereas technical education[64] shows a significant negative effect (95% significance level). Concerning IP-specific human capital, I again find a significant positive association between general IP know-how and VC's attitude towards patents (95% significance level). Having a law degree significantly lowers the value a VC attributes to patents (99% significance level), while neither experience in patenting nor in a patent lawsuit affect the dependent variable.

Table 20: Estimation results – patent importance score

Dependent variable: Patent importance score		Model 2a Coeff.	Model 2a SE	Model 2b Coeff.	Model 2b SE	Model 2c Coeff.	Model 2c SE
Task-specific human capital							
	experience_years			-0.002	0.057	0.001	0.053
Industry-specific human capital							
	edu_tech			-1.347**	0.612	-1.139**	0.567
IP-specific human capital							
	ip_knowhow			0.635**	0.324	0.725**	0.302
	edu_law			-2.780**	1.101	-2.234***	0.818
	patent_received			-0.450	0.635	-0.371	0.598
	patent_lawsuit			0.285	0.639	0.310	0.638
Controls							
	operational_involve	0.157	0.272	0.237	0.299		
	seed_funding	0.555	0.508	0.723	0.559		
	laterstage_funding	0.467	0.521	0.477	0.521		
	biotech_dummy	0.967*	0.534	0.824	0.521	0.953*	0.537
	ict_dummy	-0.562	0.562	-1.067*	0.622	-1.071*	0.599
	Fundsize	-0.069	0.135	-0.073	0.139		
	country_D	-0.056	0.551	-0.161	0.567		
	type_cvc	-0.498	0.798	-0.239	0.828		
	type_pvc	-1.086	0.761	-1.081	0.716	-1.115*	0.630
Constant		14.612***	1.210	13.250***	1.323	13.775***	0.989
	Regression	OLS		OLS		OLS	
	F-value	2.03**		2.66***		3.38***	
	R^2	0.14		0.24		0.20	
	Adjusted R^2	0.06		0.11		0.13	

Note: *** p<0.01, ** p<0.05, * p<0.1, n=102, Robust standard errors reported

[63] An according F-test results in no joint significance of the omitted control variables (F= 0.84, p= 0.52).

[64] Splitting technical education into two separate variables results in a significant negative influence of engineering education (95% significance level) and a non-significant negative influence of science education on *patent importance score*.

I now relate the findings of both main models to my research hypotheses. I find strong support for *Hypothesis 2,* regarding industry-specific human capital, by observing a significant negative effect of technical education on VCs' attitude towards patents in both models. *Hypothesis 3* is also strongly supported, as both models consistently show a significant positive influence of general IP know-how on the dependent variables. In line with my expectations, experience in a patent lawsuit is negatively associated with VCs' attitude towards patents at a high significance level in Model 1, but not in Model 2. *Hypothesis 6* is thus only partially supported. Regarding the role of legal training, I observe a significant negative effect in Model 2, thus finding support for *Hypothesis 4b* and not *Hypothesis 4a*. Surprisingly, no influence of patenting experience on either dependent variable can be found, resulting in no support for *Hypothesis 5*. Regarding task-specific human capital, I do not find any significant association with neither of the two dependent variables, thus *Hypotheses 1a and 1b* are not supported either.

I conduct several robustness checks to further substantiate my findings. The results of these additional estimations are displayed in Table 21. First, I estimate a Tobit regression on the dependent variable *patent importance score* in addition to the OLS-based Model 2. A Tobit model provides more accurate parameter estimates than an OLS regression in case the dependent variable is censored (Cameron and Trivedi 2009). In my dataset, the observations of the dependent variable *patent importance score* may be regarded as right-censored since the variable is restricted to a maximum value of 20. In estimating the Tobit model (Model 3) I accordingly censor the three applicable observations at the right end of the distribution. The results come out to be in line with the previous findings, i.e. the values and significance levels of the coefficients are very much comparable to the respective coefficients in Model 2. Thus a significant influence of technical education, general IP know-how and legal training on VCs' attitude towards patents is confirmed.

As further proof of verification, I substitute the dependent variable *patent importance score* with a factor called *overall patent importance*, which is generated by a confirmatory factor analysis. Factor values are based on the same four Likert-scale ratings of different patent functions that are used to calculate the *patent importance score*. However, instead of simply adding up the ratings to an importance score, I now perform a confirmatory factor analysis to generate one explanatory factor and then predict the according factor values for each participant.[65] The values of the factor *overall patent importance* range from -2.44 to 2.02 and have an average of 0.00. When regressing this factor on the explanatory variables (Model 4) I again observe similar coefficients in terms of magnitude and statistical significance as in Model 2. Thus, my previously reported findings on the explanatory value of human capital variables still hold true.

Table 21: Estimation results – robustness checks

		Model 3: Tobit		Model 4	
	Dependent variable:	**Patent importance score**		**Factor "overall patent importance"**	
		Coeff.	**SE**	**Coeff.**	**SE**
Task-specific human capital					
	experience_years	0.003	0.055	0.002	0.024
Industry-specific human capital					
	edu_tech	-1.374**	0.577	-0.567**	0.252
IP-specific human capital					
	ip_knowhow	0.621**	0.305	0.305**	0.137
	edu_law	-2.856***	1.028	-1.118**	0.459
	patent_received	-0.494	0.597	-0.217	0.266
	patent_lawsuit	0.305	0.600	0.115	0.261
Controls					
	operational_involve	0.240	0.281	0.099	0.126
	seed_funding	0.771	0.539	0.304	0.232
	laterstage_funding	0.512	0.500	0.187	0.223
	biotech_dummy	0.886*	0.500	0.367*	0.217
	ict_dummy	-1.061*	0.577	-0.496*	0.261
	fundsize	-0.086	0.133	-0.034	0.058
	country_D	-0.175	0.543	-0.088	0.234
	type_cvc	-0.244	0.763	-0.082	0.348
	type_pvc	-1.138*	0.681	-0.412	0.307
Constant	Constant	13.303***	1.247	-0.921	0.575
	Sigma	2.100***	0.147		
	Regression	Tobit		OLS	
	F-value	3.03***		2.74***	
	R^2			0.26	
	Adjusted R^2			0.13	
	Pseudo R^2	0.06			

Note: *** p<0.01, ** p<0.05, * p<0.1, n=102, Robust standard errors reported

65 Factor analysis details. Extraction: principal-component analysis; unrotated; Eigenvalue 1.68; 42% of total variance explained; all factor loadings > 0.5; Cronbach's alpha: 0.527; KMO: 0.561; Bartlett test: p = 0.000; prediction method: regression.

To allow for a further level of variation in my analysis I split the sample into two groups based on the industry affiliation of the participating VCs. I distinguish between discrete industries (biotech) and complex product industries (cleantech and ICT) and perform separate OLS regressions for each group. Accordingly, with respect to the dependent variable *patent utility value*, Model 5 incorporates the responses from all biotech VCs, while Model 7 is estimated with data from the cleantech and ICT VCs in the sample. Models 6 and 8 are calculated analogously using *patent importance score* as the dependent variable. Table 22 offers detailed results on the various industry models. Possibly due to the small number of observations (n=29), the two biotech models are not statistically significant ($F_5=1.86$; $F_7=1.27$; $p_{5,7}>0.1$) and thus cannot be unambiguously interpreted. The two models representing complex industries come out to be highly significant ($F_6=2.96$; $p_6<0.01$; $F_8=9.74$; $p_8<0.01$). Again, the significant effects of the human capital variables are in line with the findings from the main models (Model 1 and Model 2). However, the significance levels of these effects are lower in the cleantech/ICT-models, likely due to the smaller sample size.

Table 22: Estimation results – industry models

	Model 5 Biotech		Model 6 Cleantech & ICT		Model 7 Biotech		Model 8 Cleantech & ICT	
Dependent variable:	Patent utility value		Patent utility value		Patent importance score		Patent importance score	
	Coeff.	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**
Task-specific human capital								
experience_years	-0.027	0.052	-0.001	0.038	0.319**	0.137	-0.077	0.065
Industry-specific human capital								
edu_tech	-1.210***	0.443	-0.517	0.390	-0.598	1.088	-0.470	0.785
IP-specific human capital								
ip_knowhow	0.591***	0.190	0.745***	0.213	-0.038	0.430	0.393	0.398
edu_law	-1.044	1.170	-1.670*	0.978	5.708**	2.890	-3.456***	0.885
patent_received	0.453	0.364	0.363	0.443	-0.309	0.779	-0.217	0.858
patent_lawsuit	0.158	0.519	-0.880**	0.356	-2.220**	1.073	0.620	0.706
Controls								
operational_involve	-0.004	0.350	0.038	0.232	-0.562	0.924	0.205	0.323
seed_funding	-0.137	0.398	-0.102	0.407	0.850	0.767	0.337	0.667
laterstage_funding	0.487	0.547	0.245	0.443	1.387	2.053	0.009	0.636
biotech_dummy								
ict_dummy								
fundsize	0.074	0.127	0.070	0.111	0.250	0.457	-0.159	0.177
country_D	-0.191	0.797	-0.672	0.459	0.930	2.303	0.189	0.712
type_cvc	0.182	0.795	-0.325	0.515	-1.024	2.114	-0.586	0.911
type_pvc	-0.704	0.681	0.102	0.569	-2.204	2.242	-0.910	0.851
Constant	3.585***	1.102	2.314**	1.053	15.549***	3.946	13.830***	1.565
N	29		73		29		73	
Regression	OLS		OLS		OLS		OLS	
F-value	1.86		2.96***		1.27		9.74***	
R^2	0.62		0.29		0.52		0.19	
Adjusted R^2	0.29		0.13		0.11		0.02	

Note: *** p<0.01, ** p<0.05, * p<0.1, Robust standard errors reported

6.4.2 Further results

In analyzing the survey data, a number of additional observations were made that are noteworthy despite not being directly related to one of the hypotheses. As outlined in Chapter 2.3.1 of this dissertation, a start-up patent can perform two distinct functions from the perspective of a venture capitalist: it can serve as an asset in the form of a legal right and it can serve as a signal of unobservable qualities. These two functions can be broken down further into sub-functions; e.g., regarding the signaling function, being a quality signal of the start-up's technology or the start-up team's professionalism. In the survey, I asked participating VCs for an importance ranking of four different patent functions based on a five-point Likert scale (1 = not important at all, 5 = very important).[66] A detailed summary of the respective answers is shown in Table 23.

Table 23: Descriptive statistics of patent functions

Variable	N	Median	Mean	Std. Dev.	Min	Max	Share 4 & 5
legal_protect	102	5	4.43	0.74	2	5	89.2%
legal_sale	102	4	3.85	1.06	1	5	70.6%
signal_tech	102	4	3.57	0.97	1	5	58.8%
signal_team	102	3	3.35	0.87	1	5	45.1%
legal_score	102	8	8.28	1.49	4	10	
signal_score	102	7	6.92	1.53	3	10	

A clear pattern can be observed. The original function of a patent serving as a legal right to protect a unique technology is considered most important while the importance of a patent to generate revenues from licensing or selling it ranks second. The importance of patents as signals of technological quality takes third place and their appreciation as signals of the team's professionalism ranks last. Hence the two legal or productive functions appear to outperform the signaling functions. To find out whether this difference is significant I first condense both the two productive variables and the two signaling variables into one variable each (*legal_score* and *signal_score*) by summing up their individual values. I then perform two statistical tests. A simple t-tests for equality of means (Table 24) provides evidence that a patent's productive value is

66 This data was also used to generate the above described variable *patent importance score*.

significantly larger than a patent's signaling value, at a significance level of 99%. This result is confirmed by a Wilcoxon signed-rank test, which is more appropriate when dealing with ordinal data (Siegel 1956). Table 25 shows that the difference in the rankings of the two scoring variables is highly significant. This finding is consistent with the results from the conjoint analysis in Chapter 5.4, which illustrates the overall high importance of patents as venture capital selection criterion but their low value as signals for technological quality. As a matter of fact it somewhat contradicts the qualitative statements of the VCs I interviewed at an early research stage (see Chapter 2.4.2.2), which implied a higher importance of patents as quality signals.

Table 24: T-test for equality of means

Variable	Obs	Mean	SE	Std. Dev.	99% Conf. Int.	
Legal_score	102	8.28	0.15	1.49	7.90	8.67
Signal_score	102	6.92	0.15	1.53	6.52	7.32
combined	204	7.60	0.12	1.66	7.30	7.90
diff		1.36	0.21		0.81	1.91

Ho: diff = 0; Ha: diff > 0
t = 6.434
Prob (T > t) = 0.0000

Table 25: Wilcoxon signed-rank test

Sign	Obs	Sum ranks	Expected
Positive	71	4347	2531.5
Negative	12	716	2531.5
Zero	19	190	190
All	102	5253	5253

Unadjusted variance	89738.8
Adjustment for ties	-873.9
Adjustment for zeros	-617.5
Adjusted variance	88247.4

Ho: legal_score = signal_score
z = 6.111
Prob > |z| = 0.0000

In order to further analyze the two distinct patent functions, an exploratory factor analysis is conducted. The purpose of an exploratory factor analysis is to identify patterns in the data by reducing a set of variables to a limited number of explanatory factors (Homburg and Krohmer 2003). The adequacy of a data set for a factor analysis depends on the interdependencies between the individual variables and can be measured by two tests, the Kaiser-Meyer-Olkin (KMO) criterion and the Bartlett test of sphericity. With regard to my data, a KMO value of 0.561 and a p-value < 0.001 in the Bartlett test indicate a sufficient correlation between the variables to perform a factor analysis (Backhaus et al. 2008).[67] One crucial part of the factor analysis is to choose the appropriate number of factors to be extracted. As is common I select all factors with an Eigenvalue greater than one (Backhaus et al. 2008) and accordingly retain two factors. Table 26 gives an overview of the factor characteristics. A look at the respective factor loadings after rotation (Table 27) provides clear insights about the factor meanings and the underlying constructs. Factor 1 may be called “productive value” as it relates strongly to the two productive functions of a patent. Factor 2, on the contrary, comprises of the two signaling variables and thus represents the “signaling value” of a patent. Featuring Cronbach’s alpha values of 0.51 (Factor 1) and 0.55 (Factor 2) both factors can be regarded as reliable (Bortz and Döring 2002). I conclude from this exploratory factor analysis that a patent’s importance may be explained by two separate factors, a productive and a signaling component.

Table 26: Factor characteristics

Factor	Eigenvalue	Difference	Proportion	Cumulative var. explained
Factor 1	1.681	0.604	0.420	0.420
Factor 2	1.077	0.393	0.269	0.690
Factor 3	0.684	0.128	0.171	0.861
Factor 4	0.557	.	0.139	1.000

[67] A KMO value > 0.5 is commonly regarded as appropriate for performing a factor analysis. The Bartlett test serves as further indicator in case the null hypothesis (the variables in the population are not correlated) can be rejected (Backhaus et al. 2008).

Table 27: Factor loadings after rotation

Variable	Factor 1 (Productive value)	Factor 2 (Signaling value)
legal_protect	0.8301	
legal_sale	0.8010	
signal_tech		0.8640
signal_team		0.7814

Extraction: principal component analysis; Rotation: varimax; n=102
69% of total variance explained; KMO: 0.561, Bartlett test: p = 0.000.
Factor loadings < 0.5 omitted

Following the concept of splitting VCs' appreciation of patents into a productive and a signaling component, I now investigate both components separately. Similar to the analysis performed in the previous section, I examine to what extend a VC's specific human capital explains his/her appreciation of patents as productive attributes and as quality signals. Using OLS regressions, I estimate for each factor a full model as well as a streamlined model, omitting insignificant control variables. In Model 9 (a and b), Factor 1 "productive value" is used as the dependent variable, while Model 10 (a and b) features Factor 2 "signaling value" as the dependent variable.[68] Results are shown in Table 28.

Regarding a patent's "productive value" I find very similar results as in the main analysis, predicting VCs' overall attitude towards patents. In this highly significant model (F=5.07, p<0.01, adjusted R^2=0.25) technical education and law education appear to have a negative influence on the importance VCs attribute towards patents. General IP know-how, in turn, seems to have a positive effect on VCs' attitude towards patents (99% significance level). Regressions on the "signaling value" of patents do not result in a significant model (F=0.74, p=0.67), as none of the human capital variables is significantly associated with the dependent variable.

[68] The values of both factor variables were generated using linear regression. Factor values are standardized with a mean of zero and a standard deviation of one.

Table 28: Estimation results – factor models

Dependent variable	Model 9a Factor "productive value" Coeff.	SE	Model 9b Factor "productive value" Coeff.	SE	Model 10a Factor "signaling value" Coeff.	SE	Model 10b Factor "signaling value" Coeff.	SE
Task-specific human capital								
experience_years	-0.012	0.019	-0.017	0.021	0.014	0.029	0.015	0.025
Industry-specific human capital								
edu_tech	-0.434*	0.237	-0.389*	0.218	-0.367	0.267	-0.272	0.256
IP-specific human capital								
ip_knowhow	0.392***	0.128	0.420***	0.116	0.034	0.154	0.068	0.139
edu_law	-2.010***	0.512	-1.729***	0.435	0.463	0.486	0.595	0.398
patent_received	-0.261	0.226	-0.188	0.219	-0.043	0.265	-0.077	0.237
patent_lawsuit	0.220	0.190	0.248	0.189	-0.062	0.293	-0.097	0.283
Controls								
operational_involve	0.068	0.127			0.073	0.152		
seed_funding	0.187	0.174			0.244	0.282		
laterstage_funding	-0.082	0.242			0.353	0.222		
biotech_dummy	0.464***	0.178	0.493***	0.183	0.050	0.249	0.081	0.261
ict_dummy	-0.501**	0.231	-0.468**	0.230	-0.196	0.267	-0.234	0.261
fundsize	-0.063	0.059			0.016	0.069		
country_D	-0.043	0.183			-0.082	0.244		
type_cvc	0.014	0.362			-0.132	0.291		
type_pvc	-0.376	0.352	-0.345	0.294	-0.204	0.317	-0.292	0.359
Constant	-0.918	0.566	-0.935**	0.364	-0.378	0.635	-0.032	0.405
Regression	OLS		OLS		OLS		OLS	
F-value	3.27***		5.07***		0.80		0.74	
R^2	0.35		0.33		0.08		0.05	
Adjusted R^2	0.24		0.25		-0.07		-0.06	

Note: *** p<0.01, ** p<0.05, * p<0.1, n=102, Robust standard errors reported

6.5 Discussion and Conclusion

The purpose of this study is to provide a better understanding of VCs' attitude towards patents in the screening of technology start-ups. While patents are commonly known to involve a number of benefits for technology-based companies, they are at the same time not free from having drawbacks. Recognizing that some VCs regard patents as more useful than other VCs, I establish the link between these differing attitudes and VCs' specific human capital. By analyzing a unique dataset stemming from a survey with 102 European VCs and measuring VCs' attitude towards patents in two different ways, I find notable results.

Overall, my regression models show that specific human capital has a substantial impact on VCs' attitude towards patents. Especially the dimension of IP-specific human capital, which I introduce, shows strong effects. For instance, VCs who claim to have a high knowledge of general IP related topics appreciate start-up patents much more than VCs who are not familiar with IP issues. This may be due to the fact that IP savvy VCs know how to employ patents effectively and thus can offer strategic advice to patent-owning start-ups, which in turn provides them with the desirable feeling of being in charge. This positive effect could be further explained by the common phenomenon that people appreciate things more when they are personally familiar with them (e.g., Levinthal and March 1993). A rather negative attitude towards patents is the case for VCs that have experienced a patent lawsuit during their prior career. When screening business plans, VCs with a patent lawsuit experience attach a significantly lower utility to patents than their colleagues without this experience. I assume that this is due to the fact that for young and small companies patent lawsuits mostly have a negative outcome and that it takes a lot of money to defend a patent. "VCs hate to see their start-ups getting bogged down in lawsuits" (Nesheim 2000), and owning a patent simply might increase the risk of getting into a lawsuit. I furthermore find a negative impact of legal training on VC's attitude towards patents by observing that VCs with a law degree rank the importance of patents for high-tech start-ups much lower than VCs with a different educational background. One could argue that lawyers, due to the nature of their legal training, most likely are familiar with the legal aspects rather than the commercial aspects surrounding patents. Thus, they may be more aware of the difficulties and costs regarding patent application and enforcement than patents' commercial benefits, which could explain why lawyers appreciate start-up patents less than an individual with a business background. Surprisingly, personal patenting experience does not show the expected positive impact. Apparently the learnings from this type of experience are too diverse to consistently influence VCs' attitude towards patents.

Looking beyond IP-specific human capital I find that industry-specific human capital is also significantly related to a VC's appreciation of patents. The negative effect of technical education that I observe in both main models may seem surprising at first but can be explained with the help of the control group. Technically educated VCs are likely oriented towards technology and innovation in their selection of start-ups (Wiersema and Bantel 1992, Patzelt et al. 2009). When assessing the quality of a start-up's technology they can be assumed to rely rather on their own technical expertise than on quality signals such as patents. In fact, they may be aware that patents are rather weak signals of technology quality and also often limited in their protective function (Cohen et al. 2000, Hoenig and Henkel 2011). VCs without a technical background, on the contrary, are possibly overrating the usefulness of patents as signaling and protective mechanisms, as they lack more fundamental skills to judge a technology. This may explain why VCs with industry-specific human capital appreciate patents comparatively less than their non-technically educated peers.

While I can explain a considerable share of variation in VCs' attitude towards patents through IP-specific human capital and industry-specific human capital, I find no effects related to task-specific human capital. Despite the fact that a VC's amount of investment experience has the potential to influence his/her decision making (e.g., Shepherd et al. 2003, Franke et al. 2008), I do not find such effects related to VCs' appreciation of patents. This may be reasonably explained by the lack of specificity incorporated in the knowledge gained through working as a VC. Solely considering the amount of experience in terms of time working as a VC is simply not specific enough to affect a person's attitude towards patents in one way or the other. For instance, a very senior VC may have made positive or negative experiences with patent rights throughout his/her career with the same likelihood. Thus, the non-existing association between investment experience and appreciation of patents I observe is not really surprising.

This study makes several contributions. First, it adds to a recent stream of literature on drivers and determinants of venture capital decision making (e.g., Dimov et al. 2007, Zarutski 2010). By investigating the impact of VCs' human capital on their appreciation of patents, I respond to a recent call by Patzelt et al. (2009) to study the relationship between VCs' individual backgrounds in terms of education and experience and their decision policies. Through introducing a new dimension of human capital, IP-specific human capital, I manage to explain an additional amount of variation in VCs' attitudes compared to previous studies in this context (e.g., Knockaert et al. 2011). Second, my results provide evidence that the European VC community is not only diverse in terms of human capital but also in terms of the value attributed to patents. I thus contribute to the scientific discussion that is concerned with promoting the heterogeneity of the venture capital industry and asks for intra-sample distinctions in researching venture capital decision making (Dimov et al. 2007). Third, I extend the literature on the role of patents in entrepreneurial finance (e.g., Baum and Silverman 2004, Hsu and Ziedonis 2011, Long 2002). So far, patents have been mostly regarded as beneficial for start-ups in attracting venture capital, whereas I now also discuss potential downsides and show that their role, from VCs' perspective, is in reality rather ambiguous.

As all scientific studies, this research is not without limitations, which in turn offer avenues of future research. First, my analyses are based on cross-sectional data and thus can only investigate VCs' attitudes at one specific point in time. To study investor attitudes in more detail, e.g., their development over time, longitudinal data would be desirable. Second, this research is focused on one specific aspect of VCs' decision making only (i.e. appreciation of patents). It could also be interesting to look at the link between VCs' human capital and their attitude towards other selection criteria such as alliances or characteristics of the entrepreneurial team. Third, while I investigate decision making of individuals, venture capitalists in practice often decide in teams or syndicates with other investors (Bygrave 1987, Lerner 1994b, Patzelt et al. 2009). Future research might thus be able to add further insights by integrating the human capital of team members or syndicate partners.

Practical implications for both entrepreneurs and VCs arise from this study. Entrepreneurs can derive information on which VCs may appreciate patents highly and which may rather have a negative attitude towards them. Accordingly, my findings may provide some guidance for ventures based on a patent-protected technology in finding an appropriate investor. The necessary human capital characteristics of the respective

VCs can often be inferred from their publicly available CVs on websites and social networks. For VCs, this research can help them to better understand how their personal background affects their decision making. Venture capital firm managers may use these findings to structure their own team of investment professionals according to a given portfolio strategy.

7 Entrepreneurial Perspective: Entrepreneurs' Perception of the Role of Patents

7.1 Introduction

For a holistic investigation of the role of patents in venture capital financing, the views of both capital providers and capital receivers need to be considered. Therefore, while the previous three chapters of this doctoral thesis are centered on the behavior of venture capitalists, the following chapter focuses on entrepreneurs.

In the following, I investigate different aspects of start-up patenting and financing from the perspective of high technology entrepreneurs. First, in Chapter 7.2, I examine how well entrepreneurs are familiar with the venture capital decision making process. In particular, I aim to determine to what extent entrepreneurs understand VCs' usage of selection criteria in the screening of business plans. Second, in Chapter 7.3, I analyze entrepreneurs' patenting activity and their attitude towards patents. Specifically, I study the relationship between entrepreneurs' experience in dealing with patents and the value they attribute to patents.

Both parts of this chapter follow the same structure. First, I introduce the research objectives and provide the relevant theoretical background. Then, I describe the data and methods, and finally I present the results of my analyses. I conclude each part by discussing my results in light of existing research and practical implications.

7.2 Entrepreneurs' View of Venture Capital Screening Criteria[69]

7.2.1 Theoretical background

Many innovative ventures struggle in commercializing their inventions due to a lack of financial resources. Finding adequate external financing is thus essential for most entrepreneurs (Ueda 2004), but appears to be difficult. Especially for early-stage ventures, existing information asymmetries between entrepreneurs and potential financiers are major obstacles in securing start-up funding (Shane and Cable 2002, Sørheim et al. 2011). When applying for external funding such as venture capital, rejection rates are commonly high (95%) and have even increased in recent years (Roberts 1991, Güllmann 2012). One reason for this trend could be the decreasing amount of venture capital available in comparison to the high demand. U.S. private equity funds, for instance, are increasingly shifting their focus from early-stage towards later-stage financing (Sohl 2003). However, there is still an active community of VCs in place that is willing to invest money into early-stage ventures. Therefore, it remains relevant to investigate why start-ups have difficulties in securing venture capital. One question that arises is whether entrepreneurs actually know how to properly approach VCs. More specifically, I aim to find out: do entrepreneurs understand what VCs are looking for in business plans?

As common in entrepreneurship literature, I define entrepreneur as a founder of a new venture. This definition comprises nascent entrepreneurs, who have only recently founded a start-up and are currently developing it, as well as more experienced entrepreneurs that have already run their start-up for several years (e.g., Honig 2001, Ebbers and Wijnberg 2011).[70] In contrast, pre-nascent entrepreneurs, who are still in the process of evaluating opportunities and have not established a legal entity yet, do not fall within this definition (e.g., Bishop and Nixon 2006). Venture capitalists, on the other hand, are defined as investors who supply new ventures with financial resources at

69 The data used in this section stems from a joint research project with Max Pfaffenzeller.

70 A start-up is commonly defined as a young venture that is no older than ten years (e.g., Certo et al. 2001, Beckman et al. 2007). In this study, an individual running a firm that is older than ten years is thus not considered an entrepreneur any more.

early development stages in exchange for an equity share in the particular venture (e.g., Gompers and Lerner 2001a).

Numerous studies have explained the investment process of venture capitalists and in particular the selection criteria employed at the different stages of that process (e.g., Hall and Hofer 1993, Tyebjee and Bruno 1984).[71] For instance, at the screening stage, we know that besides a large addressable market the start-up's available resources are of major importance. One might expect there is enough evidence on VCs' selection criteria that entrepreneurs can use for orientation. But what do entrepreneurs actually know? As a matter of fact, there are hardly any scientific studies that investigate entrepreneurs' perspective of venture capital selection criteria. Only Bruno and Tyebjee (1985) explore the view of entrepreneurs by surveying ventures that were denied venture capital. Moreover, Rakhman and Evans (2005) compare the perspectives of entrepreneurs and VCs regarding specific investment criteria and find only minor differences. However, the general validity of their results is questionable, as they used different questionnaires and variables for each group and as all participating VCs and entrepreneurs are connected to the same venture capital firm which is based in the South Sulawesi Province of Indonesia. There is – to the best of my knowledge - no scientific study that directly examines whether founders understand VCs' decision behavior. I aim to fill this gap by conducting a conjoint survey with a sample of entrepreneurs and a sample of venture capitalists. Using the same choice experiments for both groups, I first determine the importance the respondents in each sample attach to various venture capital selection criteria. Then, by comparing the results of both samples I identify similarities and differences between entrepreneurs and VCs. In other words I am able to specify to what extent entrepreneurs understand VCs' selection criteria.

[71] For an overview of relevant studies see Chapter 3.1of this thesis.

7.2.2 Data and methods

I investigate entrepreneurs' perspective of venture capital screening criteria with a sample of 91 entrepreneurs from Germany. All participating entrepreneurs fulfill the requirement of having founded a technology-based venture in either the biotech, cleantech, or ICT industry.

Potential participants were selected by first identifying start-up firms from one of the relevant industries through publicly available lists of firms from start-up competitions, government programs and venture capital portfolios. While only selecting start-ups younger than ten years I created a database of 250 relevant ventures. I then tidentified the actual founders and collected their contact information through a web search, which resulted in a list of 201 potential participants. Different methods were used to approach these entrepreneurs. In most cases I was able to establish a personal contact by phone before sending out the survey link by e-mail. Whenever a phone number was not available, an e-mail was sent directly to the entrepreneurs. In the e-mail, respondents were provided with an individual link to the online survey and asked to forward this link to additional relevant entrepreneurs in their network. A maximum of two reminders was sent out two weeks and four weeks after the initial contact. I eventually received answers from 91 entrepreneurs, who completed the entire survey. The direct response rate of 31%[72] is a sign of participants' high interest in this research.

Out of the 91 survey participants, 45% have founded an ICT start-up, 33% run a biotech business, and 22% are active in the cleantech sector. The sample features a broad range of experience, ranging from 1 to >15 years of being an entrepreneur. Even though a large share (67%) has only five or less years of experience, 46% of participants have already founded more than one firm in their career and can thus be regarded as experienced entrepreneurs. In respect to financing experience, 59% of participants have received venture capital, including 29 entrepreneurs who have already received multiple rounds of venture capital. Independent from venture capital funding experience, 48% of the sample have experience in dealing with business angels. A descriptive overview of the entire sample is provided in Table 29. As a comparison group for the sample of

[72] 63 out of 201 invitees responded to the survey directly. The remainder received the survey link from a colleague or business partner.

entrepreneurs I use the sample of 102 German venture capitalists that is described in Chapter 3.4.2 of this thesis (Table 7).

Table 29: Descriptive overview of entrepreneurs sample

Individual entrepreneurs (n=91)	
Entrepreneurial experience (in years)	Range 1- >15; Median 4
Position*	CEO 74; CTO 22; CFO 11; Head of Marketing 10; Other 22
Education* (Type of degree)	Business 28; Engineering 37; Science 37; Law 0; Other 5
Industry affiliation**	Biotech 30; Cleantech 20; ICT 41
Venture capital experience	Yes: 54 (one round 25; several rounds 18; several rounds & start-ups 11) No: 37
Office location	Germany 81; Austria 6; no answer 4

* Multiple answers possible
** As selected for experiment

Participating entrepreneurs were presented with a conjoint survey very similar to the one described in Chapter 3.4.1. First, they received a short introduction into the setting of start-ups applying for venture capital funding comparable to Figure 3.[73] After selecting their industry of expertise, respondents were shown six choice sets of three hypothetical start-ups each. The start-ups were described by different levels of three attribute variables: team's experience, patent protection, and alliances. Participating entrepreneurs were asked to rely on their own opinion and pick the best start-up ("highest likelihood of receiving venture capital") and worst start-up ("lowest likelihood of receiving venture capital") in each choice set. In sum, each respondent thus made twelve decisions.

All in all, compared to the original VC survey, only a few necessary adjustments (e.g., descriptions and demographic questions) were made to aim the survey toward entrepreneurs. The actual choice sets and variables used were exactly the same as in the

[73] Only the scenario of "technologies unknown" was used for the survey with entrepreneurs.

VC survey. The data collected from entrepreneurs and venture capitalists is thus highly comparable.

To analyze entrepreneurs' choices, I use the same methods as outlined in Chapter 3.4.3. I estimate rank-ordered mixed logit models to determine the contribution of each start-up characteristic to the likelihood of receiving venture capital. Comparisons between the two samples, entrepreneurs and VCs, are based on average marginal effects of the respective models and testing for significance is done by using simulations.

7.2.3 Results

I start the analysis of entrepreneurs' perception of venture capital screening criteria with an overall model that takes into account choice data from all entrepreneurs in the sample, independent of their industrial background. Results of the mixed logit model are displayed in Table 30.

Table 30: Estimation results – entrepreneurs sample

	Model 1: Overall model		
Model specification	Rank-ordered mixed logit		
Dependent variable: firm ranking	**Coeff.**	**SE**	**AME**
Patent applied for	1.988***	0.307	0.163
Patent granted	3.958***	0.373	0.351
Experience 5 years	1.557***	0.274	0.134
Experience 10 years	2.178***	0.355	0.191
Research alliance	2.145***	0.230	0.176
Sales alliance	4.047***	0.375	0.355
Obs/Persons	2730	91	
LR Chi-squared (6)	219.41		
Prob > Chi-squared	0.000		
Log likelihood	-660.86		

* p < 0.1; ** p < 0.01; *** p < 0.001

Robust standard errors reported

From the perspective of entrepreneurs all dummy variables have a highly significant positive influence on a start-ups' likelihood of receiving venture capital. To determine the relative importance of the individual start-up attributes I take the AME of each attribute's highest level and normalize them.[74] Alliance agreements turn out to be the most important attribute with a normalized value of 39.6%, only slightly higher than patent protection (39.1%). The team's relevant experience clearly shows the lowest importance value in the perception of entrepreneurs (21.3%). This importance ranking is very similar to the ranking observed in the VC sample and thus serves as a first indication that entrepreneurs, on average, have a solid understanding of VCs' selection criteria.

In order to investigate differences and similarities between entrepreneurs and VCs in more detail I compare the AMEs of each attribute level individually. Figure 16 plots the AMEs of both models for each attribute level next to each other and indicates the respective deviations. Somewhat surprisingly, I observe only minor differences between the two samples, of which none are statistically significant. I determine a descriptive measure of deviation between entrepreneurs and VCs by summing up the absolute values of the six deviations and dividing that by the sum of the AMEs of the VC model. This calculation returns an average deviation value of 7.8%[75], indicating that entrepreneurs understand VCs' usage of decision criteria quite well. However, one difference is noteworthy, even though it is not statistically significant: entrepreneurs attach a lower value to the team's experience than VCs. Thus, they seem to underestimate the importance of the team dimension in VCs' screening decisions.

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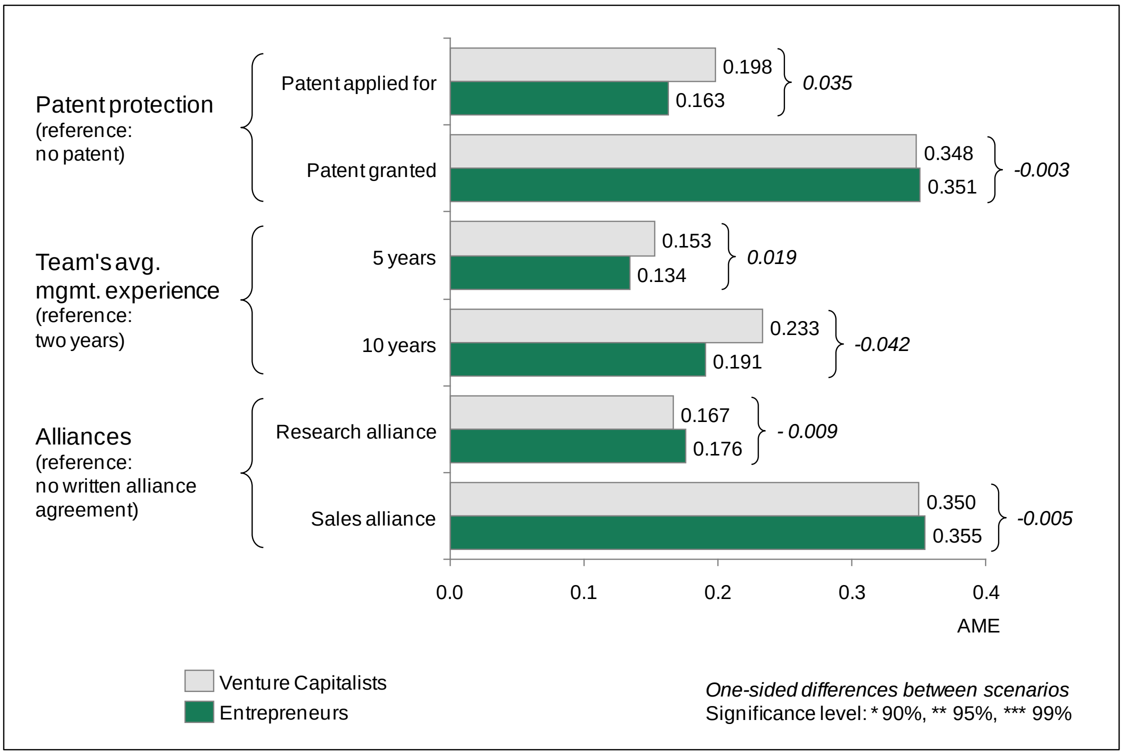
[74] Normalization analogous to calculation in Chapter 3.5

[75] 0.113 / 1.449 = 0.078

Figure 16: Comparison of average marginal effects between entrepreneurs and VCs



To account for industry-related effects and the slightly different sample composition[76] I now compare the choices of entrepreneurs and VCs in each industry separately. I split both samples by industry and estimate individual models for each industry. Table 31 shows the results of both samples within each of the three industries. To discuss differences and similarities I rely on the predicted AME values.

Differences between entrepreneurs and VCs are somewhat larger within each industry than in the overall model: biotech entrepreneurs deviate on average by 19.8%, cleantech entrepreneurs by 26.5%, and ICT entrepreneurs by 9.7%. In biotech, entrepreneurs appear to underestimate the importance of granted patents and research alliances. Similar differences are notable for both team experience variables. In contrast, entrepreneurs seem to overestimate the value of sales alliances. In the ICT sector, entrepreneurs attach a slightly higher importance to granted patents than VCs while the

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[76] Both samples consist of an equal amount of participants from the biotech and ICT industry. The VCs sample, however, features a higher share of participants from the cleantech sector than the entrepreneurs sample.

differences for both alliance variables are negligible. With regard to the team experience variables, I again observe lower values in the entrepreneurs’ than the VCs’ model. Concerning the cleantech industry, I find an overestimation of granted patents and research alliances by the entrepreneurs. On the other hand the value they attribute to patent applications, sales alliances and ten years of experience appears to be too low. When testing each dummy variable for significance, however, none of the AME differences between VCs and entrepreneurs turns out to be statistically significant.

All in all, I find that on the industry level, differences between entrepreneurs and VCs, despite not being significant, are more pronounced. Hence, entrepreneurs do not necessarily understand VCs’ decision making as well as it appeared on the aggregate level. Interestingly, the importance of the start-up team’s experience is consistently underestimated by entrepreneurs from all industries.

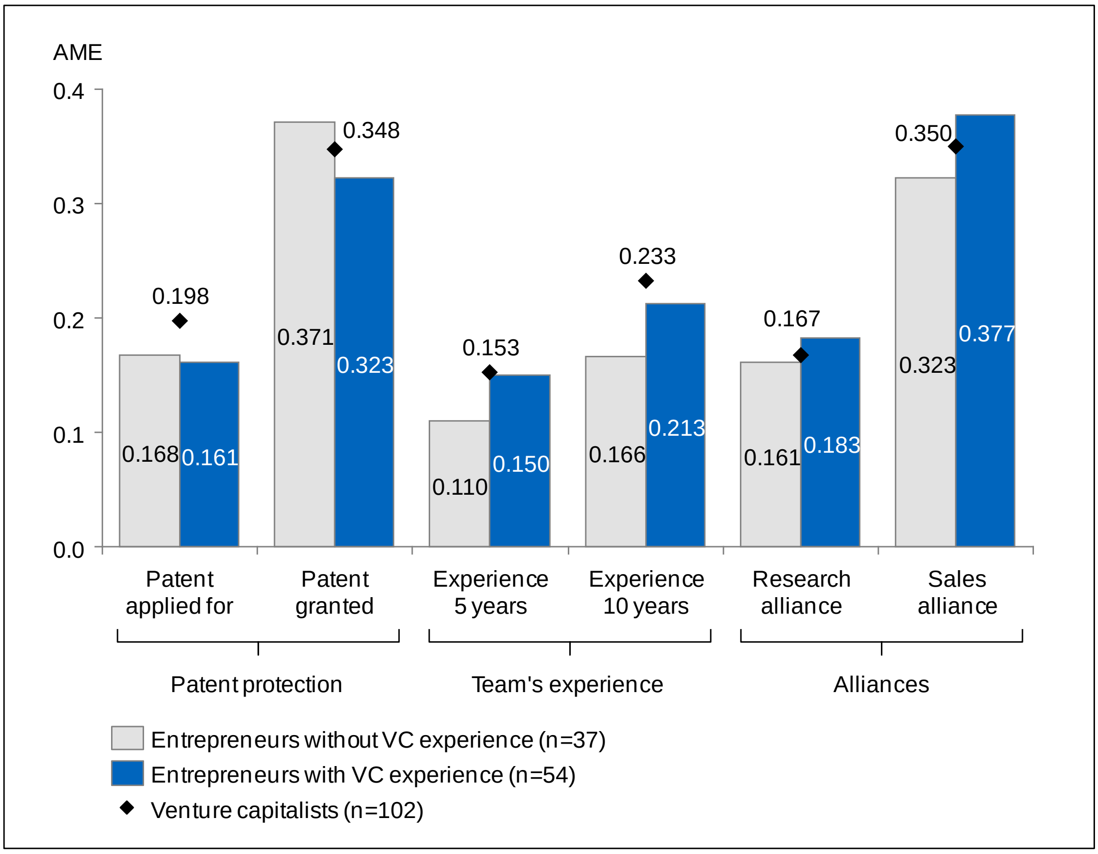
Table 31: Estimation results – comparison of industry models

	Biotech						Cleantech						ICT					
	Entrepreneurs			VCs			Entrepreneurs			VCs			Entrepreneurs			VCs		
Dependent variable: firm ranking	Coeff.	SE	AME	Coeff.	SE	AME	Coeff.	SE	AME	Coeff.	SE	AME	Coeff.	SE	AME	Coeff.	SE	AME
Patent applied for	3.471***	0.832	0.195	3.096***	0.765	0.190	1.201*	0.574	0.115	3.277***	0.761	0.227	1.943***	0.456	0.163	2.067***	0.470	0.167
Patent granted	6.031***	1.127	0.370	6.115***	0.949	0.435	3.326***	0.627	0.354	4.101***	0.806	0.285	3.801***	0.608	0.341	3.629***	0.520	0.317
Experience 5 years	2.448***	0.661	0.148	3.206***	0.693	0.207	1.267*	0.543	0.128	1.616***	0.518	0.117	1.439***	0.407	0.125	1.714***	0.406	0.140
Experience 10 years	3.265***	0.919	0.197	3.815***	0.752	0.254	1.634**	0.626	0.168	2.690***	0.783	0.195	2.161***	0.509	0.193	2.880***	0.521	0.253
Research alliance	3.240***	0.721	0.185	3.604***	0.793	0.234	1.996***	0.608	0.194	1.526***	0.557	0.106	1.789***	0.443	0.150	2.027***	0.475	0.164
Sales alliance	6.137***	1.131	0.369	4.317***	0.827	0.286	3.125***	0.616	0.318	4.849***	0.875	0.355	4.008***	0.575	0.364	4.538***	0.637	0.385
Obs/Persons	900	30		870	29		600	20		1020	34		1230	41		1170	39	
LR chi2(6)	92.98			52.49			43.19			83.53			91.43			87.73		
Prob > chi2	0.000			0.000			0.000			0			0.000			0.000		
Log likelihood	-195.42			-181.46			-151.60			-250.84			-304.32			-275.37		

Model specification: Rank-ordered mixed logit, robust standard errors
* $p < 0.1$; ** $p < 0.01$; *** $p < 0.001$

As described above, my sample contains a relatively high share of entrepreneurs that have already received venture capital funding for their venture. The experience in working with VCs is likely to have a positive influence on understanding their decision behavior. Several studies have shown that serial entrepreneurs are advantaged in sourcing venture capital compared to first-time entrepreneurs (e.g., Gompers et al. 2006, Wright et al. 1997, Zhang 2011). One reason for this effect could be that serial entrepreneurs have a better understanding of what VCs are looking for and thus know how to write their business plans in a way to meet VCs' decision criteria. To investigate this phenomenon in my dataset, I estimate separate models for venture capital-experienced entrepreneurs and entrepreneurs without prior venture capital experience. I then compare the results of both models with the actual results of the VC sample. Figure 17 provides a summary of the results. AMEs of each selection criterion for the two groups of entrepreneurs are displayed as vertical bars, while the diamond denotes the respective AME from the VC model and thus constitutes the reference point.

Figure 17: Comparison of entrepreneurs with and without VC experience



Comparing the two groups of entrepreneurs I observe substantial differences in the value they ascribe to the given start-up characteristics. Entrepreneurs without VC experience attach the highest relative importance to “patent protection”, while entrepreneurs with VC experience put the highest emphasis on “alliances”. With regard to the attribute “team’s experience”, both attribute levels show higher AMEs in the model of experienced entrepreneurs than for inexperienced entrepreneurs, but these differences are not significant. Comparing the perceptions of the two entrepreneurial groups with the decision making of actual VCs, I find that the AMEs of VC-experienced entrepreneurs are much closer to the respective values of the VCs than the AMEs of entrepreneurs without VC experience. Especially regarding the importance of the start-up team’s experience, large differences between non-VC-experienced entrepreneurs and actual venture capital investors occur, which, however, just fail to be significant. Nevertheless, entrepreneurs who have previously worked with VCs appear to be much better informed about VCs’ usage of selection criteria than their less-experienced peers. This finding is not surprising but may explain in part why experienced entrepreneurs are more successful in attracting venture capital funding.

7.2.4 Discussion

The aim of this study is to investigate the perceptions of entrepreneurs on VCs’ selection criteria in the screening of business plans. In particular, I compare entrepreneurs’ view with the decision making of actual VCs and determine to what extent entrepreneurs understand VCs’ usage of selection criteria.

Overall, I find that entrepreneurs have a decent knowledge of VCs’ decision making. My analysis of choice data from entrepreneurs and VCs reveals that both groups attach similar importance values to the given start-up characteristics. This means that a lack of understanding VCs’ decision parameters cannot be the main reason for the high rejection rates of entrepreneurs’ business plans. If anything, entrepreneurs appear to underestimate the amount of relevant management experience VCs expect from start-up teams. This tendency holds true across all high-technology industries that I investigate. From a theoretical perspective this finding is somewhat surprising, as the central role of the entrepreneurial team, and especially its relevant experience in the venture capital selection process, is well documented (e.g., Beckman et al. 2007, Franke et al. 2008, Muzyka et al. 1996).

At a more detailed level of analysis, however, two types of diverging perceptions between entrepreneurs and VCs emerge. First, when investigating individual industries separately, larger differences between entrepreneurs and VCs come to light. For instance, in the biotech industry, entrepreneurs appear to underestimate the importance of granted patents and overestimate the importance of sales alliances in VCs' screening decisions. In complex product industries (cleantech and ICT), on the contrary, the value of a granted patent is rather overestimated by entrepreneurs. While VCs' evaluation of selection criteria significantly varies between industries (see Chapter 4.4), entrepreneurs appear not to recognize these industry-related differences. Patent protection is the best example: entrepreneurs apparently have not yet realized that a start-up's patent has a much stronger influence on the likelihood of receiving venture capital in biotech than in the cleantech or ICT industry. Thus, entrepreneurs are well advised to inform themselves about the value of start-up resources in their specific industry (e.g., Cohen et al. 2000, Levin et al. 1987).

Second, I find indications for a moderating effect of entrepreneurs' venture capital experience. Entrepreneurs who have previously received venture capital funding evaluate the given selection criteria differently than entrepreneurs who have never been financed by a VC. As a matter of fact, the estimated attribute values of the VC-experienced entrepreneurs are much closer to the actual VCs' values than those of the inexperienced entrepreneurs. In particular entrepreneurs who have never received venture capital funding appear to underestimate the importance of relevant management experience for raising venture capital. Even though a statistical significance of the differences between the two groups of entrepreneurs cannot be proven due to the small sample size, these findings are not surprising as it seems logical that individuals who have worked with VCs know better what screening criteria they use. My results provide a further argument in explaining why experienced entrepreneurs are advantaged in sourcing venture capital financing (Wright et al. 1997, Zhang 2011). Hence, inexperienced entrepreneurs are advised to seek the support of VC-experienced entrepreneurs before submitting their business plan to a VC.

The study presented in this chapter makes an important contribution to the literature on financing technology start-ups through venture capital (e.g., Muzyka et al.

1996, Petty and Gruber 2011, Tyebjee and Bruno 1984). To the best of my knowledge, it is the first study to assess entrepreneurs' perceptions of VCs' selection criteria and to compare them with the usage of these criteria by actual VCs. Thus, I am able to provide new insights to the start-up financing process by explaining to what extent entrepreneurs understand VCs' decision making.

A number of implications for researchers and practitioners can be derived from the results of this study. First, since I find that high-technology entrepreneurs understand the decision behavior of VCs quite well, scholars and policy makers should continue to focus on other explanations for the "financing gap" that many high-technology start-ups face. Second, my industry-specific analysis shows that entrepreneurs need to be better informed about the value of start-up resources in their respective industry. Third, since they are less familiar with VCs' selection criteria, novice entrepreneurs should reach out for help from VC-experienced entrepreneurs when writing up a business plan to increase their chances of raising venture capital funding.

7.3 Determinants of Entrepreneurs' Attitude towards Patents

7.3.1 Theoretical background and hypotheses

The patenting behavior of technology firms has been in the interest of innovation scholars for many years. Existing research provides insights into corporations' motives for patenting, the perceived usefulness of patents, and the various patenting strategies that technology firms employ. Technology firms file patents for various reasons that often go well beyond the original purpose of a patent to protect an inventor's proprietary technology (e.g., Blind et al. 2006, Cohen et al. 2000). The utility that managers attribute to patents and thus the decision to patent or not strongly depends on the technology structure and the competitive environment of the industry their company is active in (e.g., Arundel 2001, Levin et al. 1987). Among the firms that decide to actively engage in filing patents, various patenting strategies can be observed ranging from building patent fences to intentionally keeping patents pending (e.g., Bessen 2003, Hall and Ziedonis 2001, Henkel and Jell 2010, Schneider 2008).

While most existing papers focus on patenting issues in large established corporations, some recent studies investigate what the managers of small and young firms think about patents (e.g., Graham and Sichelman 2008, Graham et al. 2009, Veer and Jell 2011). What still is missing, however, is an understanding of the drivers of entrepreneurs' attitude towards patents. In particular it would be interesting to know whether a person's own experience in patenting changes his/her perception of the usefulness of patents for start-ups. Both a positive and a negative influence seems possible; entrepreneurs possessing a patent might have experienced that the patent was very helpful in developing their venture and thus have a more positive attitude towards patents than non-patenting experienced entrepreneurs. On the other hand, patent-holding entrepreneurs might also be frustrated with the patent system and have come to the conclusion that patents are often only of limited value. Consequently their attitude towards patents would be rather negative. This analysis might give us an indication whether entrepreneurs, in retrospect, regard their patenting activities as useful or not.

As shown in Chapter 6 of this dissertation, an individual's attitude towards patents can to a good extent be explained through his/her human capital characteristics.

Human capital, in this context, refers to a person's education and experience, and may be divided into general human capital and specific human capital (Becker 1975). Specific human capital relates to an individual's acquired knowledge that is applicable in a certain profession or in a certain field (e.g., Dimov and Shepherd 2005, Zarutskie 2010). It can cover several knowledge dimensions and may for instance be industry-specific, task-specific or IP-specific. In my analyses of VCs' decisions, especially IP-specific human capital has a strong impact on the importance individuals attribute to patents (see Chapter 6.4.1). Thus, for the purpose of this study with entrepreneurs, I put a particular focus on IP-specific human capital and investigate how it influences entrepreneurs' attitude towards patents.

An entrepreneur's main source of IP-related knowledge is experience in dealing with patents. Prosecuting a patent application from filing to granting and beyond provides the inventor with profound insights into the patent system and may certainly shape his/her perception of patent utility (e.g., Granstrand 1999). Furthermore, an entrepreneur who holds a patent him/herself can be assumed to understand more how valuable and useful patents actually are for technology start-ups than an entrepreneur without such experience. Regarding the question in which direction patenting experience influences entrepreneurs' attitude towards patents, current literature offers arguments for both a positive and a negative influence.

On the one hand, entrepreneurs' experience with patents might be predominantly positive. As outlined in Chapter 2.1.3, patents theoretically provide a number of benefits for developing ventures beyond their original protective function (e.g., Graham and Sichelman 2008, Veer and Jell 2011). Founders who are in possession of patents can judge to what extent these benefits materialize in practice. If patent owners have been able to benefit from their patents, e.g., by securing their USP against competitors or by impressing customers and investors, these entrepreneurs should have a rather positive perception of patents.

On the other hand, the negative aspects of patenting might prevail in practice.[77] Filing a patent is not only expensive and time-consuming but also requires a lot of patience during the examination process (Lemley 2001). Even when granted, the actual effectiveness of patents as value appropriation mechanisms is often limited (e.g., Cohen

[77] See Chapter 2.1.3 for a discussion of disadvantages related to patenting.

et al. 2000, Teece 1986). Thus, the money invested may not pay off. Furthermore, many scholars argue that patents are only valuable if they can be enforced, which leads to the conclusion that start-ups without sufficient financial resources may only receive little benefit from their patents (Bessen 2008). Again, patent holding entrepreneurs should be able to judge the drawbacks of patents better than non-patenting entrepreneurs. Assuming that many patent applicants become frustrated with the patent system and personally experience the limited effectiveness of IP rights in practice, they may realize that patents are commonly overrated. Consequently, patent owning entrepreneurs may attach a lower importance to patents as their non-patent experienced counterparts.

To account for both lines of argumentation, I present two opposing hypotheses.

Hypothesis 1a: *Patenting experience positively affects entrepreneurs' attitude towards patents.*

Hypothesis 1b: *Patenting experience negatively affects entrepreneurs' attitude towards patents.*

Patenting experience incorporates two main levels: experience in filing patents and experience in dealing with granted patents. To further explore the impact of patenting experience on entrepreneurs' appreciation of patents I include both levels in my analysis.

7.3.2 Data and methods

For the purpose of this study, I analyze data from two main sources: a survey with entrepreneurs and a patent database provided by the EPO. In the following, I first explain how I collected the relevant data from both sources and then provide a detailed description of all variables that I incorporate in my analysis.

7.3.2.1 Survey data

I base my analysis on the same sample of entrepreneurs as described in Chapter 7.2.2. This group consists of 91 founders of high technology start-ups in Germany, who are active in either the biotech, cleantech or ICT industry. Table 29 in the previous section of this chapter shows the diversity of their educational backgrounds and amount of working experience.

A large part of the data used in this investigation stems from a survey conducted in the first quarter of 2011. This survey consisted of three parts. In the first part, I collected data on respondents' human capital characteristics by requesting information on their academic and professional background. The second part featured a choice experiment to determine the importance of start-up resources for venture capital funding (see Chapter 7.2.2 for a detailed description). In the last part, participating entrepreneurs were asked questions regarding the role of patents for technology start-ups. I use and combine data from all three parts of this survey in the following analysis.

7.3.2.2 Patent data

To adequately investigate entrepreneurs' patenting experience I complemented the survey data with patent data from the EPO Worldwide Patent Statistical Database (PATSTAT). In particular, I searched for all patents filed by the entrepreneurs represented in my sample. This search process was structured as follows.

I prepared for the patent search by gathering all available information on the entrepreneurs in the sample. In addition to the survey data I collected further personal and firm information through a web search. As a basis for finding all patents filed by my sample of entrepreneurs, I used raw patent data from PATSTAT (version April 2011).[78] PATSTAT covers patent applications from more than 80 countries and contains information on the patent itself as well as on the inventor and applicant (EPO 2012a). For the identification of all patents relevant for my study I relied on a search mechanism developed by Schön et al. (2011). This mechanism uses a "2-gram algorithm" to match inventors in PATSTAT with the given entrepreneurs based on similarity of names (first name and surname). Applying this procedure resulted in a list of 416 inventor names, with 1,751 corresponding patent applications, matched to 39

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[78] This version includes patent applications published between 1978 and early 2011.

entrepreneur names.[79] As this list is based on a matching of names only, it had to be filtered further to make sure that it only represents the wanted entrepreneurs and not other individuals with the same name. This filtering was done manually on an individual patent basis. I used all available information, e.g., patent abstracts, industry affiliations, company names, or addresses, to verify whether an inventor was part of my sample or not. The resulting list consisted of 261 inventors (person_ids) matched to 36 entrepreneurs holding in total 1,130 patents.[80]

In short, the patent data shows that out of the 91 entrepreneurs in my sample, 36 have filed a patent and 24 have been granted a patent. Their 1,130 patent filings range from September 1978 to June 2010. More patent-related findings will be presented in the descriptive results section (Chapter 7.3.3.1).

7.3.2.3 Variables

In line with my analyses in Chapter 6.3 I use standard regression models to investigate the determinants of entrepreneurs' attitude towards patents. In the course of this, I employ three different dependent variables as measures for entrepreneurs' attitude towards patents: (1) a *patent utility value* revealed in a choice experiment, (2) a *patent importance score* based on traditional Likert-scale questions, and (3) a variable called *funding score* that is also derived from a survey question.

The first measure, *patent utility value*, is based on the conjoint analysis described in Chapter 7.2.2. In this conjoint experiment, entrepreneurs were presented with choice sets of three hypothetical start-ups each and asked to select the one they believe to have the highest chance of raising venture capital funding. As a basis for these decisions, the start-ups were described with different levels of three attributes: team experience, alliances, and patent protection. Levels of the attribute "patent protection", for instance, were "none", "patent applied for", and "patent granted". By analyzing the choice decisions with rank-ordered mixed logit models, I determine the value contribution of each attribute to the odds of being chosen as most preferred

[79] It is important to note that one individual may have several „person_ids" in PATSTAT. This means that often several inventors refer to the same person.

[80] The final list of patents includes utility patents only and has been cleaned from double listings and other errors. Again, most entrepreneurs have filed patents under several "person_ids".

venture. For each attribute level, participant-specific coefficients can be derived from the estimation.[81] As I am interested in entrepreneurs' perception of patents, I select the investor-specific coefficient of the attribute level "patent granted" as the dependent variable. It can be interpreted as the utility an entrepreneur attaches to a patent in the context of venture capital funding. This measure of entrepreneurs' attitude towards patents varies considerably among survey participants with the *patent utility value* ranging from 0.24 to 6.28 with an average of 3.95.

To construct the second measure, *patent importance score*, I asked respondents (after the choice experiment) for their rating of different patenting motives. More precisely, entrepreneurs had to judge the usefulness of patents as (a) a legal right to protect a unique technology, (b) a legal right to generate revenues from licensing or selling the patent, (c) a signal of the quality of a start-up's technology, and (d) a signal of the start-up team's professionalism, using a five-point Likert scale (1 = not important at all, 5 = very important). Every entrepreneur's four answer values were added up to a *patent importance score*.[82] The average value of this second dependent variable is 14.0, with a minimum of 5 and a maximum of 19.

The third dependent variable I investigate, *funding score*, relates to the direct association between patenting and external funding. On a five-point Likert scale[83], respondents were asked to judge the importance of patenting as a means to "improve a start-up's chances to secure future funding." Answer values for this variable range from 1 to 5 and average 3.93.

As explanatory variables, I include several human capital variables and control variables in my analyses. I test the influence of *IP-specific human capital* on entrepreneurs' attitude towards patents with help of the two dummy variables, *patent_filed* and *patent_granted*. *Patent_filed* indicates whether a participant has ever applied for a patent, and *patent_granted* denotes whether a participant has ever been granted a patent. According to my previously described patent search, 40% of the entrepreneurs in my sample have filed a patent application and 26% hold a granted

[81] The mixed logit estimation and calculation of entrepreneur-individual coefficients is done analogously to the VC study. Refer to Chapter 6.3.2 for more details.

[82] This variable is constructed analogously to the variable *patent importance score* in the VC study presented in Chapter 6.3.2.

[83] 1 = not important at all, 5 = very important

patent. Furthermore, I incorporate the variable *ip_knowhow*, which is based on participants self-assessment regarding their "knowledge on topics related to intellectual property" on a five-point Likert scale ranging from 1 = "IP novice" to 5 = "IP expert". The sample features all levels of *ip_knowhow* and an average value of 3.20.

As stated in Patzelt et al. (2009) and my analysis in Chapter 6, *industry-specific human capital* is defined by a respondent's technical education. The dummy variable *edu_tech* indicates whether an entrepreneur holds a university degree in either engineering or science. Seventy-seven percent of the participants have a technical background by this definition. *Task-specific human capital* is operationalized as the number of years a participant has worked as an entrepreneur *(experience_years*). A median of four years suggests that most of the entrepreneurs are rather inexperienced; however, 10% of participants have more than 15 years of entrepreneurial experience. Both *industry-specific* and *task-specific human capital* have been shown to influence managers' decisions and are therefore included in this analysis (e.g., Dimov et al. 2007, Patzelt et al. 2009, Zarutskie 2010).

To properly isolate the effects of human capital characteristics on entrepreneurs' attitude towards patents I include the following control variables in my estimations. The two variables *biotech_dummy* and *ict_dummy* account for the fact that an individual's appreciation of patents may depend on the industry he/she is mainly active in (e.g., Cohen et al. 2000, Mann and Sager 2007).[84] *VCfunding* describes whether an entrepreneur has received venture capital financing at some time and thus potentially perceives patents as more important. The variable *edu_business* accounts for the possibility that people with a management degree may regard patents differently. The two dummy variables *pos_ceo* and *pos_cto* check for a potential influence of different organizational positions, Chief Executive Officer (CEO) and Chief Technology Officer (CTO), on the dependent variables. Finally, the variable *country_D* accounts for potential regional differences by taking on a value of 1 if the respondent is based in Germany and a value of 0 otherwise.

Table 32 provides an overview of all variables by showing descriptive statistics as well as correlations between the respective variables. To avoid issues associated with multicollinearity, the two highly correlated variables *patent_filed* and *patent_granted*

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[84] See also Chapter 4 of this thesis.

will not be jointly included in the statistical estimations. In the next section, I first present some descriptive findings before I show the results of my estimation models.

Table 32: Descriptive statistics and correlations

No.	Variable	Mean	S.E.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	patent utility value	3.95	1.33	1														
2	patent importance score	14.00	2.67	0.35	1													
3	funding score	3.93	1.08	0.27	0.39	1												
4	patent_filed	0.40	0.49	0.14	0.08	0.13	1											
5	patent_granted	0.26	0.44	0.04	0.04	0.06	0.74	1										
6	ip_knowhow	3.19	1.00	-0.02	0.13	0.05	0.26	0.29	1									
7	edu_tech	0.77	0.42	-0.06	-0.02	0.09	0.02	-0.03	-0.05	1								
8	experience_years	5.81	4.77	-0.10	-0.09	-0.20	0.12	0.16	0.34	-0.02	1							
9	biotech_dummy	0.33	0.47	0.02	0.12	0.28	0.20	0.00	0.01	0.22	0.05	1						
10	ict_dummy	0.45	0.50	-0.07	-0.18	-0.27	-0.06	0.01	0.01	-0.13	-0.07	-0.64	1					
11	VCfunding	0.59	0.49	-0.13	-0.08	-0.05	0.26	0.19	0.16	0.02	0.41	0.10	0.03	1				
12	edu_business	0.31	0.46	-0.03	0.14	0.02	-0.15	-0.13	-0.05	-0.43	-0.05	-0.21	0.11	0.02	1			
13	pos_ceo	0.81	0.39	0.11	0.24	0.00	0.16	0.03	0.20	0.14	0.18	0.04	-0.02	-0.05	0.01	1		
14	pos_cto	0.24	0.43	-0.07	-0.09	-0.20	0.07	0.07	0.10	0.13	0.10	-0.12	0.21	-0.11	-0.04	-0.06	1	
15	country_D	0.89	0.31	0.03	-0.07	0.11	0.00	-0.03	-0.22	0.06	0.14	-0.05	-0.03	0.14	0.08	0.01	-0.13	1

Note: All correlations with absolute value above 0.21 are significant ($p<0.05$), n= 91

7.3.3 Results

7.3.3.1 Descriptive results

A descriptive analysis of the matched patent data provides some interesting insights into the background of my sample of entrepreneurs. Table 33 shows that the overall patenting experience of the participating entrepreneurs is quite high. Forty percent of all participants have applied for a patent and 26% have even been granted a patent. When splitting the sample into two groups, entrepreneurs who have at some time received venture capital funding (VC-funded) and entrepreneurs who have never received venture capital funding (non VC-funded), an interesting difference comes to light; the group of VC-funded entrepreneurs exhibits a significantly higher share of active patentees than the non VC-funded comparison group. Accordingly, the data suggests that holding patents, in the form of either applications or grants, increases a start-up's likelihood of raising venture capital financing.[85] This observation relates well to previously reported positive effects of patent ownership on start-up evaluation by VCs (e.g., Baum and Silverman 2004, Engel and Keilbach 2007, Mann and Sager 2007).[86]

Table 33: Proportion of entrepreneurs with patenting experience

	Total	**Non VC-funded**	**VC-funded**	**p-value***
Patent_filed	0.40	0.24	0.5	0.014
Patent_granted	0.26	0.16	0.33	0.070
N	91	37	54	

* based on a two-sided t-test.

An analysis of the number of patent applications and grants per group of entrepreneurs yields similar results. Table 34 provides evidence that entrepreneurs who

85 Please note that this analysis does not unambiguously prove a causal effect of patenting on venture capital funding. The successful receipt of venture capital may also lead to higher patenting activity (e.g., Bertoni and Tykvova 2012). Since I do not have any timing information regarding the venture capital funding data this issue cannot be resolved.

86 See also Chapter 2.3.1 of this dissertation.

have managed to source venture capital hold a significantly higher number of patent applications than non-funded entrepreneurs (9.00 compared to 1.78). The same effect appears when comparing the average stock of granted patents (2.81 vs. 0.50). Apparently, engaging in patenting activities increases start-ups' chances of external financing.[87]

Table 34: Average number of patent applications and grants by groups of entrepreneurs

		Non VC-funded	VC-funded	p-value*
Applications				
	All entrepreneurs (n)	1.78 (36)	9.00 (53)	0.014
	Biotech (n)	0.60 (10)	15.40 (19)	0.053
	Cleantech (n)	3.50 (10)	2.33 (9)	0.711
	ICT (n)	1.44 (16)	6.53 (25)	0.123
Grants				
	All entrepreneurs (n)	0.50 (36)	2.81 (53)	0.025
	Biotech (n)	0.00 (10)	4.84 (19)	0.083
	Cleantech (n)	1.10 (10)	1.22 (9)	0.925
	ICT (n)	0.44 (16)	1.84 (25)	0.157

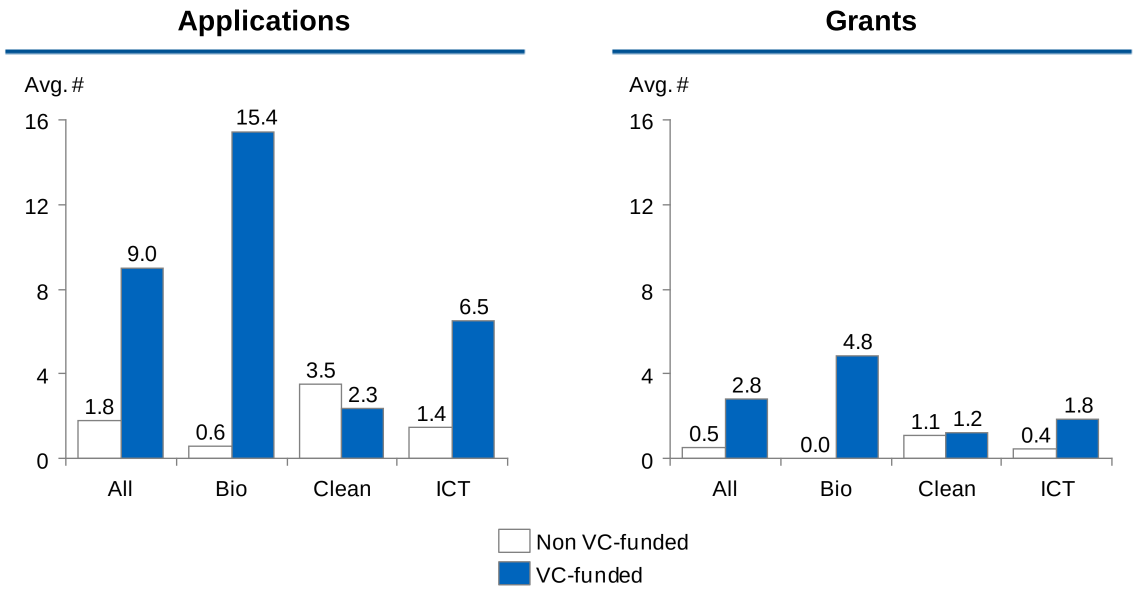
* based on a two-sided t-test
Note: Two outliers with >100 patent applications have been omitted from this analysis

The observed differences can be further broken down by industries; Figure 18 provides a graphical illustration. While in the biotech sector patenting activity and success in raising venture capital seem to be highly associated, this effect is not as pronounced in the two other industries. In biotech, especially the observation that none of the entrepreneurs without financial funding owns a granted patent is noteworthy, as it implies that an approved patent is a necessary condition for receiving venture capital in this industry. In ICT, the average number of both patent applications and grants is also much higher for the group of VC-funded entrepreneurs but does not pass the significance test, most likely due to the small sample size. The situation is different in the cleantech industry, where funded and non-funded entrepreneurs hold on average a

[87] Again, the observed differences may also be driven by the fact that entrepreneurs patent more after they have received financial capital from VCs.

similar stock of patents. No direct relationship between patenting and sourcing venture capital, or vice verse, appears to exist.

Figure 18: Average patent stocks per group of entrepreneurs



As outlined in Chapter 2.1.3, various reasons may motivate entrepreneurs to file patents. Motives related to two types of patent functions are particularly important in the context of venture capital financing: the usage of patents as quality signals and as productive assets. In my survey, I asked entrepreneurs what importance they attribute to these different patent functions on a scale from 1 (not important at all) to 5 (very important). According results are displayed in Table 35.

Table 35: Importance ranking of patent functions by entrepreneurs

Variable	N	Median	Mean	Std. Dev.	Min	Max	Share 4 & 5
legal_protect	91	5	4.42	0.92	1	5	86.0%
legal_sale	91	4	3.56	1.07	1	5	53.8%
signal_tech	91	3	3.11	1.23	1	5	44.0%
signal_team	91	3	2.91	1.08	1	5	29.7%
legal_score	91	8	7.98	1.67	2	10	
signal_score	91	6	6.02	2.08	2	10	
diff: p=0.000							

The original function of a patent serving as a legal right to protect a unique technology is considered most important while patents' function to generate revenues from licensing or selling takes second place. Using patents as signals of technological quality ranks third while patents' function as signals of the team's professionalism is regarded as least important. Interestingly, this ranking of the four patent functions is exactly the same as the ranking that is derived from VCs' answers to the same questions (compare Chapter 6.4.2). To investigate the difference between patents' signaling and productive value I generate two additional variables, one for each main function: *legal_score* reflects the sum of the values of the two productive functions (mean 7.98) and *signal_score* sums up the values of the two signaling functions (mean 6.02). When comparing the means of the two variables, both a t-test and a Wilcoxon signed-rank test confirm that the difference in values is highly significant (p=0.000). This finding is again in line with results from the VC survey. Both parties (VCs and entrepreneurs) appear to agree that patents' productive value outperforms their signaling value.

7.3.3.2 Multivariate models

For the purpose of investigating the determinants of entrepreneurs' attitude towards patents I use standard regression models. I estimate the two dependent variables *patent utility value* and *patent importance score* with OLS regressions, analogous to the estimation models in Chapter 6.4.1. For each dependent variable, I construct two models, one that incorporates the variable *patent_filed* (a) and a second one that includes the variable *patent_granted* (b). Estimation results are displayed in Table 36, which features coefficient values, robust standard errors, and model specifications.

Table 36: Estimation results – patent utility value and patent importance score

	Model 1a		Model 1b		Model 2a		Model 2b	
Dependent variable	**Patent utility value**		**Patent utility value**		**Patent importance score**		**Patent importance score**	
	Coeff.	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**
IP-specific human capital								
patent_filed	0.468	0.340			0.226	0.561		
patent_granted			0.187	0.383			0.286	0.638
ip_know	-0.039	0.161	-0.013	0.162	0.390	0.298	0.381	0.302
Industry-specific human capital								
edu_tech	-0.331	0.347	-0.391	0.334	0.009	0.817	0.000	0.801
Task-specific human capital								
experience_years	-0.026	0.042	-0.033	0.043	-0.099	0.079	-0.102	0.080
Controls								
biotech_dummy	-0.168	0.428	-0.063	0.420	0.186	0.801	0.243	0.791
ict_dummy	-0.257	0.384	-0.238	0.377	-0.975	0.833	-0.961	0.832
VCfunding	-0.334	0.383	-0.230	0.386	-0.135	0.659	-0.116	0.662
edu_business	-0.171	0.321	-0.229	0.318	1.007	0.623	1.010*	0.605
pos_ceo	0.385	0.375	0.487	0.383	1.561*	0.921	1.607*	0.926
pos_cto	-0.147	0.356	-0.086	0.355	-0.190	0.669	-0.177	0.663
country_D	0.205	0.478	0.251	0.493	-0.269	0.754	-0.256	0.742
Constant	4.258***	0.851	4.169***	0.856	12.400***	1.585	12.375***	1.574
Regression	OLS		OLS		OLS		OLS	
F-value	0.71		0.56		1.16		1.17	
R^2	0.08		0.06		0.16		0.17	
Adjusted R^2	-0.05		-0.07		0.05		0.05	
N	91		91		91		91	

Note: *** p<0.01, ** p<0.05, * p<0.1, Robust standard errors reported

Unexpectedly, none of the four models comes out to be statistically significant with F-values ranging between 0.56 and 1.17. In other words, the two dependent variables measuring entrepreneurs' attitude towards patents cannot be explained by the independent variables used in the analysis. With regard to my research variables, this means that human capital characteristics, such as patenting experience, cannot be regarded as determinants of entrepreneurs' appreciation of patents.

As third measure of entrepreneurs' attitudes towards patents, I consider the variable *funding score* (see Chapter 7.3.2.3). Since the values of this variable are based on an ordinal ranking scale I estimate an ordered probit model (Dougherty 2002). Table 37 summarizes the estimation results.

Table 37: Estimation results – funding score

Dependent variable: Funding score		Model 3a Coeff.	Model 3a SE	Model 3b Coeff.	Model 3b SE
IP-specific human capital					
	patent_filed	0.271	0.268		
	patent_granted			0.253	0.299
	ip_know	0.245*	0.136	0.243*	0.140
Industry-specific human capital					
	edu_tech	0.302	0.327	0.280	0.295
Task-specific human capital					
	experience_years	-0.068**	0.030	-0.071**	0.033
Controls					
	is_biotech	0.527	0.352	0.598*	0.363
	is_ict	-0.302	0.312	-0.287	0.334
	VCfunding	-0.147	0.287	-0.115	0.310
	edu_business	0.330	0.297	0.318	0.296
	pos_ceo	-0.064	0.321	-0.007	0.281
	pos_cto	-0.456	0.289	-0.431	0.266
	country_D	0.690*	0.396	0.708**	0.353
	Regression	Ordered probit		Ordered probit	
	LR Chi^2	24.03**		27.43***	
	Pseudo R^2	0.10		0.10	
	N	91		91	

Note: *** p<0.01, ** p<0.05, * p<0.1, Robust standard errors reported

Even though both models are statistically significant (Model 3a: p<0.05, Model 3b: p<0.01), their explanatory power is still quite low (pseudo R^2=0.10). I find a positive influence of IP know-how on entrepreneurs' appreciation of patents and a negative impact of task-specific human capital on the dependent variable. Contrary to my expectations, patenting experience seems to have no influence at all on the importance entrepreneurs attribute to patents as a means to acquire external funding.

In sum, the results of all three estimation models suggest that human capital can only explain a very little share of entrepreneurs' attitude towards patents. Especially the expected impact of patenting experience cannot be observed. Neither *Hypothesis 1a* nor *Hypothesis 1b* is thus supported. This finding proves to be robust in a number of checks. Testing the influence of patenting experience by using the number of patent applications and grants instead of the original dummy variables does not reveal any significant effects. Estimations of separate industry models (e.g., for complex and discrete industries) do not produce more explanatory results either.

7.3.4 Discussion

The aim of this study is to investigate entrepreneurs' opinions of patents. I use a unique combination of patent data and survey data to analyze the patenting activity of a sample of 91 German entrepreneurs and explore how it affects their attitude towards patents.

Matching inventor information from worldwide patent data with the names of the entrepreneurs in my sample reveals that 40% of the study group holds a patent application. This comparatively high patenting rate is not surprising in view of the fact that all participating entrepreneurs stem from high technology industries. It is rather interesting to note that venture capital funded entrepreneurs show significantly higher levels of patenting activity than non-funded entrepreneurs. This finding relates well to previous studies in this field and can be attributed to two causal effects: first, start-up patenting may have a positive impact on VCs' financing decisions (e.g., Engel and Keilbach 2007, Mann and Sager 2007) and second, venture capital funding may have a positive impact on start-ups' innovative output (e.g., Bertoni et al. 2010, Kortum and Lerner 2000). In studying the link between patenting and venture capital funding I observe considerable differences between industries: There is a much higher correlation between patent ownership and venture capital funding in discrete (biotech) than in complex (cleantech and ICT) industries. While the fact that none of the biotech entrepreneurs without venture capital funding owns a granted patent strongly suggests that patents are a necessary requirement for raising external financing in this industry, the importance of patents in that regard seems to be much lower in the other two industries. Overall, these industry-related observations confirm my findings from Chapter 4.4, which indicate that patents play a much more important role in the decision making of VCs from the biotech industry than of those active in the cleantech or ICT industry.

Entrepreneurs' attitude towards patents is measured with three different variables that are all based on the importance entrepreneurs attribute to patents in the context of start-up financing. As expected, participants' attitudes towards patents vary considerably throughout the sample. However, my attempt to explain these variations through differences in entrepreneurs' human capital is not crowned with success. Regressing entrepreneurs' appreciation of patents against specific human capital variables does not produce any statistically significant results. The low explanatory power of entrepreneurs' human capital in this context is surprising since a comparable analysis with VC data did produce meaningful results (compare Chapter 6.4.1). Apparently there is in particular no direct association between an entrepreneur's patenting experience and his/her attitude towards patents. This could have two main reasons. First, the experience of filing a patent may simply not change an entrepreneur's opinion on patents assuming that new insights are minimal because the benefits and drawbacks of the patent system are already well described and commonly known. Second, the benefits and problems that entrepreneurs encounter when and after applying for patents may be too diverse to shape their attitude towards patents in one consistent way. It might well be the case that one entrepreneur has been able to build a successful venture based on a patent and thus has a very positive attitude towards patents while another entrepreneur has mainly experienced problems with his/her patents and regards them as a waste of money. This would imply that both positive and negative effects exist but in sum cancel each other out in the statistical analysis.

This work contributes to the growing literature on the patenting behavior of young firms and entrepreneurs (e.g., Graham and Sichelman 2008, Graham et al. 2009, Veer and Jell 2011). By providing evidence that entrepreneurs rather patent for productive reasons than for signaling reasons I add to Graham et al.'s (2009) research on start-ups' patent filing motives. To the best of my knowledge this study is the first attempt to investigate the determinants of entrepreneurs' attitude towards patents. The finding that entrepreneurs' attitudes towards patents differ considerably but appear to be independent from human capital characteristics may serve as a basis for future research projects on this issue.

The following three implications for practice and research can be derived from this study. First, investment in patents appears to be useful for most technology start-ups that plan to apply for venture capital funding, especially in the biotech industry. Second, since entrepreneurs attach a higher importance to patents' property rights function than to their signaling function and thus further confirm the findings of Chapter 5, patents should be rather regarded as productive assets than as signaling devices. Third, as human capital, and in particular patenting experience, does not explain entrepreneurs' attitude towards patents, it is left to future research to determine what factors shape entrepreneurs' appreciation of patents. In doing that, scholars may address some limitations of this analysis by increasing the number of observations and collecting more information on entrepreneurs' background, e.g., their personality traits.

8 Summary and Conclusion

The purpose of this dissertation was to investigate the role of patents in venture capital financing. Using data from my own surveys with 102 German VCs, 85 U.S. VCs, and 91 high-tech entrepreneurs in addition to information from patent databases, I applied several perspectives in my analysis.

International perspective. In *Chapter 3,* I examined the importance of start-up resources as venture capital selection criteria in the screening of business plans. To that end, I analyzed data from a conjoint survey among VCs investing in Germany and the United States. In general, both regional estimation models show similar results; alliance agreements are the most important selection criterion followed by patent protection, while the start-up team's experience ranks last. Looking more closely at patent protection in Germany, the value contribution of a granted patent is about twice as high as that of a patent application. Similarly, regarding alliance agreements, a sales alliance is considered about twice as important as a research alliance. In comparing the importance of individual start-up characteristics across the two regions, I found that patents are considered significantly more important by VCs in Germany than in the U.S.

By providing a detailed picture of the importance of start-up resources at the initial stage of the venture capital investment process my findings extend the existing literature on VCs' decision making. While the comparatively strong impact of pending and granted patents is in line with results from recent transaction data based studies (e.g., Baum and Silverman 2004, Häussler et al. 2010, Hsu and Ziedonis 2011), the even stronger influence of alliance agreements on VCs' decisions is rather surprising since alliances have hardly been recognized as a selection criterion in previous studies. My finding that VCs in Germany attach a much higher value to patents than VCs in the U.S. challenges the results of earlier studies (Brettel 2002). The higher value of patents in Germany, however, can be explained through regional differences in the patent system and legal practice and thus may even apply to business contexts beyond venture capital financing.

Industry perspective. In *Chapter 4*, I investigated how VCs' usage of selection criteria differs between industries. For that purpose, I split each regional sample into three groups based on the underlying industry. When comparing VCs' decision making across industries, significant differences between discrete and complex industries emerged, supporting most of my research hypotheses. Granted patents and research alliances are considered much more important in the biotech industry than in the cleantech and ICT sectors. Sales alliances, on the contrary, show a higher value contribution in the cleantech and ICT industries than in biotech.

My findings fill a gap in entrepreneurship literature by describing industry-related differences in VCs' decision making. I provide quantitative evidence that the importance of individual resources, in particular patents and alliances, as selection criteria is strongly moderated by the industry the respective start-up is active in. Patents' strong impact in VCs' screening of biotech start-ups is concurrent with management studies reporting a higher effectiveness of patents in discrete rather than in complex product industries (e.g., Cohen et al. 2000, Levin et al. 1987).

Functional perspective. Motivated by a recent discussion on the potential role of patents as signals of technological quality, in *Chapter 5*, I investigated whether patents have a signaling function in VCs' screening of business plans. I developed a scenario-based conjoint experiment to quantify the relative value of start-up resources as productive assets and as quality signals in this context. My results are somewhat surprising. While patent protection turned out to be of comparatively high importance as selection criterion, I could not identify a signaling effect of patents. In other words, VCs highly appreciate patents, but only in their function as property rights, not as quality signals. Instead, VCs appear to rely on research alliances as signals of technological quality.

This study contributes new insights to the discussion on the twofold role of patents in venture capital financing. I present and implement, for the first time, a method to disentangle the signaling effect of start-up resources from their productive effect. My finding that patents fail to serve as quality signals is highly interesting in light of existing studies on patents' signaling value (e.g., Conti et al. 2011, Long 2002, Hsu and Ziedonis 2011) and calls for further analysis. The strong signaling effect of R&D alliances, on the other hand, fits well into a recent stream of literature on the importance of open innovation for developing and commercializing innovative technologies (e.g., Chesbrough 2003, Faems et al. 2010).

Human capital perspective. In *Chapter 6*, I took a closer look at VCs' attitude towards patents and studied how it can be explained through their human capital, i.e. their education and experience. Using data from my survey with German VCs, I measured VCs' appreciation of patents in two different ways and regressed both variables on various types of education and experience. My results show that human capital, in particular IP-specific human capital, does have a significant influence on VCs' attitude towards patents. VCs with a high level of general IP-related knowledge appreciate patents much more than VCs who are less familiar with IP issues. On the contrary, both an education in law and the experience of a patent lawsuit are negatively related to VCs' attitude towards patents. Industry-specific human capital, defined by a VC's technical education, also has a negative effect on a VC's appreciation of patents.

In responding to a call by Patzelt et al. (2009) to study the relationship between VCs' human capital and their decision policies, this investigation adds to a recent stream of literature on drivers and determinants of VCs' decision making (e.g., Dimov et al. 2007, Zarutski 2010). I introduce a new dimension of human capital, called IP-specific human capital, which explains an additional amount of variation compared to previous studies in this field (e.g., Knockaert et al. 2011). Furthermore, I extend existing knowledge on the role of patents in entrepreneurial finance (e.g., Baum and Silverman 2004, Long 2002, Mann and Sager 2007). While patents have commonly been considered as beneficial in raising venture capital, I now present evidence that VCs appreciation of patents is highly variable.

Entrepreneurial perspective. In *Chapter 7*, I completed my investigation of patents in venture capital financing by analyzing the perceptions of entrepreneurs. More precisely, I used data collected in a survey with high-tech entrepreneurs in Germany to perform two types of analyses.

The objective of the first analysis was to determine how well entrepreneurs understand the decision making process of VCs. To answer this question, I compared the results of my conjoint experiment among VCs with the results of the same conjoint experiment among entrepreneurs. Since no significant differences resulted from this comparison, I conclude that entrepreneurs are well aware to what extent VCs employ patents and other start-up resources as selection criteria in screening business plans. When investigating the sample in more detail, I found that entrepreneurs who have previously received venture capital seem to understand VCs' decision behavior better than entrepreneurs without such experience. This study is the first one to examine entrepreneurs' perceptions of VCs' selection criteria and directly compare them with the actual usage of these criteria by VCs. In doing that, it adds to the literature on financing technology start-ups through venture capital (e.g., Muzyka et al. 1996, Petty and Gruber 2011, Tyebjee and Bruno 1984).

In the second study, I analyzed the patenting activity of my sample of entrepreneurs and examined how it affects their attitude towards patents. To facilitate this analysis, I complemented my survey data with patent data from the PATSTAT database. A first comparative analysis demonstrated that venture capital funded entrepreneurs hold a significantly higher amount of patents than non-funded entrepreneurs, a result that concurs with previous studies finding a positive relationship between patenting and venture capital funding (e.g., Engel and Keilbach 2007, Mann and Sager 2007). Comparable to the analysis of VC data in *Chapter 6*, I then regressed entrepreneurs' attitude towards patents on their patenting experience and other human capital variables. Surprisingly my estimations did not reveal any statistically significant correlations. In particular, there appears to be no direct association between an entrepreneur's patenting experience and his/her attitude towards patents. This study contributes to the growing literature on the patenting behavior of young firms and entrepreneurs (e.g., Graham and Sichelman 2008, Graham et al. 2009, Veer and Jell 2011) by showing that entrepreneurs differ considerably in their attitudes towards patents, which, however, seem to be independent from their patenting experience and other human capital characteristics.

Relevant implications for both practitioners and researchers arise from the findings presented in this dissertation. For high-tech entrepreneurs who are in need of external financing, filing a patent on their start-up's key technology appears to be a worthwhile investment in order to increase their chances of raising venture capital. However, entrepreneurs must understand that this positive effect will differ greatly between individual start-ups, depending on the region and industry they are active in. For instance, for a biotech start-up in Germany, a patent protected technology can be regarded as a necessary condition to receive venture capital, whereas for an ICT venture in the United States, resources other than patents, first and foremost downstream alliances, are much more important. Furthermore, entrepreneurs need to be aware of the fact the patents are only of limited use as quality signals. To signal the technological quality of their firm to a VC or possibly other external parties, an existing research alliance is much more effective. Thus, entrepreneurs in technology-driven industries should focus on building up their research network early and emphasize these alliances in their business plan, especially if the start-up is unknown to the potential investor. Moreover, before approaching a VC, entrepreneurs should try to gather as much information as possible about the respective investor. Publicly available information on his/her educational background and job experience can already be a useful indicator about what a particular investor will look for in a business plan. Lastly, while writing a business plan, novice entrepreneurs are encouraged to reach out for help from experienced entrepreneurs since the latter have a better understanding of VCs' decision making process and can advise newcomers in optimizing their business plan accordingly.

Future research should, on the one hand, incorporate the results of my analyses and, on the other hand, aim to address some of the limitations. To begin with, my results underline that patents have become a crucial element in VCs' assessment of technology start-ups and should thus be represented in future studies on venture capital decision making. The same applies to alliance agreements which are an even more important selection criterion in some industries, e.g., cleantech and ICT. In fact, the strong impact of alliances on VCs' screening decisions is a new insight that may be worth investigating further.

Second, my results clearly suggest that contingency effects need to be accounted for when analyzing VCs' decision behavior. In contrast to common assumptions, not all VCs act similarly but substantial differences between individual investors exist. Differences in regional orientation, industry focus, and human capital are only some examples that cause variations in VCs' decision making. Exploring further differences in order to explain VCs' decisions and attitudes even better may be a promising research avenue.

Finally, my finding that patents fail to serve as signals of technological quality is highly relevant for patent research, because it contradicts the interpretation of patents' signaling value in previous studies. Despite being highly appreciated as productive assets, patents' signaling effect is de facto very low. Patent scholars should incorporate this fact when discussing the ambiguous role of patents in venture capital financing. Since my study was designed to specifically test for the effect of start-up resources as signals of unobservable technological quality, I could not control for signaling functions regarding other qualities, such as the team's professionalism. Future studies might want to address this limitation and complement this research by using alternative methods of isolating signaling from productive effects. Additionally, scholars may even consider going beyond the context of venture capital financing and investigate the relevance of alliances and patents as quality signals from the perspective of product customers.

Appendix

A.1 Interview Guide

General questions on role of patent

- How important are patents for you when evaluating technology start-ups?
  - Compared to other criteria?
  - Does that differ by industry?
  - Does that depend on the phase of financing?
  - Does that depend on the stage of the VC evaluation/screening process?
- Does the valuation differ between patent applications and patents granted?
- What is the main value of a patent?
  - Signal
    - For technology?
    - For the team (eg. professionalism)?
  - Information
  - Property right
- How does a patent's signaling function change with technological familiarity?
- What is your personal experience with patents?
  - Patent application, patent lawsuit, etc

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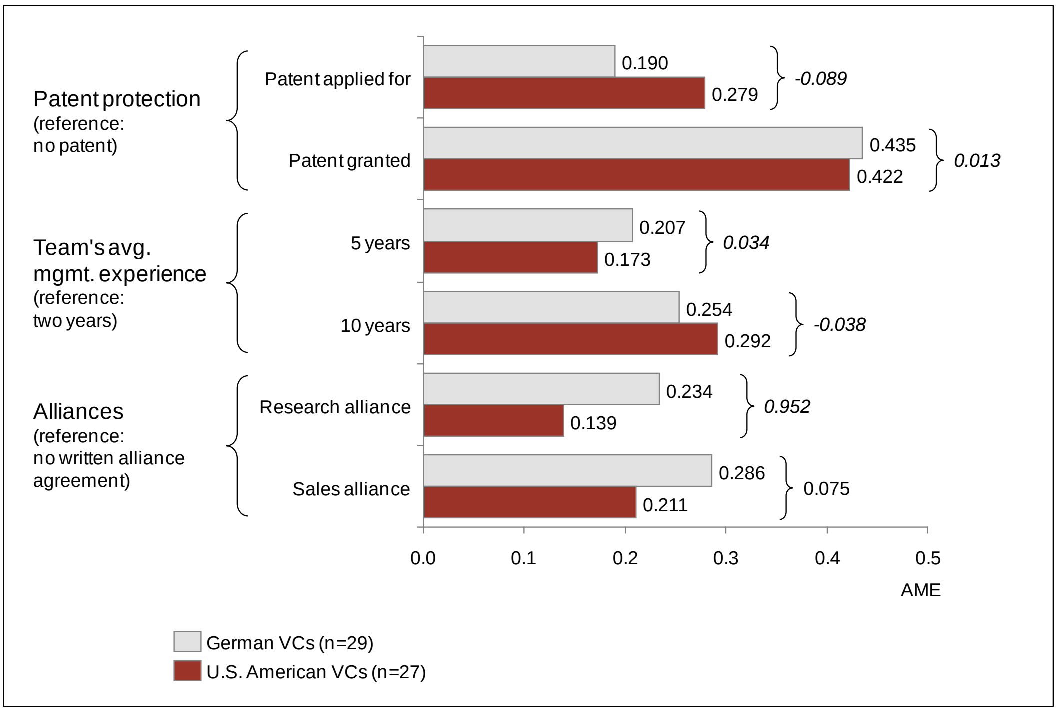
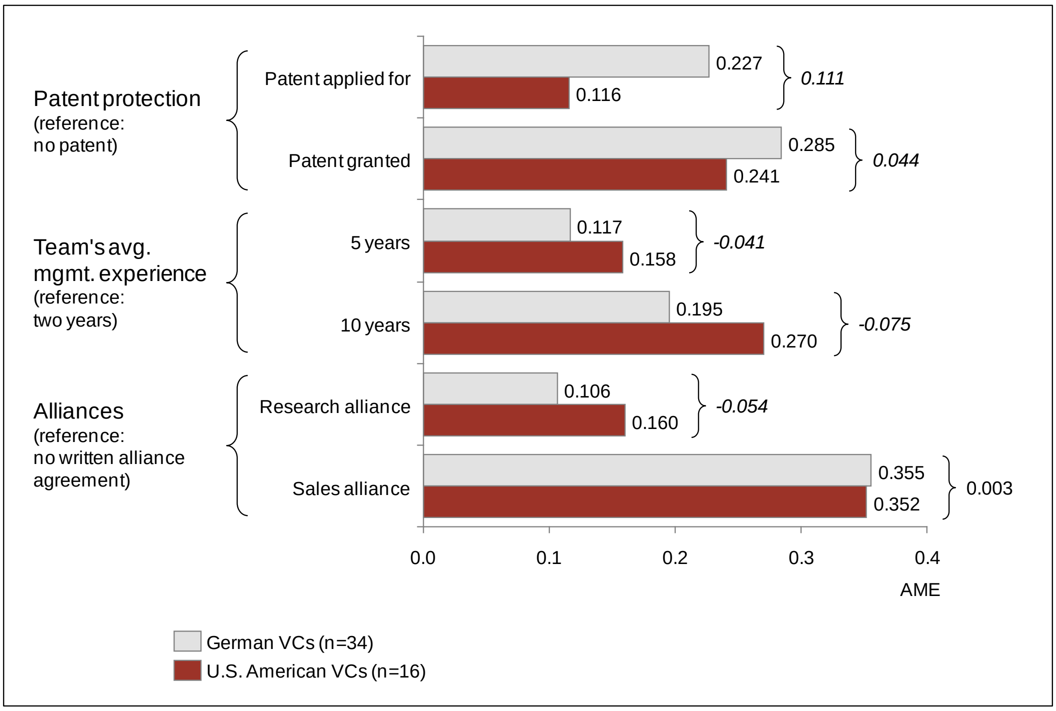
A.2 Regional Differences in AMEs per Industry

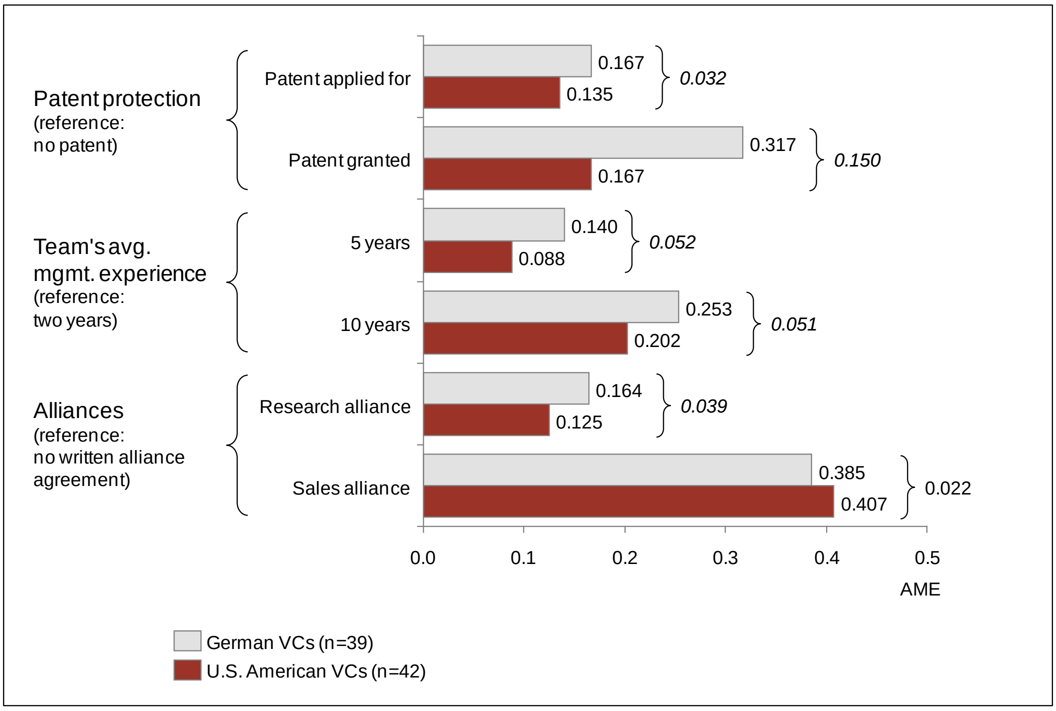
A.2.1 Biotech



A.2.2 Cleantech

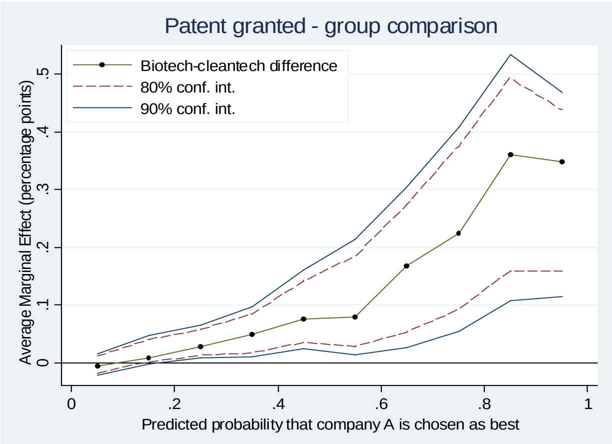


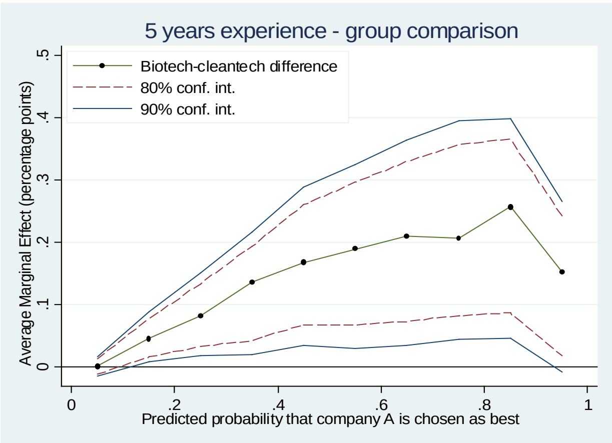
A.2.3 ICT

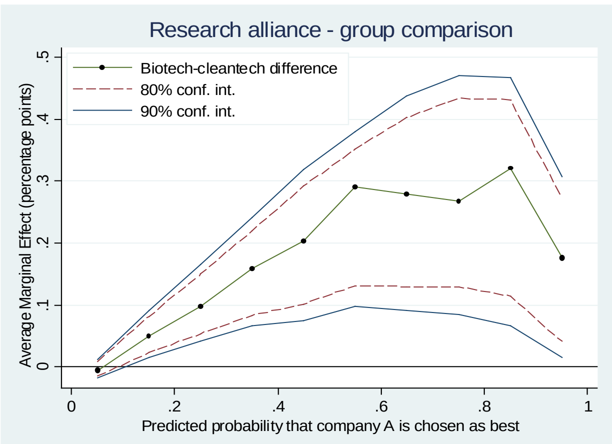

Patent protection
(reference:
no patent)
Patent applied for
0.167
0.135
0.032
Patent granted
0.317
0.167
0.150
Team's avg.
mgmt. experience
(reference:
two years)
5 years
0.140
0.088
0.052
10 years
0.253
0.202
0.051
Alliances
(reference:
no written alliance
agreement)
Research alliance
0.164
0.125
0.039
Sales alliance
0.385
0.407
0.022
0.0
0.1
0.2
0.3
0.4
0.5
AME
German VCs (n=39)
U.S. American VCs (n=42)

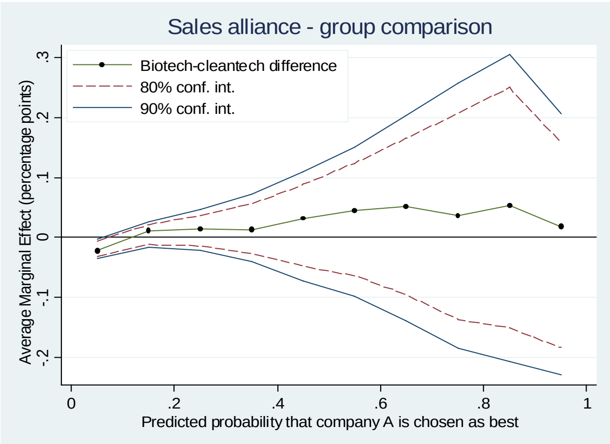
A.3 Industry Differences Based on AMEs in Germany

A.3.1 Biotech vs. cleantech

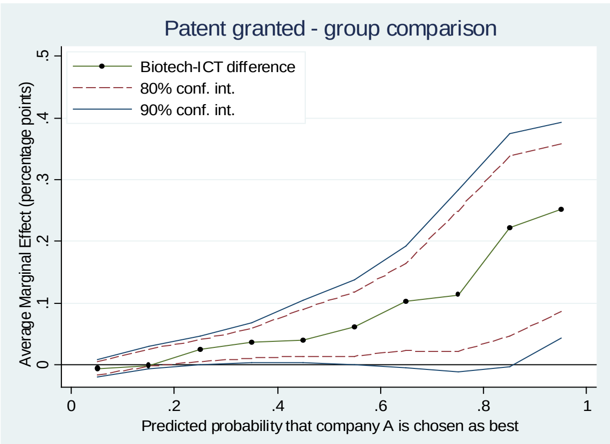


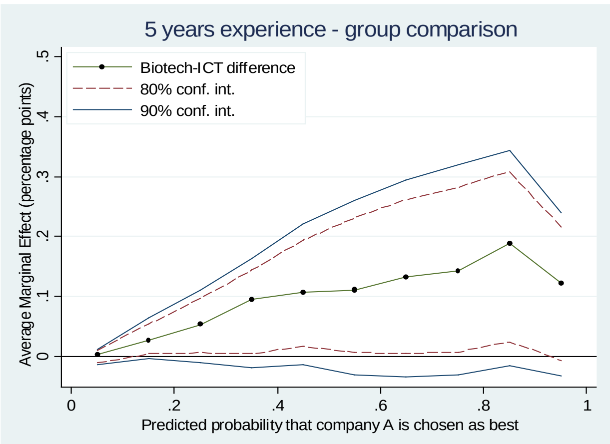


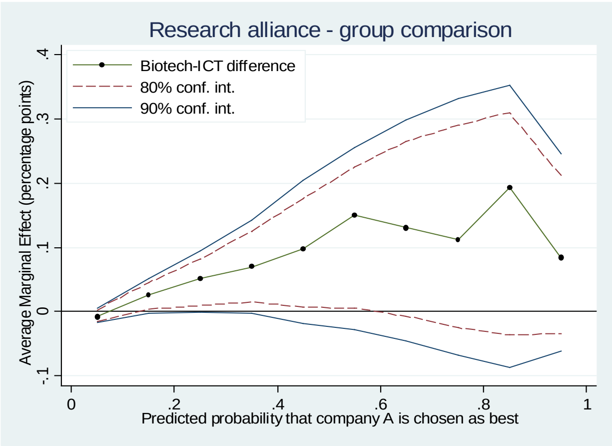


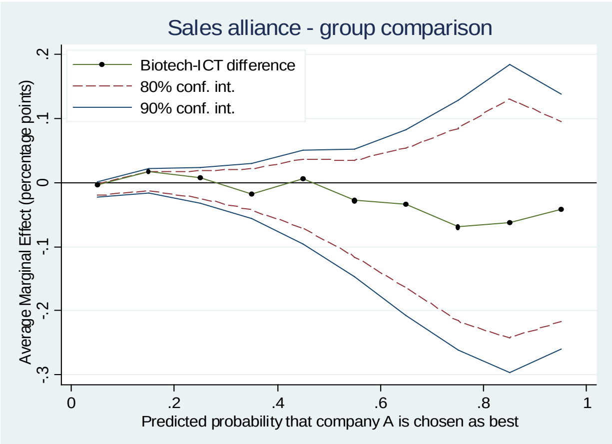


A.3.2 Biotech vs. ICT

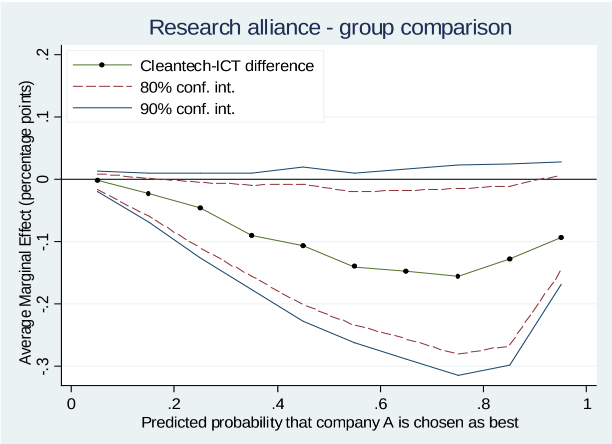








A.3.3 Cleantech vs. ICT



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