TECHNISCHE UNIVERSITÄT MÜNCHEN

Dr. Theo Schöller-Stiftungslehrstuhl für Technologie- und Innovationsmanagement

The patent value chain: Organizational processes, strategic integration, and implications for management research

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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:	Prof. Dr. Christoph Ann
Prüfer der Dissertation:	1. Prof. Dr. Joachim Henkel
	2. Prof. Dr. Oliver Alexy

Die Dissertation wurde am 25.04.2018 bei der Technischen Universität München eingereicht und durch die Fakultät für Wirtschaftswissenschaften am 15.06.2018 angenommen.

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AMJ	Academy of Management Journal
ASQ	Administrative Science Quarterly
BU	Business unit
CIO	Chief Information Officer
CTO	Chief Technology Officer
DPMA	Deutsches Patent- und Markenamt (German Patent Office)
EPO	European Patent Office
EUR	Euro
FTO	Freedom to operate
IBM	International Business Machines Corporation
IP	Intellectual property
IPR	Intellectual property right
IT	Information technology
JOM	Journal of Management
MS	Management Science
NBER	National Bureau of Economic Research
NDA	Non-disclosure agreement
NPE	Non-practicing entity
OEM	Original equipment manufacturer
OS	Organization Science
PCT	Patent Cooperation Treaty
PPH	Patent Prosecution Highway
R&D	Research and development
SIPO	State Intellectual Property Office (Chinese Patent Office)
SMJ	Strategic Management Journal
TRIZ	Theorie des erfinderischen Problemlösen (Theory of inventive problem solving)
U.S.	United States
USPTO	U.S. Patent and Trademark Office

Acknowledgements

Pursuing a Ph.D. and writing a dissertation is sometimes quite a solitary endeavor – no matter what people want to make you believe in their acknowledgements. At some point in the journey no one around you will match your level of expertise in your very particular, very small niche.

Pursuing a Ph.D. and writing a dissertation is also an incredibly humbling endeavor, because for the majority of the time you feel like you haven't produced anything of value and for the rest of the time you feel like you should finally get your shit together and finish the goddamn thing.

Pursuing a Ph.D. and writing a dissertation has taught me more than what I can put on this page and I am beyond grateful for this experience. Of course, writing a dissertation teaches you a lot about research, about your field and your research question. But what is even more, writing a dissertation teaches you a whole lot about yourself and about what you care about. When I started this journey, I had no idea where it would lead me. All I knew was that it made complete sense, and that it was the right step to take. And it was. It was precisely the right step to take and I am incredibly grateful to everyone involved who helped give me this opportunity and make the experience as great as it was.

Because even though pursuing a Ph.D. and writing a dissertation is sometimes solitary, it is also an endeavor that you do not embark on alone. It is an endeavor that you cannot succeed in without the help and support, the encouragement and companionship, the belief and love of others.

I want to thank my supervisor Prof. Dr. Joachim Henkel for allowing me to find my way in this endeavor. He never doubted that I could do whatever ideas I came up with and

I am grateful for his unwavering belief in me. I would also like to thank my interview partners for being generous with their time and for sharing their expertise. I want to thank Prof. Dr. Oliver Alexy for being part of my committee and for all the wisdom on management theories, empirical models, and patents he shared with me over the course of this dissertation. I also want to thank Prof. Dr. Christoph Ann, who kindly agreed to chair the committee for this dissertation and who also brings a wealth of knowledge on patents to the table – quite fittingly, as this dissertation once started with the vague idea to "do something with patents".

In addition, I want to thank the chair's team for being a source of inspiration when I was stuck, a source of pushback when I needed to take a step back and question my approach, and a source of comic relief during our lunch and countless coffee breaks. Writing a dissertation may sometimes be quite solitary, but having a team that can relate to the experience and that does not get tired in trying to build bridges across our undoubtedly different niches has been invaluable.[1]

I would also like to thank my family and friends for the continued love and support throughout this journey. They all had the invaluable skill to assure me that patents and a Ph.D. are really not that important in the grand scheme of things, while simultaneously making me feel like I totally got this.

--- *Katharina Tanimura*

March 2018

[1] Equally invaluable and noteworthy: you made sure I left the chair with some decent dart skills!

Abstract

This dissertation investigates the organizational structure and strategic integration of the intellectual property (IP) protection process – and what the configuration of this process means for innovation researchers interested in leveraging the huge amount of patent data for their empirical studies.

To the research community patent data has provided a wealth of research opportunities in entrepreneurship, innovation, and management alike. At the same time, patent data – the records of patent offices worldwide – was never built with statistical analyses in mind and is therefore riddled with flaws. In addition, the patent protection process puts into question in how far patents indeed reflect theoretical constructs of interest for innovation and management researchers. The first study of this dissertation therefore investigates in how far the research community is aware of these flaws and limitations. Based on a sample of 92 empirical studies published in the field's most prestigious outlets the study investigates how these publications approach the issues related to the use and interpretation of patent data and proposes avenues for research to increase the methodological rigor while at the same time exploiting the richness of patent data.

While patent data itself has provided an interesting entry point for research, this dissertation also shifts the focus to what goes on inside a company before it files a patent application on an invention. Given firm practices such as strategic patenting that have promoted patenting on a larger scale, the second and third study explore how companies organize their internal IP protection processes, i.e. the part of the patent value chain that lies entirely within the boundaries of the company (and that encompasses the steps before external patent attorneys or the patent examiner are involved). Taking a qualitative approach of 16 case studies, the second study

investigates the selection process that each invention goes through and that results in the decision of whether an invention is patented or not. Using the same rich dataset, the third study then analyses how companies' IP protection processes are cross-functionally integrated into the invention generation process in the R&D department.

Zusammenfassung

Die vorliegende Dissertation untersucht, wie Unternehmen den Prozess der Patentierung strategisch und organisatorisch gestalten – und was die Ausprägungen dieses Prozesses für Innovationsforscher bedeutet, die in ihrer Forschung auf großzahlige Patentdaten zurückgreifen möchten.

Die Existenz riesiger Patentdatenbanken ermöglicht der Forschergemeinde die Untersuchung und Beantwortung vieler Forschungsfragen im Bereich Entrepreneurship, Innovation und Management. Allerdings stellen Patentdatenbanken schlicht die Aufzeichnungen der jeweiligen Patentbehörde dar und wurden daher weder aufgebaut noch aufbereitet, um statistische Auswertungen zu ermöglichen. Die einzelnen Einträge sind so oft fehlerhaft. Darüber hinaus stellt insbesondere auch der Prozess der Patentierung viele Interpretationen in Frage, die Innovations- und Managementforscher bei der Benutzung von Patentdaten für theoretische Konstrukte heranziehen. Die erste Studie dieser Dissertation untersucht dementsprechend, inwiefern sich Forscher dieser Fehler und Probleme bei der Interpretation bewusst sind. Ausgehend von einer Stichprobe von 92 empirischen Studien, die in den am höchsten gerankten, fachrelevanten Zeitschriften publiziert wurden, untersucht die erste Studie den Umgang mit diesen Schwierigkeiten bezüglich der Daten und deren Interpretation und macht darauf basierend Vorschläge, in welche Richtungen sich die Forschung weiterentwickeln könnte, um methodisch genauer vorzugehen und gleichzeitig Patentdaten weiter für die Forschung zu nutzen.

Obwohl Patentdaten einen interessanten Ausgangspunkt für die Forschung darstellen, schlägt diese Dissertation einen anderen Weg ein und verlagert den Fokus auf die Prozesse, die innerhalb von Unternehmen stattfinden, bevor eine Patentanmeldung auf eine Erfindung erfolgt. Gerade weil Unternehmenspraktiken wie die strategische

Patentierung zu einer insgesamt verstärken Patentierung geführt haben, untersuchen die zweite und dritte Studie dieser Dissertation, wie Unternehmen den Prozess der Patentierung gestalten, d.h. wie sie den Teil der Patentwertschöpfungskette gestalten, der ausschließlich innerhalb des Unternehmens liegt (bevor externe Patentanwälte oder der Patentprüfer des Patentamts involviert sind). Beide Studien haben einen qualitativen Forschungsansatz und basieren auf 16 Fallstudien. Die zweite Studie dieser Dissertation untersucht den Auswahl- und Entscheidungsprozess, der innerhalb des Unternehmens für jede Erfindung erfolgt, und anhand dessen entschieden wird, ob eine Erfindung zum Patent angemeldet wird oder nicht. Die dritte Studie dieser Dissertation untersucht dann, wie die Prozesse zur Patentanmeldung in den Erfindungsprozess integriert werden und so über Abteilungsgrenzen hinweg in die Arbeit der Forschungs- und Entwicklungsabteilung eingreifen.

1. Introduction

1.1 Motivation

Advancing knowledge, creating inventions, and turning them into innovative products has long been recognized as the key driving force behind company performance and competitive advantage. As Teece (1981: 82) stated almost 40 years ago: “Economic prosperity rests upon knowledge and its useful application”. But knowledge is mobile, and it is prone to leakage and imitation. Patents appear to be a powerful remedy for this, as they disclose the knowledge and the originator and award her the right to exclude others from imitating the invention.

Patents, patent offices, and the foundation of the modern patent system have been around for far more than a century. For reference, in the Western Hemisphere patent offices were mostly founded during the industrialization period in the 19th century. For instance, the German Patent Office (Deutsches Marken- und Patentamt, DPMA) was founded in 1877 (DPMA, 2018a). The United States Patent Office, USPTO, was already formed almost half a century earlier, in 1836 (Kingsland, 1948). Fast forward, in the last few decades, the dynamism in the patent system has increased considerably and mirrors the change in how the value of patents is perceived by companies and countries alike. For instance, the Patent Cooperation Treaty, concluded in 1970, allows member states of the Paris Convention for the Prosecution of Industrial Property in 1883 to seek patent protection in several countries through a single application making it easier and more cost-efficient to attain patent protection in multiple countries on the same invention.[2]

Recent years have seen several initiatives with the goals of harmonizing patent systems across countries and of simplifying the application process in an international

[2] http://www.wipo.int/pct/en/treaty/about.html.

context. In 2013, the U.S. patent system effectively switched from its “first to invent”-patent system to the “first to file”-system that is used in all other countries (Leip and Scholer, 2018). Until then, U.S. patents could be challenged if an inventor could prove that she in fact made the invention before the patent owner. The “first to file”-patent system on the other hand favors the applicant that files first. Moreover, several patent offices, including the DPMA, EPO (European Patent Office), USPTO, and SIPO (State Intellectual Property Office, the patent office of China) have agreed to create the so-called Patent Prosecution Highway (PPH) which is supposed to speed up and harmonize the examination procedures in the participating offices (DPMA, 2018b). If a company files for the PPH, the relevant patent offices will share their search reports compiled for examination in order to accelerate the grant process, if at least one claim is deemed valid by the first patent office (USPTO, 2018). Lastly, harmonization and internationalization of patent rights are also at the forefront with regard to the European Unitary Patent, which will grant a patent right in up to 26 member states of the European Union through a single patent application (EPO, 2017).

Against this backdrop of continuous legal change, patent data has also become a resource to academic research over the last few decades. Starting in the fields of economics and law, patent data has proliferated into management research. To researchers patent data poses quite the conundrum. On the one hand, each jurisdiction’s patent database constitutes a large panel data set that allows to investigate the importance and management of innovation and promises to unveil a wealth of insights into management, strategy, and potentially even company performance. Moreover, this data provides the opportunity to deduce normative and policy implications in order to inform continuous reforms of the patent systems.

On the other hand, the patent offices' patent databases were never set up to accommodate researchers' interests or needs. Therefore, the data is riddled with inconsistencies and selection biases that should caution the keen researcher from sweeping conclusions about underlying mechanism. Even more so, companies now use patents for a variety of reasons – beyond the original intention of protecting inventions from being copied – which puts into question in how far patent data actually reflects the theoretical constructs researchers aim to understand. For one, patents are now also used to stake a company's claims in the technical landscape. In addition, patents are also a token in the business arena. They are used to stake a company's claims in the market, to limit other companies' claims in the same market, or even to deter companies from entering a given market. What is more, patents may also be a legal weapon to defend those claims. Consequently, patents not only determine *what* a company can produce, but increasingly *how* it may produce.

The original intent of a patent is not to award an automatic market monopoly to its holder, but to provide the patent owner the *right* to exclude others from using the underlying invention as it is outlined in the patent's claims. A patent hence awards the right to enforce the exclusion in court. In order to be awarded a patent the underlying invention needs to be novel and non-obvious and needs to be described in a way that a person skilled in the art can understand the invention. The patent right then pertains only to the novel aspects of the invention, i.e. the ones that differentiate it from the existing prior art.

In order to attain patent protection a patent application needs to be filed with the desired patent office. Applications are then examined by patent examiners knowledgeable in the respective field of technology in order to ensure that the criteria put forth by the law are abided by and that the scope of the patent, if awarded, reflects

the actual advance in knowledge over prior art. In practice, this means that an applicant is awarded a patent right because she – or more likely the patent lawyer she hired – could convincingly argue during the examination process that the piece of knowledge underlying the patent is new and sufficiently non-obvious.

The process of pursuing patent applications through to grant is, however, vulnerable. In reality, all major patent offices deal with substantial backlog (Ackerman, 2011; Mejer and van Pottelsberghe de la Potterie, B., 2011; Stahl and Boeshore, 2011) which means that patent examiners do not have the time and bandwidth to examine each incoming patent application in great detail. Hence, patents may be granted when they really should have been denied or they may have been granted beyond the extent they should have received. Consequently, patent rights are imperfect and "fuzzy" with regard to their scope and validity (Linden and Somaya, 2003; Teece, 2000; Lemley and Shapiro, 2005). In fact, this problem of patent validity may be quite pervasive (Zischka, 2015).

Consequently, these weaknesses in the patent process may encourage both tactical moves and strategic behavior by applicants. While not all inventions are patented and the propensity to patent has been found to vary with regard to the type of invention, firm size, and industry sector (Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999; Scherer, 1983), companies may attain more patent rights than justified, especially by pursuing patents on marginally new knowledge. Such expansive patent portfolios may be valuable to companies to ring-fence own inventions, to block competitors from entering a market or technology, and to ensure a better bargaining position in cross-licensing negotiations (see among othersHall and Ziedonis, 2001; Ziedonis, 2004). In addition, companies may actively try to exploit the ambiguity of patent rights by withholding prior art citations in the patent application in order to increase the scope of

the patent (e.g., Lemley and Tangri, 2003; Alcacer and Gittelman, 2006; Lampe, 2012; Steensma, Chari, and Heidl, 2015).

Consequently, both managers and researchers alike should be cautioned to follow the interpretation that patents capture the inventive power of companies and individuals. Admittedly, this interpretation is luring – especially, because it is not entirely wrong. But it is not entirely true either, as it only captures part of the picture and disregards all the other reasons that lead a company to file an additional patent application.

In recent years, "fuzzy" and potentially overlapping patent rights were seen to spur a litigation frenzy, especially in complex industries like telecommunications where a single product contains a multitude, hundreds or even thousands, of individual patents (Cohen, Nelson, and Walsh, 2000). Beyond garnering a lot of media attention for patents, these lawsuits showed that failing in the patent arena may result in real business damages, most notably, when Apple succeeded to enforce a preliminary injunction on Samsung's rival product to the iPad in the European Union except for the Netherlands (Mueller, 2011).

These recent developments are likely to spur more strategic patenting and more deliberate patent management practices. Against this backdrop, this dissertation aims to explore the patent value chain from an intra-firm perspective in order to investigate the organizational processes that take place before competitors, researchers, and the general public may observe the publication of a patent application. This dissertation strives to expand our understanding of how the complexity of patents affects the patent value chain inside companies. Patents are not the result of a clear-cut, black and white-type decision, but of a complex process, first inside the firm and then through the collaboration with the patent office. This complexity warrants a more nuanced, qualitative, investigation and a shift of focus from the output (i.e., the patent) to the process – two motivations this dissertation aims to follow.

1.2 Contextualization and motivation and research objectives

This dissertation comprises three studies related to the role of patents in innovation management. In particular, this dissertation approaches the role of patents from both a research and a management perspective. In the following, I outline the three studies of this dissertation. In the first study, titled "Encouraging better practice: Patent data in management research", I study how the research community has dealt with the ever more broadly accepted realization that patent data sourced from patent offices worldwide is not only riddled with flaws but also problematic in terms of its interpretation. The paper analyzes the use and interpretation of patent data in top management research and shows in how far top empirical studies in the field acknowledge the limitations of patent data. The paper then proposes avenues for improving the fields' practices with regard to patent data.

The second study, titled "To patent or not to patent? How firms decide on patent protection for inventive knowledge", analyzes how firms choose among different appropriability mechanisms and investigates the internal decision process that each invention runs through in order to determine whether the invention will be turned into a patent application, a defensive publication, or a trade secret. Moreover, the paper analyzes the framework that companies use to evaluate inventions and decide on the appropriability mechanism.

The third study, titled "Marrying patent protection and invention generation: Cross-functional integration of IP and R&D processes", focuses on how IP protection processes are embedded in the invention generation process. The study identifies several measures that companies have established to achieve this cross-functional integration of IP and R&D processes.

1.3 Structure of this dissertation

The remainder of this dissertation is organized as follows. Chapter 2 consists of the first paper, titled “Encouraging better practice: Patent data in management research” and focuses on the role – and shortcomings of patent data – for management research. Following an introduction section (2.1), I discuss the challenges of patent data (2.2). After describing the data set (2.3), I present results on the operationalization of patent data in leading management research and provide insights into how the research community deals with the shortcomings of patent data (2.4). I then discuss these findings to propose new and improved ways to exploit patent data for innovation and management research (2.5)

Chapter 3 consists of the second paper, titled “To patent or not to patent? How firms decide on patent protection for inventive knowledge” and shifts the focus to the managerial domain in order to analyze how companies choose among different appropriability mechanisms. I first outline the direction of the study (3.1), before motivating the novel, qualitative approach to the topic based on the primarily quantitative literature (3.2). After presenting the unique dataset (3.3), I then describe in detail how firms decide on patent protection for inventive knowledge, both based on the process and the decision framework (3.4). Thereafter, I discuss the implications of these results both from a managerial and an academic perspective (3.5).

Chapter 4 consists of the third and final paper, titled “Marrying patent protection and invention generation: Cross-functional integration of IP and R&D processes”, which, again, is positioned in the managerial domain and focuses on how IP protection processes are embedded in the invention generation process. I first outline the scope and direction of the study (4.1.) and then motivate the study based on insights of the organizational capabilities literature (4.2). After providing insights into the research design (4.3), I show how cross-functional integration between the R&D and IP

department is changing how the patent value chain is organized (4.4). I then present the measures that companies apply to achieve this cross-functional integration between the R&D and IP department (4.5). After discussing how the integration differs across the sample (4.6) and is being achieved from a dynamic perspective (4.7), I discuss the implications of the cross-functional integration (4.8).

Finally, Chapter 5 will provide a conclusion and outlook.

2. Encouraging better practice: Patent data in management research

2.1 Introduction

Innovation has become an important reference point of economic actions, both on the country level and the firm level. The increased political and managerial attention to innovation has been mirrored by an increased scholarly interest in understanding the dynamics of innovation. The desire to measure innovation processes has stimulated the use of patent data for research purposes, and the availability of the data has made it a popular starting point for empirical analysis. The scope and depth of patent data, particularly in the longitudinal dimension, have allowed for complex inquiries and have promoted progress in management, strategy, and innovation studies. Patent data has since been used to study attributes of innovation and knowledge, firms and markets.

While management research continues to advance through the use of patent indicators, there are signs of a "patent fatigue" (Ziedonis, 2013) seizing parts of the field. Although these two trends are opposing, they both demonstrate the need to evaluate the application and interpretation of patent indicators and to consolidate our knowledge. Moreover, patent data itself is riddled with problems. Since the seminal review on the uses of patent data by Griliches (1990), there have been a few recent endeavors to increase our understanding of specific shortcomings of patent data itself (e.g., Alcacer and Gittelman, 2006; Gittelman, 2008). Reviews on the development of the field have, however, focused only to a limited extent on the challenges of operationalization (e.g., Nagaoka, Motohashi, and Goto, 2010; Ziedonis, 2008). While already the pioneers of patent data based analyses stressed that patent data suffers from important limitations (e.g., Griliches, 1984, 1990; Schmookler, 1966), my review of

recent articles in the six most influential management journals reveals that these shortcomings have not yet been comprehensively addressed by researchers.

Patent data originates from the patent offices worldwide, but their databases were not built with statistical analysis in mind. Inconsistencies in the spelling of inventor and firm names require large data cleaning and harmonization projects and are just one example of imperfect data quality. Moreover, the information requirements of patents were conceived with a legal perspective in mind and aim to satisfy the original target group of patents: examiners, potential licensees, and competitors (Rip, 1986). At the same time, firms' motives permeate the information on their patents. A patent document is the result of several trade-offs and choices by the applying firm and the patent examiner and their interaction during the examination process. Lastly, it is important to acknowledge that patent databases cover a firm's patented inventions; they do not provide an inventory of all the firm's inventions and even less of its innovations.

The aim of this paper is twofold. First, I provide an analysis of the operationalization and interpretation of patent data based measures. In order to help inform the interpretation of patent based indicators, I provide stylized insights about firms' patenting behavior. I identify three issues related to patent data that may complicate the application and especially interpretation of patent measures: the attribution of internal resources and innovative performance, the attribution of origin and ownership, and the attribution of knowledge flows. Second, I investigate the extent of awareness of the shortcomings of patent data in the research community. I find that most empirical research using patent data concentrates on the topics of internal knowledge resources, innovation performance, and knowledge flows. While most authors appear to be aware, at least in part, of potential issues of patent data, my analysis shows that these limitations are not fully acknowledged and addressed in empirical research. I suggest three sets of strategies for future research to advance the

field as a whole. While the limitations of patent data have been raised before, my study is the first to analyze in how far the research community accounts for these issues in the research design of their empirical studies. With this endeavor my study contributes to the newly emerging emphasis on scientific rigor in management research (Bettis, 2012; Goldfarb and King, 2016).

2.2 Patent data and its inherent challenges

The use of patent data in empirical research has advanced our understanding with regards to a multitude of questions. But patent data suffers from important limitations that may compromise the validity of these analyses. Patent databases were set up by patent offices without academic statistical analysis in mind. The data for instance falls short in terms of the consistency of company and inventor names and hence requires substantial care with regard to data hygiene. In addition to data-inherent issues, measures based on patent data may suffer from limitations that result from the patenting process itself. These shortcomings put many of the popular interpretations of patent measures in question and therefore cast into doubt the reliability of empirical studies that rely on patent data. In the following, I describe the patent process and its influence on three broad topics of interest for empirical innovation research - knowledge resources and innovative performance, knowledge flows and collaboration, ownership and origin of knowledge and innovation – in order to highlight how patent measures may be compromised and even biased.

2.2.1 Attribution of internal resources and innovative performance

Patents are assumed to constitute a paper trail of inventive activity and therefore are often interpreted as an inventory of a firm's or an inventor's innovations. Patent data, however, is subject to selection bias (Griliches, 1984). A firm's patent stock underestimates both its knowledge and innovative performance as it neglects knowledge protected by other appropriability mechanisms (or not formally protected at all). A firm's appropriability strategy comprises several mechanisms, some of a formal nature such as patents and trademarks, others of an informal nature such as lead time, secrecy, or product complexity (Cohen *et al.*, 2000). Firms often use both types of appropriability mechanisms, formal and informal, simultaneously to exploit their innovations (Arora, 1997; Fischer and Henkel, 2013). Consequently, a firm's appropriability strategy is to a large degree a matter of choice, endogenously determined by a firm's strategies and actions (Pisano, 2006). By focusing exclusively on patent data, studies implicitly dismiss both the existence of other mechanisms of appropriation and firms' heterogeneity in their reliance on the different appropriability strategies.

Moreover, strategic patenting motives likely inflate patent numbers as they promote the patenting of incremental inventions. The extent of strategic patenting is in fact sizeable: depending on the industry, about half of a firm's patents may be filed for strategic reasons (Gambardella, Giuri, and Luzzi, 2007; Giuri *et al.*, 2007; Motohashi, 2008). Patents are used strategically as bargaining chips for cross-licensing (Hall and Ziedonis, 2001) and to block other firms (Ziedonis, 2004). Firms even file patents to mislead competitors (Langinier, 2005) and abandon applications later as the mere existence of these unexamined patents creates uncertainty for competitors (Jell, Henkel, and Hoisl, 2013). Artificially inflated numbers of patents due to incremental inventions affect our interpretation of a firm's knowledge base and innovative performance.

Inflated patent counts may be mitigated by weighting them by forward citations which correlate reasonably well with a patent's value (Harhoff *et al.*, 1999; Trajtenberg, 1990). Nevertheless, citations are themselves the result of a complex process (see below) and may therefore introduce noise on their own. Likewise, introducing forward citation-weighted patent counts does not solve the underlying issue that patents do not correspond one-to-one to a firm's population of inventions. Overall, there is a fair amount of bias in a firm's aggregate number of patents. The number of patents is likely to be upward biased due to strategic patenting activities as well as downward biased due to the use of other appropriability mechanisms. While the biases work in opposite directions, they do not mitigate each other as the inventions patented for strategic reasons likely differ from the inventions protected by alternative appropriability mechanisms.

What is even more, without an understanding of what knowledge each individual patent covers it is hard to draw reliable inferences on both innovative capabilities and innovative performance. As Kuhn, Roin, and Thompson (2017) assert by quoting the renowned patent attorney Darin Gibby: "Nearly anyone can get a patent on anything, if they want to make their claim narrow enough." For innovation researchers this insight from patent practitioners means that in order to understand who is more innovative and why, it might be more relevant to understand what is being covered by a firm's patents instead of measuring the size of their respective pile.

2.2.2 Attribution of knowledge flows and inferences on collaboration

Pioneered by the seminal work of Jaffe, Trajtenberg, and Henderson (1993), backward citations have since been widely used to render knowledge spillovers quantifiable. By now, the analysis of patent citations is at the core of the study of knowledge flows, even

though several scholars have acknowledged that the paper trail of citations is noisy and incomplete (e.g., Agrawal and Henderson, 2002; Griliches, 1990; Jaffe, Trajtenberg, and Fogarty, 2000).

2.2.2.1 Determinants of patent citations

From the perspective of the patent system, citations limit the scope of a patent by delineating the pieces of knowledge on which the patent is built. By definition, patent citations cannot provide insights into knowledge diffusion which does not result in a patent, such as learning via imitation or reverse engineering (Griliches, 1990; Pavitt, 1991). Legally, citation regimes and examination practices differ across patent systems. The USPTO imposes the "duty of candor" which requires the inventor and her patent attorney to provide a list of resources that they are aware of that describe the state of the art in order to support the patentability of the invention The European Patent Convention requires a patent application to indicate the prior art that is useful for understanding the invention and for the patent examination and to preferably cite the respective documents. Nevertheless, for both EPO and USPTO patents the majority of citations are in fact added by the examiners (Criscuolo and Verspagen, 2008; Alcacer and Gittelman, 2006). Ultimately, patent citations are the result of the actions and strategic behavior of several actors: the inventor, the inventor's patent lawyer, and the patent examiner. Most applicants rely on lawyers and professional prior art searchers to anticipate examiner requirements regarding prior art (Alcacer and Gittelman, 2006; Alcácer, Gittelman, and Sampat, 2009). Examiners on the other hand have developed their own citation styles and may even have "favorite" citations (Cockburn, Kortum, and Stern, 2004; Cotropia, Lemley, and Sampat, 2013). The shortage of time an

examiner can spend on a patents, particularly given the current backlog at the patent offices worldwide, likely exacerbates these effects.

During the application and grant process patent citations may be altered, excluded, or added to alter the scope of the patent. Since prior art citations limit the breadth of the property right, the applicant has an incentive to omit prior art citations to claim ownership over the technology embedded in the prior art. In addition, firms may withhold prior art citations on purpose to reduce damage fees from willful infringement (Lemley and Tangri, 2003). Patents filed for defensive purposes or cross-licensing tend to contain fewer citations to increase the likelihood of grant (Jaffe *et al.*, 1993; Lampe, 2012). Lampe (2012) estimates that across industries patent applicants withhold up to 33% of relevant backward citations known to them. The citations that applicants appear to withhold preferably are those that compromise the patent application's novelty (Criscuolo and Verspagen, 2008). On the other hand, citations may be added to the application in later stages to strengthen the legal stability of the patent (Allison and Lemley, 1998; Harhoff, Hoisl, and Webb, 2006; Harhoff *et al.*, 1999).

Overall, patent citations are highly mediated by the technology, the examiner, and the applicants' lawyers. Firms are faced with incentives to both exclude and add citations and there is evidence that they navigate these conflicting interests according to their respective needs (Steensma *et al.*, 2015). To the extent that citations are subject to firms' own discretion, this raises questions about their interpretation as knowledge flows. The interpretation of examiner-added citations remains equally fuzzy. Some patent citations may indeed indicate knowledge flows, but many others are confounded by the latitude available to both applicants and examiners.

2.2.2.2 Knowledge diffusion through interpersonal networks and job-hopping

Knowledge diffusion takes place before patenting because knowledge is exchanged when individuals interact during the development process. Interpersonal ties are particularly important as knowledge relevant for inventions tends to be tacit and "sticky" (Hippel, 1994). The decisive factor for the extent of knowledge shared is mutual trust (Hippel, 1987; Bouty, 2000). Because of the importance of an individual's network, job mobility events of individual inventors are assumed to trigger knowledge flows between firms that translate into an increase in backward citations from the recipient to the source firm. The use of patent data to capture both the mobility event and the subsequent knowledge flow, however, suffers from several shortcomings in addition to the noise in the backward citations, as is highlighted in the recent study by Ge, Huang, and Png (2016). First, patents do not contain continuous organizational affiliations of inventors. While inventors need to be named, less diligence is shown with regard to naming their actual employer. Inventors may therefore be attributed to the wrong entity. Similarly, because names are often misspelled in the patent database, researchers may "lose" an inventor over the duration of her career or miscount an inventor's productivity solely because of typos in her name. Second, if the location of the inventor is of interest, the information on the patent may not contain the location the researcher is interested in. The inventor's address on a patent may be either his home address or his business address. In the latter case it may be the actual address of the inventor's business unit or it may be the address of the firm's headquarters. Third, the timing of the move is difficult to retrace based on patent applications alone. Lastly, the data suffers from a survivor bias, as only inventors who continue to patent after a move are identified. For instance, employees may be restricted by non-compete clauses

(Marx, 2011) and may therefore not be identified as mobile inventors based on patent data alone.

2.2.3 Attribution of origin and ownership of knowledge

Even more fundamentally, patent data is subject to limitations with regard to the attribution of the origin of the invention and the ownership of knowledge. This means that as long as the research community cannot properly attribute the true originator and owner of the patent, this will affect the interpretation beyond theoretical constructs such as innovative performance or inventive capabilities. If patent data does not easily allow to identify the true locus of invention then this has repercussions for other constructs, like knowledge flows, too. Consequently, effort and diligence with regard to name disambiguation is critical when researchers want to know where the knowledge originated. But beyond data hygiene issues, patent records often obscure the true creator of the patented knowledge.

The use of patent data to capture innovativeness, knowledge resources and knowledge ownership underestimates the importance of external sources to firms' knowledge development for four reasons. First, the focus of collaboration is typically solving a specific problem or challenge; hence the main focus is on the invention without necessarily generating a patent for each advance of knowledge. While certainly patents may be one result of collaboration, they are not the only one. Collaboration with academics often takes the form of consulting activities and involves less codified private interactions (Cockburn and Henderson, 1998; Roach and Cohen, 2013) which may often not translate into patents. Instead, collaborations with academe may lead to open science contributions through co-authorship of scientific articles and conference presentations (Roach and Cohen, 2013; Simeth and Raffo, 2013).

Second, collaborating companies may contractually agree on the allocation of intellectual property ex ante (Belderbos *et al.*, 2014; Hagedoorn, 2003). These nominal ownership rights may be supplemented with agreements regarding the exploitation rights, for instance an exclusive licensing agreement (Somaya, Kim, and Vonortas, 2010). IP arrangements may be particularly influenced by partners' bargaining power. Firms in a weak bargaining position, such as cash-constrained firms, may contractually cede large parts of the IP rights to the more powerful partner, for instance in exchange for funding (Aghion and Tirole, 1997; Lerner, Shane, and Tsai, 2003).

Third, the patent document alone does not provide consistent information, such as company affiliation, on the contributing parties. While contributing inventors have to be listed, it is not possible to identify whether, at the time of the invention, they were employed by the company, employed by a different company, or active as freelance inventors. A focus on patents alone may therefore discount the importance of external knowledge in firms' innovation processes and may perpetuate an individual firm-centered notion of innovation. Moreover, firms may have distinct assignment policies (e.g.,Arora, Belenzon, and Rios, 2014) and may therefore differ in their practices of assigning patent applications to headquarter vs. assigning them to the respective subsidiary. This is especially troublesome, as in this case, the error introduced is not random and may therefore result in biased estimates.

Lastly, reassignments are an underexplored area of IP activity that may obscure true ownership of patents. Reassignments of patent rights do not need to be reported to the respective patent office. While the U.S. Patent Act provides some incentives for recording the assignment, the new owner has some latitude regarding whether and when she reports the reassignment. This may hold in particular if the new owner has something to gain from obscuring her patent position—a claim sometimes raised with regard to non-practicing entities (NPEs) (Reitzig, Henkel, and Heath, 2007). There is

also anecdotal evidence that firms rely on straw firms for patent transactions, for instance during patent auctions, to conceal the parties truly interested in the patents. In addition, if companies acquire patents during the application stage, they may be assigned to the entity that eventually holds them at the time of grant. Likewise, these reassignments make the interpretation of owning a patent quite fuzzy, especially when the differentiation between creating the invention, i.e. value creation, and exploiting the invention, i.e. value capture, is important for the theoretical construct under study.

2.3 Research method

I followed a four-step approach to achieve a fair representation of the current state of the art of research using patent data and to manage the scope of this analysis. First, I limited the search to research published in six leading management journals: *Academy of Management Journal (AMJ), Administrative Science Quarterly (ASQ), Journal of Management (JOM), Management Science (MS), Organization Science (OS),* and *Strategic Management Journal (SMJ)*. Second, I limited the time horizon from 2004 to 2014 to give a fair impression of the popularity of certain measures in the research community. Third, I searched for "patent*" in the title, keywords, or abstract of the published studies and identified 114 articles. Finally, I reviewed these articles for relevance. Since the focus of this study is on empirical research that relies on patent data, I removed qualitative, analytical, and theoretical articles, as well as quantitative articles that exclusively used survey data or other non-patent data. Moreover, I excluded studies that used patent data for control variables only. I also excluded variables and studies that used patent data as a mere descriptive of patents and not as an operationalization of a theoretical construct. Overall, this approach yielded a final set of

92 articles. Table 1 provides a detailed account of the distribution of the sample studies across journals and years.

Year	AMJ	ASQ	JOM	MS	OrgSc	SMJ	Total per year
2004	-	-	1	1	1	5	8
2005	-	-	-	1	-	2	3
2006	-	-	-	-	1	2	3
2007	2	1	-	2	3	1	9
2008	1	1	-	1	1	5	9
2009	-	1	-	5	-	2	8
2010	1	-	-	3	1	4	9
2011	-	-	-	4	-	1	5
2012	-	-	1	1	3	3	8
2013	1	-	-	5	2	4	12
2014	3	-	3	1	4	7	18
Total	**8**	**3**	**5**	**24**	**16**	**36**	**92**

Table 1: Number of sample studies per journal and year

It becomes apparent that outlets differ noticeably in their publication of patent data based studies. Also, patent data related studies seem to have become more popular in recent years. The development in total is illustrated in figure 1 in the following.

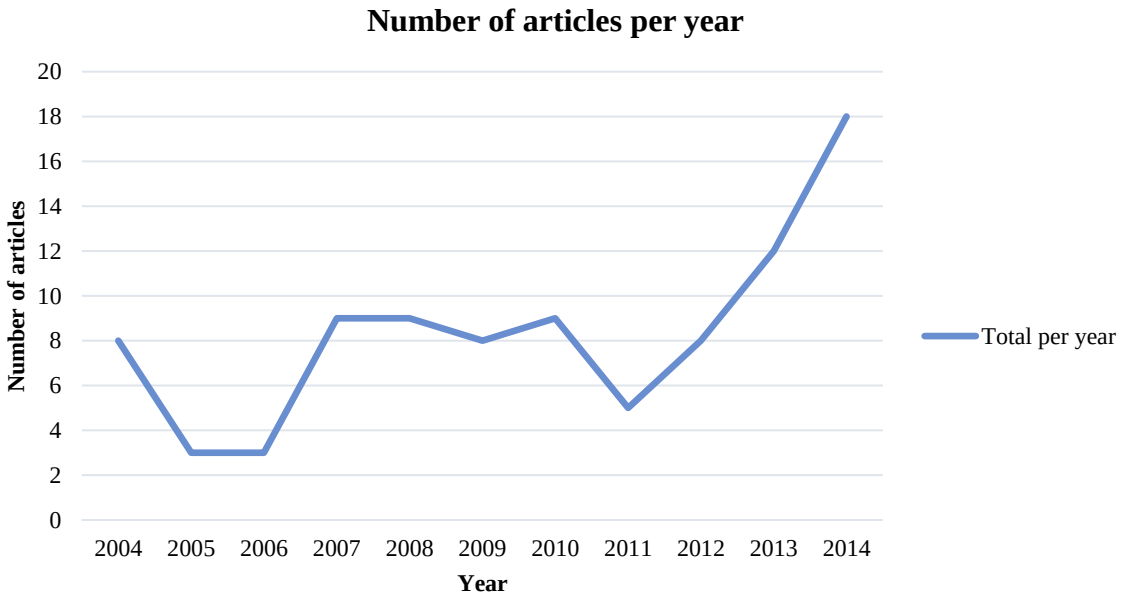

Figure 1: Number of sample studies per year

In order to get a sense of how many variables per study are based on patent measures, figure 2 plots how many studies rely on a specific number of variables based on patent data. While 29% of studies use patent data for a single variable in their

empirical specification, more than half of the sample studies (56%) use patent data for up to four variables. Interestingly, there are a few studies that rely on patent data for practically their entire empirical specification (see table 19 in the Appendix for a detailed account of the use patent data based variables across studies).

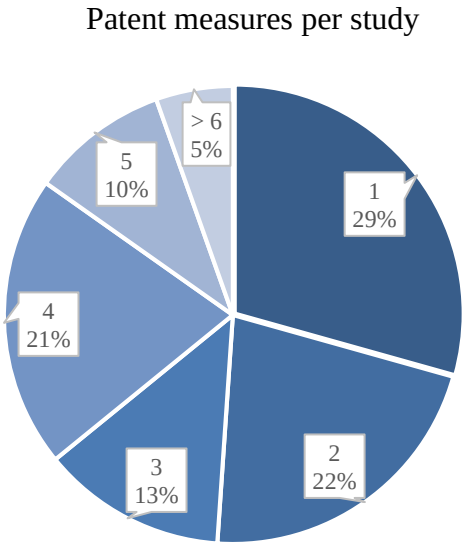

Figure 2: Number of variables based on patent data per study

For the further analysis, I identified both the measurement of the primary variables (dependent and independent variables) and the constructs the variables were supposed to measure and coded them according to the patent data based measure and the underlying construct respectively. To identify and code the measurement of the primary variables, I read the method section of each paper. To identify the constructs that the operationalizations were supposed to measure, I analyzed both the hypotheses development section as well as the method section. Lastly, for the second set of analyses, I manually reviewed the method, results, and discussion sections to identify and code the extent to which the sample studies acknowledge and address potential limitations of patent data.

2.4 Results

2.4.1 Innovation constructs and patent measures

Throughout the 92 sample studies I found a great diversity on theoretical constructs and identified a total of 44 distinct constructs. In order to better compare studies and their use of patent data I organized the individual constructs into a framework of seven higher-level theoretical constructs. These are: knowledge resources, innovative output, knowledge flow and collaboration, characteristics of the invention / innovation[3], characteristics of the inventor, market positioning, and environment. The seven higher-level theoretical constructs each comprise between four and nine individual constructs, as table 2 shows.

Theoretical construct	Examples of individual constructs	Number of constructs
Knowledge resources	Internal knowledge, R&D capabilities	9
Innovative output	Innovation, knowledge creation	4
Knowledge flow and collaboration	Knowledge flow, network characteristics	6
Characteristics of the invention / innovation	Invention / innovation impact, maturity of the technology	7
Characteristics of the inventor	Inventor knowledge base, individual innovation productivity	6
Market positioning	Propensity to patent, new market entry	7
Environment	Distribution of ownership rights, extent of competition	5
Total		**44**

Table 2: Theoretical constructs and examples

To elaborate the framework of higher-level theoretical constructs, *knowledge resources* comprise constructs concerned with the internal knowledge base and capability stock of firms. *Innovative output* consists of constructs about the innovative performance and the knowledge creation of firms. *Knowledge flow and collaboration* contain constructs that are concerned with knowledge transfer and knowledge networks.

[3] Sample studies differed as to whether they claimed to measure constructs of invention vs. constructs of innovation.

Characteristics of the invention / innovation comprise constructs that describe the invention / innovation such as the degree of radicalness or the maturity of the technology. *Characteristics of the inventor* contains constructs that are concerned with the inventor-level and describe her knowledge base or her individual innovative performance. *Market positioning* is concerned with manifestations of firm strategy and firm investments. And lastly, *environment* comprises constructs that describe the environment in which the focal firm is active, such as the competitive situation within the industry. What becomes apparent already in this early step of the analysis is that patent measures are used for a variety of theoretical constructs on the level of the invention, the individual inventor, and the firm.

To reach an even deeper understanding of how patent data is used in empirical studies I then analyze how often theoretical constructs (i.e., the higher-level constructs aggregated in table 2 and described above) are being operationalized using patent data across the 92 sample studies. Within the 92 studies, I identified a total of 256 uses of patent measures, in 98 instances the operationalization was used for a dependent variable and in 158 instances it was used to measure an independent variable. Table 3 on the following page shows the operationalization of the seven theoretical constructs as dependent and independent variables. *Knowledge resources*, *innovative output*, and *knowledge flow and collaboration* account for 170 instances, equivalent to 66% of all patent data based operationalizations in the sample. For the four less popular theoretical constructs, i.e. *characteristics of the invention / innovation, characteristics of the inventor, market positioning*, and *environment*, the figures are relatively similar with respect to both dependent and independent variables.

Knowledge flow and collaboration is the most popular construct and is frequently analyzed as both a dependent and an independent variable (21% and 32% respectively).

Innovative output is a popular dependent variable (35%), but plays a minor role in the form of an independent variable (7%). In contrast, *knowledge resources* are frequently analyzed as an explanatory variable (27%), but are only of minor importance as the explained variable (10%).

	DV		IV		Total
Topic	**Incidences**	**Frequency**	**Incidences**	**Frequency**	
Knowledge resources	10	10%	43	27%	53
Innovative output	34	35%	11	7%	45
Knowledge flow and collaboration	21	22%	51	32%	72
Characteristics invention/ innovation	8	8%	10	6%	18
Characteristics inventor	15	15%	22	14%	37
Market positioning	9	9%	14	9%	23
Environment	1	1%	7	5%	8
Total	**98**	**100%**	**158**	**100%**	**256**

Table 3: Theoretical constructs operationalized as dependent and independent variables

Next, I investigate which patent data based measures are being used across the 92 sample studies. Across the sample I identify 13 distinct types of patent measures. Four of these categories of patent measures use a single indicator, i.e., a patent count, backward citations, forward citations, or another patent data point such as technology classes or inventor data. Another five of these categories of patent measures use a combination of two patent based indicators, e.g., a combination of forward citations and patent counts or a combination of patent counts and other patent data such as technology classes. In addition, two categories combine patent measures with non-patent data. Lastly, another two of the categories of patent measures use a combination of three patent based data point, such as a combination of forward citations, patent counts, and other patent data like technology classes. Table 20 in the Appendix presents the distribution of all patent data based operationalizations coded from the sample studies across the seven theoretical constructs. Out of the recorded 256 instances of

patent data operationalizations 64% (164 instances) are a single indicator measure (patent counts, other patent data such as inventor data or technology classes, backward citations, or forward citations). The three most widely applied measures are based on (1) patent counts, (2) other patent data, such as inventor information, number of claims, or technology class, or (3) a combination of the two and account for more than half (56%) of the operationalizations identified in the sample.

Patent counts constitute the most important measure for five of the seven theoretical constructs, namely *innovative output*, *knowledge resources*, *characteristics of the inventor*, *market positioning*, and *environment*. Other patent data are mostly used for capturing *knowledge flow and collaboration*. The information predominantly used here is data on inventors (careers and employers, locations, etc.) to track inventors and deduce their knowledge sharing. Backward citations are also mostly used to capture *knowledge flow and collaboration*, following the arguments that backward citations provide a paper trail of who built on which knowledge and that citing prior art is preceded by actual knowledge exchange.

For the three most widely studied theoretical constructs – *knowledge resources, innovative output, knowledge flow and collaboration* – the application of patent data is illustrated in figure 3 on the following page. For the construct *knowledge resources*, the main operationalization is based either on a single measure of backward citations, patent counts, or other patent data – or a combination of two of these measures.

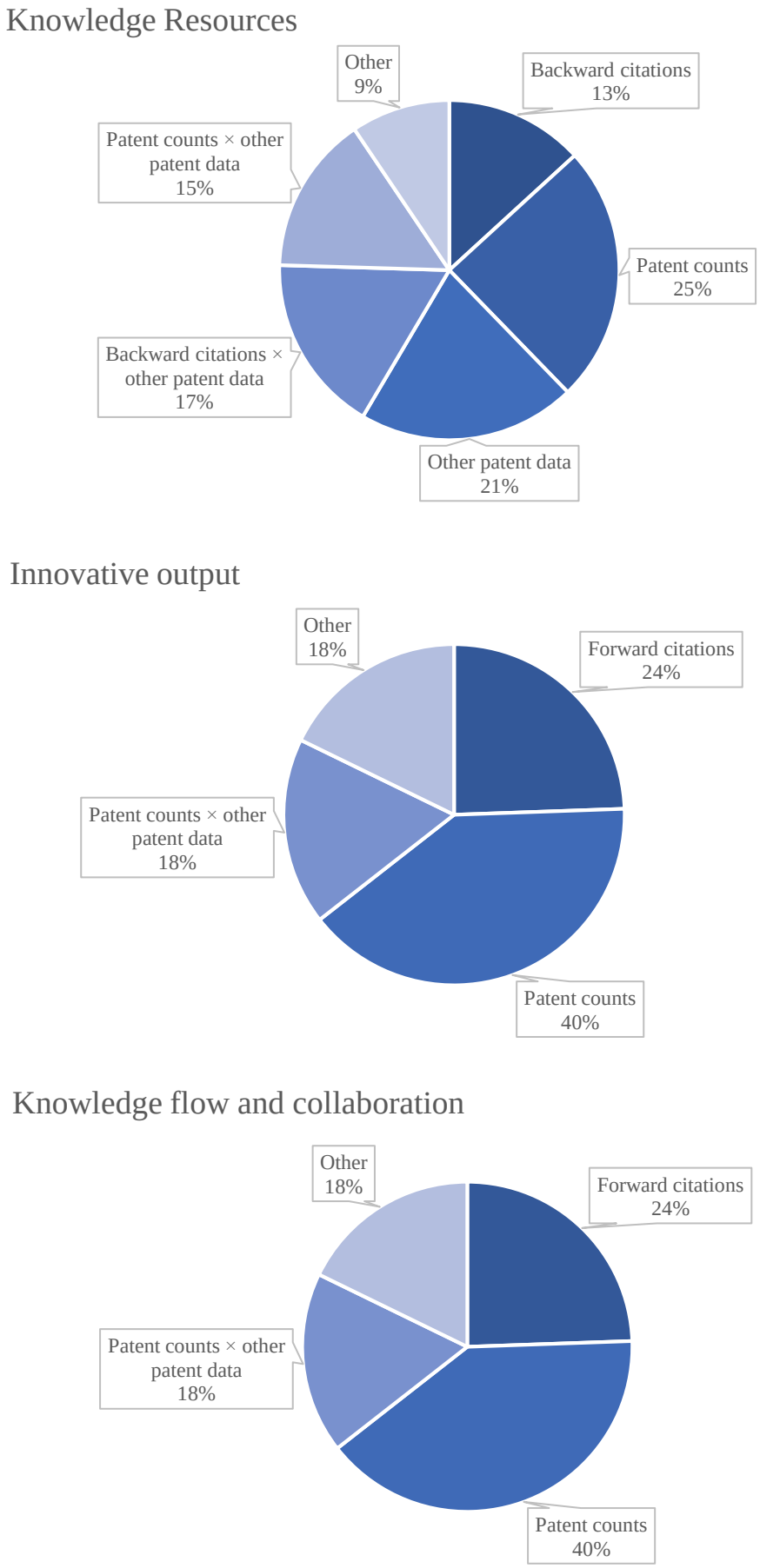

Figure 3: Operationalization of key theoretical constructs

For the construct *innovative output*, the main operationalization is based either on a single measure of forward citations or patent counts – or a combination of patent counts and other patent data, such as technology classes. For the construct *knowledge flow and collaboration*, the operationalization is more varied across single or combined measures, but is mostly based on backward citations and other patent data or a combination of the two.

Overall, the prevalence of the three measures patent counts, inventor data (i.e., other patent data), and backward citations either on their own or in combination with each other is worth stressing, since these measures are prone to exhibit noise or even bias due to the patent process, as detailed above. In terms of the empirical specification, when the measurement error of the dependent variable is correlated with any independent variable, biased estimates will result. When an independent variable is subject of measurement error, estimated coefficients will be biased towards insignificance, if the measurement error can be assumed to have a mean of zero. If, however, the measurement error of an independent variable is correlated with other independent variables, the bias may be more pervasive (Bound, Brown, and Mathiowetz, 2001).

Moreover, many studies use the exact same measures, particularly patent counts, as an operationalization for several constructs within the same study. If, however , constructs, assumed to influence each other such as knowledge resources and innovative output, are operationalized by the same measure, this weakens the confidence in the measure's validity (Bono and McNamara, 2011). Concluding this step of the analysis, patent data based measures are used to operationalize a multitude of theoretical constructs. The most widely used measures – patent counts, inventor data, and backward citations – are likely to be subject to noise or even bias and put into question in how far they truly reflect the theoretical constructs they are supposed to measure.

2.4.2 Why research uses patent data

In this step of the analysis, I investigate why innovation and management researchers decide to use patent data and whether the research community is aware of the potential shortcomings of patent data. To this end, I first coded the extent to which the sample studies provide arguments for the use of patent data in their specific empirical design. Figure 4 shows how many sample studies provided arguments in their research design description for why they utilize patent data in their empirical specification.

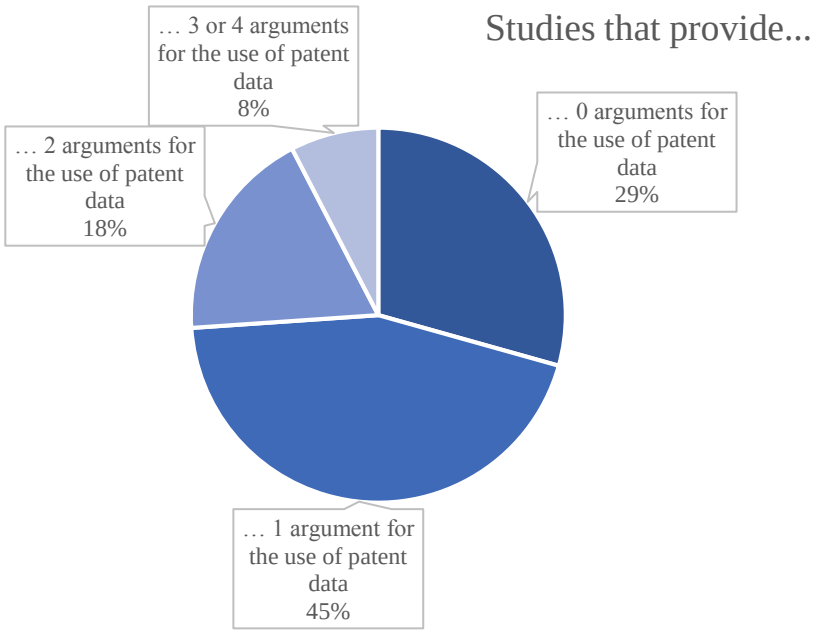

Figure 4: Number of arguments sample studies provide to motivate the use of patent data

A grand majority of the sample (71% or 65 out of 92 articles) provides arguments for why they rely on patent data for the operationalization of one or several theoretical constructs in their studies. Nevertheless, almost one third of the studies (27 out of 92 sample studies) do not even comment on why they use patent data in their empirical design. Since each data choice in an empirical study is subject to tradeoffs but should ultimately reflect the underlying theoretical constructs that are being analyzed, this lack of transparency is noteworthy.

Across the 65 studies that commented on the reasons for using patent data, I recorded a total of 97 arguments. Out of the 65 papers, 41 studies provide one argument and 24 studies provide between two and four arguments (see also figure 4 above). The 97 reasons provided could be coded in eight distinct arguments to support the use of patent data in the respective study. Table 4 shows how often the eight distinct arguments were used in the sample.

Arguments for the use of patent data	**Incidences**	**Frequency**
Patent data provides established measures	34	35%
Patents are relevant in the industry context	18	19%
Patent data is fitting for the construct studied	17	18%
Data availability	15	15%
Patent data provides a paper trail of firm/ inventor activities	7	7%
Interviews support the use of patent data	2	2%
Patent data addresses or overcomes limitations of other data	3	3%
Patent data is used to test the validity of patent data	1	1%
Total	**97**	**100%**

Table 4: Arguments for the use of patent data as mentioned in the sample

In practice, four of the eight arguments dominate the narrative provided by the sample studies (accounting for 87%), as can be seen in figure 5.

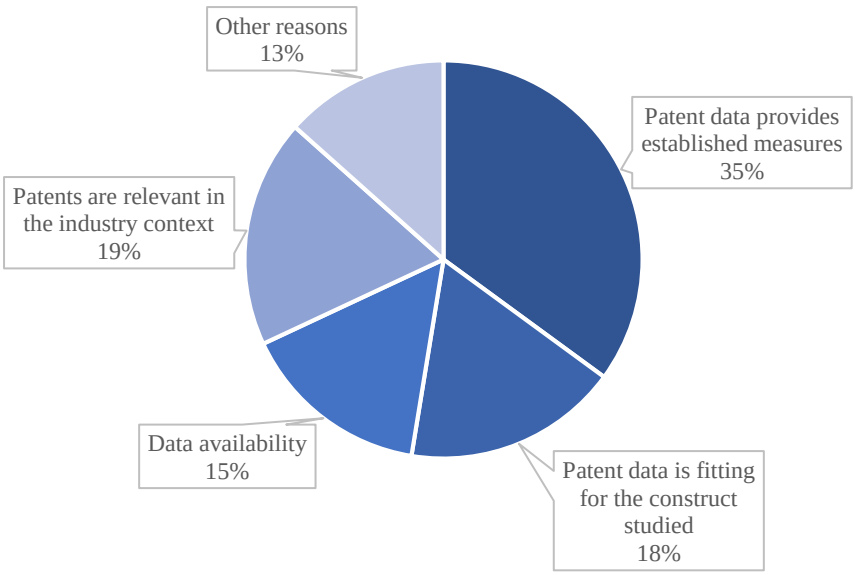

Figure 5: Arguments for the use of patent data

These four arguments are that (1) patent data has been used in the literature before; that (2) patents are a relevant tool in the industry of study; that (3) patent data is a fitting operationalization of the construct of interest; and that (4) patent data constitutes a rich data source to be exploited in empirical studies. It is worth noting that the majority of arguments provided to support the use of patent data are in fact uncoupled from the respective research question and setting of the study. Instead, the prime reason to justify the use of patent data is that it has been used before. Needless to say, in other contexts of research design, for instance the use of a certain estimation method, this argument would be regarded as highly questionable and would not be considered as a sufficient reason for choosing a certain specification.

2.4.3 Awareness to potential problems of patent data

Next, I analyze the awareness and sensitivity in the innovation and management research community towards potential shortcomings of patent data. To this end, I coded the extent to which the 92 sample studies acknowledge and address potential limitations of patent data. First, I coded whether studies proactively acknowledge the limitations that are inherent to patent data and that hence might influence the results of the respective studies.

Figure 6 shows how many sample studies acknowledge in their research design description that patent data has shortcomings (in terms of data hygiene and / or its interpretation) that may affect both the operationalization and the results. Out of the 92 studies a slight majority (58% or 53 out of 92 papers) indeed acknowledge that patent data may suffer from limitations. About 30% of the studies (27 papers) even provide more than one reason for why patent data may have shortcomings. In contrast,

more than 40% of studies (39 out of 92 studies) do not acknowledge that patent data is fraught with problems that need to be acknowledged and dealt with.

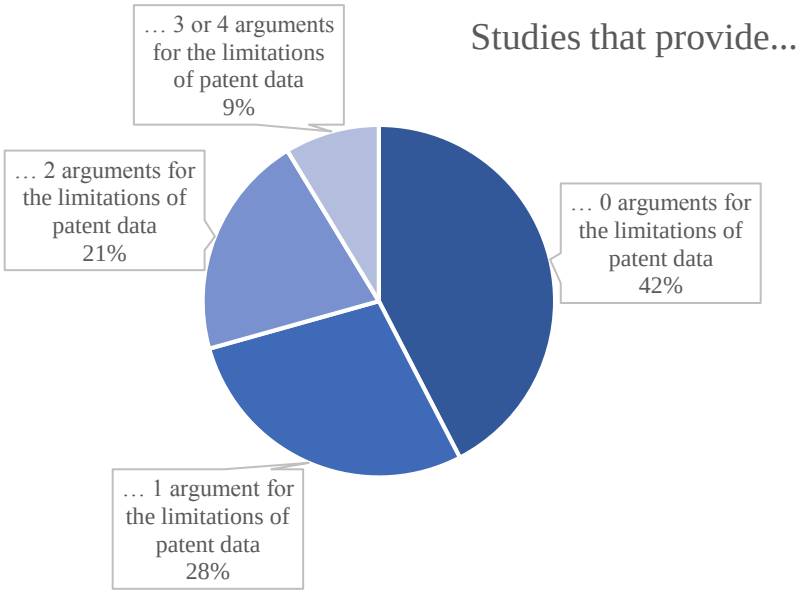

Figure 6: Number of arguments sample studies provide to acknowledge the shortcomings of patent data

In total, I recorded 89 arguments that studies provided to acknowledge that patent data comes with potential limitations. As figure 6 shows, 26 papers provide one argument and about the same number of studies provides two to four arguments to acknowledge potential problems related to patent data.

Potential shortcomings of patent data	**Incidences**	**Frequency**
Patents do not reflect all inventive activity	24	27%
Noisy backward citations as a result of the patent process	17	19%
Data hygiene of patent databases	15	17%
Patents do not reflect the entire knowledge base	10	11%
Industry-specific patent propensity	10	11%
Measurement error and potential bias in estimates	6	7%
Strategic patenting	3	3%
Other	4	4%
Total	**89**	**100%**

Table 5: Potential limitations of patent data as mentioned in the sample

I identified seven distinct limitations of patent data that the sample studies acknowledge. Table 5 shows the popularity of certain arguments. To provide further insights, the issues of patent databases regarding data hygiene that were specifically

mentioned are detailed in table 6 below. The problems of data hygiene that are raised are that (1) inventor careers can only be imperfectly tracked by patent data; (2) there are frequent misspellings or typos that make the name-matching of inventors difficult; (3) location data is not reliable, because for instance it is subject to firm policy which address is recorded in a patent application; and (4) patent assignments to subsidiaries, headquarters or collaborating firms may not be reliable, because again this may be subject to firm policy.

Potential shortcomings due to data hygiene	Incidences	Frequency
Missing data on inventor careers	6	40%
Name-matching inventors	3	20%
Reliability of location data	3	20%
Patent assignment to a/ in a firm	3	20%
Total	**15**	**100%**

Table 6: Potential shortcomings of patent data due to data hygiene issues

Overall, one argument dominates the conversation with about half of the explanations provided (44 arguments or 49%) and that is that patents are the result of a selection process and therefore do not reflect all inventive activity or the entire knowledge base and are a product of industry-specific practices. It is, however, surprising that an issue, such as the selection effect, that has been raised in the literature already more than 30 years ago, is only being acknowledged by 27 studies. It is also worth noting that that both pervasive – and potentially critical – issues of data hygiene related to name-matching and firm boundaries and the potential for measurement error are only rarely acknowledged: only 11 studies out of 92 point out this fundamental shortcoming of patent data. Similarly astonishing, only three studies raise the point of strategic patenting that is likely to both inflate the number of patents and result in patents on incremental inventions with questionable validity.

2.4.4 Mitigation of potential problems of patent data

As a last step in the analysis, I investigate whether and how the sample studies address the potential limitations of patent based measures. In this analysis, I code three potential routes that studies may take to mitigate or refute the potential shortcomings of patent data: (1) studies may provide arguments for why their empirical design relies on patent data *despite* the potential shortcomings associated with it; (2) studies may use other, non-patent data as a supplement or substitute for patent data based measures; (3) studies may conduct robustness tests to strengthen the confidence in their empirical results.

Overall, a grand majority of sample studies (65 out of 92 studies, equivalent to 71%) aim to address potential limitations of patent data through at least one of the three coded ways of mitigating potential data problems. This is worth highlighting, as not all of these studies even raised concerns about potential problems of patent data (as highlighted in chapter 2.4.3 above). The majority of the studies that address the potential shortcomings of patent data (45 out of 65 studies) do so, however, through only one of the three coded ways to address problems with patent data.

On the flipside, about one third of the sample studies (27 out of 92 studies) do not make the effort to address potential issues related to patent data. Similarly interesting, four studies do not try to mitigate the potential shortcomings of patent data, even though they actually acknowledge the limitations of their measures in their data description. This is particularly noteworthy, as in these studies patent data was used for several variables in the model, and, in two of the four cases, was even used to measure the dependent variable. If a single data source is this important to empirical specifications, there should be at least some critical evaluation of potential issues related to the data – especially if the limitations are being acknowledged. Assuming that editorial quality is

highest in the chosen outlets this finding poses questions as to the rigor expected and enforced by editorial boards for empirical investigations.

The first means – and the one that requires the least effort by researchers – through which a study may try to mitigate shortcomings of patent data, is to provide an argument for why the problem does not prevail in its specific context or why it is assumed to not bias the results. Figure 7 shows how many sample studies provide one or more arguments for why potential shortcomings of patent data do not constitute a problem in their specific research design.

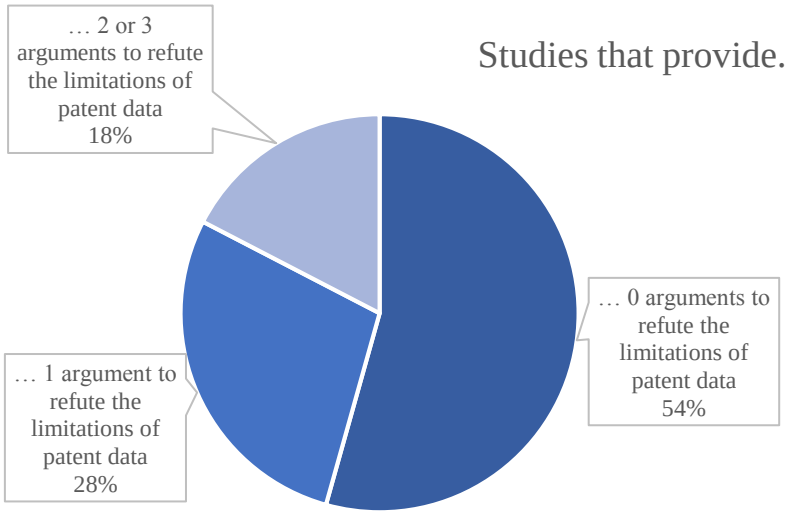

Figure 7: Number of arguments sample studies provide to refute the limitations of patent data

A little less than half of the studies (42 studies or 46% of the sample) give at least one argument in their article for why they use patent data to operationalize their constructs of interest despite the potential issues regarding both data hygiene and interpretation. On the other hand, more than half of the studies (50 studies of the 92 sample studies) do not provide an argument for why the limitations do not apply. Again, given the pervasiveness of the issues with patent data, this raises concerns as to how researchers have chosen do deal with them. In total, across the 42 studies, I identified 62 individual arguments that could be coded into six distinct categories, as can be seen in table 7.

Arguments for why potential shortcomings of patent data do not apply	Incidences	Frequency
Use of patent data is supported by previous studies	16	26%
The choice of research design mitigates problems	24	39%
Data limitation will not introduce systematic bias	6	10%
Data limitation will bias only toward insignificance	4	6%
Diligent assignment	6	10%
Data availability offsets the concerns	2	3%
Other	4	6%
Total	**62**	**100%**

Table 7: Arguments to refute potential limitations of patent data as mentioned in the sample

First, the mere use of patent data in previous studies is the single most used argument (26% or 16 studies) to refute concerns about data issues and the interpretation of patent data. Just because ways of thinking or measuring have been done before does not make them just or appropriate. Complacency does not yield new and interesting insights that advance the field. To the contrary, advances in science require some kind of challenge to the status quo of thinking and doing research.

Moreover, a good third of the arguments asserts that the choices made regarding to the study's research design mitigate the potential problems of patent data. To further illustrate, table 8 breaks this coding up into a more fine-grained analysis of arguments.

Arguments for why the research design mitigates the problems with patent data	Incidences	Frequency
Patents are relevant in the industry context	9	38%
Use of control variables to rule out alternative explanations	7	29%
Single industry focus	3	12%
Adaptation of the research design	2	8%
Use of other (better) patent-based measures	3	12%
Total	**24**	**100%**

Table 8: Arguments to refute potential limitations of patent data with regard to the choice of research design

The arguments related to the choice of research design mostly claim that either the industry context – the fact that patents are important in the respective industry, or that the study only looks at one industry – or the use of control variables lessens the problems related to patent data. While it is certainly desirable to rely on an industry that

regularly patents, if patents are used to capture theoretical constructs such as innovative output or knowledge resources, the problems of firm boundaries and the attribution of patents to their originator, the selection of inventions to patented, and the fuzziness introduced by strategic patenting still remain in place.

Lastly, one argument in particular needs to be stressed, as it should caution the research community as to the standards that are being applied to research. Two studies made the argument that the end justifies the means, i.e. that the fact that the patent data is there offsets the concerns with regard to data hygiene and interpretation. Luckily, it was only two studies and this line of thinking does not appear to be pervasive, but still as a research community, there should be a consensus that mere data availability is not an acceptable reason for using it in and of itself.

In the next coding step, I examined whether studies address potential shortcomings of patent data by supplementing it with data from non-patent sources. Of the 92 sample studies, eight studies (9%) use data from a non-patent data source to supplement or substitute variables based on patent data in their regression analysis. Table 9 shows the type of non-patent data used: the eight studies rely on five different data sources. Overall, the small fraction of studies that use alternative data, use it exclusively to operationalize the theoretical constructs *innovation output* and *knowledge flow*.

Data from non-patent sources	**Incidences**
Survey data on inventors' histories to measure knowledge flow	3
R&D expenditures as an alternative measure for innovation	1
New product data as a measure for innovation	2
Trade association data on firm locations to measure knowledge flow	1
Patent attorney location to capture law capabilities as a factor of innovation output	1
Total	**8**

Table 9: Data from non-patent sources

Lastly, I analyzed whether studies address the potential limitations of patent data based variables by performing robustness checks. As figure 8 shows, half of the studies (46 out of 92) perform at least one robustness check related to patent data based measures.

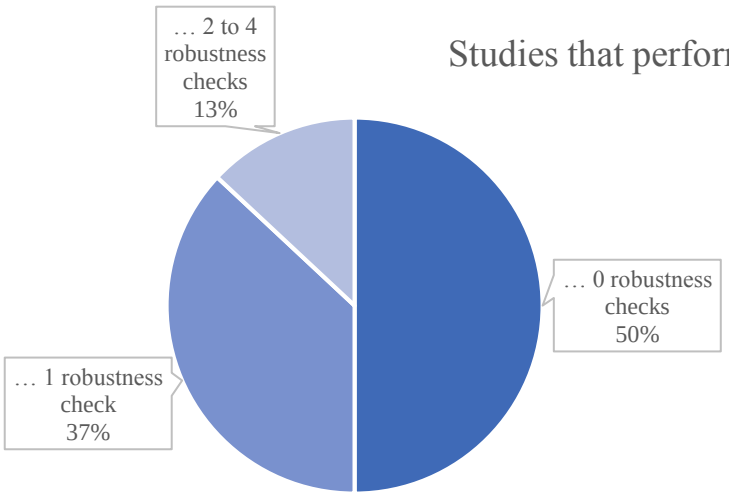

Figure 8: Number of robustness checks sample studies perform related to patent measures

The majority of studies (34 out of the 46 studies that perform robustness checks) perform one robustness check related to the patent measure. In addition, 12 papers perform several patent data related robustness checks (between two and four). In total, I recorded 49 individual robustness checks that can be coded in eight distinct categories of robustness checks, as shown in table 10. It is important to note that the majority of robustness checks performed primarily focus on the sensitivity of the results to variable definitions, the sampling choice, or the estimation method.

Most often, studies check whether (1) the results hold to changes in the variable definition, e.g., whether the results hold when innovation output is measured with a forward citation-weighted patent count instead of just a patent count; (2) the results are sensitive to thresholds related to time or citations; or (3) the econometric model has an effect on the results.

Robustness checks	Incidences	Frequency
Use of other patent data based measures	17	35%
Use of other cutoff thresholds (e.g., point in time)	9	18%
Estimation of a different econometric model	6	12%
Rerun regression with a subsample	5	10%
Differentiation inventor vs. examiner-added citations	4	8%
Introduction of non-patent measures	3	6%
Introduction of additional control variables	2	4%
Other	3	6%
Total	**49**	**100%**

Table 10: Robustness checks performed related to patent data based variables

Analyzing the sensitivity of estimation results is a valid and relevant starting point that helps strengthen our confidence in the cutoff choices researchers make. But sensitivity checks do not challenge the underlying assumptions of the model and do not aim to rule out alternative explanations. They therefore cannot strengthen our confidence regarding the validity of patent data to capture the theoretical constructs in the first place.

In contrast, 9 studies check the use of patent data more rigorously, for instance by checking whether the origin of prior art citations (applicant vs. examiner) has an effect, as this could directly affect the interpretation of the results. Similarly, five studies introduce new data to rule out other explanations and check the validity of the patent data based measure.

In conclusion, the extensive analysis of the state of research using patent data reveals several important insights: (1) patent data is used to measure a broad scope of theoretical constructs of interest for innovation and management researchers; (2) while simple count measures are still the most prevalent, patent data based measures can be quite intricate, for instance linking citations, patent counts, and technology classes in a single measure; (3) many studies motivate the use of patent data through rather weak arguments such as prior use instead of deriving it from their specific research context;

(4) while it appears that the research community is largely aware of the limitations of patent data, it also seems that the research community avoids to address this problem head-on through transparent communication and rigorous testing.

2.5 Discussion and conclusion

The availability and richness of patent data have without a doubt allowed for important inquiries in questions of management, strategy, and innovation. At the same time, patent data suffers from serious shortcomings. While these shortcomings are by no means new (e.g., Griliches, 1984; 1990) and there have been a few recent endeavors to increase our understanding of these limitations (e.g., Alcacer and Gittelman, 2006; Fontana *et al.*, 2013; Gittelman, 2008), this study is the first to analyze whether and how the research community approaches and handles these data issues. Overall, my extensive analysis of how patent data is used in the six leading management journals and how leading researchers address the issues related to patent data in their studies suggests that the research community has not fully acknowledged the consequences these limitations have – or alternatively, is afraid to openly acknowledge them for fear of foreclosing a large and interesting data source.

To be clear, the implication of this study is not to stop using patent data in management research. Patent data offers a plethora of information and advances in matching algorithms and in-text search will allow for new forms of analysis. Currently, there are several ongoing projects on name disambiguation (e.g., Li *et al.*, 2014; Pezzoni, Lissoni, and Tarasconi, 2014) that address one of the fundamental shortcomings of patent data. Moreover, patents are an important instrument to innovative firms and as such, the topic and data warrants exploration by management scholars. But the inherent problems in patent data will not vanish and therefore the

research community needs to find a way to balance the need for large-scale analyses with the need for methodological rigor. In order to move forward I present three implications from this study that provide promising avenues for this endeavor: challenging the status-quo, promoting broader and deeper exploration, and striving for more transparency.

2.5.1 Challenging the status-quo

The analysis suggests that the research community exhibits quite a bit of inertia when it comes to the use of patent data: the fact that patent data has been used before is a common argument in empirical studies to motivate the use of patent data—as is the fact that the data is simply there. While I agree that it would be foolish not to use the wealth of information that is hidden in patent data bases worldwide, the research community needs to be careful that the attraction of a large dataset and the fact that there are many precursors do not cloud its judgment regarding the use of patent data. While making compromises is part of research, where, in particular, first and bold strides into a field are not perfect (Popper, 1959), research should progress in a sense that as the field matures, the research community pushes the boundaries not only in terms of the questions it asks, but also in terms of the ways it tries to answer these questions.

Given the results of this study, it is reassuring that the majority of the sample articles try to mitigate the shortcomings in their data. But again, the research community exhibits a degree of inertia and even complacency when it comes to addressing patent data issues. Limitations of patent data are refuted exclusively by citing the use of patent data in prior studies. This is particularly arbitrary when prior studies that call the use or interpretation of patents in doubt are ignored. Likewise, the acknowledgement of data issues appears rather ceremonial, when potential limitations are quickly refuted with the

reference to the widespread use of the measure. Less than 10% of the sample studies venture outside the beaten track and supplement or substitute their patent measures with non-patent data. While half of the sample studies do perform robustness checks related to the patent measures, most only perform sensitivity analyses regarding certain cutoffs or time-windows, avoiding to truly challenge the assumptions of their model or to address the underlying problems of the patent data based variables.

In order to challenge the status quo, the research community should encourage authors to question the use of patent data. Researchers should feel confident to explore and investigate whether the underlying assumptions of the theoretical constructs of interest truly fit those of patent data, especially with regard to firm practices of patenting. Constructs constitute the basic building blocks that connect theory development to empirical testing (Echambadi, Campbell, and Agarwal, 2006: 1802). If constructs and their operationalizations do not overlap sufficiently, this may at a minimum result in noise, and more critically in measurement error. While sensitivity checks are a valuable starting point, robustness checks that challenge the obtained empirical results as well as studies that aim to investigate the validity of patent data itself should become more prevalent.

Moreover, studies should investigate how patents are being produced and strategically used by companies in order to further the research community's understanding of how and when patent data provides interesting insights into innovation practices and how empirical results derived from patent data may be interpreted. For instance, the issue of patent families is still quite underresearched and the implications for interpretation remain unsolved (Rios, 2014). If applications are combined or split up or replaced by continuations, what does this choice mean for the underlying invention? Which individual application is the result of strategic behavior and which application covers the true inventive progress? Answering these and similar questions is

fundamental for the understanding and interpretation of patent data and research should move into this direction to advance the field as a whole.

2.5.2 Promoting broader and deeper exploration

While the scope and depth of patent data will continue to allow for complex inquires, management research should venture off the beaten paths of prior literature. Enriching patent data with data from other sources or creating entirely new data sets from primary data most certainly provides a promising avenue for future research. For instance, Dokko and Rosenkopf (2010) use a unique source to identify job mobility. They exploit meeting rosters of a standard-setting organization as their primary data source, since attendees to the meetings had to sign with their name and company affiliation. Patent data information on inventor careers only acts as a supplement. Primary data from inventors and companies will continue to benefit our understanding of key innovation concepts, particularly those that are subject to selection processes. Relying on other data sources also allows for the triangulation of results (Jick, 1979) that were generated exclusively from patent data.

Moreover, future research should make more inquiries into the fit of patent data operationalizations with the respective theoretical construct of interest. This may for instance be done through interviews as part of the research design to validate the match between theoretical construct and operationalization in the respective research setting. In addition, future studies should focus on exploring the intra-firm processes that lead to patent data. While we do know that patents are not the only appropriability mechanism that firms use, we know very little about the intra-firm processes that lead to the decision on one or a combination of appropriability mechanisms. So far, there are only few studies that enlighten our understanding of what happens inside the firm before we

observe a patent application (Alexy *et al.*, 2014; Bhaskarabhatla and Hegde, 2014). In-depth studies on within-firm processes and intra-firm selection mechanisms will promote our understanding of how, when, and why patents result. Chapters 3 and 4 of this dissertation provide a starting point into this area of exploration.

A deeper understanding of intra-firm innovation processes is particularly crucial as data availability on other appropriability mechanisms is limited, if not nonexistent, and makes it very unlikely that future large-scale empirical studies can rely on data on several appropriability mechanisms, besides patent applications. For the research community as a whole, a proliferation of qualitative inquiries into patent processes and the application of mixed methods of analysis within this particular stream of research will promote the confidence in the results derived from patent data, as the weaknesses of one method may be mitigated by the strengths of another (McGrath, 1982).

2.5.3 Striving for more transparency

The results of this study suggest that overall the research community seems to be aware that patents are both an incomplete and a noisy indicator. Nevertheless, the result that almost half of the sample studies – derived from the top outlets in the field – do not acknowledge that patent data has inherent problems that could affect the empirical results is worrisome for the community as a whole. What remains to be analyzed is what drives this finding. Is the research community in fact aware of the problems, but does not dare to openly address them for fear of jeopardizing the publication of its studies (and ultimately jeopardizing individual careers) or is the lack of transparency in fact a sign that the proliferation of patent data based studies has actually reduced the awareness in the research community about the inherent problems of patent data.

Either reason could of course be confounded simply by the choices of the reviewers and the respective editor in charge. Researchers could have provided more in-depth arguments for why they use patent data and for why patent data is useful in their study despite its shortcomings, but those arguments could have been deleted or significantly shorted as a result of the editorial process. While this study tried to mitigate this effect by only sampling from leading management journals that should be expected to exhibit the highest standards both with regard to the empirical studies that are being published and the review and editorial quality, I explore this issue by analyzing whether there are systematic differences across journals with regard to the studies' transparency about potential problems of patent data. Tables 11 and 12 on the following page show the results of this exploration. While the six chosen outlets differ in their respective mission and focus with regard to empirical work and theoretical contributions, the findings summarized in both tables suggest that there are differences across journals with regard to the transparency provided by their published articles. While ASQ seems to expect a high standard of transparency, articles published in AMJ show a higher level of non-disclosure with regard to patent data issues.[4]

In order to advance the field, researchers should be upfront about potential issues inherent in the data. It should be standard practice when patent data is used to operationalize theoretical constructs that the authors acknowledge the possibility of data issues and address them in their paper through research design, an evaluation of why these issues are only marginal, or through robustness checks that challenge the results more than a sensitivity check of the time window.

[4] The reader should, however, bear in mind that this exploration does not account for the rigor and quality of the arguments provided. Still, the exploration is at least indicative in the sense that non-disclosure, i.e. not even providing an argument in the first place, is a sign of lower transparency.

Journal	Studies that		Total sample studies	Percentage of non-disclosure
	provide arguments for using patent data	do not provide arguments for using patent data		
AMJ	4	**4**	8	**50%**
ASQ	3	**0**	3	**0%**
JOM	5	**0**	5	**0%**
MS	19	**5**	24	**21%**
OS	6	**10**	16	**63%**
SMJ	28	**8**	36	**22%**
total	**65**	**27**	**92**	**29%**

Table 11: Non-disclosure across journals

Journal	Studies that		Total sample studies	Percentage of non-disclosure
	acknowledge problems of patent data	do not acknowledge problems of patent data		
AMJ	3	**5**	8	**63%**
ASQ	3	**0**	3	**0%**
JOM	2	**3**	5	**60%**
MS	13	**11**	24	**46%**
OS	9	**7**	16	**44%**
SMJ	23	**13**	36	**36%**
total	**53**	**39**	**92**	**42%**

Table 12: Non-disclosure of problems with patent data

Second, the research community should strive to be more transparent with regard to how the original data retrieved from the USPTO or NBER, National Bureau of Economic Research, or other databases is handled, in terms of name-matching of companies and inventors and the assignment of patents to companies. Researchers, particularly those that are novices with patent data, should look for guidance regarding both data cleaning and matching. While written for researchers in corporate finance, Lerner and Seru (2015) provide a starting point for management researchers who want to start working with patent data.

Lastly, editorial boards should expect and ask for higher levels of transparency regarding the use of patent data. In recent years, the innovation research community has seen cases of scientific misconduct, most notably the retractions of several studies by

Lichtenthaler (West, 2014). While some journals now ask for more disclosure on the data and how it is used, confidence in empirical results should also be strengthened through more transparent disclosures with regard to the data tradeoffs and choices of the research team.

2.5.4 Limitations, future research and conclusion

This study aims to consolidate knowledge about the state of the art of patent research. Over the last few decades, patent data has been used for an ever increasing number of studies and constructs. This popularity warrants the need to evaluate the application and to consolidate our knowledge. This study provides a comprehensive overview of the major challenges of patent data, of the use of patent data in empirical studies, and of the awareness of the research community to the issues of patent data. Of course, this study is not without limitations of its own. First, the review only covers a selection of journals to keep the scope manageable, but fails to comprehensively review the entirety, or at least the majority, of the field. I expect this to only affect my results in a conservative way, since the study's focus on highly-ranked journals should make it less likely to find shortcomings in the sample studies' research designs.

Second, published work has been changed throughout the editing process. Authors may have provided information on why they use patent data or on how they argue to cope with potential limitations of patent measures, but this information may have been deleted during the editing process. I explore this issue and do find some evidence that suggests that journals differ with regard to the amount of transparency they provide in their published work. However, it is not obvious why these highly acclaimed outlets should actively and regularly edit out information on the validity of the data and the research design that had originally been included in the submitted drafts. Lastly, since I

rely on published work instead of working papers or even interviews of researchers, I cannot distinguish whether researchers were simply not aware of the magnitude of some problems of patent data or whether they deliberately choose to not address the concerns in order to not jeopardize the publication of their work.

The conclusion of this study is not to discard patent data from an innovation researcher's toolbox. The scope and depth of the data, particularly in the longitudinal dimension, will continue to allow for complex inquiries and advance the research community's understanding of an array of firms' management decisions. Nevertheless, I suggest three sets of strategies that will increase the rigor of empirical studies and advance our understanding of the underlying processes. First, researchers should be upfront with the challenges of patent data and communicate their data handling in a transparent way. Awareness about the limitations of patent data is especially vital for new scholars entering the field. Second, study designs should account for the challenges of patent data. Failure to account for the fundamental limitations of patent data risks the validity of otherwise carefully crafted studies. Low validity will lead to noisy results, but, more critically, it may lead to partial or biased results and may jeopardize the interpretation of empirically found relationships. Third, researchers should aim to address the limitations of patent data by rigorous robustness checks and/ or by using supplementary data from other, non-patent sources. Lastly, efforts to further understand the underlying processes and assumptions of patent data are valuable steps for future research that will benefit the field as a whole.

3. To patent or not to patent? How firms decide on patent protection for inventive knowledge

3.1 Introduction

Innovative firms aim to appropriate the returns to their innovations. In order to do so firms may use appropriability mechanisms to facilitate capturing the value that their innovations created. Patents are one of those appropriability mechanisms. Even the general public has picked up on the importance of patents due to the patent related litigation frenzy in the telecom and IT space in the last few years. While management and innovation research eagerly seized the opportunity to utilize the wealth of information hidden in patent databases, the intra-firm processes that lead to a patent application have largely remained a black box. Even though Griliches (1984) already stressed that through an intra-firm selection not every invention is turned into a patent, we still know surprisingly little about firms' decision making on whether to patent an individual invention. This research sets out to shed some light on the selection processes taking place within companies that lead to patent applications on some, but not all inventions. Especially since patent data is of high importance to researchers, it is an important question for the whole research community to answer how and why companies decide to patent some of their inventions. This study is a step in this direction. Through qualitative, exploratory research with 16 companies from various industries this study seeks to advance our understanding of how firms make the choice – including who is involved and who is in charge – as well as to provide insights into why companies make the choice for patent protection.

The decision to patent is an inherently complex one, fraught with uncertainties, and influenced by many variables, only some of which are under the control of the company. One of the key findings is that companies simplify this complex decision and turn the decision to patent into the frame of reference and even the de-facto default in the decision making. Given the number of inventions large innovative companies have to deal with on a weekly or monthly basis, it is not surprising that the individual decision is reduced in complexity. What is interesting is that this behavior is consistent across companies, sizes, industries, and organizational structures.

Organizational structures are where companies appear to differ. I find that companies fall in one of two distinct organizational decision structures, IP controlled and business unit (BU) controlled. The IP controlled type keeps the patent decision process entirely under the prerogative of the IP department. The IP department remains highly involved throughout the process and decision making, and the decision is made by someone in the IP department. On the other hand, the BU controlled type transfers the decision capabilities from the IP department (where the initial evaluation takes place) to a dedicated committee of business unit representatives. The IP department therefore shows a lower degree of involvement throughout this type of decision making.

From a research perspective this study makes several contributions. First, the results of this study contribute to the literature on appropriability mechanisms. It sheds light on how companies decide on the kind(s) of appropriability mechanism(s) used for their inventions. This is especially interesting as the choice of mechanism is not in its entirety observable from the outside. As per definition, trade secrets remain secret inside the company and therefore unobservable to researchers and the general public. Likewise, (defensive) publications are only imperfectly observable given the many possibilities to publish and the often underlying desire to publish covertly.

Moreover, this study informs empirical researchers about the validity of patent numbers as a means to measure innovation. While there is still a selection taking place, the finding that companies lean towards patenting means that patent numbers will underestimate innovative capacity and inventive productivity only to a limited extent. To the contrary, patent numbers are more likely to overestimate actual inventive productivity if measured by patent output as the preference for patents means that also low-value and incremental inventions are regularly patented as a way to increase the portfolio size, to secure space in the technical landscape, and to protect the company's stake against competitors' claims.

Lastly, the findings of this study are also interesting from a normative perspective, as they demonstrate how far the actual use of patents and their intended function have diverged. It is questionable whether it is beneficial to society that exclusion rights are granted on inventions with only marginally new knowledge and that patents are turned into offensive tools to hinder competition by blocking competitors and new entrants.

3.2 Theory

Firms use appropriability mechanisms to facilitate capturing the value that their innovations created. Appropriability mechanisms constitute isolating mechanisms that create barriers to imitation (Mahoney and Pandian, 1992; Rumelt, 1984) and thus help firms create or preserve their competitive advantage. Firms may rely on a variety of appropriability mechanisms, some of a more formal nature, such as patents and trademarks, and some of a more informal nature, such as secrecy, lead time, and product complexity (Cohen *et al.*, 2000; Levin *et al.*, 1987).

Appropriability mechanisms differ on two important dimensions: the level of disclosure required by using the mechanism and the level of control retained by the

firm. Trade secrets do not require any disclosure – in fact they require complete secrecy – and retain their legally protected status only until they become public knowledge (Hannah, 2005). Firms retain complete control over the knowledge, as long as every employee involved is aware of the trade secret requirements and the necessary rules of conduct.[5] In order to protect proprietary knowledge and trade secrets, firms may design specific rules and routines regarding disclosures in order to retain a higher degree of control over their knowledge (Liebeskind, 1996). Other appropriation mechanisms come with different sets of disclosure–control specifications. If a firm decides to patent a piece of knowledge, it accepts the need to disclose sufficient information about the invention in order to attain the exclusion right that a patent grants. While firms may try to obscure information in a patent application, the document does provide valuable information to competitors (Magazzini *et al.*, 2009; Hippel, 1988). Disclosing knowledge to the public domain without pursuing a patent application means that the firm cedes its control over the knowledge. Other firms, including competitors, can exploit and use the knowledge freely and without legal boundaries. Of course, they cannot pursue a patent application on that knowledge as the disclosure constitutes prior art. Although somewhat counterintuitive, this behavior is not of an altruistic nature, but often of a strategic one. For one, revealing knowledge may aid value capture through creating an ecosystem or encouraging the development of complementary products (Alexy, George, and Salter, 2013; Henkel, 2006). In sum, firms face a trade-off between control and disclosure whenever they decide among different appropriation

[5] Also in essence, pursuing a trade secret means the company trusts that no one else will independently make the same invention and decide to pursue a patent on it. While there are legal possibilities to ascertain prior use, the patent system is generally based on a “first to file” system (see chapter 1).

mechanisms. The decision only gets more complicated as control over the knowledge is systematically imperfect.[6]

There is quite a bit of survey evidence on how firms regard patents with regard to appropriability – albeit somewhat dated at this point – that suggests that firms attach different levels of importance to the appropriation mechanisms at their disposal (e.g., Arundel and Kabla, 1998; Levin *et al.*, 1987; Cohen *et al.*, 2000). In both European (Harabi, 1995; Arundel and Kabla, 1998) and U.S. surveys (Levin *et al.*, 1987; Cohen *et al.*, 2000) the findings consistently point in these directions: product innovations are more likely to be patented than process innovations; and patents are not considered the most effective means of appropriability – in fact, firms typically score patents as (one of the) least effective means of appropriability. Taken together, this survey evidence suggests that patents matter – they may even matter a lot depending on the industry – but that they are not the only appropriability mechanism that matters. Ultimately, this means that inventive firms may patent – they may even patent a lot depending on the industry – but they will most certainly not patent everything.

Knowing that not all inventions are turned into patent applications – something that already Griliches (1984) pointed out – asking why and how companies decide to patent an invention becomes an interesting and important question to answer. Understanding the intra-firm selection process of which inventions are turned into patents becomes even more relevant, because research suggests that the reasons to pursue patents have become more diverse and go much further than preventing imitation. Already in their 1994 survey, Cohen *et al.* (2000) find evidence that the

[6] If the company decides in favor of a trade secret, it runs the risk of someone else making the same invention and attaining a patent on it. If the company decides in favor of a patent, it has to actively monitor whether other actors are infringing on the patent in order to attain control over the knowledge.

reasons to pursue patenting go beyond preventing imitation – and that these reasons appear to be related to the industry the firm operates in. Firms may apply for patents for strategic reasons that are much more concerned with the competitive landscape than the underlying inventive knowledge. Strategic patenting may entail using large numbers of patents as bargaining chips for cross-licensing (Hall and Ziedonis, 2001) and to block other firms through patent thickets (Ziedonis, 2004). Firms may file patents to create uncertainty in the market (Jell *et al.*, 2013) and even to mislead competitors (Langinier, 2005). Research suggests that the extent of strategic patenting is in fact sizeable: depending on the industry, about half of a firm's patents may be filed for strategic reasons (Gambardella *et al.*, 2007; Giuri *et al.*, 2007; Motohashi, 2008).

The variety of motives that may cause a firm to pursue a patent application – or to disregard this possibility – highlights the complexity of the appropriability decision. Yet research on value capture has largely taken the firms' internal decision making as given, and the majority of studies has focused on a specific mechanism, be it patents or secrecy or another mechanism (James, Leiblein, and Lu, 2013), instead of promoting our understanding of how a decision is being reached across mechanisms.

A few recent studies have started venturing down a different path and have allowed a glimpse into the firm. These studies suggest that firms make a deliberate choice among appropriability mechanisms. On a more strategic level, Bhaskarabhatla and Hegde (2014) show that a shift at IBM (International Business Machines Corporation) towards a more patent focused appropriation paradigm was the result of both a management change and financial pressure on the company. Moreover, Alexy *et al.* (2014) suggest that firms may apply specific selection mechanisms when deciding on whether an invention is patented or not. These results highlight that zooming-in on the intra-firm processes that determine an invention's appropriation mechanism will be

a fruitful avenue for research. This is in line with Perry-Smith and Mannucci (2017) who stress the need for research that looks inside the company and seeks to understand the decisions that turn an idea into a patented invention and an innovative product. This study follows this avenue and analyses two dimensions of the patent decision process: (1) the actual process, i.e. how decisions are made on an organizational level and (2) the decision-making framework, i.e., how actors reach the decision to patent.

3.3 Research design

The focus of this study to understand the underlying process of firms' appropriability decision requires an in-depth qualitative approach (Eisenhardt and Graebner, 2007). The main goal of this study is hence inductive theory development through multiple case studies (Eisenhardt, 1989; Eisenhardt and Graebner, 2007) as multiple cases allow for a replication logic (Yin, 1994). Moreover, as the innovation literature has seen a strong focus on patent data driven quantitative studies, following a qualitative approach and thus applying different methods of analysis to the field will allow to triangulate our knowledge and deepen our understanding (McGrath, 1982).

The research focuses on technology-driven firms in knowledge-intensive industries as these firms' performance depends strongly on their ability to appropriate the returns to their innovations. These firms should therefore have established intra-firm routines and processes on how to decide whether new inventions receive patent protection or not.

Following the standards of qualitative research, I select both the cases and the respective informants purposefully (Pratt, 2009). All 16 companies of the study are German and have their headquarters in Germany. I focus exclusively on German firms

to provide a consistent setting, especially from a legal perspective.[7] The extent to which the decision process differs in other jurisdictions is a matter of future research. I anticipate that the intra-firm decision process on appropriability mechanisms varies among firms both within and between industries, as prior research suggests differences in the reliance on different appropriability mechanisms (Cohen *et al.*, 2000). I therefore follow a strategy of diverse theoretical sampling in order to increase the scope of the findings and to facilitate pattern recognition (Eisenhardt, 1989). As Table 13 shows the sample firms differ in terms of their main industry focus, their size, and their ownership structure providing a diverse data source and thus following the principles of theoretical sampling.

Firm (codename)	Size (employees)	Ownership	Main industry
Alpha	>200,000	public	Engineering
Beta	<1,000	private	Additive Manufacturing
Gamma	<1,000	public	Biotechnology
Delta	<200,000	public	Chemical
Epsilon	<50,000	private	Glass production
Zeta	<50,000	public	Semiconductor
Eta	<100,000	public	Automotive
Theta	<10,000	public	Aviation
Iota	<200,000	public	Engineering
Kappa	<100,000	public	Cable and wiring systems
Lambda	<100,000	public	Gas and engineering
Mu	<100,000	public	Chemical and pharmaceutical
Nu	<100,000	private	Automotive
Xi	<50,000	public	Chemical
Omicron	<10,000	public	Software
Pi	<10,000	public	Media, Digital Commerce

Table 13: Sample firms

One company was deliberately chosen for its low patent numbers. Following the idea of polar sampling, the goal was to provide a contrasting case to the traditionally

[7] In Germany, employee inventions fall under the Gesetz über Arbeitnehmererfindungen , a law about how companies are supposed to deal – also from a financial perspective – with employee inventions. (https://www.gesetze-im-internet.de/arbnerfg/).

patent-heavy industries of pharmaceuticals, biotech, and chemistry. This particular company has a portfolio of trademarks and the respective capabilities such a portfolio requires, but is just beginning to pursue patents. The sample includes both very small companies with fewer than 1000 employees (Beta, Gamma) as well as very large companies with more than 100,000 employees (Alpha, Delta, Iota). Moreover, I include a variety of industries from biotech and pharma to engineering to the previously rather low-tech industry of media that is experiencing a shift to more technology-intensive innovation. I rely on four data sources: (1) qualitative data from semi-structured interviews with all sample firms, (2) archival data, including company websites, materials produced inside the firms[8], and press articles about the sample firms, (3) company organigrams, and (4) the CVs of the key informants. The combination of different data sources allows for triangulation of the results (Jick, 1979). The semi-structured interviews constitute the primary data source.

As this study as well as the study in chapter 4 aim to deepen our understanding of the intra-firm patenting process, the interviews were designed to cover all relevant aspects for both studies. Each interview consists of three parts: (1) a walk-through through the intra-firm appropriation decision process and its drivers; (2) questions related to how and when the IP department collaborates with the R&D department; and (3) the company's overall appropriability strategy. For instance, the interviews cover aspects such as IP application behavior and enforcement, decision criteria for different means of appropriation, as well as the interviewed firm's perception on the IP behavior of competing firms. Combining the research question of interest of this study and the

[8] Documents relevant to the process were either collected during the research or discussed (and in some cases inspected) during the interviews.

following study in chapter 4 allowed for a more meaningful and comprehensive conversation with the interview partners that generated a deep understanding of the relevant intra-firm patenting processes. The semi-structured approach to the interviews ensures a consistent line of inquiry across interviews, but allows to address interesting topics and themes as they arise during the conversation (Rubin and Rubin, 2005).

I interviewed heads of IP departments and senior IP managers with extensive knowledge on their company's IP strategy and the related organizational processes. In the case of one company, the interview was conducted with a member of the board of the company as he has been directly involved in setting up and shaping the intra-firm appropriation decision process. Given the sensitivity of the matter, anonymity was ensured for both companies and informants, encouraging the candor of the interviewees. A total of 18 interviews were conducted over a period of seven months, May 2016 to December 2016. 17 conversations were held in German, one in English. Six interviews were conducted in person and 12 by telephone. The interviews lasted between 31 and 84 minutes with the average interview lasting 52 minutes. In total, close to 16 hours of interviews were recorded and transcribed. At five companies, informants invited colleagues to the interviews who provided additional depth and granularity of information.

Throughout the fieldwork, I engaged in an iterative process of data collection, data condensation, and coding to guide further data collection (Edmondson and McManus, 2007; Eisenhardt, 1989). The interview transcripts were coded at different levels of analysis (Miles and Huberman, 1994). Codes were continuously revised during the analysis. The coding was implemented in NVivo11 and the final coding scheme consisted of 174 items on four hierarchical levels and 990 text segments. The data was synthesized and analyzed both on a within-case and a cross-case basis to identify similar

themes across cases (Eisenhardt, 1989). Cases were analyzed individually to understand the idiosyncrasies of each case and to identify relationships from each case (Eisenhardt, 1989). The cross-case analysis then led to emerging patterns and themes. Overall, the analysis iterated between data and theory to sharpen my findings and the emergent theoretical framework. During the whole analysis I remained open for constructs that are not yet part of the literature.

3.4 How firms decide on patent protection for inventive knowledge

Patenting decisions constitute an interesting and challenging hybrid from a decision making perspective. Patenting decisions are non-routine and complex as each invention and its potential applications as well as the respective competitive environment are unique. In addition, patenting decisions constitute – as many management decisions – decisions under uncertainty, since at the time of the invention it is unclear whether it can be converted in a marketable, profitable product, whether a competitor is researching or developing a similar technology and how far competitors may have progressed, how close a competitor (or new entrant) is to patenting or publishing knowledge that is relevant to the invention, etc. But at the same time, for innovative firms these decisions (need to) occur relatively frequently as new inventions are regularly being made and the technology is constantly evolving.

The combination of these factors – uniqueness, complexity, inherent uncertainty, and frequency – ultimately contribute to a standardization of the process in order to ensure consistency across decision makers and to make it more likely that decision makers arrive at the best strategic solution in a given situation. This standardization

happens on two levels: the process and the decision framework. The study first focuses on the decision process and then analyzes the decision framework.

3.4.1 The patent decision process

One of the core reasons for the existence of firms are the efficiency gains that result from standardization and alignment of tasks (Coase, 1937; Williamson, 1975, 1981). It is therefore not a surprise that firms have established a dedicated process for reaching patenting decisions. While the lead up is remarkably similar across companies, it is interesting that firms can be sorted into two distinct groups when it comes to the process of making the decision. First I describe the preparation phase, i.e. the preparation of the decision, and then I focus on how the decision process happens in both groups of companies.

3.4.1.1 The preparation phase: What happens prior to the decision?

I find that across firms the patenting decision is prepared by the IP department and that this process is practically identical across companies. Decisions are being prepared, i.e., inventions are being evaluated, once an invention notification reaches the IP department. Gamma, the smallest firm in the sample, often starts the evaluation process even without a formal invention notification. The head of IP of Gamma explains: *"We are quite a small company. The IP department is integrated in all important committees. Basically, we sense when there is an invention and most parts of the process are triggered by us. So often there is no invention notification."*

Once the process is triggered through an invention notification, the invention is being assigned to a patent specialist (based on workload and technical specialization) within the IP department to prepare a review of the invention and to recommend the appropriate appropriability strategy. During the review, the patent specialist evaluates the invention with regard to two distinct questions: *(1) is this invention patentable?* and *(2) does the company want to patent it?* To answer the first question – is this invention patentable? – the patent specialist assesses the invention with regard to the completeness of information and the fulfillment of general patentability criteria. If relevant technical information is missing the invention is circled back to the inventor team who then has to provide additional information, if they wish to pursue the invention in terms of IP. This first question of patentability is not a hard one. General patentability criteria – e.g., inventive step, novelty – are analyzed somewhat cursory, as there is still a degree of unpredictability in the patent examination process that IP department employees are well aware of. As a senior patent specialist of Gamma illustrates: *"We have patents where we know that we should have never gotten them."*

The evaluation of patent-worthiness on the other hand is of much larger importance and forms the basis for the eventual decision making. It is noteworthy that across companies, decision makers follow the recommendation formed in this evaluation stage for the majority of inventions. For the decision framework on patent-worthiness, refer to chapter 3.4.2.2 further below.

3.4.1.2 The decision process typology: IP controlled vs. BU controlled

The analysis of the extensive interview data shows that when it comes to the decision making process, firms differ on two important dimensions: (1) where (in the company)

the decision is made and (2) who gets to make the decision. The locus of the decision may be inside the IP department or outside the IP department. In addition, the decision may be made by an individual decision maker or it may be the result of a group decision. This differentiation in the decision process can be visualized by a 2x2-matrix, as illustrated in figure 9.

	Decision Maker		
Locus of Decision		Individual	Group
	Inside the IP department		
	Outside the IP department		

Figure 9: The decision process typology

The analysis of the data shows that firms can be differentiated into having one of two distinct types of decision processes: the upper-left quadrant can be described as the IP controlled type, with an individual decision maker who is located inside the IP department. The lower-right quadrant can be described as the BU controlled type with the decision being made outside of the IP department based on a group decision of actors from the business unit(s). All sample firms fall on this diagonal, i.e. can be identified as having an IP controlled decision process vs. a BU controlled decision process. Figure 10 shows the distribution of sample firms across both types. Five firms fall into the upper-left quadrant, the IP controlled decision process, where the decision maker is an individual located in the IP department. The remaining 11 firms fall in the

lower-right quadrant, the BU controlled type, where the decision is made in a group setting outside of the IP department. In the following subchapters I will explain each decision type individually.

		Decision Maker	
Locus of Decision		Individual	Group
	Inside the IP Department	Omicron Mu Eta Beta Theta	/
	Outside the IP Department	/	Alpha Gamma Delta Epsilon Zeta Iota Kappa Lambda Nu Xi Pi

Figure 10: Sample firms across decision process types

3.4.1.2.1 The decision process typology: the IP controlled type

Overall, five firms fall into the IP controlled decision process type. While always located within the IP department, decision makers in this category can come from varying hierarchical levels. For instance, at Omicron, the decision is made by the head of IP. The head of IP at Omicron recounts that she reads the recommendation of the patent specialist, has a discussion with her, and then makes a decision. If necessary she consults with technical experts: *"We have integrated the patent decision making into the IP department and largely, I make the decision alone. Sometimes, if it's necessary, I'll*

call someone in the company and ask them what they think of the invention, if it is in line with the company or not. I do that selectively."

On the other hand, two firms, Eta and Mu keep the decision making process rather lean by having the evaluating patent specialist make the patenting decision. Both firms consider the patent specialist's recommendation as the final decision and directly move on to acting according to the recommendation. The head of IP of Eta explains: *"We don't do what you can find in many other firms […]. These IP committees with participants from different departments. This is too time-consuming to prepare and considering the number of inventions we have, it would be difficult to put into practice."*

Both Theta and Beta involve the IP team to discuss recommendations, but ultimately decisions are being made by a single person. At Theta the decision is made by the individual patent specialist. At Beta, the head of IP has the final word and only the CTO could veto the decision based on budgetary reasons.

3.4.1.2.2 The decision process typology: the BU controlled type

Overall, 11 firms across different industries have been identified as exhibiting the BU controlled type of decision making. In these companies patent decisions are made outside of the IP department in a dedicated patent committee. Companies either have one patent committee for the entire company or several committees with different technical specializations in order to mirror the different technologies a company may house in distinct business units. These committees are hosted and chaired by a representative of the IP department (either a senior patent specialist or the head of IP). All other participants come from the business units, for instance senior technical experts or senior R&D executives. A senior patent expert of Zeta explains: *"Patent committees*

typically consist of four or five experts, who will then discuss the inventions. One of the inventors is also invited […].” At Nu, business unit executives are present as a senior patent specialist explains: *“This is a dedicated meeting, when all heads of the respective business units like electronics […][9] come together and discuss all inventions that happened during the month prior.”*

In the BU controlled type of decision making several large firms (e.g., Kappa, Delta, Iota, Alpha) have created the bridge-function of patent manager. Patent managers are technical experts employed in the R&D division of the BU who have received special patent training by the IP department. The goal is to transfer some of the specialized IP knowledge out of the IP department and into the BUs. These patent managers participate in the patent committee. At Kappa, all patent managers participate in the patenting decision committee, as that committee also serves as a platform to spread information on inventions across business units. As the head of IP of Kappa explains: *“This results from our firm structure because we have several legal entities, so in total we have about 30 patent managers[10] who participate in these meetings.”* He goes on to explain: *“The technical aspects of each invention are then explained, so that all patent managers know which inventions have been made in the company and can use that knowledge for their respective units. It’s a decision committee as much as an information committee. So we don’t have to put inventions in a display case, but simply share the communication across units.”*

[9] The remaining business units that the interview partner described were left out to ensure the anonymity of the company.

[10] Kappa uses a slightly different official title for patent managers. For comparability and anonymity purposes, I use the most prevalent title in the sample “patent manager” for all companies.

At Epsilon not only representatives from the business units attend these patent-decision meetings, but also experts from the strategic innovation department. At Epsilon, the strategic innovation department is already involved in the yearly strategic and technological planning for each business unit, a planning that also involves deducing a general patent strategy for the individual technologies. The department thus has relevant insights into how individual patent decisions link to both the patenting strategy and the technology roadmap of each business unit. Therefore, a representative of the strategic innovation department is present during the patent committee meetings in order to participate in patenting decisions.

During the patent committee meetings, inventions are briefly presented and then discussed among participants in order to determine the patenting potential of each invention. Decisions are then reached on a consensus basis. As the head of IP of Nu states: *"It's my job to moderate the discussion and, at the end, to distill a decision that everyone can live with."* If there is a conflict in the meeting, the business unit representative (e.g., the head of R&D of the respective business unit) who has the operative responsibility (and thus pays for the costs involved in the decision) has the final word. As the head of IP of Xi and the head of IP of Epsilon both noted independently: *"At the end of the day, it's the decision of the one who pays for it."*

3.4.1.3 The decision process typology: A dynamic perspective

The general dynamism in the patent arena (see also chapter 1) can be expected to promote change in companies' patent processes. In the sample seven firms reported a

change in the dedicated patent decision process in the last three to four years[11]. Figure 11 shows the seven firms that changed the process and how they are positioned according to the decision process typology.

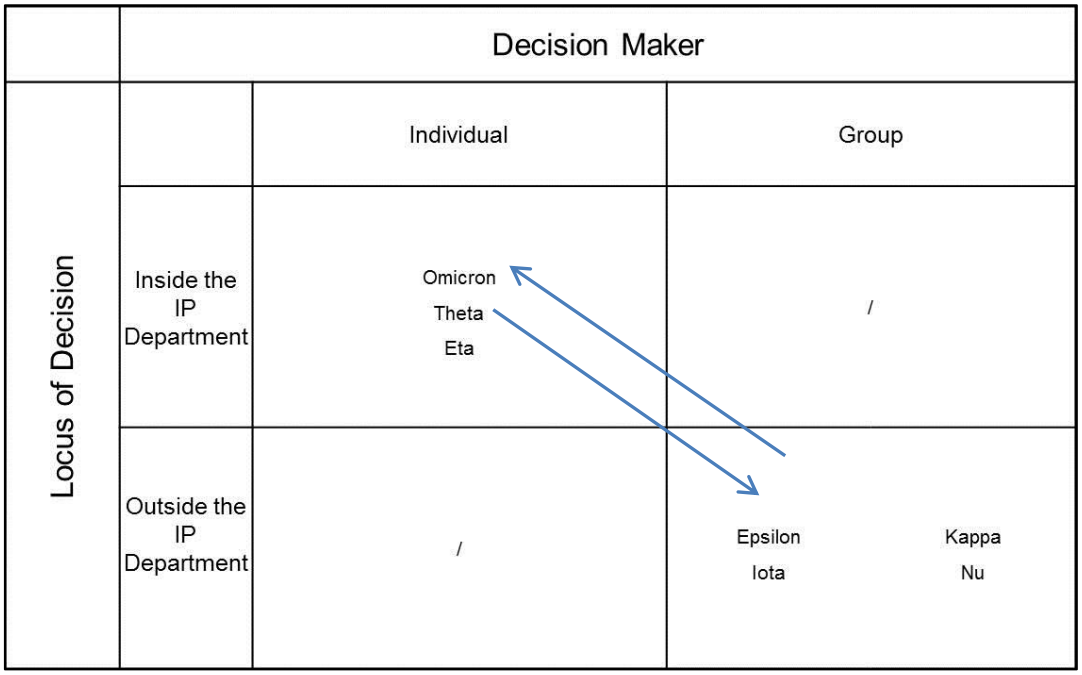

Figure 11: Change in decision processes

What is interesting is that two firms actually changed their decision making process: Omicron has moved from a BU controlled process to an IP controlled process, whereas Theta is currently shifting from a single decision maker in the IP department to a group decision of BU representatives. Omicron has moved away from a multi-functional decision committee and has centralized the decision in the IP department. At Omicron the head of IP makes the individual patent decisions and only consults with knowledgeable experts when deemed necessary. She describes the change as follows: *"A few years ago we had a dedicated patent review board. This included the heads of the different R&D departments and they evaluated whether or not we wanted to file a*

[11] Based on the time of the interview.

patent application. We had a meeting or telco, because some of them are located internationally, the U.S., India, etc. We talked about it and then came to a decision. But in the last three years we moved away from this process. Sometimes it was simply not feasible to get it on everyone's calendar. In addition, there wasn't the kind of input we [the IP department, added by the author] expected. So we decided to do it on our own."

On the other hand, Theta is currently implementing a change that shifts some of the decision-making capabilities from the IP department to the business units. As the head of IP of Theta explains: *"For all the cases, in which we aren't really sure, we now have this committee with eight or nine people from the respective department. There we would present the invention and discuss the possibilities."* The committee is a rather new addition to the process and therefore has only been implemented for the less obvious cases, such as inventions in pre-commercial development. The head of IP of Theta explains: *"There are invention notifications that suggest a future market. It's not something we currently do, but we have the feeling that it's not too far away from our business. This is something we would discuss in the committee."*

The other five companies that experienced a change in the recent years prior to the interview have not changed the decision making responsibilities, but have rather focused on streamlining and systematizing the process. The case of Iota illustrates a change in the process that did not lead to a shift in the locus of decision. Iota has kept to the BU controlled patent decision process. However, prior to the change, the process had been in the hands of the business units without a central IP department. While before, the head of R&D of each BU (in some units together with an individual patent

specialist) would decide rather haphazardly what would get patented[12], now Iota has a dedicated committee for this decision with the head of R&D and the head of Marketing / Sales of the respective business unit as well as a patent specialist and a patent manager present. The managing director of the IP department of Iota describes the situation prior to the change like this: *"Our starting point was characterized by extreme decentralization. Iota has more than 600 subsidiaries and units and in each of them IP – patents and trademarks – were either not managed at all or in a few cases there was a small patent department, but always without patent lawyers. Decisions were made in an extremely decentral fashion and by not really paying attention to patent management. It resulted in quite a few law suits…"* Through the change, the decision process was streamlined and standardized with a new division of labor and responsibilities between the business units and the new central IP department.

The case of Iota also illustrates how several factors concur – patent related law suits, intransparent cost structures, and a change promoter in the C-Suite – and bring forth an extensive and company-wide overhaul of how patent decisions are made. As the managing director of Iota's IP unit highlights: "*In all honesty, all those changes would not have been possible to that degree and with that success, if Mr. X [anonymized by the author, Mr. X is a member of the C-suite of Iota] hadn't said that he wants a sensible patent strategy and a central IP department because he knew that from his prior employer.*"

[12] This is the description of the new head of IP, so the characterization as "haphazardly" should be taken with a grain of salt. Nevertheless, given the extent of change with regard to the patenting process, the importance this change had for members of the board, and the fact that Iota was subject to patent related lawsuits, it is reasonable to assume that the decisions before the process change lacked strategy and consistency at least to some extent.

In addition, as the quote of the managing director of Iota's IP department above already shows, lawsuits play an important role in putting IP management and a more active patent policy on the corporate agenda. The head of IP of Iota corroborates this with regard to several patent law suits the company faced: *"I think a really big accident would have been even better, but never mind. It was enough. By now, practically everyone in the company knows what IP is, and that's good. And lawsuits do help with that."* The simultaneous blessing and curse of patent related law suits is a narrative that several other heads of IP share – regardless of whether law suits triggered or promoted a change in the patenting process. As the head of IP of Xi explains: *"In fact, this lack [of lawsuits, added by the author] is currently our biggest problem. We need to produce more drama."* He goes on to explain that law suits do not only help to generate awareness about the issue (and expose the lack of attention it received in the past), but also help to boost the reputation of the IP department in a positive sense: *"If you really win a law suit and make 20 million, then even the chairman of the supervisory board starts noticing you."*

3.4.2 How firms decide on patent protection

3.4.2.1 The appropriability decision: A staged decision

While the decision can be made among three distinct appropriability mechanisms – patenting, (defensive) publishing, and trade secrets – the study finds that all firms make the appropriability decision in a staged fashion, where in the first stage the decision is focused on patenting, and only if patenting is rejected as an option, (defensive) publication and trade secrets are considered viable options. In essence, the open-ended question of '*what is the most suited appropriability mechanism for an invention at*

hand?' is reduced to the set of questions: (1) *do we patent this, yes or no?*, and (2) if the answer is no, *what do we do instead, defensively publish it or keep it secret?* Patents therefore become the frame of reference for identifying the most appropriate appropriability mechanism. As the head of IP of Delta puts it: *"[...] in the discussion you actually assume that you pursue a patent application – unless certain criteria are met."* This decision pattern holds even for the extreme case of Pi, where only few inventions have been patented so far. The CIO of Pi explains what happens after an invention has been made: *"The first check is more towards management. Do we want to patent this? With all known advantages and disadvantages? This is a decision that management needs to make."*

Figure 12 shows the staged decision making with regard to patent protection vs. trade secrets and publication. Across the sample, all firms start the decision with the evaluation of whether an invention should be patented or not.

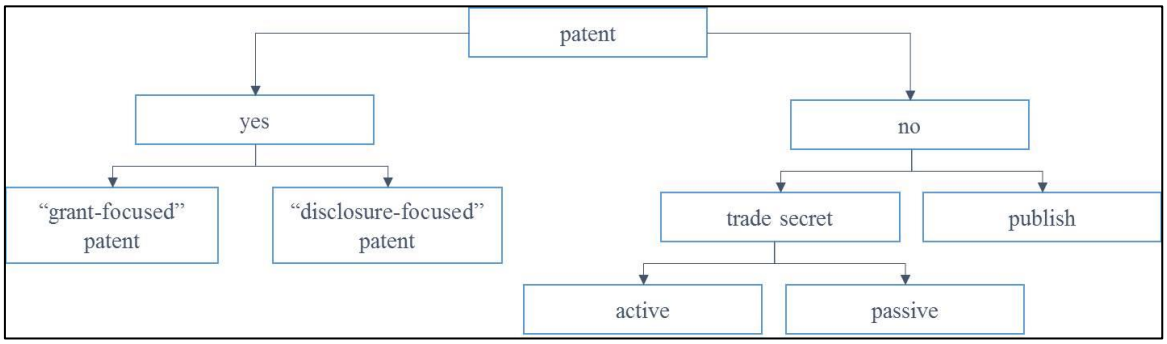

Figure 12: Staged decision making

It is important to note, that the intention behind the patent application can be quite different depending on the circumstances. Based on the interviews I find that firms differentiate between a "grant-focused" patent and a "disclosure-focused" patent. In case of a "grant-focused" patent the firm intends to seek protection for the underlying invention. In case of a "disclosure-focused" patent the patent is filed primarily to create

prior art – similar to the disclosure through a defensive publication – not to see the application through to grant. [13]

The differentiating factor between a "grant-focused" and "disclosure-focused" patent is the intention behind the application: "grant-focused" patents are applied for in order to actually attain a patent right, whereas "disclosure-focused" patents are simply another way of defensively publishing knowledge, next to internet platforms or other outlets. More specifically, a "grant-focused" patent may have a variety of goals: a defensive character to ensure freedom to operate, it may have a more offensive character to block competitors, or it may follow a proprietary strategy to protect the underlying invention from copying. As the head of IP of Nu illustrates: *"For us filing a patent application costs about as much as publishing defensively, so that a defensive publication is purely a stylistic difference which doesn't really serve a purpose."* He goes on: *"A patent application that is not examined or granted still generates uncertainty for competitors […]. If both means [patents and a defensive publication through Internet platforms, added by the author] cost about the same, then a patent application is of course the more attractive option."*

These "disclosure-focused" patents are often prepared less thoroughly, as the goal is not to see the application through to grant and create a solid exclusion right but simply to disclose inventions in a way that creates prior art. As a senior IP manager of Beta explains: *"One way to publish is through a patent application, where we know from the beginning that we most likely won't pursue it. We often use a Gebrauchsmuster*

[13] Of course, a company may decide to actually see the "disclosure-focused" patent through to grant (transforming it into a "true" patent), for instance based on new information from the market or about competitors' related patents. But the intention in the first place, at the time of the initial decision, is primarily to create prior art.

application for that purpose, maybe not even prepared by the patent lawyers and without major edits to keep it low-budget."

If the firm decides against a patent application, the invention may either be published defensively through non-patent measures or it may be kept secret. Defensive publishing typically describes the publication of inventions either through dedicated platforms like IP.com, company publications, scientific publications, or conference presentations, or in a more disguised manner, e.g., hidden in documents that are published on the Internet. While the inventing company foregoes the possibility to apply for a patent, research has argued that defensive publishing may be an attractive mechanism to protect the company's freedom to operate (e.g., Henkel and Lernbecher, 2008). As a senior patent executive of Zeta puts it: *"Well, typically this is something we do want to use or want to have the possibility to use it, but we don't see any value in actually patenting it."* Similarly, the head of IP of Delta, a company in the chemical industry, points out: *"It means a lot of extra work, if there are patent applications by other firms that stand in the way of our product development or even products on the market. That's basically the worst-case scenario and that is why we use those internet platforms."* Across firms, defensive publishing is indeed more akin to a residual category. As the head of IP of Alpha explains: *"In simple terms, those are the bad ones. Where we consider the chances of getting a patent small and where it doesn't hurt to publish. Alpha doesn't work like that, that we strategically reveal."*

On the other hand, all publications that could contain information about patentable inventions, especially scientific articles, posters, and presentations by inventors, are checked pre-publication by the IP department. The goal is to avoid that inventors or publications unintentionally create prior art that later stands in the way of receiving patent protection on a follow-up invention. As the head of IP of Nu explains:

"Yes, publications need clearance, where we ask 'does this contain anything we want to protect?', and if so, then protection needs to happen prior to publication." Moreover, by checking publications the IP department avoids that know-how and process tweaks that could never be detected if a competitor used them become common knowledge. As the head of IP of Gamma explains: *"We have edited publications down. We just had a case where we decided against a patent because we could never proof infringement. So we decided to go for a publication. But the article by the scientists was really detailed. Lots of know-how, all the little tricks that you normally can't see. Then we [the IP-department, added by the author] edited the article down. Feel free to publish, but not that many details please."*

Lastly, firms may choose to keep an invention secret. For all firms in the sample except Pi this option is chosen only for the minority of inventions. Guestimates of the interviewees range in the low single-digit percentiles. The head of IP of Epsilon estimates that *"secrecy is maybe about 5%"*. The head of IP of Alpha similarly states: *"If active trade secrets are in the single-digit percentiles, then that's probably a very high guess. We really try to patent the majority of cases."* Similarly, the head of IP of Xi explains the company's perspective on the patent vs. trade secret question: *"In all business units we have come to the conclusion that we are such a globalized company, that our products and processes are known on a global scale, that we could only generate a very limited, short-time benefit through keeping certain inventions secret."* He goes on to explain: *"Therefore, as a globally active company we decided a few years ago, first in the IP department, that we stop with this secrecy stuff and then we convinced all business units."* He estimates that *"98 to 99 percent of all invention notifications are turned into patent applications."*

Interview partners stressed that they make an important distinction between active and passive secrecy. Choosing the mechanism of secrecy may mean that the firm actively introduces trade secret measures like contracts, black boxes, etc., or it may mean that the firm simply chooses to not talk about a certain piece of knowledge, i.e., to remain passive about it. As the head of IP of Kappa explains: *"It's important to distinguish whether something is really worth keeping a secret, i.e. something needs to be locked in a safe, there needs to be a black box in production etc., or whether we simply don't pursue and patent it, for instance because it's a true process invention and that would give too much information to competitors."* On the other hand, passive trade secrets are inventions that the decision body (the IP department or the patent committee, see chapter 3.3) decides to simply remain quiet about it – without any of the measures initiated for active trade secrets. As the head of IP of Omicron clarifies: *"When we don't make a patent application, that's a denial and that stays internally. In that sense it's a secret, because it didn't transpire outside the company."* But as she then explains, no measures of active trade secret protection are being taken.

3.4.2.2 What makes a firm patent?

Across all firms I find that the motivation and arguments in favor of patent protection are the same, no matter whether the company has established an IP controlled or a BU controlled decision process. In order to understand the drivers of a patenting decision it is important to understand what patents are to companies. First and foremost – and in fact, each interview partner stressed this notion during their interviews repeatedly – patents are instruments with an outward focus. The head of IP of Eta points this out explicitly: *"Actually, using a patent yourself isn't at all of interest, because I*

can always use it, if I have a patent or not. A patent is an exclusion right and is really only directed at outside third parties, that I can forbid to use it. It's really only interesting if a third party also wants to use it. If a third party has no interest in this, then my patent is useless, because I forbid something that they are not interested in doing." In a very similar vein, the head of IP of Delta recounts: *"This is a thing that we [the IP department, added by the author] have to address within the company or even counter and say 'the firm-lens doesn't matter here, but what the patent triggers at the competitors'."*

When firms decide whether they pursue a patent application on an invention they trade off the (intended) outside effect of the patent against budgetary constraints. Figure 13 illustrates the trade-off.

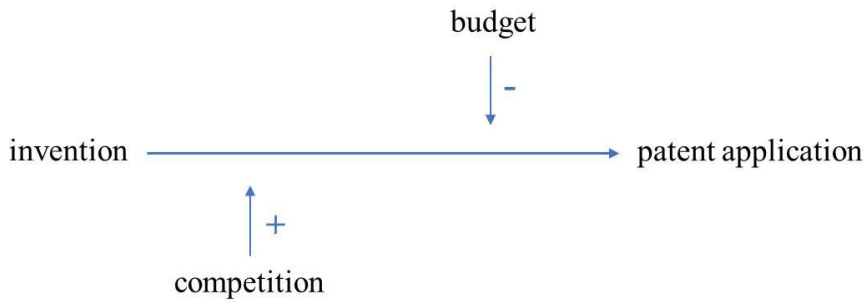

Figure 13: The patening decision

The head of IP of Eta elaborates on this budgetary trade-off: *"When you apply for a patent for one invention and you internationalize it and go for five countries, then you just spent EUR 20.000 in the first few years. When you total that up to the whole patent portfolio, then you see how much money is in this. And because of that you need to ask with each application 'do I put money in that?'."* Similarly, the head of IP of Omicron explains: *"I really want to read the evaluation regarding prior art. When some prior art is really close, then it's kind of useless. Then I say no. I don't want to argue with the*

patent examiner and spend money on something like that, when I could be spending that money on something else."

Competition, and therefore the intended effect of a patent application on outside actors, is determined based on the interaction of the company's technological and market strategy and its competitors' strategies. The head of IP of Iota describes this interaction: *"The IP strategy has several determinants, for one technologies, then competitors, and markets or regions. Per BU we identified the critical factors, so for instance, the three critical technologies, the three critical markets, and the three to five competitors we need to monitor. […] So we then have a matrix of technologies, markets, and competitors for each BU and based on that we have their IP strategies. So we know the approach and the boundaries."*

Considerations that play into the evaluation of inventions with regard to the competition are freedom to operate (FTO), blocking, and the ability to detect infringement. With regard to FTO, the head of IP of Theta explains: *"As a supplier the biggest goal is freedom to operate. We want to make sure that we don't violate anyone's patent rights, as we are well aware of the U.S. law system and the high damage claims there […]."* But as the head of IP of Iota explains, offensively blocking competitors may be a consideration, too: *"[…] also pure blocking patents, which we don't have for our own use, but simply to keep the market small and block others."* In addition, the ability to detect infringement is of importance as the value of a patent may be questionable if the patent cannot be enforced in court. As the head of IP of Alpha stresses: *"Being able to detect infringement is a highly rated criterion."* Likewise, a senior patent specialist of Gamma explains how the ability to detect infringement – and therefore act on it – is an important criterion for whether Gamma even pursues a patent application: *"Ultimately, it's a decision of what this invention is about. This includes in*

how far can the invention be exploited? Maybe there would only be patents based on that invention where an infringement would be difficult to detect. In that case the question is how valuable such a patent would be?" He then continues: *"Those patents, they are nice and pretty, but their value is questionable. I think in such a case [when infringement would be hard to detect, added by the author] we are more willing to forego a patent, because we simply don't see the necessity."*

In sum, it is not surprising that patenting is the benchmark and often the de-facto default in the appropriability decision making. For one, as intended by the patent system, the exclusion right (and thus the right to go to court) acts as the compensation for revealing the knowledge. Moreover, as long as the focal firm cannot predict the competitors' behavior and their own technological trajectory (which in turn depends on the reactions of competitors and new market entrants) the "right" decision is unknown ex ante and only reveals itself after the companies have made their choice. Again, this makes patenting the favorable option, since it will preserve the largest option value (pursue and potentially enforce the patent vs. do not pursue it and use it as a defensive publication instead). This proclivity to maximize option value is intensified by the practice to revisit patent decisions after 12 months. Hence the decision maker(s) of the initial patent decision have an even larger incentive to decide in favor of a patent.

3.4.2.3 Does it matter whether the invention is a product or a process?

Existing survey research by Cohen *et al.* (2000) suggests that patenting is less prevalent for process inventions, so the question emerges whether this is borne out by the data of this study, too. The results of this study show that the way decisions are made is essentially the same, regardless of whether the invention is product or process based.

Consistent with existing research, I find that process inventions are generally more likely to be kept secret. The core argument raised by companies is that it is hard to prove that a competitor is infringing on a process invention. Hence, patents are often dismissed as they only provide little leverage in order to deal with infringement. For instance, the head of IP of Delta explains: *„One [reason, added by the author] would be a small tweak in the process, which you could never prove based on the product, and at best maybe directly in the production – which you typically can't do at a competitor. So there isn't a balance. We would reveal more than what we would get from the patent protection. This is something we would keep secret."* Similarly, the head of IP of Kappa explains when asked about the factors in favor of secrecy: *"The main reason is that you don't want the competition to catch up on what you're doing. Or that you couldn't prove an infringement."*

But interestingly, several interview partners stressed that factors grounded in the market or the competition may overrule considerations around the possibilities of detecting infringement. For instance, the head of IP of Nu, a supplier company to OEMs (original equipment manufacturers) argues that the practice of a second source practically eradicates the use of secrecy: *"Sure, customers sign an NDA [non-disclosure agreement, added by the author], but let's not kid ourselves. At the end of the day, information leaks through to competitors. If a customer sees something from us that they like, it's hard to believe that they won't make a comment when they look at other suppliers' products, which points the competitor in the right direction."*

Another argument raised against relying on secrecy for process inventions is grounded in global production and global markets. As the head of IP of Epsilon states: *"It's the ability to detect infringement and the markets and production locations the invention is located in. Even if you can't prove the use of an invention, but once you*

start rolling out the technology worldwide, then of course the probability rises that the invention inadvertently diffuses somewhere it shouldn't. And then your only protection is a corresponding IP right. So that is folded over the invention." Similarly, the head of IP of Iota explains with regard to China: *"Since by now a large part of production takes place in China, where employee fluctuation is very high, process know-how and process-IP are now of relevance. In areas where employees change often, we should also apply for a patent for things you cannot directly detect on the product."*

Consequently, the study reveals that making decisions about the "right" appropriability mechanism is complex and firms structure the decision making in a way to substantially simplify the individual choice. Patents are the primary mechanism of choice.

3.5 Discussion and conclusion

While a substantial body of research has analyzed theoretical concepts of innovation utilizing patent data (see chapter 2), the intra-firm process of how inventions are selected to be protected by a patent has gone largely unanswered. This study offers a first step in closing this gap by analyzing how firms actually decide whether inventive knowledge will be patented or not. I find that companies fall in one of two distinct decision types: IP controlled, with the decision prerogative within the IP department, and BU controlled, with the decision prerogative in a cross-functional committee with technical and / or market experts of the respective business unit(s). Moreover, I find that patents are the de-facto default in the decision process with the main motivation being the outward orientation of a patent and the option value a patent application offers to its

holder (the ability to sue, the ability to license out, but also the ability to let the application lapse, effectively turning the patent application into a defensive publication).

3.5.1 What determines a company's decision type?

Summarizing the results above, I find that firms' patent decision process can be differentiated according to two dimensions: (1) where, organizationally, the decision is being made, and (2) who makes the decision. The locus of the decision may be within the IP department or outside of the IP department under the prerogative of the BUs. Moreover, companies can be distinguished in terms of whether the decision is made by an individual or by a group. For visualization, see figure 9 above. I find that the sample firms exhibit one of only two specific types of decision processes, the IP controlled decision process and the BU controlled decision process. In the IP controlled decision process the decision maker is an individual within the IP department, whereas in the BU controlled decision process the decision is made in a group-setting by members of the BUs.

What is interesting is that one traditional differentiator in firms' patenting behavior, namely industry-type (Cohen *et al.*, 2000), does not coincide with my findings on the patent decision process outlined above and in chapter 3.4. I find that companies from both complex and discrete industries rely on an IP controlled patent decision process. For instance I find that firms in the software, automotive, and pharmaceutical industry all rely on the IP controlled decision process. Similarly, the BU controlled decision process can be found in various firms from both complex and discrete industries. Figure 14 illustrates this result.

	Decision Maker		
Locus of Decision		Individual	Group
	Inside the IP Department	Software Chemical and pharmaceutical Automotive Additive manufacturing Aviation	/
	Outside the IP Department	/	Engineering Biotechnology Chemical (2x) Glass production Semiconductor Cable and wiring systems Gas and engineering Media, digital Commerce

Figure 14: Industries across decision process types

Moreover, the results do not appear to be driven by firm size. Compared to larger firms, it seems plausible to assume that employees in smaller companies have more connections across departments (a claim also raised by both very small companies in the sample) which could allow to bridge the information gap across departments and functions and which therefore might allow for more centralization while keeping the information flowing from the business functions. Arguably, this could favor an IP controlled decision structure. However, this is not borne out by the data. The IP controlled patent decision process can be found in small firms with about 1,000 employees and large companies with close to 90,000 employees. Likewise, the BU controlled patent decision process is found in both very small companies with less than 500 employees and huge companies with more than 200,000 employees. Consequently, size alone does not appear to be a driving factor for the structure of the patent decision process.

What emerges across all companies is the notion that patents are an outwardly-focused instrument. Indeed, this point was stressed by all companies repeatedly throughout the interviews. It therefore might be an interesting avenue for future research to analyze whether a firm's position in its core markets or the dynamism in the company's main markets, could be a driver for how the decision making process is structured. Arguably, BUs have superior knowledge as to market dynamics and key competitors' strategies which could very well be the original intent for the IP department to enlist the business units as participants and decision makers in the patent decision process. On the other hand, companies are built on specialization and efficiency gains from that specialization. With regard to patents (and IP in general), it is sensible to assume that the highest quality know-how about patents is located within the IP department, favoring the IP controlled process. Likewise, this process configuration involves fewer people in the evaluation and decision making which likely leads to faster decisions and further efficiency gains. While this study cannot make any concluding remarks on this question, this tension provides an interesting field for future research.

Lastly, another possible argument for the structure of the patent decision process could be rooted in the experiences, values, and beliefs of key managers. While some heads of IP have grown the ranks of their companies, several IP executives in the sample have been recruited from other companies.[14] It is therefore likely to assume that modus operandi in prior jobs and personal styles affect the way the patent decision process is structured – either involuntarily or by design. As the head of IP of Lambda states matter-of-factly: *"They [C-suite executives, added by the author] wanted*

[14] Almost all interviewed heads of IP have been in their role less than 10 years, six of them had been the head of IP at the respective company for three years or less at the time of the interview.

something done, and they hired me to do it." And the head of IP of Alpha stresses how the processes had to change because of a different philosophy about doing IP: *"I don't want to criticize my predecessor […]. I'm exaggerating – invention notifications were slipped under the closed door of the patent attorneys' offices, patent attorneys then worked on them, and then slipped them back out. And that's not what I want. I want IP to be integral part of the innovation process."*

3.5.2 What kind of information do companies need to make a patent decision?

What is interesting is that irrespective of the type of decision process, the study does not uncover diverging criteria that are used to produce the patent decision. The single most important aspect raised by all interview partners is market knowledge in a broad sense – relevant competitors and their (potential) technological trajectories, the firm's own position with regard to those competitors in a given market, a technological field, or the IP landscape, products on the market, a company's own product pipeline and competitors' product pipelines, etc. What this result highlights is that the decision to patent based on patent law (inventive step etc.) is often, at least in part, uncoupled from the decision to patent based on market dynamics. Likewise, the value of an IPR is often uncoupled from the value of the underlying invention. As the head of IP of Alpha states after explaining the decision to file a patent application on a particular combination of technologies: *"I think it clear to all of us that this is not a brilliant technical coup. It's a combination of known features, intelligently combined with an additional feature. But this combination would give us a competitive advantage in this field."* He goes on to explain that technical ingenuity should not be the benchmark for a patent decision: *"[…] so that commercial relevance, enforceability, and other factors have a higher*

weight than technical brilliancy." While the invention may actually be incremental – to the point where the novelty step required for a patent grant is questionable – the company still has an incentive to apply for a patent because it could still result in a grant[15] and the value of that patent is not determined by the underlying invention but by its contribution to the portfolio, e.g., through fencing a core invention or blocking a competitor from a technology.

However, based on the result that firms' decisions are majorly skewed in favor of patent protection, with patenting being the de-facto default option, the question arises in how far specific market knowledge actually matters for the decision. Playing devil's advocate: if you know how you decide a priori, you will produce evidence to support your decision. One could therefore raise the argument that integrating technical and market experts into the process only provides marginal value to the decision process, given the de-facto default of patenting. This is indeed in line with the argument of the head of IP of Omicron where the process was altered from a BU controlled decision to an IP controlled one: *"Sometimes it was simply not feasible to get it on everyone's calendar. In addition, there wasn't the kind of input we [the IP department] expected. So we decided to do it on our own."* In more general terms, future research should investigate in how far cross-departmental patent committees really provide superior decisions as compared to decisions under the prerogative of the IP department.

[15] As quoted already above, interview partners across sample firms know that some of their patents should not have been granted.

3.5.3 Implications for patents as an appropriability mechanism

Seminal works by Cohen *et al.* (2000) and Levin *et al.* (1987) have shaped our understanding of how firms view and use patents. Bridging those seminal works with this study and the recent developments around patents and the way they are used leads to this corollary: sentiment and action may be two different things. Just because a firm patents, does not mean that said firm thinks patents are directly important for appropriation. Patents may be worth the investment through indirectly contributing to appropriation such as through keeping competitors at bay – even hindering competitors to patent and commercialize something themselves – , as bargaining chips, etc. This, however, means that the research community needs to change its perception of patents as an appropriability mechanism closely linked to its underlying invention. Instead, researchers need to interpret patents as a strategic tool in the market place and ultimately a means to improve the bottom line.

This result substantiates insights by Mansfield (1986). Even though his study is more than 30 years old and the state of art of how management research is performed has evolved tremendously, it provides a very interesting – and still relevant – result that my research corroborates: there is a disconnect between the inherent *need* to patent in order to get a product on the market and the *decision* to patent.

The results of this study suggest that to companies, patents have become the de-facto default, or in the very least the decision benchmark when it comes to appropriability. From a managerial and normative perspective this finding raises the question: is this good or bad? While my study cannot (and never intended to) answer this question, it provides meaningful insights that will hopefully fuel further research in the area.

First, from a company-perspective, patents have become a means to reduce uncertainty and risk. The interplay of existing and future market actors and technology is complex and the outcome is unknown. Patents allow their holder to reduce this uncertainty, because irrespective of how everything plays out, the patent stakes off the companies' claim, and provides the right and leverage to go to court against a competitor or new entrant that interferes with that claim. The head of IP of Nu phrases this motivation like this: *"[…] it's difficult to gage which patent application will be the one to change the market. Thus we can also increase the likelihood of success by having more eggs in the basket."* In a similar way, the head of IP of Beta stresses the importance of the portfolio when future developments are uncertain: *"It's not about having a 100% hit rate and every singly patent being successful, it's about having enough of a portfolio, to reach our goals."*

This tendency to take precautionary measures, to patent "just in case", became apparent during several interviews. For one, several interview partners commented on how they increased their patent output in recent years in response to an industry-wide increase in patenting and patent-related litigation. As the head of IP of Delta explains: *"Well, we are far away from what you see in IT or similar industries, but still, we are involved in a steadily increasing number of patent litigations and this means we need to have a portfolio handy just in case."* Hence, in an environment where a company (1) can expect the competitors to patent their inventions, irrespective of whether they want to market them or not, (2) can expect the competitors to patent inventions in order to block the focal company, and (3) all actors are aware of the legal arsenal surrounding patents (oppositions, infringement suits, etc.) and the effects a law suit may have, it is very unlikely that decision makers (individuals and groups alike) change the current modus operandi and reduce the company's patent activities. Likewise, all companies in

the study are aware of the possibility of strategic disclosure but not a single company actually considered this possibility as a viable option. When asked, what emerged was a chicken and egg argument: companies argued to be willing to consider this option, just not as a first-mover in the industry. If industry dynamics were to change towards a more open strategy, then companies argued they would consider following that development.

From a more normative perspective the results of this study pose the question of whether the patent system is due for reform for instance with regard to a more strict interpretation of the novelty step required for patent protection as a way to reduce patenting activities. This becomes even more relevant given that a large number of patents would likely be deemed invalid if they were challenged in court (Zischka, 2015).

Lastly, from a management and innovation research perspective, it is important to acknowledge that firms do not act on their own – in a vacuum – when they decide on technologies and patents. Patents are an outward instrument. A patent's protection for the company's products and processes is inseparable from the exclusion right targeted at the competition. Management and innovation research so far has implicitly – and sometimes even explicitly – assumed that patents are a function of the technology of the underlying invention (for instance, is the technology new or valuable; see also chapter 2 for how empirical studies in innovation and management research frame the connection between patents and the underlying inventions). While this notion is not entirely wrong, it analyses the question – what is being patented? – through a distorted lens. Ultimately, firms patent because of other firms. This is what makes patents so interesting, but also so difficult to do research with, because for the large part, researchers cannot trace (and measure) the determinants of patents to factors that the patenting company can actually control (and therefore causally affect).

3.5.4 Limitations and future research

As with every study this one is not without limitations. It is important to acknowledge that this study cannot make any claims on the actual company ratio of patented to not-patented inventions. What this study does provide, however, is an intuition that the more interesting question for research might be to zoom in even more, to truly understand the decision making on the level of individual inventions. While I cannot observe the respective trade-offs in individual patenting decisions, my interviews reveal that how companies evaluate their inventions against the competitive landscape, their own strategic position, and potential technological trajectories constitutes a promising avenue for future research for instance into questions of sense making in dynamic and uncertain environments. Because patenting decisions are complex, how managers, both IP professionals and patent committee members, interpret the environment will affect the decisions they make. Moreover, identifying the drivers to individual appropriation decisions will also inform quantitative research that leverages patent data for large-scale empirical studies.

In addition, the scope of this study is limited to German firms, which poses the question of whether my findings are generalizable to other settings. While this is certainly up to future research, I believe that the results will be generalizable at large. The Gesetz über Arbeitnehmererfindungen (law about employee inventions) is of course specific to Germany and may force a certain formality and uniformity on the process that otherwise would not be there. However, I believe it to be unlikely that international firms in technology-intensive industries would be more superficial or haphazard with regard to the process of making appropriation decisions, when inventions are a regular

occurrence and something that is critical for creating and sustaining a competitive advantage.

Moreover, this study may suffer from a selection bias since, with one exception, only companies with dedicated IP departments were sampled for this study. As the focus of this study was to shed light onto the patent decision process, the sampling focused on companies that would be rather frequently in the position to make this decision. In order to mitigate this potential bias and increase the richness of the description I added the extreme case of Pi where an IP department is yet to be formed. What I find is that while the patent output of Pi is vastly different from all the other cases, the *process* of deciding on patent protection is in fact quite comparable. While it is certainly important for future research to look more broadly into potential differences across firms and their patent decision processes, especially when patents are not the preferred appropriability mechanism, the results in this study appear robust to these potential inter-firm differences.

4. Marrying patent protection and invention generation: Cross-functional integration of IP and R&D processes

4.1 Introduction

"It is important to me that we patent attorneys and patent professionals influence the innovation process and ensure that innovation processes and IP processes are married and closely linked to each other." – One head of IP

"Marrying" IP and R&D processes solidifies the notion that inventions are not the result of a serendipitous discovery, but a managed process, where patent protection is not an afterthought, but instead woven into the trajectory of an idea to a marketable product. Grounded in a larger literature on organizational capabilities (e.g., Puranam, Singh, and Zollo, 2006; Schoonhoven, Eisenhardt, and Lyman, 1990) a few studies suggest that the intra-firm processes related to IP generation have implications for companies' performance. Both Somaya, Williamson, and Zhang (2007) and Reitzig and Puranam (2009) conclude that the structure and set-up of the intra-firm appropriation process actually matters with regard to patenting performance. More recent work (Cesaroni and Piccaluga, 2013; Ernst and Fischer, 2014) indicates that the cross-functional integration of IP and R&D processes may also be valuable to firm's strategic position and firm performance. While cross-functional integration may be beneficial, it is also fraught with tension. Both the IP department and the R&D department are likely to exhibit distinct thought worlds with different norms, incentives, and even languages (Dougherty, 1992).

Using a multiple case study approach (Eisenhardt, 1989; Yin, 1994) I analyze how IP protection processes of technology-driven firms are integrated into R&D processes of invention generation. Analyzing companies' patent generation processes, I find that IP protection processes are increasingly integrated into invention generation processes located in the R&D department. Cross-functional integration may be differentiated into measures of R&D push, i.e. measures that facilitate the flow of information and inventions initiated from the R&D department to the IP department, and measures of IP pull, where the IP department proactively identifies, extracts, and even triggers inventions with the purpose of filing patent applications on them. These measures both aim at overcoming the distinct thought worlds of both departments and at creating organizational routines that ensure the cross-functional integration of patent protection and invention generation processes.

The results of this study contribute to the literature in multiple ways. First, I contribute to the literature on appropriation and value capture by shedding light on how firms organize their patent value chain, in particular with regard to IP protection processes. Secondly, I contribute to the literature on organizational capabilities and their importance for competitive advantage. Lastly, this study contributes to the growing number of studies that investigate strategic IP management.

4.2 Theory

Intellectual property, in particular patents, matters for competitive advantage. This is one of messages behind Teece's (1986) warning "to those science and engineering driven companies that harbor the mistaken illusion that developing new products which meet customer needs will ensure fabulous success". And indeed, nowadays, companies

are using patents increasingly for strategic purposes such as blocking competitors from entering a market or at least delaying their market entry (e.g., Cohen *et al.*, 2000; Blind *et al.*, 2006; Lanjouw and Lerner, 2001; Guellec, Martinez, and Zuniga, 2012).

While patent data itself has been used to increase our understanding of innovation management, our knowledge about how firms shepherd an invention from idea to patent grant remains fragmented. There is plenty of research on ideation and how ideas are turned into marketable products (see among othersAnderson, Potočnik, and Zhou, 2014; Perry-Smith and Mannucci, 2017 for a review) and increasingly on how firms act strategically during the patent application and examination process (e.g., Harhoff and Wagner, 2009; Steensma *et al.*, 2015; Süzeroğlu-Melchiors, Gassmann, and Palmié, 2017). But what remains underresearched is *when* in the process of idea to product IP protection is being considered and *how* companies ensure that IP protection is being considered strategically and not as an afterthought. What is therefore required is a shift in research towards studies that look inside the firm. This is reflected in Somaya's (2012) call for case study research to improve the research community's understanding of how firms develop sophisticated patent management capabilities.

Intra-firm processes and organizational capabilities have been repeatedly found to matter for innovation outcomes (e.g., Puranam *et al.*, 2006; Schoonhoven *et al.*, 1990). A few recent studies suggest that the configuration of the patent value chain matters for a company's ability to appropriate the returns to its innovations. Somaya *et al.* (2007) analyze the effect of internal versus external patent law expertise and conclude that in-house capabilities increase the firm's patenting performance. Similarly, Reitzig and Wagner (2010) conclude that outsourcing of patent filing activities negatively affects a firm's ability to detect competitors in the IP landscape as the firm lacks the relevant technological and legal knowledge in-house. Analyzing the job configuration of

IP executives, Reitzig and Puranam (2009) find that intermediate levels of cross-functional integration of IP and R&D activities lead to faster grant rates. These studies highlight that the organizational configuration of the patent value chain may be a source of competitive advantage.

Two recent studies highlight how the cross-functional integration of IP and R&D activities can benefit companies. Cesaroni and Piccaluga (2013) study how one semiconductor company went through a shift in its IP strategy from purely defensive to more proactively generating and leveraging IP and analyze how this shift necessitated the cross-functional integration of IP and R&D activities. Ernst and Fischer (2014) use survey evidence to show that the cross-functional integration between the IP and the R&D department has a positive impact on the performance of new products. While their sample is rather small and the measurement of cross-functional integration rather unspecific [16], their findings are at least indicative of the competitive advantage companies may be able to achieve through coordinating and integrating their R&D and IP protection processes.

However, cross-functional integration of departments may be prone to problems, and the R&D and IP departments are no exception. Organizationally, both departments are independent, each with their respective management levels and reporting structures. Even more so, both departments are characterized by different thought worlds (Dougherty, 1992). While within each department, employees share an understanding of what activities in that domain mean (e.g., “we, the researchers, do things like this”, “we as patent attorneys consider this like that”), these thought worlds differ across functions

[16] E.g., one item on Ernst and Fischer ('s) (2014) scale asked whether there was an open atmosphere between inventors and patent managers throughout the project.

and therefore may lead to misunderstandings and may create an “us vs. them”-mentality. As employees in both departments have received different training, have established different routines, strive towards different performance indicators, speak a different jargon, and may even experience a different culture, these differences may pose impediments to cross-functional integration (Dougherty, 1992).

Consequently, this tension around cross-functional integration between IP and R&D processes warrants a closer look into and this study constitutes a step in this direction. In this study I analyze how IP protection processes are integrated into invention generation processes located in the R&D department.

4.3 Research design

As described in chapter 3.3, this study uses the same dataset as the study in chapter 3, as they are both part of a research project focused on answering Somaya's (2012) call for case study research on intra-firm patenting processes and patent management capabilities. In order to understand how IP protection is cross-functionally integrated into R&D invention generation processes, I rely on an in-depth qualitative approach (Eisenhardt, 1989; Eisenhardt and Graebner, 2007) with multiple cases to allow for a replication logic (Yin, 1994).

To recapitulate from chapter 3.3 the research focuses on technology-driven firms in knowledge-intensive industries as these firms’ performance depends strongly on their ability to appropriate the returns to their innovations and they should therefore have established IP related organizational processes. The sample consists of 16 German companies with their headquarters in Germany, as shown in table 13 (see chapter 3.3). The sample spans from very small companies with fewer than 1,000 employees to very large corporations with more than 100,000 employees. Moreover, the sample covers a

variety of industries, from biotech to engineering to software.[17] Both cases and informants were selected purposefully (Pratt, 2009). I follow a strategy of diverse theoretical sampling in order to increase the scope of the findings and to facilitate pattern recognition (Eisenhardt, 1989).

As for the study in chapter 3, I rely on four data sources: (1) qualitative data from semi-structured interviews with all sample firms, (2) archival data, including company websites, materials produced inside the firms[18], and press articles about the sample firms, (3) company organigrams, and (4) the CVs of the key informants. The combination of different data sources allows for triangulation of the results (Jick, 1979). The semi-structured interviews constitute the primary data source. This approach allows a consistent line of inquiry across interviews, but offers the flexibility to alter the course through the interview guidelines and to address interesting topics as they arise during the conversation (Rubin and Rubin, 2005).

As the interviews combined the research questions for this study and the study covered in chapter 3, each interview comprised three parts: (1) a walk-through through the intra-firm appropriation decision process and its drivers; (2) questions related to how and when the IP department collaborates with the R&D department; and (3) the company's overall appropriation strategy. Covering these topics all in one interview allowed for a deeper conversation with the interview partners that generated meaningful insights into the relevant intra-firm patenting processes.

To recapitulate from chapter 3.3, I interviewed directors of IP departments and senior IP managers with extensive knowledge on their company's IP strategy and the

[17] For a more in-depth description of the sample please refer to chapter 3.3.

[18] Documents relevant to the process were either collected during the research or discussed (and in some cases inspected) during the interviews.

related organizational processes. In the case of one company, the interview was conducted with a member of the board of the company as he has been directly involved in setting up and shaping how the firm approaches the generation of patent applications. Given the sensitivity of the matter, anonymity was ensured for both companies and informants, encouraging the candor of the interviewees. A total of 18 interviews were conducted, mainly in the second half of 2016.[19]

Throughout the fieldwork, I engaged in an iterative process of data collection, data condensation, and coding to guide further data collection (Edmondson and McManus, 2007; Eisenhardt, 1989). The interview transcripts were coded at different levels of analysis (Miles and Huberman, 1994) using NVivo11. Codes were continuously revised during the analysis. Overall, the final coding scheme consisted of 174 items on four hierarchical levels and 990 text segments.

As described in chapter 3.3, the data was synthesized and analyzed both on a within-case and a cross-case basis to identify similar themes across cases (Eisenhardt, 1989). First, cases were analyzed individually to understand the idiosyncrasies of each case and to identify relationships from each case (Eisenhardt, 1989). Then, the cross-case analysis led to emerging patterns and themes. Overall, the qualitative analysis iterated between data and theory to hone the results. During the entire analysis I remained open for constructs that are not yet part of the literature.

[19] For more in-depth information on the interviews, please refer to chapter 3.3.

4.4 Organizational antecedents to patents: A shift to cross-functional integration

This study finds that IP and R&D processes are being cross-functionally integrated, so that patent processes – something that, in the traditional value chain, comes *after* the invention has been made – are being considered and pursued already *during* the invention generation process – *before* a dedicated invention notification exists. In this chapter I describe on a general level this shift from a sequential process to a cross-functionally integrated, iterative process of patent protection and R&D. I will then continue in the following chapters with an in-depth description of how and why patent processes are being integrated into R&D processes and how the sample companies are navigating this shift, before I provide avenues for future empirical research.

In the traditional notion of organizational processes, innovation follows a linear and sequential process from invention generation within the R&D department to the market entry by the respective business unit, as figure 15 shows.

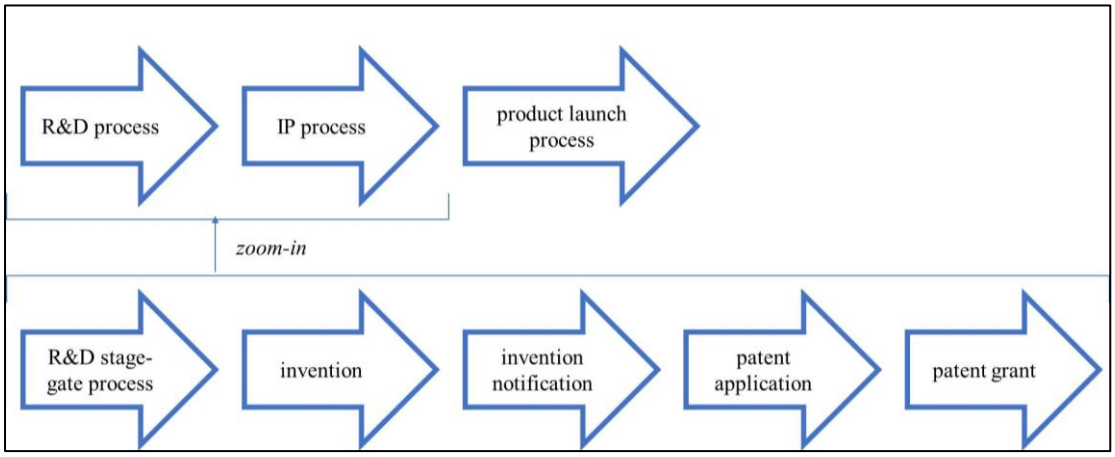

Figure 15: The tradional sequential innovation process

The patent protection process is just one step in this journey, starting with the invention disclosure and ending with a patent grant or denial. In this study I zoom in on the interface between R&D invention processes and IP protection processes.

The process of turning an idea into an invention that can be protected by a patent consists of many choices about the direction of development, the majority of which (if not all) is traditionally made in the R&D department where development takes place. But contrary to this traditional perspective, the data in this study reveals that across sample firms patent generation processes are increasingly integrated into the invention process and are not only of concern in later stages, but already in earlier stages of development when the trajectory of technological development has not even crystalized yet. Figure 16 shows the integrated patent value chain.

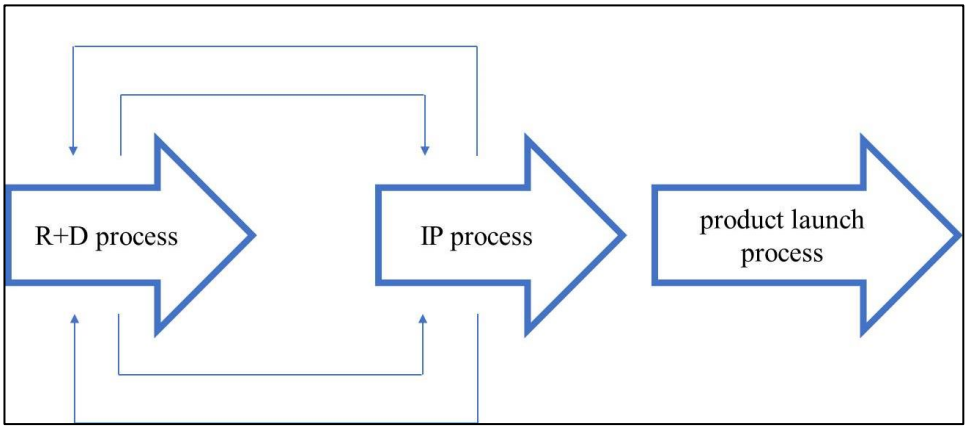

Figure 16: The cross-functionally integrated patent value chain

This ongoing shift from a sequential to an integrated process that I observe in all sample companies is fittingly captured by the head of IP of Alpha when he says: *"Honestly, I want to get away from this traditional process. From my point of view, innovation and inventions aren't something that just happens, but they are things that can be influenced. This is why it is important to me – and I know here at Alpha we aren't where we should be – that we as patent attorneys and patent professionals influence the innovation process and ensure that innovation processes and IP processes are married and closely linked to each other."* Similarly, the head of IP of Epsilon stresses: *"It's not like we in the patent department sit and wait until an invention notification arrives at our desks and then we start acting."* In order to reach a deeper understanding of how

patent protection processes are integrated into R&D processes, this study now analyzes distinct measures that have been implemented to integrate the IP value chain into development processes.

4.5 Measures to integrate IP protection processes

Based on all interviews I find that the IP department aims to fulfill three distinct goals with regard to the generation of IP protection: (1) to increase the volume of invention notifications that reach the IP department, so they can patent more and / or more selectively (depending on the overall IP strategy and budgetary constraints); (2) to decrease the time it takes from when the R&D department makes an invention to when the IP department is notified on that invention; (3) to increase the precision of the IP department's evaluation of an invention in order to know with higher certainty what the best appropriability mechanism and, if it is a patent, what the best course of action is in that respective case (e.g., how to draft the claims in the patent application, where to apply for patent protection, etc.). These three strategic goals of the IP department cannot be perfectly aligned all at once. For instance, improving speed through having inventors notify the IP department in earlier stages of the invention, likely decreases the precision with which the IP department can evaluate the invention. Cross-functional integration therefore aims to improve the odds of achieving these goals through several measures.

Based on the data I find six distinct measures that companies take to integrate their IP protection processes into their invention generation processes. These six measures align with the three strategic goals of IP protection described above. Table 14 shows the measures and their focus.

Initiative	Measure	Related to
IP pull	Personal ties between IP and R&D personnel	Different thought worlds
	Presence of IP specialists in key R&D meetings	Organizational routines
	Extracting inventions through harvesting	
R&D push	IP training for R&D staff	Different thought worlds
	Integration of IP matters into R&D project milestones	Organizational routines
	On-demand consulting by the IP department	

Table 14: Measures of IP integration

For one, the six measures can be differentiated according to whether they facilitate IP pull or R&D push. IP pull measures improve the possibilities of the IP department to proactively identify, extract, and even trigger inventions worth patenting. R&D push measures focus on facilitating the flow of inventions initiated from the R&D department to the IP department. Moreover, the six measures can be differentiated according to whether they facilitate cross-functional integration through targeting the different thought worlds that characterize the IP and R&D department or through targeting organizational routines. Measures focused on overcoming the different thought worlds – improving personal ties and dedicated training – focus more on implementing change and integration on a personal level through changing how R&D staff perceives IP issues and IP personnel. On the other hand, measures focused on organizational routines aim to establish the cross-functional integration through change on the level of routines and processes. In the following subchapters, the six measures are introduced, and their how and why are explained. The description follows the differentiation between IP pull and R&D push.

4.5.1 Measures of R&D push

Measures of R&D push aim to facilitate the existing flow of information and invention notifications from the R&D to the IP department along the traditional sequential patent value chain. Table 15 summarizes the measures and the operational challenges each measure aims to address. The following subchapters will then introduce the measures in detail.

Measure	Operational challenge addressed
IP training for R&D staff	• Increase awareness of and operational knowledge about patents and the patenting process • Stimulate filing of invention notifications • Reduce potential barriers to reaching out to the IP department
Integration of IP matters into R&D project milestones	• Increase awareness about patents • Include patent related matters in the R&D decision making • Stimulate filing of invention notifications
On-demand consulting by the IP department	• Promote involvement of patent specialists in how projects are set up • Include patent related matters in the R&D decision making

Table 15: Operational challenges addressed by measures of R&D push

4.5.1.1 IP Training for R&D staff

Organizationally, invention generation, i.e. the ideation and invention process, takes place in the R&D department. During this process, both inventors and R&D project managers are the key decision makers for the direction an invention takes. As inventors and R&D project managers often lack specific know-how in patent law, they often experience difficulties in judging the patenting potential of inventions. Often, R&D staff overestimates the level of novelty and technical sophistication that is required for a patent. This means that the lack of knowledge about patents results in certain inventions

not being written up for the IP department or information about ideas and inventions being held back in the R&D department. Since in the traditional sequential patent value chain the IP department depends on the notification by the R&D department, the IP department potentially misses to protect valuable inventions because R&D personnel selected to not share the knowledge about it. As decisions in the invention generation phase may have a direct and indirect effect on the appropriation decision and the potential scope of IP protection, companies have implemented dedicated trainings in order to raise awareness about the IP department and its function as well as the importance of patenting. This measure aims to increase the volume and the precision of reporting from the R&D to the IP department.

For one, the aim is to increase the likelihood that inventors inform the IP department about an invention either informally or through filing an actual invention notification. This is achieved by informing R&D staff in detail about the process of submitting an invention notification, the information requirements of the IP department, and the steps that will follow after the notification. In addition, awareness is raised about potential monetary rewards that accompany a patent application[20] and in some companies even the mere submission of an invention notification. Moreover, the IP department tries to increase the quality of submissions through creating awareness about the process in general and the information the IP department needs in order to evaluate an invention. The goal is to make the process of reporting an invention more seamless, more transparent, and thus less frustrating for both inventors and patent specialists. Likewise, trainings are supposed to empower R&D personnel to make better

[20] As part of the Gesetz über Arbeitnehmererfindungen (law on employee inventions) employees are awarded a monetary reward if an invention is patented by the company. Many companies supplement this payment with additional monetary incentives.

judgements about what and how to report so that inventions are easier to evaluate with regard to their patenting potential, i.e. increasing the precision of the IP department's evaluation of an invention.

For example, the head of IP of Omicron recounts the shift in perception that accompanied the training of inventors: *"They had an idea and we [the IP department, added by the author] said 'Look, that can be patented. We'll check for prior art and then we'll see.' And inventors used to answer 'But that's obvious…?!?'. Well, in their world it's obvious. But when you explicitly show them where the novelty is, then they understand. That used to happen a lot more often."* Similarly, the head of IP of Iota sees the lack of awareness of inventors as a major impediment to the companies' patent output: *"Again and again the inventors' astonishment, where they say 'oh, that can be patented?!?' I think that we still struggle with the cultural issue that many inventors don't regard their inventions as patentable, because when they hear patents they think of Gyro Gearloose and rocket science. And they need to overcome their own pride to ask for patent protection on the small things."*

To overcome the lack of awareness and reach as many inventors as possible, IP departments have implemented several trainings. This starts with simple things like having guidelines in the intranet for how an invention notification needs to be filled out. For example, at Omicron the invention notification process is embedded in the company's intranet with guidelines what inventors need to submit with their invention notification, which information needs to be provided, etc. If certain fields are left empty or there is no additional document with the invention description, then the invention notification is automatically rejected by the system. Moreover, the IP department offers an online training for all relevant departments, where inventors are walked through the notification and patenting process and get the opportunity to ask questions. The head of

IP of Omicron explains: "*We talk a lot about awareness and how the process works. Just to explain to people the whole process. What do we [the IP department, added by the author] do? And how do we do it? What do we expect from inventors? What can they expect from us? That's what we show them there."* In addition, the head of IP of Omicron travelled to most international locations of the company to give in-person presentations in a variety of departments about patents, their importance for the company, the role of the IP department, and how the inventors will interact with the IP department during the process. She recounts: *"A few years ago, I started a campaign where I visited the international locations, and also here in Germany with different departments, where I gave talks again and again."*

It is important to note that awareness measures, such as trainings and talks by IP specialists not only target the inventors but also R&D managers and executives to ensure that people in charge of development projects have a solid understanding about the necessities, opportunities, and risks associated with patenting in a competitive market environment.

At Iota – as explained above – the IP department has been faced with a company-wide lack of knowledge about patents. In order to increase awareness, the IP department developed several trainings, including one targeted at management. The head of IP of Iota explains: *"We also have a training for management, where we [the IP department] explain in a playful way – think Lego-Bricks and building towers – what patents are, why they are valuable, and what to do with them."* Likewise, the managing director of Iota's IP unit explains how middle and top management had to be brought on board with the company-wide initiative to increase awareness about patents and to increase the company's patent output: *"I talked with the C-suite, then with business unit executives, then with R&D managers, and further down. […] At the end the response of all of them*

was 'that was an interesting conversation about IP. I haven't talked that much about patents in the last 20 years.' So, and that's the key. You have to create awareness for this topic with everyone and then you have to enforce it."

4.5.1.2 Integration of IP matters into R&D project milestones

Research and development of new technologies, features, and products is typically managed through a stage gate process. Once a project has been set up, it is evaluated in regular intervals, the gates, according to its progress, marketability, financial, and other aspects. In order to ensure that projects do not run into a deadlock towards the end, because for instance the key technology cannot be protected through one or several patents, the gates also contain criteria that require R&D managers to get the opinion or input of patent specialists on the project. Through these formal requirements at the gates of the project development process, the IP department is organizationally integrated into the ongoing invention generation process.

Typically the involvement starts as early as the conceptualization phase, where a more or less in-depth patent landscape analysis is required, and ends with the formalized requirement that invention notifications are being submitted to the IP department. Throughout the development more in-depth analyses of prior art and competitor patenting may be required. For instance, the head of IP of Lambda explains: *"Sometimes it's simple things like 'does anyone else do something like this?' We do a straightforward search, a prior art search. And as the project develops from concept down to realization we have to get more sophisticated with what's out there. And at some point we go from simply looking for stuff to evaluating the stuff and putting it into context. That's later steps."* Similarly, the head of IP of Eta explains: *"There are several*

mechanisms that integrate us into the development process. For instance, early in the development, there is the requirement 'has there been an IP search?' and 'what's the result of that search?' So you are notified that you have to request an IP search. Then there is 'were invention notifications submitted, yes or no?' as part of the process." He reinforces: *"So there are several milestones and we [the IP department, added by the author] are integrated in the process, so that it's ensured that we are a part of all the steps."* Typically, the involvement of the IP department is a hard criterion, meaning that if the R&D manager has not actively sought out the advice and input of the IP department, the project cannot progress beyond the gate. As the head of IP of Omicron states: *"Absolutely, they have to make the infringement check with us. That's a mandatory step."*

The goal of integrating matters of IP protection into R&D project milestones appears to be twofold. On the one hand, firms try to avoid running into infringement cases, as they pose a substantial risk to the marketability of a product[21] and in severe cases even the going concern of the company. The head of IP of Omicron explains this motivation like this: *"Yes, it [IP matters, added by the author] is integrated. Without that, it could be fatal. Because in IP management it's like that: making patents is the lovely part. But the infringement part, that is much, much more dangerous and worse. That's why we have to have our eyes on both. Through the IP check, we call it IP check, we evaluate, whether we infringe other patents and whether others infringe our patents. We check both, and we check whether there's a new idea we can file a patent for. That's what we check for at the respective milestone."*

[21] Infringement, if brought forward in court, can lead to the ruling of a (preliminary) injunction.

At the same time though, the process also ensures that more invention notifications are being filed and sent to the IP department. The head of IP of Theta stresses this motivation: *"In the foreground, it's about patents by competitors, so 'what am I allowed to do, what am I not allowed to do?' and the intent is that for everything we develop that we didn't find something on, that is not covered by prior art, to write invention notifications. That's a hard criterion, there is a stop light symbol and we ask the respective R&D project lead quite aggressively that these invention notifications are being written."*

It is important to note that for this R&D push measure, the responsibility for integrating IP protection processes into the R&D project pipeline is entirely on the respective R&D manager. She is the one who has to solicit the input of the IP department at or before the various gates of the R&D process. As the head of IP of Lambda explains: *"The project manager needs to satisfy this [the requirement of the gate, added by the author]. So the project manager has to come here and say 'guys, ladies, what's up with this? Is somebody else doing this?' Or 'if we want to develop in this direction what's our road block – what's in the way?' And that's what we [the IP department, added by the author] do."* Similarly, the head of IP of Nu stresses that, as far as the R&D project management process is concerned, the responsibility remains with the R&D department: *"Well, we don't attend these gate meetings. We don't have to sign off 'have all patent related questions been answered?' The company has a development process for R&D, and our involvement is detailed there. We don't scrutinize whether we were really involved in all projects."* Lastly, as a byproduct, the formal integration of IP protection matters into each R&D project also increases the awareness of R&D management – and probably also of the inventors – about the

significance of patent protection and the interdependencies between the two departments.

4.5.1.3 On-demand consulting of the IP department

In addition to the IP department being contacted by R&D personnel before certain milestones as part of the formal R&D process, R&D managers may integrate patent specialists' input on-demand in the ongoing invention development process or into strategic questions. The head of IP of Theta explains how IP know-how can be integrated on an ongoing basis into R&D projects: *"For instance, we may ask the R&D project lead to attend a regular patent monitoring. In that case, he receives biweekly notifications on relevant competitor patents, so that he can evaluate them, and so that he is continually aware of the patent landscape, especially for longer projects that stretch over three, four, five years."* With regard to strategic business considerations, the head of IP of Lambda explains his department's involvement: *"There is no gate involved. It's just, we, Lambda, want to enter a particular market, can we do it? So I've got to answer that question."*

Consulting by the IP department may also take place surrounding the filing of invention notifications. Before an invention notification may be filed, the IP department of Kappa is notified and consults on the writing of the invention notification. The head of IP of Kappa explains: *"We usually get a call or the invite for a meeting where the invention or a prototype is being discussed. […] In this consult for the invention notification we talk about the technical specifications and you see what is patentable and what isn't, just based on the knowledge that you acquired over the years."* Similarly, the head of IP of Nu recounts: *"We work closely with the inventors. It's not*

like we are an independent law firm within the company that only starts acting, once an invention notification arrives. No, we are actually involved in projects from an early stage onwards and we discuss with the inventors early on 'does it make sense to already write an invention notification?' or 'should we support this with prior art searches? So I would say we work closely with inventors on this." Lastly, the head of Omicron recounts how patent specialists support inventors in writing the invention notification: *"They talk about the invention and we sort of motivate them like 'write this part like that'. Sometimes we have even shared an older invention notification that was good and got to the grant with inventors that weren't really sure. I have filed a few of these exemplars. We take those and show them to the inventors and say 'look, when you write it like that, like he did it, then we'll get to the grant in no time."*

4.5.2 Measures of IP pull

IP pull measures allow the IP department to proactively identify and evaluate inventions with regard to their patent potential and patent worthiness. Table 16 shows how measures of IP pull address operational challenges in the company.

Measure	Operational challenge addressed
Personal ties between IP and R&D personnel	• Increase awareness and operational knowledge about patents and the patenting process • Stimulate filing of invention notifications • Reduce potential barriers to reaching out to the IP department
Presence of IP specialists in key R&D meetings	• Include patent related matters in the R&D decision making • Stimulate filing of invention notifications • Identify inventions and ideas for strategic patents
Extracting inventions through harvesting	• Fast-track the process of filing a patent application • Identify inventions and ideas for strategic patents

Table 16: Operational challenges addressed by measures of IP pull

4.5.2.1 Personal ties between IP and R&D personnel

Functional specialization often leads to the development of a dedicated identity and distinct thought worlds (Dougherty, 1992) ("we, the engineers", "we, the patent attorneys") that hinder knowledge exchange and collaboration between two departments or entities. The purpose of establishing personal ties between IP and R&D personnel is therefore to overcome this divide and facilitate the flow of information between the two departments. As there is an information asymmetry about the intricacies of IP protection between IP and R&D personnel, the motivation for personal ties between patent specialists and inventors is that it will reduce the barriers for the inventors to ask patent related questions and to contact patent specialists early and frequently during the invention process. Quite simply, if there is a personal connection, it is easier to ask questions and to access relevant knowledge from others.

For example, Beta's IP department invested considerable time and effort in creating personal ties between the individual patent specialists and the company's inventors, including potential inventors outside of the development teams. Inventors are advised to get in touch personally with one of the patent specialists whenever they are unsure about the IP potential of an idea. Through their personal network the individual patent specialists hear about inventors' projects and ideas, and proactively approach inventors in regular intervals to keep track of their development activities and potential IP avenues that open up during this development phase. One senior patent specialist of Beta recounts: *"The other thing is that also outside of projects, where processes are explicitly laid out, inventors just easily get in touch with us, simply because we are well connected throughout the house and we are located closely to each other. That's an important thing; we are really close to the inventors. That means we hear stuff via office*

grapevine, who's working on what, and we follow up on these things. That means that when we hear something, that someone asks 'has that been done before? You know that kind of stuff', then I schedule a quick informal meeting – 15 minutes, 30 minutes tops – and try to get more insight. When I have the feeling there's something there, or one of my colleagues has the feeling that something's there, then we schedule a follow-up, so that these things don't get lost."

Arguably, creating and nourishing personal relationships across departments is much more feasible for smaller companies, where – as the head of IP of Gamma puts it *"inventors just approach us in the hallway. […] Everyone knows everyone here.*" Large and diversified companies have hence created dedicated middle men, the patent managers[22], to connect the R&D department and the IP department and – among other things – to emulate the close cross-departmental ties possible in smaller companies on a larger scale. Thus, the patent manager, who is an employee in the respective R&D department, acts as a boundary spanner between the IP department and the R&D department and consequently acts as a substitute for a close personal contact between patent specialists and inventors. Patent managers are R&D specialists who received training on patents, strategic IP management, and the companies' IP protection process. As the head of IP of Eta explains: *"We also have a position we call patent manager*[23]*. They aren't part of the IP department, but are the contact person for everything related to patents in the respective development divisions. They are responsible for making sure that we are contacted, that inventions reach us, and that questions can be answered on*

[22] Often being a patent manager is not a full-time position, but responsibilities that an experienced R&D employee takes on in addition to her "regular" job.

[23] Eta uses a slightly different official title for patent managers. For comparability and anonymity purposes, I use the most prevalent title in the sample "patent manager" for all companies.

the spot, for instance how to fill out the invention notification form, which documents to enclose, etc. These patent mangers work in the development divisions. They don't do the work of a patent attorney, just some support work. There are some development divisions with 1,800 people and through that position we can stay in touch and coordinate stuff." Similarly, patent managers at Iota are supposed to be a contact person for inventors about everything related to patents in an approachable, non-intimidating way. The function is still being rolled out to the entire company and the head of IP of Iota explains the current setup like this: *"We have some who are a true contact person for the inventors. They provide coffee, cake, cookies, and apples in their office, and inventors can simply drop by and exchange ideas with them. That's what we have in some business units. And in other cases, where the patent manager role is not a full-time position, the inventor coaching is rather more rudimentary."*

The drawback, of course, with this measure is that it is harder to ensure that all relevant people in the R&D department (or even beyond) are being reached. This is much more easily achieved with implementing mandatory trainings on patents and the IP protection process (see chapter 4.5.1.1). Nevertheless, the advantage of creating personal ties between IP and R&D staff, and the reason for why IP departments have invested resources into this measure is that the potential impact of that connection can be much stronger than that of a mandatory training. As the head of IP of Delta puts it: *"The output of patents is higher where you nourish the relationship with inventors in this way."*

4.5.2.2 Presence of patent specialists in key R&D meetings

While during the individual R&D projects, R&D managers are supposed to address matters of IP protection, firms have also implemented the practice that patent specialists attend crucial R&D meetings. While the authority and responsibility over the results of the R&D meetings remains with the respective R&D manager, matters of IP protection can be addressed much more directly than through the mandatory prior art search that is part of specific product development gates. By being present when crucial development decisions are being made, patent specialists can ensure that patent protection is a factor in the decision making. Even more so, patent specialists can highlight promising technological avenues from a patent landscape perspective.

Interview partners varied in their assessment of the impact that patent specialists may have in the meetings and on the technological trajectory of the project. Very well, this could be dependent on the respective industry the company is active in and therefore could be an interesting avenue for future research. On the one hand, some argue that the impact of IP personnel on R&D projects is limited. For instance the head of IP of Eta argues: *"Well, not in which direction the technology should move, what should be developed. That's not something the patent attorney will tell them. But he may suggest things like 'think about whether you want to protect this and that' or 'you should do a prior art search to figure out what the others are doing', that's the direction he takes. But we won't change the direction of technical development."* One patent specialist of Beta has an even stronger opinion on the influence of IP personnel on R&D projects: *"If we were to give advice like that, we would act like we're in the know. Sure, when you have worked together with inventors on a technological area for a longer time, then we can give clues on what people should search for. But that's more in the*

direction of 'look, read that patent, that gives you plenty of inspiration' or 'there you get a good impression on the prior art'. But to boldly say 'this is a white spot in the patent landscape' – those white spots might actually be there in our technology, I would be much more skeptical with regard to other technologies – but I wouldn't presume making such a statement and I think no one of my colleagues would either."

On the other hand, some interview partners acknowledge the role of patent specialists in giving impulses for development. For instance, the head of IP of Mu says: *"Well, we don't choose the targets, but we do say 'look, if you could add this chemical structure here, that would be really good. Does that make sense for you?' And they tell us whether it does. That's how the discussion works."* Moreover, the head of IP of Delta highlights the possibility to elicit inventions during these R&D project meetings: *"Also the active collaboration in project meetings. It's kind of a beaten term, but to strategically patent in a way that you try to file patents in an area that you recognize as valuable. And they [the patent specialists who attend the meetings, added by the author] say 'this is valuable, look into this direction and make a few experiments in the laboratory, so that we have enough for the application'. That's really valuable work, absolutely."*

What remains in both cases, is that patent specialists proactively identify and distill those inventions from the ongoing development that are patentable and most likely patent-worthy. Again, knowledge asymmetry about what makes an idea patentable may prevent R&D project teams to file invention notifications. Having patent specialists attend R&D meetings allows them to identify and elicit valuable inventions.

In some cases, patent specialists not only attend relevant development meetings but are an official part of the development project team. For instance the head of IP of Alpha recounts regarding a new development project: *"There is a whole*

interdisciplinary team that works on this and now we added two people, patent specialists, to the team, so that patent attorneys are part of the development from the early stages on."

4.5.2.3 Extracting inventions through harvesting

Harvesting refers to the practice of patent specialists extracting inventions from inventors both within development projects and outside of projects. The goal of the meeting is to identify patentable (and patent-worthy) inventions directly at the source, i.e. the inventor. The motivation, for one, is to overcome the knowledge asymmetry of inventors about patentability by bringing inventors and patent specialists together in a dedicated meeting so they can exchange ideas and address IP related questions head-on. In such a harvesting meeting, patent specialists may identify ideas worth patenting irrespective of whether the inventors' ideas relate to specific development projects, the chosen technological trajectory of a development project, or are simply a pet project.

Another motivation clearly is increasing the number of patent applications that fit the company's patent portfolio and the patent landscape in the respective technology, especially for strategic purposes such as ring-fencing and blocking. For instance, during harvesting meetings patent specialists may try to elicit ideas from inventors around existing products, technologies, and solutions. The head of IP of Kappa points out: *"What also happens is that we are invited to a workshop, and there we identify inventions and assign them to inventors."* He adds: *"Of course, based on the product we also look on our own whether we can patent some more before it moves to the market."* Similarly, the head of IP of Iota explains: *"So what we do in particular is that in the early stages of development we host an inventor workshop, where we walk through the*

product step by step or even with problem solution methods like TRIZ [Acronym for the "Theory of Inventive Problem Solving", added by the author] in order to find additional solutions to be patented and we do that already in the early stages of development."

Inventions identified during a harvesting meeting are directly funneled into the appropriation decision process (see chapter 3) and the patent application process. Hence, through intensively collaborating in a harvesting session, a process that typically takes months can be fast-tracked to a few days or weeks at most. As the head of IP of Alpha emphasizes: *"Of course, such an invention would fly through the process. The invention has the support from the inventor from the get-go, it has the support from the patent attorney – in a way, it's kind of his baby – and, because of the economic significance, it has the support of the business unit executive, so the person who controls the budget. Sure, you would have to discuss such an invention in the formal appropriation decision process, but in my view, it would simply fly through."*

4.6 Differences in the cross-functional integration of IP protection and invention generation

Across the sample – with the exception of the extreme case Pi – all companies engage in R&D push and IP pull measures. Pi is currently only implementing R&D push measures, which is not surprising given the low number of patent applications and the very recent change within the company towards a more patent-oriented development process. Table 17 shows how the sample companies differ in their use and / or implementation of R&D push and IP pull measures.

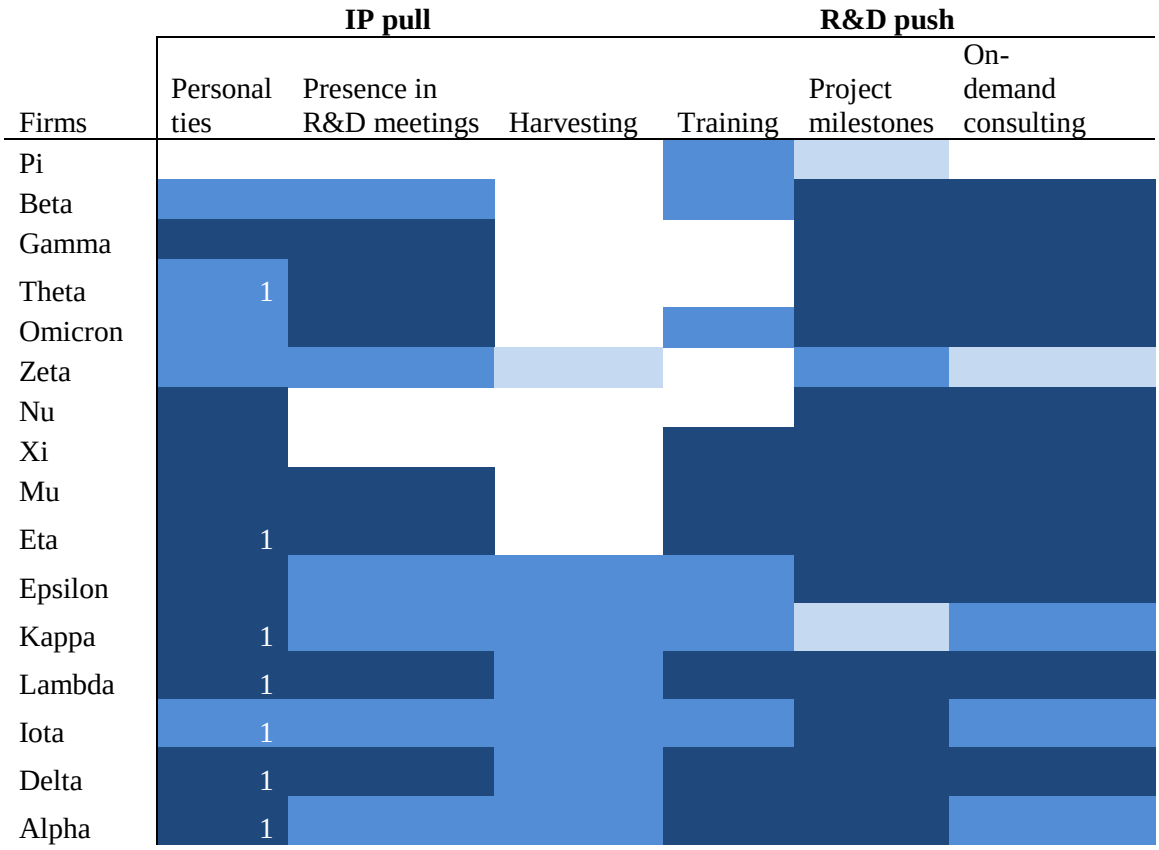

Table 17: Cross-sample differences in IP pull and R&D push measures

The most striking distinction is that harvesting as a practice is being implemented exclusively in larger firms. These larger firms appear to rely more on organizationally institutionalized routines than smaller firms in the sample. Smaller sample companies, especially the two smallest ones, Beta and Gamma, stressed the importance of personal ties and described how personal ties are crucial for the entire cross-functional integration to be successful. One senior patent specialist of Beta recounts: *"We get in touch with the inventors way before an invention notification. This is where being connected is really important, the personal ties. Then of course we try to motivate them, to see them through the process, to act as a service provider, so that on the one hand, we*

get a better result for our department [i.e. the IP department, added by the author] through a higher quantity of invention notifications, but also that on the other hand, the inventors feel taken care of, feel safe and motivated throughout the entire process." Similarly, the head of IP of Gamma explains how the IP department's strong ties affect cross-functional integration: *"We are quite a small company. The IP department is integrated in all important committees. Basically, we sense when there is an invention and most parts of the process are triggered by us."* In the presence of strong personal ties between patent specialists and inventors it is quite likely that these ties substitute – at least in part – organizational routines of R&D push and IP pull. Given strong personal ties, harvesting – extracting and triggering inventions in order to patent them – could take place between individual inventors and patent specialists without a dedicated organizational routine of regular harvesting workshops.

Apart from harvesting, it seems that, while some larger organizations have implemented more measures than smaller firms, there are no distinct differences. Similarly, it does not seem that differences across firms are driven by the companies' main industries. While some chemical and pharmaceutical companies (Delta, Mu) have implemented the majority of cross-functional integration measures discovered in the study, there are other companies in similar fields (Gamma, Xi) that have implemented fewer measures than, for instance, Omicron, a software company.

Overall, these findings suggest that in order to judge the effectiveness of the cross-functional integration, the differences across companies rest not as much in the measures implemented but in the implementation of those measures. Even just a look in

the conference calendar of a popular German conference and training organization[24] suggests that knowledge about the measures of cross-functional integration is rather widespread and easy to get by[25]. What appears, however, to be challenging is ensuring that measures of IP pull and R&D push are in fact implemented and lived by the people in charge. Interview partners at both Iota and Kappa stressed that the success of integration depends to a large part on the patent managers and how proactively they approach "their" inventors. The managing director of Iota's IP unit explains: *"The patent manager is the lynchpin. He has to observe the landscape, he has to manage his 20 to 100 R&D colleagues, he has to start thinking about licensing, about managing a patent portfolio. Honestly, there were quite a few differences in how long it took us to get those 25 people into this role."* Likewise, the head of IP of Kappa points out: *"It happens that we are included too late in the process. With a company of our size, it's sometimes just not possible to avoid that. There are several development units and not every unit is really patent-savvy and the patent managers obviously differ with regard to their knowledge. If someone got promoted to that role recently, then he obviously does not have the know-how of someone who has been in that position for years."*

4.7 Measures to integrate IP protection processes: A dynamic perspective

What is notable is that across the sample, many companies have been intensifying their efforts to integrate IP protection processes into R&D processes. Out of the 16 companies in the sample 11 companies stated that they have recently (about the last

[24] See for instance this seminar on the collaboration between IP and R&D: http://www.managementcircle.de/seminar/optimale-zusammenarbeit-von-ip-und-fe-4.html?pid=pardot.

[25] One interview partner shared that he actively sought out speaking opportunities to talk about the organizational routines and measures of integration that his IP department has implemented.

three years at the time of the respective interview) gone through a change in the way the IP department and the R&D department are working together, are currently going through such a change, or are intensifying their efforts to increase the impact of their collaboration. The bandwidth of change ranges from a virtual overhaul at Iota, to first steps towards integration at Pi, to more punctual efforts at Delta or Omicron. Table 18 summarizes these changes.

Implementation of new measures	**Intensified efforts with regard to existing measures**
Pi, Epsilon, Kappa, Iota, Alpha	Beta, Theta, Omicron, Zeta, Lambda, Delta

Table 18: Dynamism in the sample

At Iota, integration of IP protection processes into the R&D process was practically non-existent a few years ago. During the three years preceding the interview, the IP department had been building structures, routines, and processes to achieve the integration of invention generation and IP protection. Both R&D push and IP pull measures were introduced, as the only existing touchpoint before an invention notification was submitted by R&D was during the R&D project stage gate process. A key driving force in this change has been a member of the board who put a company-wide IP strategy and patent initiative on the agenda. As the managing director of Iota's IP unit highlights: "*In all honesty, all those changes would not have been possible to that degree and with that success, if Mr. X [anonymized, Mr. X is a member of the C-suite, added by the author] hadn't said that he wants a sensible patent strategy and a central IP department because he knew that from his prior employer.*" Both the managing director of the IP unit and the head of IP were hence hired to execute this change.

At other firms, too, a change in the position of the head of IP brought about a change in the process. For instance, the head of IP of Alpha stresses how the processes

had to change because of a different philosophy of doing IP: *"I don't want to criticize my predecessor […]. I'm exaggerating – invention notifications were slipped under the closed door of the patent attorneys, patent attorneys worked on them, and then slipped them back out. And that's not what I want. I want IP to be an integral part of the innovation process."* This is why, he points out that he promoted in particular the change towards IP pull measures, such as harvesting and the integration of patent specialists in R&D project teams: *"My goal is – and in some divisions that works already quite well – that patent attorneys accompany the entire innovation process. That patent attorneys are there when decisions are being made."* He elaborates: *"We only achieve that if patent attorneys are involved in the innovation process early on and accompany the development, and get the opportunity to strengthen or improve ideas that are being considered through their patent-specific expertise."*

At Pi, a media company, several developments concurred and spurred the decision of management to become more proactive about patents. For one, the technology and technological roadmap had become more high-tech and at the same time more observable to competitors. Moreover, the company was sued for patent infringement. These changes put patents on the agenda for management, as a C-suite member explains: *"Taking all those things together, we said 'ok, this is somehow becoming more important. We need to make up our minds how we want to protect our technologies and how we want to exploit them."* As Pi is only starting to move into this direction, the initiatives are currently limited to R&D push measures. First and foremost, they decided to create awareness with inventors and relevant middle management and are planning to implement measures of IP protection in the project development process.

Several IP departments have decided to intensify their efforts to achieve a stronger integration of IP protection in the R&D process. For instance, at Zeta the IP department

realized that they could improve the information flow from R&D personnel, but also be more proactive in identifying patentable (and patent-worthy) inventions. The IP department thus attempts to intensify the connection. A senior patent attorney of Zeta explained: *"Yes, partly we do [proactively approach inventors, added by the author]. But there is still room for improvement. In a few areas we proactively approach inventors and ask about their projects and try to filter stuff out that is worth patenting. But we need to do more in that area."*

4.8 Discussion and conclusion

4.8.1 Integration of IP protection processes as a source of competitive advantage

So far, the process of how patent applications originate within a company has remained largely underresearched. The results of this study suggest that companies utilize their IP processes to derive a competitive advantage in the patent and even technical landscape. While prior research by Somaya *et al.* (2007), Reitzig and Puranam (2009), and Reitzig and Wagner (2010) suggests that firm's organizational configuration has important repercussions for the production of patents, the results of this study show how firms deliberately structure the IP protection process in order to create a competitive advantage based on their patent portfolio.

The data reveals that firms engage in considerable cross-functional integration along the patent value chain. IP protection processes are integrated into R&D processes through measures focused on R&D push and IP pull. All these measures aim to enlarge the funnel of inventions and inventive ideas that are being considered for IP protection. In addition, cross-functional integration of the R&D and IP department is pursued to increase both the speed and the precision with which the IP department evaluates an

invention in terms of its patenting potential and filing strategy. As the head of IP of Kappa points out with regard to the cross-functional integration: *"It's a must. In order to work efficiently with regard to cost and time, there has to be integration."*

Cross-functional integration is especially promising between the R&D and IP department because there is a high interdependency between their processes, particularly with regard to IP protection. Invention generation is the key competence of the R&D department but pursuing IP protection on a given invention remains under the prerogative of the IP department. The IP department thus depends on the input of the R&D department. Each individual invention, however, is the result of development activities and related decisions that are located outside of the IP department within the R&D department. Most notably, the inventor team and / or the respective (project) manager have the biggest influence on what reaches the IP department in the form of an invention notification. Moreover, decisions and actions by the R&D project team may impose constraints on the IP department's scope of actions. During the R&D process the inventor team may make decisions about the focus of the invention that may not be aligned with the knowledge of the IP department about potentially fruitful avenues of development in terms of a patent portfolio perspective. Lastly, if an invention notification is indeed filed, the details that are disclosed by the inventor and project team determine the options of the IP department in terms of whether (and which and how many) IP rights are pursued. The cross-functional integration I find in this study thus has the aim to better manage this interdependence between the tasks of the R&D and the IP department.

In line with research by Reitzig and Wagner (2010), the result suggest that cross-functional integration also yields benefits further down the patent value chain. As the head of IP of Epsilon explains: *"You write a patent application and then you get the*

feedback from the patent office. Often, that's when you have a problem, because there are several ways to restrict the patent's claims in order to still get the patent to grant. This is typically when the guessing game starts, the big discussion which aspects in the application are truly critical and which changes are reasonable, so that the patent still protects the product. This is the part that we dramatically shorted through an integrated patent strategy, because we know exactly what part of the invention we want to protect. There is no longer a long discussion."

An organizational setup that generates more and / or "better" patents faster than the company's competitors will clearly improve the focal company's position in its competitive environment. The question, however, remains whether this claim of "better" patents that several heads of IP voiced withstands the test of empirical research. Are patents derived from a cross-functionally integrated IP protection process really stronger and remain valid more often, if they are challenged in court? Are they discontinued less and later? Even more so, the question remains of what "better" in this context actually means. Does "better" refer to a better fit with the company's strategy? Does it refer to the contribution of value to the overall patent portfolio? Does it mean more destructive potential towards competitors? While the results of this study hint at potential answers, future research is needed to provide deeper and more conclusive insights.

4.8.2 Boundaries to cross-functional integration

The results of this study show how firms achieve cross-functional integration of invention generation, located in the R&D department, and patent protection, located in the IP department. Cross-functional integration of specialized, interdependent tasks, however, takes place in an area of tension. On the one hand, it is precisely the

specialization and creation of distinct, internally-homogenous departments that allows for efficiency gains. On the other hand though, the interdependence of tasks means that coordination across departmental boundaries and identities can be beneficial. This is what this study's results suggest. But trade-offs between two opposing goals often suggest an intermediate solution, just as Reitzig and Puranam (2009) conclude in their study of firms' patenting performance, where intermediate levels of integration between the R&D and IP department appear most beneficial for achieving fast grants on patent applications. Consequently, the boundaries to measures of R&D push and IP pull will require more research in the future.

In addition, the measures of R&D push and IP pull are a matter of implementation. The official IP department guideline of increasing the personal touchpoints between patent attorneys and inventors may push one patent attorney to start networking and to proactively approach inventors to offer support, while other patent attorneys may remain more passive.[26] Even organizationally embedded routines may be subject to carelessness and willful neglect as this conversation with one head of IP highlights:

> *Interviewer: "Are you really part of the team?"*
>
> *Interviewee: "Officially, we are part of the team."*
>
> *Interviewer: "And unofficially?"*
>
> *Interviewee: "Unofficially, the project team has tapered off. In the beginning, this practice was lived really intensively, but then people got tired of it and it has just discontinued more and more."*

[26] Two interview partners even pointed out that patent attorneys who were trained and still invested in the "old" way of doing things – waiting for invention notifications to be submitted – were transferred to other positions or let go.

Lastly, the results of this study hint at a potential tension between innovation generation, i.e. value creation, and appropriation, i.e. value capture. While several interview partners stressed the importance of patent protection for successfully marketing innovative products and for fending off competitors that might threaten the market position and penetration of the company's products, ultimately innovative products should be grounded in customers' needs not the patent landscape of the technology. As one head of IP stated: *"We aren't involved to an extent where it's our job to 'find the projects for next year'. Honestly, I think it wouldn't be sensible to do that with a theoretical approach, because in fact our projects should be driven by the markets and our customers. Between you and me, they don't care about patents."* How this tension plays out in the future will provide interesting avenues for research.

4.8.3 Contributions

This study contributes to several streams in innovation research. For one, this study contributes to the literature on appropriation and value capture by shedding light on how firms organize their patent value chain, in particular with regard to IP protection processes. Apart from a few exceptions (e.g., Alexy *et al.*, 2014; Bhaskarabhatla and Hegde, 2014), the majority of empirical studies on appropriation and appropriability mechanisms takes an outside perspective and often considers companies' patent output as given. Shifting the focus to how patent applications originate within companies and further evidence on what drives and determines a company's patent output enriches our understanding of the role patents play for companies.

Moreover, the results of this analysis contribute to the growing number of studies on strategic IP management, that have explored questions such as the effect of

outsourcing patent law work (Somaya *et al.*, 2007) and the choice to not disclose prior art in patent applications (e.g., Alcácer *et al.*, 2009; Lampe, 2012; Steensma *et al.*, 2015). Following Somaya's (2012) call for case study research on patent management capabilities and strategic IP management practices, this study provides answers with regard to how matters of strategic IP protection – a focus of the IP department – are integrated into the invention generation process located in the R&D department.

In addition, this study contributes to the literature on organizational capabilities and their importance for achieving a competitive advantage. This study finds that companies perceive the organizational configuration of their IP protection processes as an important lever for capturing value from inventions. In particular, companies strive towards a cross-functional integration of R&D and IP processes through measures of R&D push and IP pull. These findings supplement quantitative research by Reitzig and Puranam (2009), who find that intermediate levels of cross-functional integration between R&D and IP processes are beneficial for firms' patent performance in terms of how fast a patent can be brought to grant. By looking deeper into how this cross-functional integration is achieved, this study continues down this path of inquiry.

Lastly, this study also has important implications for the appropriability decision process. For many companies appropriability decisions, i.e. the choice of whether to pursue a patent application on an invention notification or to keep it a secret or to defensively publish it, are being made by a committee of business unit representatives (see the study in chapter 3). Hence, the decision authority on the appropriability mechanism rests with the business unit(s), not the IP department. If, however, inventions are being harvested in dedicated workshops or are being extracted in R&D project meetings with the purpose of turning them into patent applications, then

the appropriability decision has effectively already been made by members of the IP department.

Beyond the contributions to the literature on innovation management and organizational capabilities, this study offers interesting implications for practice. Insights into underlying organizational processes of IP protection may be particularly interesting to firms that feel a pressure to adapt their IP strategy and processes, either because they are growing, moving into a new-to-them market, or because external events such as a patent law suits force them to overthink their IP management practices. This study shows the bandwidth of measures that companies may adopt in order to increase the funnel of inventions evaluated for patent protection, to increase the precision of that evaluation, and to prepone the evaluation to earlier stages of the invention.

This study also provides interesting implications from a normative perspective, as the strategic management of patenting may be considered an undesirable result of the patent system as a whole. This is especially the case, if the goal of cross-functional integration of R&D and IP processes is to increase the number of patents uncoupled, at least in part, from development activities – a goal that appears quite realistic given the practice of harvesting. While some companies confirmed that, at least for certain business units, increasing the patent output was a deliberate strategy, others highlighted that the desired outcome of integration was simply a larger funnel of inventions, therefore providing the IP department with more choice. Nevertheless, if that choice is used, as the head of IP of Alpha stated, so that patent attorneys *"can harvest the important and fitting ideas and that they can then patent them skillfully and broadly."* the question remains on a societal level, whether and in how far this behavior is problematic.

Lastly, the practices of strategic IP protection described in this study challenge our understanding of what constitutes innovation. If an engineer or a researcher sit together with a patent attorney and conjure up ideas with the deliberate purpose of turning them into a patent application, what exactly about their ideas constitutes an invention? Do these ideas contribute to innovation? What is the contribution to innovation if patents are generated to ring-fence a product, an innovation itself? These are just a few questions that researchers, managers, and policy makers will have to tackle in the future.

4.8.4 Limitations and future research

As with any other academic endeavor, this study is subject to several limitations which may provide valuable opportunities for future research. For one, this study focuses on German firms, which poses the question of whether the findings are generalizable to other settings. While this is certainly up to future research, I believe that the results will be generalizable at large. For one, the idea of actively managing the invention process can be found in international law publications that most likely will be known to IP executives in Germany.[27] Moreover, many patent executives I interviewed have worked outside of Germany and / or for non-German companies, which makes it likely that certain practices have diffused and are not unique to Germany. This knowledge diffusion is particularly likely given that there are a multitude of national and international conferences focused on patents and IP management where patent executives from around the world and from different industries get a chance to meet and exchange best practices.

[27] In fact, one interview partner shared a document from an international IP law course about active patent management that motivates a stronger integration of IP topics in the R&D process.

Moreover, the study may suffer from a single informant bias. Interview partners were exclusively recruited from the IP department and this clearly limits the richness of insights that can be provided on the integration of IP protection processes into R&D processes. Therefore, there is the possibility that interview partners described the role of IP processes in an aggrandizing manner. While this may certainly be true for interviewees' evaluation of the effect of the integration and the importance of the IP department, it is unlikely to be the case for the description of measures itself. Especially for routines that are organizationally established, e.g., the integration of IP protection at certain points in the development stage gate process, that is embedded in companies' project management tools, it is unlikely to have resulted in a biased representation of the measures implemented.

But what is a more pressing issue that deserves further investigation in future research is that how these measures are implemented, interpreted, and ultimately lived depends very much on the individual patent specialists and inventors. For instance, the knowledge flow between a patent specialist and an inventor depends on the depth of the interpersonal connection and this cannot be achieved through establishing an organizational routine or even giving patent managers an office with coffee and cookies to entice inventors to engage. A few interview partners stressed that the job description of patent specialists is changing to a more outgoing, socializing personality that actively searches for patentable matter as opposed to a paper tiger who waits for invention notifications to come to his desk to be examined. For instance, the head of IP of Alpha stressed: *"There is a change in the requirements of a good patent attorney. They need to be more proactive, they need to approach people and actively look for ideas, maybe even stimulate ideas, and so on, and not just wait for an invention notification."*

Hence, beyond differences in organizational routines, the effectiveness of companies' IP management may also be grounded in the way that its IP professionals do their jobs.

It is precisely these shortcomings that offer fruitful avenues for future research. For one, this study has identified the variables that make up integrated IP protection processes (i.e., the measures of IP pull and R&D push). Large-scale surveys could therefore investigate on a much broader scale how companies differ with regards to the integration, and, potentially, what this integration leads to. Moreover, more in-depth case studies could investigate in greater detail how companies live these measures, chronicling the development of an invention from ideation to a fully identified invention. Another interesting line of inquiry may be to further analyze the relevance of outsourcing patent law expertise for the effectiveness of the integration, given that firms may follow very different strategies in terms of in-house patent lawyers vs. external patent support. Lastly, my results suggest that integration of IP protection processes into R&D processes might create some tension between value creation and value capture. This line of research certainly merits closer observation in the future.

5. Conclusion and outlook

Innovation is fraught with uncertainty – uncertainty about the trajectory of research and technologies, uncertainty about the moves of competitors, and uncertainty about new competitors planning to enter the market, to name a few. Patents have become one tool for companies to manage some of the uncertainty associated with innovation. A patent grants its owner the right to exclude others from using the underlying invention as it is described in the patent's claims. While the original intent of patent rights was focused on preventing imitation, patents are increasingly used for strategic purposes such as blocking competitors.

But pursuing patents – filing an application and seeing it through the examination process, having it translated into other languages, pursuing validation in other jurisdictions, and being prepared to enforce them in court – is a costly endeavor. At the same time, not pursuing patents may be a costly endeavor, too, as infringement suits can lead to huge damage payments and even injunctions on products (Rivette and Kline, 2000). Research on patenting and patent management is therefore important for management practitioners and scholars alike.

This dissertation aimed to shift the focus away from the observable result, i.e. the patent application or grant, to the processes that take place inside firms before a patent application. In order to do so this dissertation utilized a qualitative approach to provide rich and deep insights into how patent protection is organizationally and strategically integrated into firms' processes, most notably R&D processes. Since patent data has been used in a large number of studies the dissertation also analyzed how the research community deals with the shortcomings of patent data and the ambiguity in the interpretation of patents that results from the intricacy of the patent protection process.

The findings of this dissertation highlighted how patent applications are not the result of meaningful, but serendipitous eureka-moments a company's inventors could conjure up, but the result of a managed process with strategic and tactical objectives, and, more often than not, only cover incremental advances of technological development. From a research perspective, these results show that more investigation is required into how firms pursue patent applications and what that means for the interpretation of innovation. If patents are the strategic tool they appear to be, then they have, at least in part, become uncoupled from technological development and innovation. This poses important questions as to which activities constitute and contribute to innovation.

The increased importance of patent portfolios and the growing attention companies pay to patents across industries has profound implications for managers as well. Overall, the "patent-game" is quite resource-intensive for companies, especially since cross-functional integration of IP protection in R&D invention generation processes requires staff and resources. Moreover, strategic patenting is likely to lead to more patenting, more intensive monitoring of competitor patents, and more legal actions in the form of oppositions and law suits. On a more profound level, the increased awareness about the destructive potential of patents (for the own company and against competitors) and companies' responses to this threat, will likely to change how companies view innovation.

At the same time, new concepts of innovation management focused on generating successful innovation are being published and increasingly implemented in companies. Crowdsourcing, agile development, and design thinking appear to be considered the new panacea to create successful innovation that will lead to a competitive advantage. On an abstract level, what these innovation concepts have in common is a new set of beliefs about how to identify the most promising avenues for development and more

responsive, iterative, and integrated methods of bringing innovative products to the market.

What makes both trends – and their interaction – an exciting field of future research is that while design thinking is very much focused on value creation, patents are very much focused on value capture. How companies navigate those two opposing goals and integrate them into their invention generation process will provide interesting and promising avenues for future research.

Appendix

Patent data based variables (per study)	Studies	Total (in %)
1	27	29%
2	20	22%
3	12	13%
4	19	21%
5	9	10%
6	2	2%
7	2	2%
8	-	0%
9	-	0%
10	1	1%
Total	**92**	**100%**

Table 19: Sample studies' use of patent measures

	Knowledge resources	**Innovative output**	**Knowledge flow and collaboration**	**Characteristics invention**	**Characteristics inventor**	**Market positioning**	**Environ-ment**	**Total**
Backward citations	7	-	13	4	1	2	2	**29**
Forward citations	-	11	1	17	1	-	1	**31**
Patent counts	13	18	-	-	7	6	2	**46**
Other patent data	11	-	29	7	8	3	-	**58**
Backward citations × patent counts	-	1	3	-	-	-	-	**4**
Forward citations × patent counts	2	3		-	1	-	-	**6**
Backward citations × other patent data	9	1	13	1	-	-	-	**24**
Forward citations × other patent data	-	1	-	6	-	-	-	**7**
Patent counts × other patent data	8	8	12	2	2	3	3	**38**
Patent counts × non-patent data	1	1	1	-	-	3	-	**6**
Other patent data × non-patent data	-		-	-	3	-	-	**3**
Forward citations × patent counts × other patent data	1	1	-	-	-	-	-	**2**
Forward citations × patent counts × non-patent data	1		-			1		**2**
Total	**53**	**45**	**72**	**37**	**23**	**18**	**8**	**256**

Table 20: Distribution of patent measures across theoretical constructs

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