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COMPETITION AND DISPUTES IN THE PATENT LIFE CYCLE

Thesis for the degree of Doctor of Science (Technology) to be presented with due permission for public examination and criticism in Hall 2310 at Lappeenranta University of Technology, Lappeenranta, Finland, on 20th June 2017, at noon.

Acta Universitatis
Lappeenrantaensis 747

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ISBN 978-952-335-086-1
ISBN 978-952-335-087-8 (PDF)
ISSN-L 1456-4491
ISSN 1456-4491

Lappeenrannan teknillinen yliopisto
Yliopistopaino 2017

Abstract

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Competition and Disputes in the Patent Life Cycle

Lappeenranta, Finland, 2017

104 Pages

Acta Universitatis Lappeenrantaensis 747
Diss. Lappeenranta University of Technology
ISBN 978-952-335-086-1, ISBN 978-952-335-087-8 (PDF), ISSN-L 1456-4491, ISSN 1456-4491

Patents are key assets in the knowledge economy. The past three decades have seen staggering volumes of patenting as innovators build technologies to gain competitive advantages. While the patent system aims to encourage innovation, expensive lawsuits and concentration of innovation can diminish societal welfare.

This dissertation uses public information contained within patent documents to *measure firm competition* and *explain drivers of patent disputes*.

Unlike usually perceived, patents are not one-shot actions. They follow an uncertain life cycle that takes many years before their acceptance or refusal is known. The methodology adopted involves scanning patent databases for early stage information that contain signs of competition and disputes. Typical information analyzed includes pre-grant citations and actions of patentees (and their rivals).

The results introduce two measures indicating *vulnerability* and *blocking power* of patent portfolios. In addition, drivers of European patent disputes and their resolution are uncovered based on earlier theories of litigation and settlement. Substantial overlap is seen among patent portfolios of European wind power firms. Pertaining to patent disputes, it is shown that patentees and their rivals constantly update their beliefs as *new information* is uncovered. Questionable validity of a patent is the biggest impediment to dispute settlement.

For academics and patent analysts, this dissertation carries out one of the most comprehensive analyses of European patent citations. Early stage procedural indicators are *validated* as determinants of patent value. For practitioners, this is one of the first studies of European patent litigation and their settlement. The results contribute to the field of patent statistics and patent value indicators. Various policy implications are drawn related to the European patent system.

Keywords: *Patent value indicators, patent life cycle, patent litigation, European Patent Office, patent opposition, patent citations, citation categories, procedural data, PATSTAT, European Patent Register*

Acknowledgements

This thesis is the culmination of research work that has led me through an extraordinary phase in life. Along with learning how to do research I have also learnt the ways of life associated with living in a new country. So much so that Finland is almost home. I have been blessed to have had top quality research infrastructure and support needed during my time in Lappeenranta University of Technology.

My gratitude goes out to everyone who has been a part of this journey. There are certain individuals, however, who deserve a special mention. I would like to start with thanking my supervisor Prof. Tuomo Kässi for his undaunted faith and support throughout my research work. His own personal energy, enthusiasm and experience have inspired many including me. I am equally thankful to my senior colleague and instructor Dr. Matti Karvonen for guidance and thorough reviews. Together, we have shared significant publication successes that I will cherish for a very long time. My own knowledge of the whole research process would have been incomplete without his experience and guidance.

I sincerely acknowledge and appreciate the support extended to me by the Finnish Patent Office (PRH). I would like to thank Dr. Jorma Lehtonen for promptly connecting me to examiners for any IP related issue. In similar regard, I would like to thank Dr. Olli-Pekka Piirilä and Dr. Ari Hirvonen. Special thanks are reserved, however, for the much revered Timo Kivi-Koskinen, former director of the PRH. His early interest in my research led to connections with the PRH in the first place.

I completed two short exchange visits during my research. I would like to thank Prof. Nicolas van Zeebroeck from Université libre de Bruxelles, for guiding me through a still ongoing research project. I gained a lot of skills during my collaboration with him. I am also thankful to Prof. Knut Blind from Technical University of Berlin for his guidance and support in work related to standardization and patent pools. For ironing out the chinks in the dissertation text, I deeply acknowledge the effort of my reviewers Prof. Bruno van Pottelsberghe and Dr. Timo Laakso.

All said and done, it is love from family and friends that makes one realize what is most important in life. I can’t thank enough Mom and Dad for their support over the years. I also can’t help but remember their own struggles to help me achieve my best. This thesis is dedicated to them. My brother and his family have been a source of personal support during my visits home. Fellow PhD students and long-time friends Arun Narayanan, Amrita Karnik, Samira Ranaei and Arash Hajikhani have been with me during times of joy and melancholy. So have old buddies Arvind Solanki and Mikko Tirronen who deserve a special mention. A big thank you also to Ashok, Dipal, Ben, Henna, Tamara, Azzurra, Päivi, Pontus, Tommi and Alyona.

12th May, 2017
Lappeenranta, Finland

Foreword

One of the first projects I undertook as a researcher was to find patent experts and interview them. Given the limited time experts have, I asked them only two questions. One was to describe their job. The other was about their opinion on patent value indicators introduced in the literature. I interviewed many experts. For example, professors who owned patents; R&D managers of big firms; technology transfer personnel who hoped to commercialize inventions; attorneys who drafted patent claims; agents who bought or sold patents; and finally patent office examiners who scrutinized patent applications. Before long, a central theme started to emerge from the interviews. On a philosophical plane, each interviewee's idea about value revolved around their own job profile. After all, we are all centres of our own universes. But there was some consensus. An overwhelming inclination regarding a strong indicator of patent value was an incidence of patent dispute.

This thesis is an attempt to advance the field of patent statistics. Patent statistics is a field that uses patent information to answer classical questions about economic growth. For example, what is the rate of technological change? What is the relationship between rate of innovation and firm competitiveness? What are the differences in value creation across regions, industries and firms? And many more such questions.

Zvi Griliches in his 1990 essay has articulated the key issues of the field so beautifully that writing this thesis will be a humbling experience. I will try to highlight what might have changed in 26 years. Nevertheless, the foundations of this book is strongly entrenched in works of Pakes, Griliches, Trajtenberg, Hall, Schankerman, Lanjouw, Harhoff, and many more. A patent, in itself, has no value. It is simply a sign of value. A sign that the applicant means (or might mean) business. This dissertation is about looking for signs of value wherever they might be available.

This work has been carried out primarily in Lappeenranta University of Technology between 2012 and 2016. Work related to European patent litigation was done in Solvay Brussels School of Economics and Management, in spring 2015.

Rahul Kapoor
November 2016
Berlin, Germany

Contents

List of appended publications

Publication 1: Patent value indicators as proxy for commercial value of inventions
Authors: Kapoor, R., Karvonen, M., and Kässi, T.
Journal: International Journal of Intellectual Property Management, Vol. 6, Issue 3, Pages: 217-232, 2013
Publication Forum Level: 1

Publication 2: Patent portfolios of European wind industry: New insights using citation categories
Authors: Kapoor, R., Karvonen, M., Ranaei, S. and Kässi, T.
Journal: World Patent Information, Vol. 41, No. 1, Pages: 4-10, 2015
Publication Forum Level: 1

Publication 3: Intellectual property and appropriability regime of innovation in financial services
Authors: Kapoor, R.
Book chapter in: Innovation in Financial Services: A Dual Ambiguity. Pages: 97-128.
Publisher: Cambridge Scholar Publishing, 2014
Publication Forum Level: 1

Publication 4: Patent citations as determinants of grant and opposition: case of European wind power industry
Authors: Kapoor, R., Karvonen, M., Mohan, A. and Kässi, T.
Journal: Technology Analysis & Strategic Management, Vol. 28, Issue. 8, Pages: 950-964, 2016
Publication Forum Level: 2

Publication 5: The laws of action and reaction: on determinants of patent disputes in European chemical and drug industries
Authors: Kapoor, R., and van Zeebroeck, N.
Working Paper: iCite RePEc (Research Papers in Economics) Working Paper WP 2016-019, Available online: http://econpapers.repec.org/paper/ictwpaper/2013_2f235144.htm
Publication Forum Level: 0
('Revise and Resubmit' status in Industrial and Corporate Change)

Author's contribution

The author is the principal investigator in all the above publications. Please see pages 28 and 29 for more detailed contribution.

Other publications

Journal articles

Karvonen, M., Kapoor, R., Uusitalo, A. and Ojanen, V. (2016). Technology competition in the internal combustion engine waste heat recovery: A patent landscape analysis, *Journal of Cleaner Production*, Vol. 112, No. 5, pp. 3735-3743.

Lehtovaara, M., Karvonen, M., Kapoor, R. and Pyrhönen, J. (2014). Major Factors Contributing to Wind Power Diffusion, *Foresight*, Vol. 16, No.3, pp. 250-269.

Conference proceedings

Kapoor R., Mention A-L., Patenting financial innovation in Europe, *Portland International Conference on Management of Engineering and Technology (PICMET)*, Pages 1071-1077, Portland, Oregon, 2015.

Karvonen M., Kapoor, R., Ojanen, V., Commercialization of Early Stage University-based Inventions, *IEEE International Conference on Industrial and Engineering Management*, Bangkok, 2013.

Kapoor, R., Ranaei, S., Karvonen, M., Patent portfolio analysis using citation categories, *IEEE International Conference on Industrial Engineering and Engineering Management*, Bangkok, 2013.

Karvonen, M., Kapoor, R., Kässi, T., Patent-based indicators for analyzing wind power markets, *IEEE International Conference on Industrial Engineering and Engineering Management*, Pages 722-726, Hong Kong, 2012.

Kapoor, R., Karvonen, M., Kässi, T., Patent portfolio efficiency using Data Envelopment Analysis: Case of wind power market, *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Hong Kong, 2012.

Kapoor, R., Karvonen, M., Lehtovaara, M., Patent value indicators: Case of emerging wind energy markets, *PICMET '12 Technology Management for Emerging Technologies*, Vancouver, Canada, 2012, Pages 1042-1048.

Ranaei, S., Lohtander, M., Siivo, T., Kapoor, R. Technological trajectories of thermal management systems in the power electronics industry: The case of emerging cooling systems, *Flexible Automation and Intelligent Manufacturing*, Wolverhampton, United Kingdom, 2015.

Abbreviations

CAFC	Court of Appeals for the Federal Circuit (US Patent Court of appeals)
CPC	Cooperative Patent Classification
ECLA	European Classification
EPC	European Patent Convention
EPO	European Patent Office
EU	European Union
FTO	Freedom to Operate
ICT	Information and Communication Technologies
IP	Intellectual Property
IPC	International Patent Classification
JPO	Japan Patent Office
NPL	Non-Patent Literature
PCT	Patent Cooperation Treaty
SIPO	State Intellectual Property Office (of the People’s Republic of China)
TPO	Third Party Observations
USPC	United States Patent Classification
USPTO	United States Patent and Trademark Office

Part I

1 Introduction

Technological change has long been of interest to economists as it is closely related to economic growth (Griliches, 1957; Rosenberg, 1974; Scherer, 1982). In the 1950s, Jacob Schmookler was the first macro-economist who used patent data to study economic progress. He produced empirical work that used patent counts in various industries and showed that inventive activity was *demand driven* (Schmookler, 1966). Firms focus their inventive efforts towards their expectations of future profits. In this regard, patent data provides a glimpse into *future technological change* and *competitive economic activity* of players.

Schmookler's work quietly gave rise to the field of patent statistics. Patent statistics is a field of research that uses and develops patent information for economics and management purposes. By nature, patents represent inventiveness and contain technical information. This information is systematically stored in databases that are improving with time. Moreover, patent information is public. Academics and practitioners have made use of this information to measure the value of inventions, assess performance of R&D, study diffusion of knowledge and industry convergence, draw strategic intelligence, assess state of the art, identify potential collaborators and competitors, and much more (Griliches, 1990; Ernst, 2003; OECD, 2009).

While Schmookler used rudimentary patent counts in his analysis, subsequent researchers understood that all patents are not alike. There is significant variance in their private and social value. Backed by advanced databases, researchers have thus built sophisticated patent value indicators since then (Trajtenberg, 1990; Hall, Jaffe & Trajtenberg, 2005, Baron and Delcamp, 2012).

This dissertation contributes to the growing literature on patent value indicators by (i) introducing new citation measures and (ii) exploring procedural indicators. The goal is to advance the use of patent information in view of the latest trends in patent life cycle management. The corresponding economic phenomena studied are that of *competitive activity* and *patent disputes*.

1.1 Background

Innovation and competition are two concepts that are strongly intertwined. Economists have widely studied the relationship between them (Futia, 1980; Gilbert and Newbery, 1982). Competition is an outcome of entities' efforts to lay hands on rare and prized resources. While competition enables entities to achieve more in a bid to outsmart rivals, it can also, inevitably, lead to outright disputes. Patents, and their strategic use, are valuable resources that have been connected to the development of sustained competitive advantage as proposed by the resource-based view (RBV) of the firm (Barney, 1991; Peteraf, 1993).

The purpose of the patent system is to encourage innovation. Inventors are invited to disclose their innovations to the public in return for a temporary monopoly over their use. Disclosure allows anybody to learn and improve an invention. Monopoly allows the inventor to reap private benefits of premium pricing. Mansfield (1986, p. 174) found that more than 30% of pharmaceutical inventions would not have been introduced in the absence of a patent system. The sheer uncertainty associated with drug trials and lengthy approval procedures do not warrant investment without the insurance of patent-induced monopoly pricing. On the contrary, Scotchmer (1991) has discussed how strong patent protection to early innovations can deter follow-on innovations, especially in complex product industries, thus acting against public interests. The patent system is thus responsible to strike a balance between public interest and the rights of inventors. The historical backdrop of the patent system is briefly discussed in Chapter 2. Here, I will discuss the current trend in global patenting to explain why patent life cycle is important, and why I study technological overlap and patent disputes. Figure 1 presents the patenting trends in the top five patent offices.

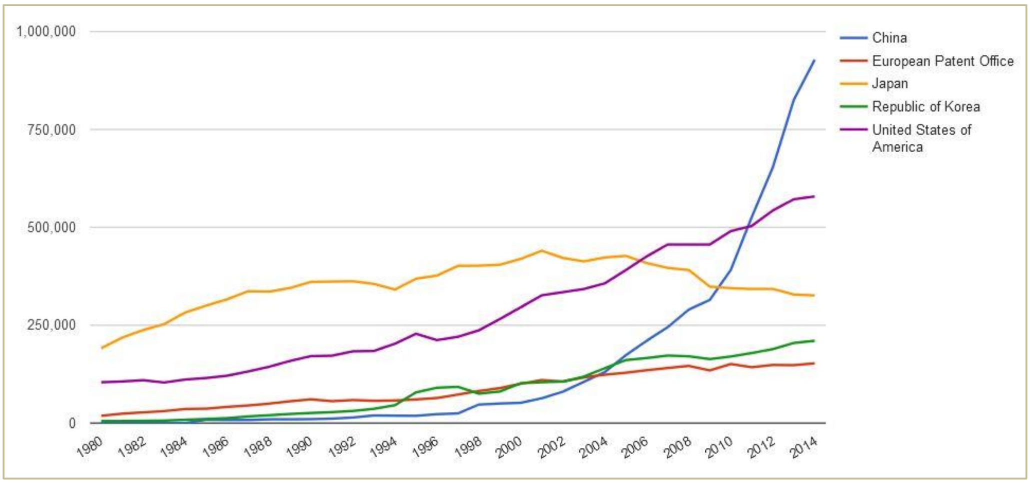


Figure 1 Total patent filings (Direct and PCT national phase entries) Source: WIPO IPSTATS[1]

The staggering volumes of patent filings in the last 30 years shows the increasing importance of non-tangible intellectual property in the knowledge economy. Innovators clearly respond to incentives offered by patent systems that also results in competition over monopoly rights. A higher demand for patents is responsible for lower quality and backlog in patent offices (van Pottelsberghe, 2011). There are many explanations for such a rise in patenting. New areas like business methods and computer software have slowly opened up for patent protection (Lerner, 2006; Bessen and Hunt, 2007; Hall, 2009). The traditional motive to obtain exclusion rights for innovations is no longer the only motive to patent (Levin, *et al.*, 1987; Cohen, *et al.*, 2000; Holgersson, 2013). New motives to patent include forearming against lawsuits, increasing negotiation power, build credibility

[1] Own compilation on: http://ipstats.wipo.int/ipstatv2/index.htm?tab=patent; [last accessed: 29.08.2016]

before investors, obtaining freedom to operate, and the like (Blind, *et al.*, 2006; Somaya 2012). Many scholars have studied the drivers of such a rise in patent applications (Hall and Ziedonis, 2001). Others have studied the resulting congestion in patent offices that are driving down the quality of patent applications (Harhoff and Wagner, 2009; Régibeau and Rockett, 2010).

The phenomenal rise in patent filings has left all major patent offices overwhelmed with backlog. This has led to:

(i) lengthy life cycles of patent applications between filing, grant, and even beyond

(ii) increase in post-grant disputes as weak and overlapping patents often leak through the system

1.1.1 **Why is patent life cycle important?**

The modern patent system in all major patent offices is characterized by a lengthy and sophisticated examination process. Every claimed invention undergoes a test for novelty, non-obviousness and industrial applicability before being accepted or refused. A granted patent can be challenged by third parties in various forms adding to the length and complexity of the patenting process. This constitutes the life cycle of a patent. The innovation life cycle is closely linked to this patent life cycle. Figure 2 below shows the life cycle of a patent application at the European Patent Office (EPO)[2].

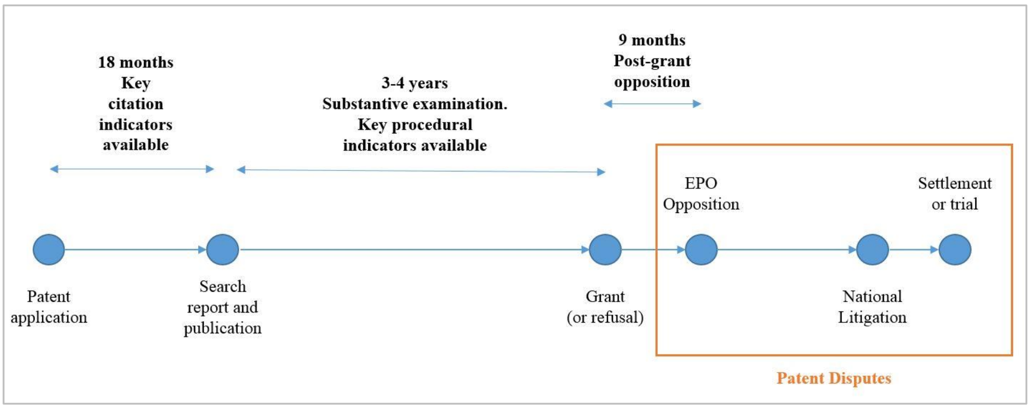


Figure 2 Simplified timeline of a European Patent application (own compilation)

Invention and commercialization are inherently uncertain processes. Patents, themselves, are uncertain instruments. There are two inherent uncertainties associated to patents: (1)

[2] My own empirical work in the wind power industry has shown that an average patent is granted 4.7 years after filing, and third-party opposition is raised 5.5 years after filing. An average national litigation in pharmaceutical and drugs industries is raised after approximately 10 years after application filing.

uncertainty over commercial significance, and (2) uncertainty over the validity and scope of the legal right. Lemley and Shapiro (2005) have indeed modelled patents as "probabilistic rights" rather than well-defined rights with clear boundaries. The boundaries of a patent right are defined by examiners' assessment of prior art pertaining to the field of invention (Merges and Nelson, 1990). Each claim of a patent application undergoes a test for novelty and non-obviousness against prior art deemed relevant by the patent examiner. Based on these efforts, a list of relevant prior art is developed.

As seen in Figure 2, the time between patent filing and grant can easily exceed five years. This time is also called patent pendency. In the field of innovation management this time is of utmost importance as key investments and technology commercialization decisions are taken. Teece (1986) has explained why many innovating firms fail to exploit economic returns out of their inventions. Innovators may fail to invest on complementary assets required to appropriate returns on their R&D. In my own unpublished interviews, inventors have revealed that they are themselves unsure about what part of their inventions can constitute "value creation" through patents. Patents are often applied for in order to "gain time for evaluation" to see which inventions have potential to be blockbusters. In view of these uncertainties, any information available during the patent life cycle is useful for making better decisions. Reitzig and Puranen (2009) note that filing and managing patents are now part of a technology firm's organizational capabilities that lend them a competitive advantage. The management of patent life cycle is often outsourced to professional law firms. Patent management constitutes all activities that enable firms to reach their strategic objectives. It encompasses identifying inventions, filing applications, managing patent office actions, monitoring status, paying renewal fees, negotiating contracts, identifying complementary investment strategies, and much more. All these efforts lead to a self-selection of the most valuable inventions. It is the aim of this dissertation to draw intelligence from the patent life cycle that reveals such a self-selection.

Results in this dissertation show that search report citations, usually available 18 months after filing, are strong indicators of imminent refusal (or withdrawal). Publication 5 uncovers the strategic games played by patent applicants and their rivals as new information unfolds during patent pendency. Rivals are usually monitoring the course of patent applications and availability of key information can influence their subsequent actions and reactions. This constitutes the utmost importance given to the patent life cycle in this dissertation.

1.1.2 Why study competition and disputes?

Patents are high stakes instruments whose enforcement or cancellation can yield or destroy billions. On 24th August 2012, a landmark verdict in *Apple Inc versus Samsung Electronics* ushered in a new age of patent litigation. Historical patent lawsuits were mere skirmishes when compared to the latest patent lawsuits between smartphone manufacturers. A one billion US dollar fine was imposed on Samsung which saw their stock market value eroded by 7.5%. The lawsuit would turn into an all-out patent war involving multiple patents across multiple jurisdictions.

Patent disputes can be complex, uncertain and expensive (Meurer and Bessen, 2005). They consume significant firm resources including management attention. Instruments like preliminary injunctions can jeopardize long term investments by completely stalling production. Court rulings have a significant impact on stock markets causing firm valuations to boost or plummet. As a result they may act as a severe deterrent for innovators to pursue innovations in fields with many existing patents. Equally important are the societal importance of patent disputes. Small companies are known to shy away from patent intensive technology fields (Lerner, 1995). Judgements passed by national courts or patent office appeal boards set precedents. Future cases are assessed in light of landmark cases. Some patent disputes turn out to be symbolic and usher in a paradigm shift in applicant behaviour. For example, the landmark ruling of US Court of Appeals for the Federal Circuit (CAFC) in *State Street Bank vs Signature Financial Group*, allowing applications in business methods, opened the floodgates for such applications (Hall and Ziedonis, 2001; Komulainen, 2011).

Because of such high stakes, patent disputes and their settlement have been widely studied in the literature (Lanjouw and Schankerman, 2001, Somaya, 2003, Lanjouw and Schankerman, 2004). Studying early stage factors that drive the demand for patent disputes and their potential settlement can be useful for tweaking the patent system to serve its purpose better. Uncovering the behaviour of patentees and their rivals can make it possible to see if parties are making fair use of the patent system. Early resolution of disputes by alternate (and cheaper) means can lend efficiency to the innovation system leading to societal benefits. I will show later that seeds of a patent dispute can already be seen in applicants' and third party actions.

The design of the patent system is also responsible for competitive behaviour and some inevitable disputes. The balancing act of the patent system (rights of inventors against the welfare of society), and the uncertain scope and validity of patent rights inevitably leaves some room for disputes. Some authors have indeed seen patent disputes as a necessary evil that keep the patent system on its toes. Graham and Vishnubhakat (2013) compiled a list of famous historical patent disputes that have continuously enabled the patent system to evolve.

There are usually two kinds of disputes that arise with respect to patents. Patent holders may *enforce* their valid patents against third-parties for alleged *infringement*. And third-parties may begin *invalidity* proceedings to *annul* patents that are considered invalid. Thus, patent disputes serve the dual purpose of protecting innovators' rights, and purging the patent system of weak or invalid patents.

Studying competitive behaviour of firms is intrinsic to studying early stage drivers of patent disputes. Disputes arise when firms vying for common markets engage in competitive behaviour. Patents, and the underlying technologies they cover, are among the key resources that firms use to maintain a sustained competitive advantage. As a result, patents are used as isolating mechanisms when firms pursue various forms of strategies like building thickets, forearming against litigation, improving bargaining power and patenting for defensive purposes (Shapiro, 2001; Blind, *et al.*, 2006, 2009).

I have studied the early stage competitive behaviour of firms by using advanced citation analysis that measure technological overlap among competing firms. Work done in Publications 2 and 3 will look into technological overlap at firm level and industry level. Two new measures are introduced, namely, *measure of encroachment* and *measure of hindrance* that assign values to a firms' patent portfolio in terms of their *vulnerability* and *blocking power* respectively, relative to their competitors. Figure 3 is an example of how competition unfolds during the life of a patent.

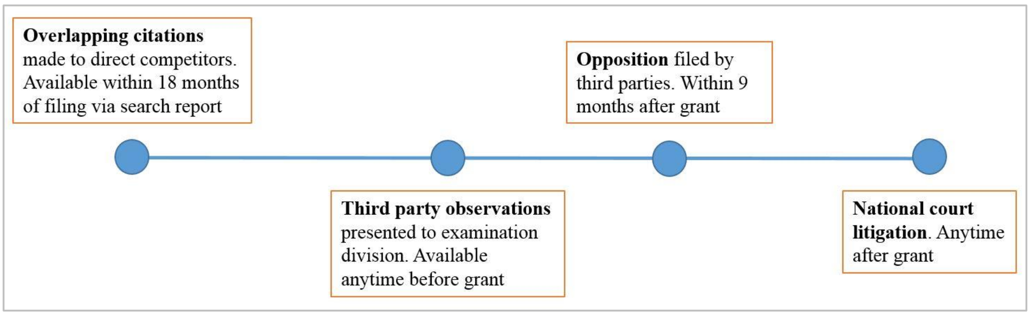


Figure 3 How competition and disputes unfold during patent life cycle (Own compilation)

Studying the patenting activity of players in the market gives a glimpse into the market dynamics of an industry. A comparative performance of patent portfolios can help make better investment decisions. For example, Publication 4 shows that the wind power industry is dominated by few major players owning half of the patents in the market. Patent information plays an important role in competitor analysis which can also include potential collaborators. At the industry level, analysing firm competition can be a useful policy tool. By combining intelligence available from the patent life cycle, we are in a better position to devise strategies that reduce transaction costs and enhance social welfare.

1.2 **Research gaps and questions**

There is a vast amount of scholarly research on developing and validating patent value indicators. For example, citations received by a patent have been consistently found to be correlated to patent value (Trajtenberg, 1990; Putnam, 1996; Lanjouw and Schankerman, 1997). Number of technical classes assigned to a patent has been shown to be indicative of technological scope, and hence, the market value (Lerner, 1994). Other correlates of patent value include patent family size (Guellec and van Pottelsberghe, 2000; Lanjouw and Schankerman, 2004), patent renewal decisions (Pakes and Schankerman, 1984;

Pakes, 1986), opposition and litigation (Lanjouw and Schankerman, 2001; Harhoff, *et al.*, 2003).

The first research gap lies in the fact that most of the research on patent value indicators have looked at them as one-shot actions. In reality, all these indicators unfold during different stages of the patent life cycle. This dissertation makes use of patent value indicators with an appreciation towards their availability in time and their impact on subsequent events.

All citations are not alike. The second research gap lies within the use of aggregate counts of citations for most forms of patent analyses. Patent examiners assign relevance to each reference they cite in order to evaluate the primary patentability criteria of novelty and inventive step. There is now research that differentiates blocking citations from non-blocking type of citations (Harhoff and Wagner, 2009; Czarnitzki, *et al.*, 2011). This dissertation attempts to build indices out of citation categories to measure the degree of technological overlap among competing firms and industries (Publications 2 and 3). The influence of citations added during different stages of the patent examination process on patent disputes is also explored (Publication 4).

The third research gap stems from the hitherto unavailable data on European patent litigation. There is a host of studies that have scrutinized patent litigation in the United States and the drivers behind it (Lanjouw and Schankerman, 1997; Lanjouw and Schankerman, 2004). There are also many studies that have studied the drivers and demographics of European patent oppositions at the patent office stage (Calderini and Scellato, 2004; Harhoff and Reitzig, 2004; Reitzig, 2004; Caviggioli, *et al.*, 2013). Given the heterogeneity of the European court system, the first studies making use of comprehensive European litigation data from courts have surfaced only in 2013 (Cremers, et al, 2013). Publication 5 makes use of this data in the chemical and pharmaceutical industries to study the drivers behind European litigation and settlement. This life cycle is unique to the proceedings of the European Patent Office (EPO) that has various structural differences from other patent offices like USPTO.

Based on the above-mentioned research gaps, this dissertation attempts to answer the following research questions:

1. How are patent value indicators related to the life cycle of innovations?
2. How can we measure technological overlap among competing firms?
3. Can citation type and timing explain the likelihood of grant and opposition?
4. What factors drive the actions of parties during patent pendency?
5. What explains the incidence and outcome of European patent litigation?
6. Are there differences between infringement and invalidity cases?

The abovementioned research questions are answered by means of five publications in three stages. Figure 4 provides a summary of the relationship of publications with each research stage.

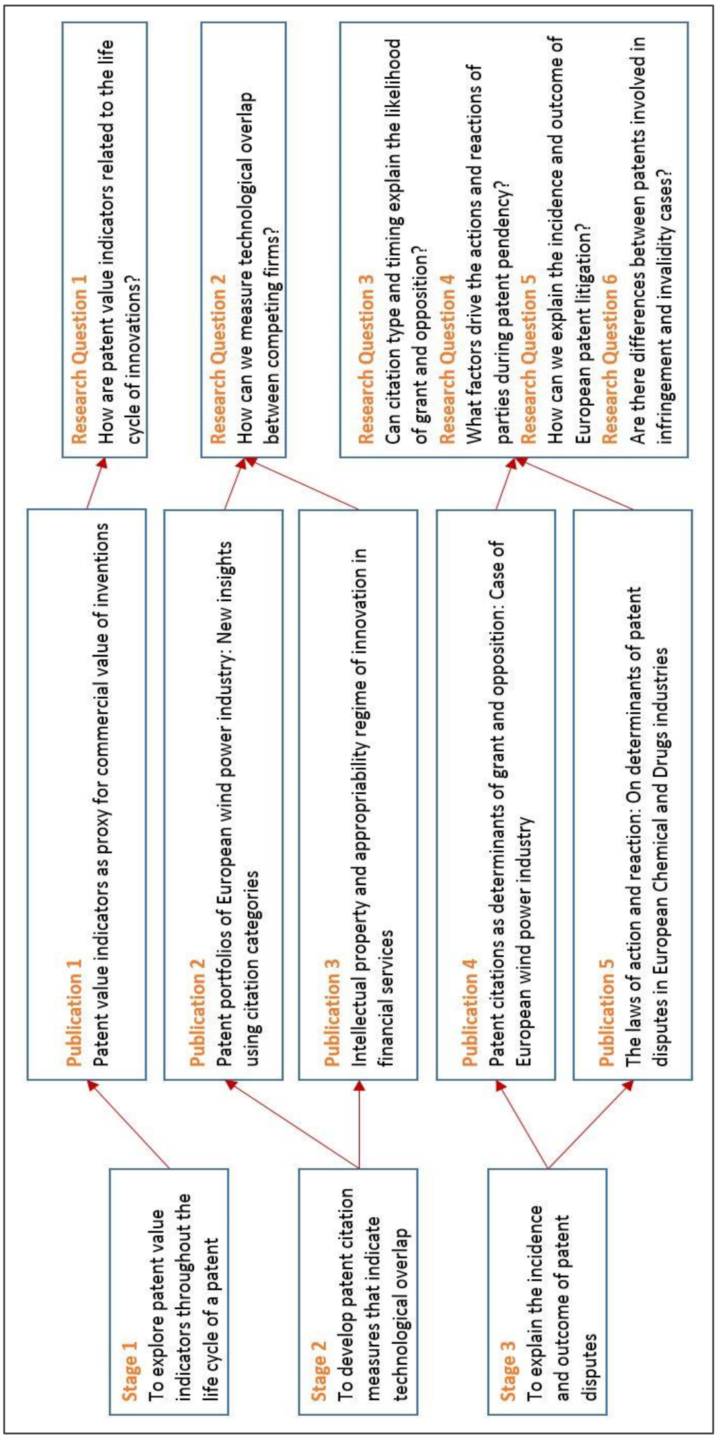


Figure 4 Relation between research stages, publications and research questions

1.3 Contribution

Work done in this dissertation speaks to at least three bodies of literature.

First, I extend findings related to previous literature on patent value indicators. Two measures are introduced using citation categories, namely, *Measure of Encroachment* and *Measure of Hindrance*. These measures can be used to evaluate the *vulnerability* or *blocking power* of firms' patent portfolios relative to their competitors. Citations added during different stages of the examination process are explored as potential value determinants. Information from patent office proceedings (procedural indicators) are validated as strong indicators of patent value.

Second, I shed light on the dynamics of European patent disputes by uncovering the early stage interactions between patentees and their competitors. The results contribute to the theory of dispute settlements. It is shown that parties continuously update their beliefs about the strength of their case as *new information* unfolds. At the theoretical level, uncertainty over the validity and scope of a patent is seen to be a major impediment towards the settlement of disputes.

Third, my findings offer empirical evidence that can impact the design and policy of patent systems. For example, the positive and adverse consequences of specific procedural arrangements of the patent office on dispute resolution are discussed. It is seen that instruments like third party observations and amendments reduce the uncertainty in the system and these should thus be encouraged. Applicants' repeated use of divisional filings should be viewed with a certain degree of suspicion as they try to isolate the most valuable (or litigious) parts of their invention.

The dissertation is compiled in two parts. The first part is the introduction that contains an extended theoretical framework along with summaries of five selected articles in the results section. The results section is extended by providing an empirical dialogue on the differences between infringement and invalidity cases. The second part comprises the full-text of the chosen five research publications. The scope of the publications is summarized below.

Publication 1: *Patent value indicators as proxy for commercial value of inventions*

This paper delineates the views of different stakeholders about the ability of various patent value indicators to signal commercial value. A list of patent-based and market-based indicators are compiled based on interview data for the entire life cycle of an invention.

The author assumed the main role in arranging, conducting and recording the transcript of interviews. Some interviews were conducted jointly with Matti Karvonen. The author was mainly responsible for writing the paper. Multiple reviews and revisions were done jointly by all authors.

Publication 2: *Patent portfolios of European wind industry: New insights using citation categories*

This paper makes use of overlapping patent citations to study the competitive dynamics of top wind power players in Europe. Measure of encroachment and Measure of hindrance are introduced.

The author was responsible for the idea and the execution of the project. SQL queries were constructed by the author and data analysis carried out by Samira Ranaei. The author was responsible for the main part of the writing process. Some writing and editing was jointly carried out with other co-authors.

Publication 3: *Intellectual property and appropriability regime of innovation in financial services*

This book chapter uses measures developed in the previous publication to study the overlap within industry sectors. Financial innovation industry is separated into three categories, namely, payment architectures, e-commerce, and finance, insurance and tax. A landscape analysis of top players is shown along with overlaps within each segment.

The chapter was sole authorship with reviews provided by the editors of the book.

Publication 4: *Patent citations as determinants of grant and opposition: Case of European wind power industry*

This paper undertakes a detailed citation analysis of EPO patents. Citations added during different stages of patent pendency are separated and their influence on patent grant and patent opposition is tested. Results show that certain types of citations have a significant influence on the success of an application, and it being subsequently opposed by third parties.

The author was responsible for idea and execution of the project. Data mining was carried out by the author and econometrics done jointly with Anmol Mohan. The author was responsible for the main part of the writing process. Some writing and editing was jointly carried out with other co-authors.

Publication 5: *The laws of action and reaction: on determinants of patent disputes in European chemical and drug industries*

Using a unique dataset of patent litigations in Europe, this paper looks into the drivers of patent litigation and their subsequent settlement. It is found that uncertainty plays a big role in determining the actions and reactions of patentees and their competitors.

The author was responsible for patent data mining of litigated patents. The idea, writing and econometrics were jointly done with the co-author Nicolas van Zeebroeck.

1.4 Research method

A mix of multiple research methods have been used in this dissertation. Interviews with experts formed the foundation of my understanding of the patent system and the latent aspects of many of the value indicators used in the articles. PATSTAT was the primary source of data for mining patent information. Since 2013, I had the opportunity to use the European Patent Register database that was made available as a PATSTAT extension for the first time in 2011. The register allowed access to detailed procedural information of European patent applications. The litigation database is described in Graham and van Zeebroeck (2014) and Cremers, *et al.* (2013).

The theoretical framework of this dissertation encompasses three strands of literature, as follows. (1) Theory on motives to patent and use of patent system; (2) theory of patent value indicators; and (3) theory on litigation and settlement of disputes. These are discussed in the three subsequent chapters that follow. An extended chapter on research methodology (chapter 5) discusses the epistemological, ontological and practical considerations pertaining to the research work in this dissertation. The results are primarily based on published articles that are appended in the second part of the dissertation. The results, along with a discussion, are introduced in chapter 6. Chapter 7 concludes by summarizing the findings, offering recommendations, and providing directions for future research.

2 The Patent System

Patent systems constitute policies for economic growth and innovators respond to their incentives. The rights provided by patent offices are thus of utmost importance to society as they can change how industries take shape. Knowledge of patent system offerings and the corresponding response of innovators form the fundamental pillars on which this dissertation is based.

This chapter starts with the historical development of the patent system. It highlights the evolution of the patent examination system, evolving motives to file patents, patenting process at the European Patent Office (EPO), and the importance of not issuing *invalid* patents.

2.1 Historical background

The existence of the first systematic use of patents can be traced back to 15th century Venice. The Venetian Patent Statute granted patents for “any new and ingenious device, not previously made” (Kostylo, 2008). However, it is the 17th century British Patent System that is considered to be the first modern patent system. Prior to that, patents were awarded by English monarchs to favourites in the form of privileges, monopolies over trade, and premium pricing for certain goods.

Patent examination itself has a long history. In late 18th century, the US secretary of state and secretary of war considered each application. It soon became apparent that these officials lacked sufficient time to evaluate the growing number of applications. Patent applications were then simply registered under an oath from the inventor rather than being examined. Before long, despite the inventor oath, it again became apparent that many issued patents did not describe anything new, either due to ignorance or fraud. This led to costly disputes in the court of law. Sometime during the mid-19th century, patent examiners started evaluating each application based on their importance and novelty. The patent examination system has continuously evolved since then. (Swanson, 2014)

The 19th century patent examiners relied on their own knowledge and the patent office library. In contrast, the modern patent examiners are backed by sophisticated prior art databases to search for patents and publications. Despite the era, patent examination is a difficult job. It is difficult to know all the prior art in a certain technology field. The examiner’s job is to avoid issuing invalid patents. At the same time, rejection makes inventors unhappy as their hard work is denied any reward. Figure 1 shows the filing trends in five of the major patent offices in the world. With such large volumes of patent filings, there is a growing need for an efficient patent system that is inventor friendly, and yet, that does not succumb to their whims.

2.2 Motives to patent and filing strategies

The traditional motive to patent has been to obtain exclusive rights to an invention. The method of appropriation involved either making and selling the invention exclusively, or extracting licensing and royalty incomes from others who are allowed to use the invention. In the last three decades, however, there has been an atypical increase in patenting. This has also led to research in the field of alternative appropriation mechanisms as opposed to traditional ones. Mansfield (1986) and Levin, *et al.*, (1987) were among the first studies that highlighted inter-industry differences between the use of patents. They showed that secrecy and lead time advantages were more important mechanisms for exploiting innovation rather than patents in certain industries like manufacturing. Cohen, *et al.*, (2000) added to these findings with a new survey of US manufacturing firms and found new reasons why firms patent, even when patenting might not be the most important appropriability mechanism. The newer motives were blocking rivals from patenting related inventions, protection against infringement suits, and using patents in negotiations over technology rights. These changing motives to patent have been considered by scholars to account for the staggering increase in patenting in the last three decades. Hall and Ziedonis (2001) showed that ICT and semiconductor firms were involved in patent portfolio races even though they did not explicitly rely on patenting as an appropriability mechanism. Jell (2012) has shown this phenomenon to exist even in the paper printing machines industry.

Specialized law firms offer patent management services as patent portfolios grow and pendency times increase. Harhoff and Wagner (2009) described the duration of patent examination at the EPO as a function of applicant characteristics, patent value, and complexity of the examination task. Jell (2012) has shown, more specifically, that examination lags can be explained by filing strategies and filing motives of applicants. Pendency times have also increased as a result of increasing size of patent applications (van Zeebroeck *et al.*, 2009). There is also a trend of applicants filing broad applications that result in multiple divisional applications that are considered fresh applications and follow their own examination timeline (van Zeebroeck and van Pottelsberghe, 2011b).

Blind, *et al.* (2006) made a survey of German companies' use of intellectual property (IP) rights and offered strategic motives for patenting in the form of *offensive blockade* and *defensive blockade*. Offensive blockade refers to patenting to actively prevent other players from making use of a certain technological field. Defensive blockade is the case when firms want to prevent other players from entering their own technological space. Jell (2012), in his book on patent management and filing strategies, has described the value of even pending patents. This is in contrast to the traditional view that only granted patents are valuable. Pendency of applications was found to be associated to filing strategies and patent management practices of a firm.

Most patent offices, to different extents, face shortage of resources in dealing with the increasing number of patent applications filed every year. They all have different mechanisms to deal with their backlog. Interviews with examiners at the Finnish patent office revealed that they may focus on Finnish patent applications and PCT applications depending on the backlog situation. Some patent offices (like Finland, UK[3]) provide fast-track processing of applications in certain fields like sustainable innovations. Applicants usually make use of such "green channels" to obtain faster search reports to have an early assessment of the commercial potential of their inventions. At the European Patent Office, applicants frequently file a request for an accelerated examination along with the application by paying an extra fee.

Following are some of the newer motives to patent that could be reasons for growing number of applications (Compiled from Blind, *et al.*, 2006; Jell, 2012).

Blocking third parties

Blocking competitors or any other third party is a common motive to patent. The patent holder may, or may not, use the invention that he/she wishes to obtain a patent for.

Securing freedom-to-operate

Freedom-to-operate (FTO) is a term used in patent prosecution terminology that gives any producer the right to make or sell products in a certain market without infringing upon patents held by third parties. It is the responsibility of the manufacturers who are planning to introduce their products in any market to carry out an FTO analysis. In industries such as ICT, patents have vague boundaries. Products are usually made by compiling various technologies and players can be less known. It is particularly challenging for a firm to carry out a flawless FTO before introducing their products in such industries.

In this regard, the phenomenon of defensive publishing is worth noting. Since a published patent is treated as prior art for a subsequently filed patents, applicants sometimes file a patent application to secure publication, and hence, the freedom-to-operate. (Johnson, 2014)

Create uncertainty

When an application is in pending status, third parties (or even the patent applicant themselves) are not fully aware of what rights will be eventually granted. Examiners may ask patent applicants to modify, add, or delete their patent claims and descriptions. This keeps third parties in anticipation about the exact scope of the patent right that is granted and is beneficial to the patent applicant.

Gain time for evaluation

[3] https://www.gov.uk/guidance/patents-accelerated-processing; The Finnish Patent Office provides fast track processing for free if certain requirements are met: https://www.prh.fi/en/patentit/applyforanationalpatentinfinland/processingofapplicationsatprh/fast-trackprocessing.html

Most inventions are serendipitous. There is uncertainty about where their actual use might lie and where the markets might exist. The inventors themselves face uncertainty due to investment or time pressures. The delayed examination process gives time for applicants to figure out these uncertainties before deciding to proceed with a patent application. This includes looking for potential licensees and investors.

Enhance reputation

Since patents are one of the most tangible measure of innovation many economists and analysts use them as innovation indicators for lack of other alternatives. Firms are also judged by their investors based on the amount of intellectual property they create. In some top pharmaceutical companies a poor patenting report might shutdown entire units. Many firms thus have guidelines as to how many patent applications they may be targeting in a year.

Forearm against infringement suits

Stacking intellectual property is a common practice among top ICT firms where the threat of counter-suing is enough to prevent many patent related lawsuits.

Increasing bargaining power

During mergers and acquisitions, firms holding large patent portfolios have bargaining power that can materialize as liquid assets. In oligopolistic industries patents can be used to improve negotiations related to cross-licensing and patent pools.

Secure priority

This motive might be important for applicants looking to target geographically dispersed markets. According to the Paris convention, patent applicants have one year after making a priority application to extend their applications to other countries. This time period can be extended to 30 months by filing patents under the Patent Cooperation Treaty (PCT). This motive is related to the motive of gaining time for evaluation and the motive of defensive publication.

2.3 National differences

Patent rights are territorial. A USPTO patent, for example, does not confer protection in China. The core principles of patent systems across the world, however, are same. Most patent offices offer protection up to 20 years, have an examination process, publish applications after 18 months, and use technical classifications to categorize patents. Differences relate to examination quality (van Pottelsberghe, 2011), examination culture (Frietsch and Schmock, 2010), interpretation of patentability criteria, and even patentable subject matter. For example, patents related to software are usually not granted by the EPO but it has been quite common to find such patents at the USPTO (Laub, 2006; Bessen and Hunt, 2007). Table 1 summarizes some of the key differences among EPO, JPO and USPTO.

Table 1 Key differences among major patent offices (Source: OECD, 2009)

	EPO	JPO	USPTO
Patents granted based on	First to file	First to file	First to invent[4]
Patent duration	20 years	20 years	20 years
Application language	English, French or German	Japanese	English
Protection area	EPC member states and "extension" states	Japan	United States
Request for examination	Yes, within 6 months of search report	Yes, within 3 years	No
Publication of application	18 months from the priority date	18 months from the priority date	18 months from the priority date
Opposition system	Yes	No	No

Different patent offices are characterized by different procedural instruments offered to applicants. The procedural differences between patent offices can influence applicants' use of the patent system. For example, there is a notable difference in applicant behaviour when there is a system of deferred request for examination. JPO's three year time window to make a "request for examination" allows applicants to have "second thoughts" about the commercial feasibility of their inventions before making investments. This can encourage applicants to file many patents but proceed with only a few. In contrast, the US has no such system as all fees are due during the filing stage. Jell (2012) has found applicant filing motives to be linked to the seven year deferred request for examination system in the German Patent and Trademark Office. van Pottelsberghe (2011) has shown that the European system provides higher quality and more expensive examination services than the US one, while the Japanese patent system is in an intermediate position.

This dissertation focuses primarily on the European patent system. More specifically, it takes into account the nuances of the European Patent Office (EPO). An EPO patent is a bundle of national patents that are effective once validated in individual member states.

2.4 The EPO timeline

This section will provide an overview of the patenting process at the EPO. The patenting process is discussed in light of the various procedural instruments that applicants have at their disposal. The procedural instruments act as independent variables in this study. Over the course of my research, I have conducted numerous interviews with examiners and patent attorneys to understand what the variables actually capture. Thus, I have tried to

[4] The US system recently changed into **first inventor to file** system on March 16, 2013: (https://www.uspto.gov/sites/default/files/aia_implementation/aia-effective-dates.pdf, p. 6)

observe the latency of these observables rather than present them directly. For example, patent applicants can file a request for accelerated examination at any time during pendency. Rather than observe such accelerated requests as just a variable, I have tried to capture what such requests might capture. Such requests are typically made to obtain a patent grant quickly to stop potential infringement, or to negotiate investments and licenses. It can be indicative of an invention that is ready for commercialization. These procedural instruments are unique to EPO proceedings and the results from these analyses are compared to prior literature. The following sub-sections describe the three stages through which a European patent proceeds.

2.4.1 Search and publication

Once filed, a European patent first undergoes a search for prior art, that results in a search report. The search report typically contains the most relevant documents that the applicant should be aware of, along with the comments of the search examiner. This search report is usually published along with the application within 18 months. Michel and Bettels (2001) have compiled intricacies of search phase for EPO, USPTO and JPO. Their article is a primer for researchers carrying out citation analysis. A sample search report is shown in Appendix A.

The search report is a key development in the patenting process. Quite often, it determines the fate of patent applications. Lazaridis and van Pottelsberghe (2007) have shown that search reports suggestive of "weak" patents and other communications from the patent office to applicants "induce" withdrawals. In my own empirical work, I have shown that more than 90% of the references in a patent document are added during the search phase. For Euro-direct applications, examiners prepare a search report from scratch. For international (PCT) applications, EPO examiners usually have access to an international search report that has been prepared by the office from where the application is incoming. Sometimes, EPO examiners add new references to those already found in the international search report. Typically, a Euro-direct application will contain only "European Search Report" and a PCT (foreign) application will contain both "International Search Report" and "European Search Report" (See Figure 5). This dissertation uses guidelines from Webb, *et al.*, (2005) to obtain a comprehensive coverage of citations for domestic and international EPO patents.

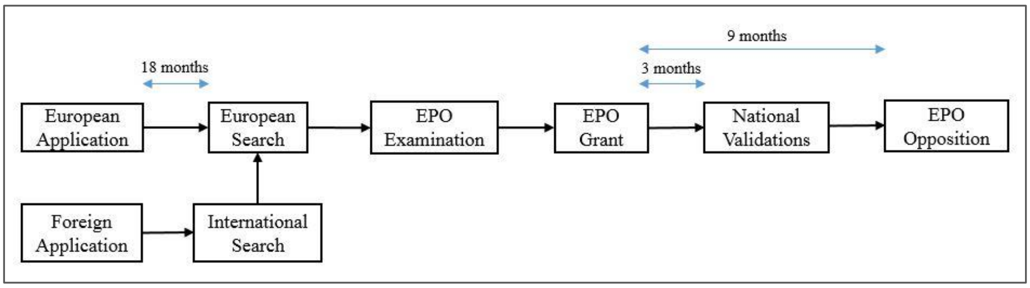


Figure 5 Simplified EPO timeline (own compilation)

2.4.2 Substantive examination

In the second stage, the application may proceed to a substantive examination phase before being granted or refused. Figure 5 shows a simplified timeline of a European patent application. After receiving the search report, the applicant has six months to decide whether or not to proceed with substantive examination. A 'request for examination' has to be filed by the applicant along with a payment of 'examination fee'. The application is then handled by the examining division. The examining division takes a decision to accept, modify or reject an application. The decisions can be challenged with the board of appeals. Depending on the backlog and the specific industry, a typical EPO examination culminates after 5 years of patent filing (Harhoff and Wagner, 2009 p. 1977; Comino and Manenti, 2015 p. 17). It is possible that the examiners find new prior art related to the application and add it to the ones added during the search phase.

2.4.3 Grant and opposition

An EPO patent is a bundle of national patents that are effective once validated in individual member states. After getting a grant decision, the applicant has 3 months to 'validate' the grant in individual member states where the applicant seeks protection. This is done by submitting translations and completing other formalities at the national patent offices. Even as the applicants undergo formal procedures to obtain patent rights, their grants are not written in stone just yet. Any third party may file an opposition to an EPO grant up to nine months after the publication of grant. The EPO opposition procedure is in place to act as a corrective post-grant mechanism. The procedure constitutes first-instance proceedings and appeal proceedings. There are three possible outcomes of the opposition procedure: (i) revocation, (ii) amendment, and (iii) maintenance.[5] Along with the appeal proceedings, the opposition procedure can sometimes last up to four years. This window of uncertainty is detrimental to patent holders because it undermines the incentives to make additional investments before the patent's validity is established.

2.5 Why is patent value so important?

For the patent system to serve its purpose toward the society, it is very important that only "valuable" patents are granted exclusive rights. Granting of weak or invalid patents leads to welfare losses that are associated with a monopoly. If left unchallenged, the patent holder can accumulate private gains at the expense of consumers. The welfare losses are more than just the losses to consumers due to monopoly pricing. Third parties may be prevented from using a patented technology *out of fear of infringement* even though the invention was not novel in the first place. Thus, granted patents that are weak or invalid may potentially obstruct the diffusion of technology. Third parties have low incentives to challenge a patent unless they are directly affected by it (Farrell and Merges, 2004). Lemley (2001) have, however, argued that some mistakes of the patent office may be

[5] Evidence suggests all outcomes are equally likely as a result of the opposition procedure (van de Kuilen, 2013 p. 126)

overlooked as the most glaring mistakes are resolved by *ex-post* litigation. Lemley's argument about *rational ignorance* of the patent office may seem prudent considering how few patents are ever litigated. But it is difficult to measure the social cost of weak patents that are barriers to diffusion.

The commercial and social value of a patent is thus important so that the patent office fulfils its purpose of encouraging only those innovations that are important for the society. In the cloud of uncertainty surrounding commercial and social value of inventions, the field of patent value indicators looks for signs that *indicate* patent value. The next section reviews the various patent value indicators introduced by researchers.

3 Patent value and patent life cycle

All patents are not same in terms of their value. There is significant variance in their technical and commercial value. Empirical research (Pakes and Schankerman, 1986) has shown that half of the estimated patent value belongs to 5% of the entire patent population. More recently, based on survey data, Gambardella and Harhoff (2008, p. 79) found the mean value of a European patent to be about EUR 3 million. The median value was roughly EUR 300,000 and mode value only about EUR 6000.[6] Owing to such skewed distribution of value, empirical research seeks to create measures that separate the wheat from chaff.

The literature (Trajtenberg, 1990) has differentiated between the private and social value of patents. The social value represents the net value created by the patented invention for social welfare. Private value is defined as the *extra* revenue generated by the patent over its lifetime for the patent holder.

For managers to make well-founded management decisions, it is important to have a fairly accurate estimate of the value of an invention. Applying and maintaining a patent is a cumulatively increasing cost (Figure 6). There are four major decision points faced by managers during the course of developing an invention. These are: (i) whether to file a patent application? (ii) Whether to continue with the patent filing following patent office actions? (iii) Whether to maintain a granted patent in force by paying renewal fees? (iv) How to exploit a granted patent? (Pitkethly, 1997)

[6] Value estimated at 2003 euro level

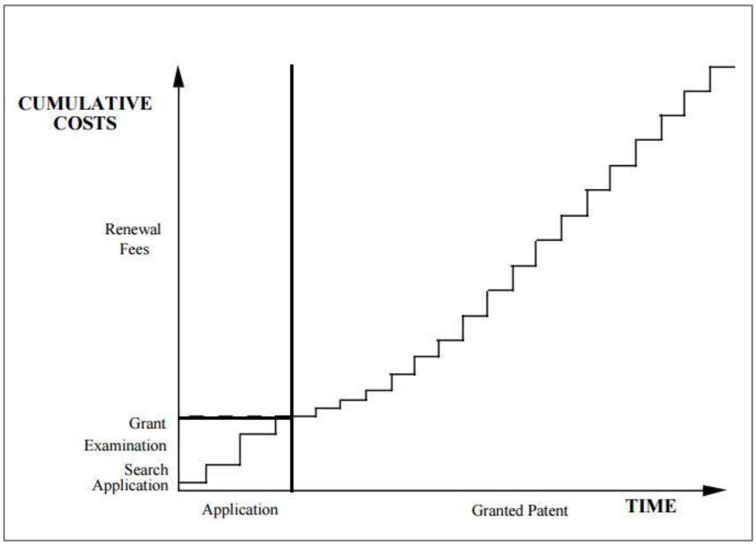


Figure 6 Cumulative cost of a patent application (Source: Pitkethly, 1997)

The three classical methods of monetary valuation of patents are cost-based, market-based, and income-based methods. Cost based method relies on the estimate of actual costs incurred in creating the patented invention. The income approach attempts to quantify the discounted future cash flow forecast of the patent's potential commercial use. The market approach estimates value based on a similar transaction accomplished in the past. (OECD, 2005)

Economics and management scholars, however, are concerned with patent-based indicators that *signal* value (or other constructs of interest). This is because they are concerned with questions related to policy, organization, management and strategy. The treatment of patent information is therefore done at a more aggregated level. Patent-based indicators have been repeatedly proven in the literature to be correlated to patent value. The patent value indicators have been validated by correlating them to (i) surveys asking inventors for perceived value of their innovations (Scherer *et al.*, 2000); (ii) market or financial data (Hall *et al.*, 2005); (iii) incidences of disputes (Harhoff et al, 2003); (iv) auction prices of patent transactions (Fischer and Leidinger, 2014); and more.

Patent value indicators churned out by researchers over time were put into four categories by Zeebroeck and van Pottelsberghe (2011). These were (i) *Patent characteristics* – these deal with the characteristics of the patent applications, for example, number of references in the patent document; (ii) *Patent ownership* – this category deals with characteristics of patent owners or applicants, for example, past portfolio size of applicant; (iii) *Insider information* – these indicators are theoretical and are created using qualitative interviews and surveys pertaining to the context of the invention; (iv) *Filing strategies* – they refer to filing strategies, patenting route selected, procedural indicators, etc.

Defining all the indicators in the literature is beyond the scope of this dissertation. The indicators used in works related to this dissertation are presented in the next section. They are separated into three categories, namely, patent characteristics, citation based indicators and procedural indicators.

A typical European patent application is divided into three parts. The first page contains general information about the patent like date of filing, family information, designated countries, name of applicant, name of inventors, technology classification of the invention, title, abstract, etc. The second part contains the full description, claims and figures. The third part consists of the search report appended by list of citations possibly added later. Patent characteristics and citation characteristics are obtained from the first and third parts of a typical patent document respectively. The procedural indicators are extracted from the European Patent Register.

3.1 Patent characteristics

Number of claims

The average number of patent claims can help in determining the breadth and scope of the invention (van Zeebroeck, *et al.*, 2009). Experts opine that the legal proceedings related to patent infringements are invariably solved by an evaluation of the claims. Typically, claims are divided into two types: independent or dependent. Independent claims are known to enhance the scope of an invention. Dependent claims usually provide more information and are built around independent claims. "…*They operationalize what patent attorneys call fall-back options for legal disputes*" (Reitzig, 2004). My own interviews have revealed that text of claims is more important than their numbers. However, it is difficult to achieve a broad enough scope with just one claim. This makes publication claims an important factor in determining the quality of the patent portfolio. The EPO allows up to 15 claims in a published patent. Any extra claim that a patentee wants to add has to be paid for (EPO, 2013). If an inventor is willing to pay for the extra claims, it can be inferred that the relevance of the patent in question is high or at least the applicant feels paying extra money will enhance the core scope of the invention. One of the major advantages of assessing the number of claims is the fact that this indicator is available early in time as soon as the patent is published. Empirical work has proven "number of claims" to be significantly associated to patent value (Lanjouw and Schankerman, 1997; Bessen, 2008). A detailed discussion on strategic aspects of drafting patent claims is avoided here as "number of claims" is only used as a *control variable* for *legal scope* of a patent.

Number of technical classes

Each patent application is technically classified into specific technology areas related to the invention. It is a hierarchical way of assigning the category to which a patent belongs and is known as International Patent Classification (IPC) classes. Number of IPC classes attributed to a patent application has been used as a proxy for the scope, and hence the market value of a patent (Lerner, 1994). It has also been argued in the literature that IPC classes have little or no association with the value of the patent rights (Lanjouw and Schankerman, 1997; Harhoff *et al.*, 2003). Empirical literature has however used “number of IPC classes” as suggestive of technological diversity of a patent (Guellec and van Pottelsberghe, 2000, 2010). Number of IPC classes has been used as a *control* for *technical scope* of inventions in some papers related to this dissertation.

3.2 **Citation based indicators**

Patent citations are references considered important by the patent examiner in determining the novelty and inventive step of a patent application. References made to previous patents are called backward citations, and references received from future patents are called forward citations. Cumulative and knowledge transfer indicators use backward citations, and impact-type indicators are based on forward citations (OECD, 2009). The history of citations in patents dates back to 1947 when examiners in United States Patent and Trademarks Office (USPTO) began citing references considered during the examination process (List, 2010). Researchers have a long history of using citation based indicators. This has helped identify many pitfalls in the use of citation indicators that are addressed in the data analysis pertaining to the thesis. Some of the key issues related to citation analysis are presented below.

Country and industry variations

Citation practices differ significantly across patent offices and across technology fields. For example, US patents contain three times more references as EPO patents (Michel and Bettels, 2001). This is because European guidelines require examiners to list only the most important references. As a result, the jurisdiction for analysis has been restricted to EPO for most of the studies related to this dissertation.

Right truncation

Forward citation analysis suffer from the phenomenon of ‘right truncation’. More recent patents cannot be analyzed as only citations received so far are known (Hall, *et al.*, 2001). A common practice adopted by researchers to counter this issue is to count citations received only in the first 5 years of patent filing.

Multiple citations to family members

Patent documents citing each other may not have a one-to-one relationship to inventions. A given invention can be covered by a number of documents issued by national, regional or supranational offices. Sometimes, different family members that cover the same invention are cited by different examiners. To account for this underestimation, forward citations are counted at the family level (count of families citing families). (OECD, 2009)

Home and language bias

Examiners may succumb to home bias as they are more likely to cite documents from the same office or documents that maybe easy to find / understand (Alcacer and Gittelman, 2006).

3.2.1 Forward and backward citations

Forward citations are citations received by a patent from subsequent patents. More valuable or impactful patents are usually associated with higher number of forward citations. Forward citations have been found to be the most stable indicator of patent value in the literature. Studies have shown that forward citations are strongly correlated to economic value of patents (Trajtenberg, 1990) as well as the social value of inventions (Scherer *et al.*, 2000). Renewal of patents is correlated to high count of forward citations (Putnam, 1996). Lanjouw and Schankerman (1997) showed that patents which receive more citations than average are more likely to be opposed or litigated.

Backward citations, or references added to a patent during patent examination, can potentially provide insights into the exploration process of new technologies (Jaffe, Trajtenberg and Fogarty, 2000; Lukach and Plasmans, 2002). The idea behind utilizing backward citations as a value determinant is in the assumption that combination and knowledge transfer from other technological domains would lead to more valuable patents (Nemet and Johnson, 2012). Backward citations have been a subject of debate among patent value researchers. The results of using backward citations as a value determinant have provided ambiguous results (Hall *et al.*, 2001; Zeebroeck *et al.*, 2011b).

References added to a patent application need not be only to other patent documents. Non-patent literature (NPL) refers to scientific articles in journal and conferences, along with other sources like books, internet links, abstract services, disclosure bulletins, and the like. A large number of NPL citations has been associated with a greater linkage to fundamental scientific research (Narin and Olivastro, 2006; Callaert *et al.*, 2006). Sapsalis, *et al.* (2006) have shown that patents citing NPL that are authored by the inventors themselves, are of much higher value. More broadly, they have argued for the importance of distinguishing the sources of citations for patent analyses.

3.2.2 Citation categories

The EPO examination guidelines[7] require all cited documents to be identified by a certain letter or a combination of letters. Citation categories are a useful way of assigning relevance to citations. Table 2 below lists some of the most common categories used. *X*, *Y* and *A* are by far the most used categories. Documents assigned *X* indicate a clear similarity between the claimed invention and the contents of the cited document. *X* citations thus present a genuine obstacle to the grant of a patent. *Y* refers to documents

[7] EPO search guidelines: http://www.epo.org/law-practice/legal-texts/html/guidelines/e/b_x_9_2.htm

that can be combined with other documents by a skilled person to develop a concept similar to the claimed invention. Documents ascribed *A* refer to citations that define the state of the art, but are not in conflict with the claimed invention. In simpler terms, an *X* reference indicates overlapping claims with a previous document; a *Y* reference means a combination of multiple *Y* documents can anticipate the claims of the patent being examined; and an *A* reference mostly defines the state of the art. Previous literature (Czarnitzki, *et al.*, 2011; Harhoff and Wagner, 2009) has combined *X* and *Y* references and called them blocking citations. *'A'* references are usually added by examiners if they are considered useful for the applicant when modifying claims.

Table 2 Most common citation categories. Source: OECD (2009)

Citation Category	Description
X	Particularly relevant documents when taken alone
Y	Particularly relevant if combined with another document of the same category
A	Documents defining the general state of the art
O	Documents referring to non-written disclosure
P	Documents published between the date of filing and the priority date
T	Documents cited for a better understanding of the invention, published after the filing date
E	Potentially conflicting patent documents, published on or after the filing date
D	Document provided by the applicant
L	Document cited for other reasons

3.2.3 Citation origin

Citations can be added to a patent document during different stages of the examination process. Most citations are added during the search phase. Some applicants may request a supplementary search report that may generate more references. Where necessary, these search reports are supplemented by the examiner and/or by third party observations during pendency. Even post-grant opposition and appeal proceedings might uncover and add prior art that may have been overlooked. For PCT applications entering Europe, citations should also be analyzed from the International Search Report (ISR) that is generated by the patent office where the application originated.

Studies related to this dissertation do exploratory empirical work related to citation origin and their influence on patent grant and opposition. Previous work related to citation origin has been done for US patents. Alcacer, *et al.*, (2009) and Cotropia, *et al.*, (2013) have noted differences in the relevance of citations originating from applicants and examiners.

3.3 Procedural indicators

Procedural indicators refer to actions made at the patent office by applicants or other stakeholders. They are not related the characteristics of the patent but with the office procedure. In the past, patent renewal information has been used to estimate the value of patents (Pakes and Schankerman, 1984; Pakes, 1986). The renewal fee of patents generally keeps increasing as the patent approaches its full term, although the extent varies between patent offices. There are limitations associated with using patent renewal as a value indicator. The renewal information comes late in the patent life cycle which makes it impossible to analyse more recent patents. Sometimes, the decision to renew or not to renew can be based on circumstances beyond the scope of economic patent value like change in organizational goals or external shocks.

The actions of applicants and third parties related to pending patent applications have more recently caught the scrutiny of researchers. van Zeebroeck and van Pottelsberghe (2011b) showed that filing routes, drafting styles and divisional applications are associated to patent value. Berger, *et al.* (2012) found essential patents in industries governed by standards were associated with longer pendency times owing to multiple amendments to their claims. Gambardella *et al.* (2007) used third-party observations presented during pendency of EPO patents as a measure of "economic value of technology." They found that patents characterized by third-party observations were more likely to be licensed. Reitzig (2004) confirmed that accelerated examination requests made by applicants are associated with patents of higher value. The impact of accelerated examination requests on opposition has also yielded positive and significant results in Jerak and Wagner (2006).

The European Patent Register database used in this thesis tracks every interaction made between the patent office and the applicant for EPO patents. This gives researchers a peek into the detailed nuances of the patent pendency process. Harhoff and Wagner (2009) have used some of these nuances to look for determinants of the duration of patent examination at the EPO. I will make a brief review of these instruments.

Opposition and litigation

The EPO opposition procedure is an important procedural tool used by third parties to invalidate or restrict patent grants considered *weak*. Opposing a patent is a costly procedure and it has been hypothesized in the literature to be strongly associated to patent value (Harhoff *et al.*, 2003). These authors have shown that only 8% of EPO patents are involved in post-grant opposition by third parties. This shows the low percentage of *valuable* patents that represent conflicting commercial interests. Opposition rates in different patent systems were compared by Graham *et al.* (2002) which revealed that the average re-examination rate in EPO is much higher than the USPTO.

The costs associated with pursuing patent litigation in courts can be significantly higher than the central EPO opposition procedure. The cost of filing an opposition at the EPO is only EUR 785 (2016 figures). The total cost of opposition to each party can be between EUR 10000 to EUR 25000 including attorney fees and other indirect costs (Graham and Harhoff, 2006). Litigation costs can be much higher. WIPO (2009) estimates a minimum cost for GBP 350,000 for a typical lawsuit in the UK. The EPO opposition system is the only time when a patent grant can be challenged centrally. Once the period of nine months post grant has elapsed, or the opposition is formally closed, a patent can only be challenged in national courts. This makes an EPO opposition a useful forum for third parties to annul patents that maybe weak or invalid.

Accelerated examination requests

According to EPO examination guidelines, an accelerated examination can be requested by the applicant at any time. In the event of such a request, the EPO does its best to issue the first examination report in less than three months. There are two classic reasons for expediting the patent prosecution process. One is to obtain a patent right and prevent infringement by a potential infringer. The other is to obtain a patent grant quickly to negotiate investments and licenses. These two reasons suggest that accelerated examination requests capture (i) the applicant's quest to achieve greater certainty related to their patent's validity and (ii) their belief that the invention is valuable or close to commercialization. Given the extra costs associated with this procedure and the self-selection applicants submit themselves to, accelerated examination requests could signal value to third parties (hence increasing the likelihood of opposition) and increase the likelihood of applicants to litigate once the patent is granted.

Amendments

We used the European Patent Register database to check for patents that have events related to their amendment. Any amendment made to the description or claims is recorded in the register. As per article 123 of the European Patent Convention (EPC), these amendments are those made by applicants of their own volition. The amendments may not, in any way, extend beyond the subject matter of the originally filed application, which is usually formulated in broad and vague fashion. Discussions with experts have revealed that amendments are usually made in a restrictive way to clear way for a grant. The only empirical work I know on amendments has been done by Berger, *et al.* (2012). These authors have shown that patents declared as 'standard essential' were more likely to be amended during patent prosecution. They conjectured that this could be because applicants participating in standard setting processes try to custom-fit claims to suit the standard.

Divisional applications

According to Rule 36 of the EPC, an applicant may file a divisional application at the EPO as long as the parent application is pending, i.e., not granted, refused, or revoked.

The usual reason for filing a divisional application is that the parent application does not satisfy the requirements as to the unity of invention and the applicant is not content with limiting it. Applicants sometimes use divisional applications to isolate a “surer” part of the application or to proceed with the examination in several parallel tracks.

From a strategic point of view, applicants may use divisional applications as means of understanding what subject matter will be allowed as a patent right for a perceptibly important invention. As a result, third parties may be kept in uncertainty over the exact nature of rights granted to an invention.

Third party observations

According to article 115 of the EPC, any third party is allowed to present observations concerning the patentability of an invention. The EPO is obliged to forward all such observations to the patent applicant. The usual grounds on which third parties can file such observations include lack of novelty, lack of clarity or sufficiency of disclosure, and/or unallowable amendments. Such observations are a rare but interesting event. They are the first evidence that third parties are interested in an application or even potentially vexed by it. These observations can be indicative of an invention’s market value and the presence of stakeholders with conflicting interests.

According to Akers (2000, p. 313), “*As a possible disincentive to the filing of observations, it should be realized that observations could give an applicant forewarning of a competitor’s interests…”* Given the risk to which third parties expose themselves, such observations should therefore be indicative of higher stakes involved for third parties. Third parties also bear the additional risk of their observations helping the patentees to modify their claims accordingly to still achieve a grant. One might argue in particular that if the third-party observations are not sufficient to prevent the patent from being granted, the chances are particularly high that the third party will challenge the patent’s validity in an opposition procedure.

4 Theory of litigation and settlement

Priest and Klein (1984) and Bebchuk (1984) have paved the foundation of an economic theory on settlement of litigation. At the core of this theory is the choice parties face between litigating and cooperating over disputes. The empirical model closely follows the uncertainty faced by litigants pertaining to patent validity and infringement. There are three main reasons presented in their studies that prevent parties from reaching a cooperative solution. These are:

1. *Divergent expectations* – when there are significant differences between the parties' view of the expected outcome of the dispute
2. *Asymmetric stakes* – when the resolution of a dispute affects one party more than the other, beyond the monetary amount of the resolution
3. *Informational asymmetry* – a situation wherein one party has private information that can help them make a better assessment of the expected outcome

Nalebuff (1987) refines the model by adding the credibility of a plaintiff's threat to litigate as an important factor during pre-trial bargaining. The following section presents Barry Nalebuff's simple model that depicts pre-trial negotiations. The model also explains why patent litigation is rare as many cases are mutually settled before it is necessary to go to court. Thereafter, section 4.2 presents a simplified model of Priest and Klein on the dynamics of litigation and post-trial settlement.

4.1 Credible pre-trial negotiation

Enforcement of patents is a bargaining process. Parties usually reach a mutual agreement before it is necessary to go to court in the form of licenses, royalties, re-assignments, etc. When patent holders (the plaintiffs) observe a potential act of infringement, they make a settlement offer *S* to the alleged infringer (the defendant). The defendant reviews the credibility of such an offer and may choose to accept or reject it. In the event that the defendant accepts the offer, she loses an amount *S* and the plaintiff correspondingly gains *S*. However, if the defendant chooses to reject the offer, it sends a strong message to the plaintiff to review the credibility of their threat to litigate. In such an event, the plaintiff will either drop the case or move to a civil court as a result of breakdown of pre-trial negotiations. Figure 7 depicts the simple theoretical model.

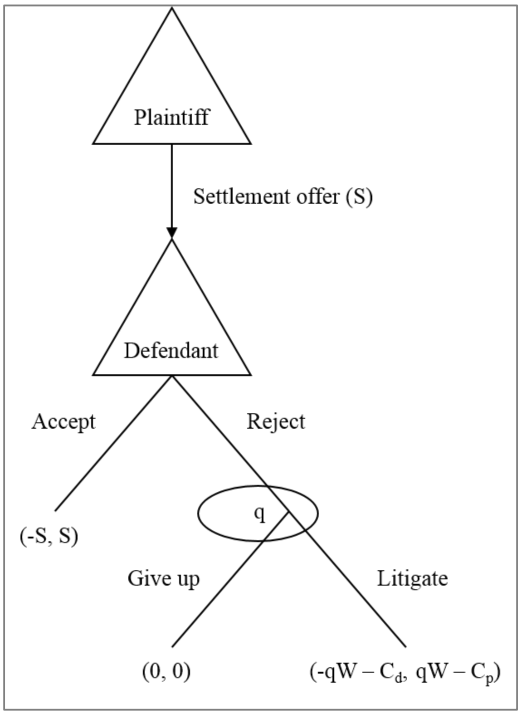


Figure 7 Game tree of bargaining and outcome. Source: Nalebuff (1987)

W refers to the total size of plaintiff injury; *q* refers to the defendant's liability in the total injury *W*. Alternatively, *q* can be assumed to be the probability of plaintiff victory with defendant being fully liable. C_p and C_d capture the costs of plaintiffs and defendants respectively. The figures in brackets refer to the respective loss of defendant and gain of plaintiff in the event of a plaintiff victory. Should a trial lead to plaintiff victory, the defendant loss is $-qW - C_d$ and corresponding plaintiff gain is $qW - C_p$. If plaintiff settlement offer S is rejected, the choice to follow through with litigation will depend upon their estimate of *q* (uncertainty surrounding the strength of the case) and the size of stakes *W*. Litigation will be prudent for the plaintiff only if $qW > C_p$.

The empirical work done in this dissertation shows that parties continuously update their beliefs regarding the strength of their case (value of *q*) as new information is revealed. As the patenting process unfolds, parties have a better idea about the potential of an invention and the corresponding strength of their case.

4.2 Non-settlement of disputes

This section presents a simplified theoretical model by Priest and Klein (1984) based on *divergent expectations* and *asymmetric stakes*. Simplified because I have adapted the model by removing settlement costs related to a dispute.

A dispute is regarded as "not settled" if a verdict was rendered during trial in a court of law. All other cases that were terminated before trial by a judge or jury are regarded as "settled".

If a plaintiff thinks that they have suffered an injury due to a defendant's action, they might bring the case to court. The amount of injury suffered by a plaintiff is denoted as J. There are costs associated with initiating a court action in the form of a variety of legal expenses. Costs for the plaintiff are denoted by C_p and costs of the defendant is denoted as C_d. Before the suit goes to a court, the plaintiff will make a settlement offer. It is upon the defendant to accept or reject the offer. If a plaintiff's threat is credible (as assumed by Priest and Klein) then the following equations should hold. A denotes the asking price of the plaintiff; and B denotes the offer or bidding price of the defendant.

$$A = P_p\,(J) - C_p$$

$$B = P_d\,(J) + C_d$$

Here P_p and P_d are the probabilities that the plaintiff or defendant will win respectively. The condition at which negotiations fail and the case will proceed to court is if $A > B$. Hence, based on the above equations, $P_p - P_d > (C_p + C_d) / J$. We see, therefore, that there are three factors that are behind non-settlement. Size of the stakes (J), legal and court expenses (C_p and C_d), and expected probabilities of the parties (P_p and P_d). The suit will move to court if the difference in expected probabilities of plaintiff and defendant (P) is greater than total court expenses for both parties (C) over size of total stakes (J).

$$\text{Hence, } P > C / J$$

4.2.1 Modelling expected probabilities

Over a period of time, the parties are well aware of their own court expenses and the size of the stakes. Uncertainty of the expected likelihood (probability) to win lingers though. The authors have provided a sophisticated empirical model that shows the difference in the expected probabilities of prevailing between plaintiffs and defendants.

The model assumptions start with a decision standard known as Y*. This decision standard is based on the historical trends related to the court, jury and nature of dispute. Both the plaintiff and defendant are aware of this decision standard (Y*) and make their own estimates (Y') about their chances during trial (for a randomly selected case). Figure 8 shows the true decision standard Y' for ***an individual case*** and a general decision standard Y*.

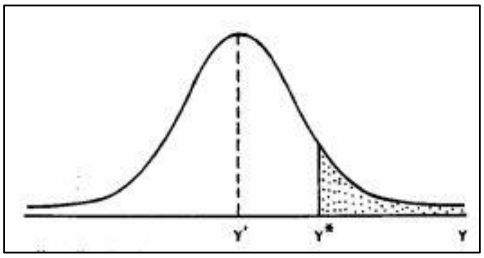


Figure 8 Probability distribution of a case. Source: Priest and Klein (1984)

The shaded part represents the chances of plaintiff winning the case. In this case the plaintiff may choose not to litigate because their own expectation lies to the left of the Y* and hence away from the shaded area.

In real life both plaintiffs and defendants have some private information that determines the variations in their own estimates. If a random dispute makes its way to the court, below are the estimates formed by the parties:

$$Y_p = Y' + \varepsilon_p$$

$$Y_d = Y' + \varepsilon_d$$

ε_p and ε_d are independent random variables with zero expectation and identical standard errors.

Figure 9 shows the probability distribution around the plaintiff's estimate for the individual dispute.

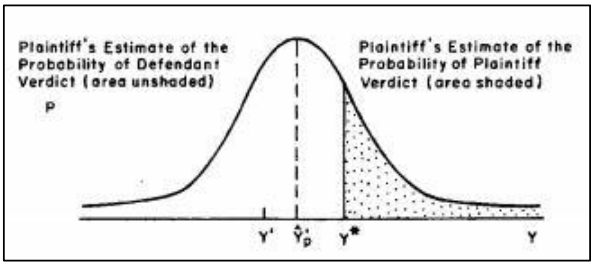


Figure 9 Probability distribution of a case with Plaintiff estimate. Source: Priest and Klein (1984)

Based on Figure 9, individual probability estimates of the two parties are drawn in Figure 10.

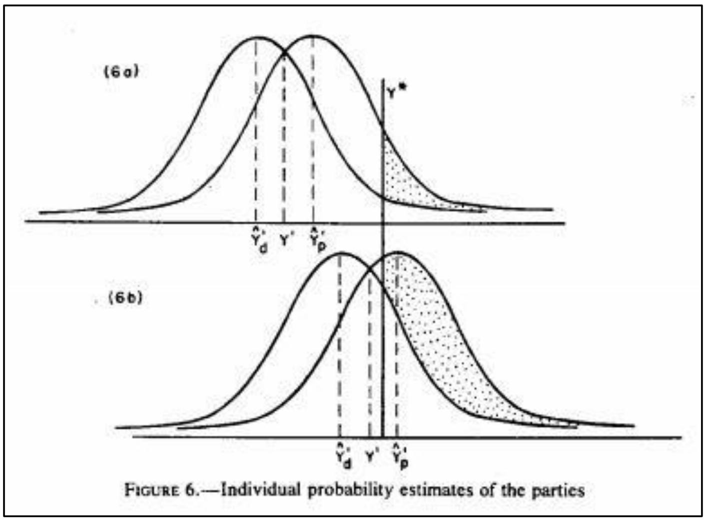


Figure 10 Individual probability estimates of both parties. Source: Priest and Klein (1984)

At the core of Figure 10 is the shaded area (from the perspective of plaintiff). The expected probabilities of plaintiff and defendant lies far from the decision standard Y* in (a). The difference in "expectations" of the parties of a plaintiff victory is low in (a). This results in a higher likelihood of settlement. The difference is parties' expectations of a plaintiff victory is high is (b). This results in non-settlement as the parties are likely to disagree on the outcome.

This constitutes the phenomenon of divergent expectations that results in non-settlement. To summarize in a simple way:

> *"Where either the plaintiff or defendant has a 'powerful' case, settlement is more likely as the parties are less likely to disagree about the outcome of trial"*

4.2.2 **Accounting for asymmetric stakes**

In the previous model, the total size of stakes (J) was held constant and equal for both parties. However, in real life situations, the resolution of a dispute may affect one party more than the other beyond the monetary amount of the judgement. For example, one party's public reputation may be at stake.

The authors empirically show that when the stakes are inequivalent, non-settlement can occur *even when the parties agree over the expected outcome* of the trial. By using the earlier inequality of comparing the plaintiff's asking price and the defendant's offer / bidding price:

$$A - B = P_p J_p - P_d J_d - C$$

J_p refers the stakes of the plaintiff and J_d refers to the stakes of the defendant. If we assume

$J' = (J_p + J_d)/2$ and $P' = (P_p + P_d)/2$;

The final inequality looks like below:

$$P_p - P_d > (C - S) / J' + P'^* \Delta J/J'$$

The interpretation of the above equation is such:

Litigation (or non-settlement) is more likely where the plaintiff has a small probability of winning and the defendant has a large probability of winning. This is contrary to the phenomenon of divergent expectations shown in the last section. An example scenario: if the stakes of the defendant are higher, relatively more disputes with a likely plaintiff verdict will be settled and relatively more disputes with likely defendant verdicts will be litigated. The effect will be the same if plaintiff has higher stakes and probabilities of winning are the other way around.

4.3 Review on drivers of patent disputes

An incidence of litigation has been found to be the ultimate test of value for a patent right (Allison, *et al.*, 2004). Lanjouw and Schankerman's (1997, 2001) studies were among the first to identify variations across patents in their likelihood of being litigated. They reported that only some 6.3 patents (involved in 10.7 cases) were involved in litigation per thousand patents between 1980 and 1984. Along with studying the determinants of patent litigation in characteristics of patents, Lanjouw and Schankerman (2004) show that small firms and individuals are at a much higher risk of litigation. Empirical work related to settlement of lawsuits has been done by Somaya (2003) who uses self-citations as a measure of asymmetric stakes (calling them strategic stakes). Galasso and Schankerman (2010) study settlement of lawsuits as a measure of efficiency in markets for technology. They show that settlement happens sooner in industries where patent holders are fragmented as this reduces the negotiation value of a patent. In a study by Llobet (2003), it is shown that patent litigation can depend on the long term economic profits of applicants. In a certain situation where an applicant holds a patent with a large inventive step, new innovators would shy away from the field and reduce licensing opportunities from the patentee. According to Bessen and Meurer (2005) patent litigation occurs when validity and infringement are unclear to the litigants. They find that when firms are larger and technologically close, likelihood of litigation is higher. They extend their model

(Bessen and Meurer, 2006) by advancing the view that litigation depends on both parties' choices about inventing, inventing around and monitoring their rivals' patents.

All the studies discussed above are based on US litigation datasets. As a result of the heterogeneity in the European Court system, literature on European patent litigation has been virtually non-existent. Cremers, *et al.* (2013, 2016) and Graham and van Zeebroeck (2014) are the first studies that have worked on a dataset of European litigation collected manually from courts across countries. This dissertation uses the same dataset as described by the above authors and studies the determinants of European litigation and settlement.

Drivers of EPO opposition have, however, been vastly studied in the patent statistics literature (Harhoff and Reitzig, 2004; Reitzig, 2004; Jerak and Wagner, 2006; Cincera, 2011). Other research have studied the effect of geographical origin (Caviggioli, *et al.*, 2013) and firm size (Calderini and Scellato, 2004) on the likelihood of an EPO opposition. Some industries see a larger incidence of EPO opposition than others. For example, Schneider (2011) show that opposition rate is far higher in the field of plant biotechnology than average. Determinants of outcome of an EPO opposition have also been studied recently by Sterlacchini (2016).

Graham, *et al.* (2002, 2006), Hall, *et al.* (2003) and Graham and Harhoff (2014) have comparatively studied EPO's opposition system to US system of re-examinations and have called for US to emulate a similar approach in an apparent praise for the EPO opposition system. By structure, an EPO opposition is fundamentally different from an incidence of court litigation. EPO opposition is an invalidity challenge made at the patent office. Court litigation is usually an infringement claim by a patent holder. I will show later in the results section that most of the invalidity challenges in courts are an outcome of an infringement claim. Pure invalidity challenges in court are very low.

5 Research methodology

This chapter details the research process adopted in this dissertation. It then continues with the data collection and data analysis methods employed.

5.1 Research philosophy

Work done in this thesis has been guided by my general interest in exploring patent data for economics and management purposes. As a result, it is not based on a commitment to a research paradigm. However, in retrospect, I am in a good position to discuss the philosophy of science aspects of my research as it has evolved over the years.

A paradigm is an epistemic justification of research process as characterized by popular beliefs of the scientific community at a certain point in time. The definition of a paradigm as per Saunders, *et al.* (2009) is 'a way of examining social phenomenon from which particular understandings can be obtained about the phenomena.' Thomas Kuhn, famous for his 1962 book "The Structure of Scientific Revolutions" (Kuhn, 1962), proposed that paradigms are rivals and are therefore incommensurable. Later researches on paradigm wars (see e.g. Shephard and Challenger (2013) for a review) have argued all possibilities like paradigm incommensurability, paradigm integration, paradigm plurality and paradigm dissolution. Of these four schools of thoughts, I am most convinced by the arguments of paradigm plurality. Exposing research to different paradigms can result in stronger theory by means of 'bridging', 'bracketing' and 'inter-play'.

Figure 11 shows the famous research onion and the boxes represent where work done in this dissertation belongs. There are many definitions of various research philosophies that are sometimes overlapping. The outermost layer includes four paradigms introduced by Burrell and Morgan (1979), namely, radical structuralist, radical humanist, interpretive and functionalist. Operating in the functionalist and interpretive paradigms might be a pre-requisite to transcend into the radical humanist and radical structuralist paradigms. The functionalist and interpretive closely represent the paradigm of interpretivism; while radical structuralist and humanist are close to positivism.

I would categorize the research philosophy used in this dissertation as primarily *interpretivist*, although Publications 4 and 5 have *positivist* inclinations. An interpretivist's view is that research in social sciences has a lot to do with people. It is thus important to study how they really think and act in everyday situations. Positivist approach is associated with testing hypotheses to make generalizations. Publication 5 uses earlier theories of patent litigation and settlement to develop hypotheses based on EPO's procedural instruments. Corresponding to the research philosophy, the methods used in this dissertation have been both inductive and deductive.

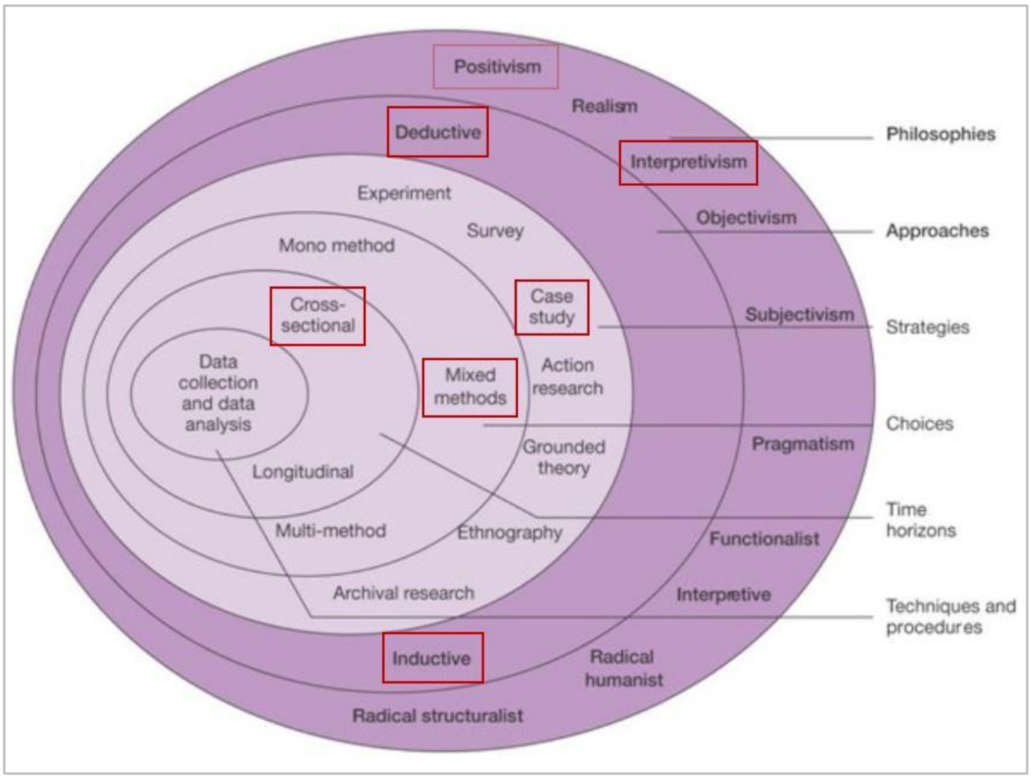


Figure 11 Research Onion (Adapted from: Saunders, *et al.* (2009))

Owing to the differences in patenting procedures, examination cultures and philosophies, it is practically impossible to use worldwide patent data in making generalized findings. This also applies to generalization of findings across industries. Different industries are marked by different propensities to patent depending upon the nature of innovation and industry dynamics. This necessitates an interpretivist philosophical approach towards using patent information in the field of social sciences. Each study in this dissertation focuses on the proceedings of the European Patent Office in one specific industry field. Publications related to this dissertation are in the field of wind power, financial services, chemical / drugs.

5.1.1 **Mixed methods approach**

A mixed methods approach is the best way to mitigate the mutual weaknesses of qualitative and quantitative research. In the context of patent data, the production of data is dependent on the actors that are involved in the various stages of the life cycle of a patent. The data is subjected to the idiosyncrasies of people who are making decisions at different points. For example, applicants can intentionally delay the proceedings that may look like a backlog situation of the patent office. The concept of patent value itself is also subjective in nature.

Personal interviews with experts have been vital in understanding the patent system and in interpreting the results. All variables used in the research related to this thesis have undergone a related personal interview session with an examiner at the Finnish Patent Office (PRH). Sometimes, patent attorneys were interviewed to understand the strategic aspects behind certain procedural variables. For example, an accelerated examination request (a dummy variable) is made when the applicant has already identified a potential infringer or seeks early certainty related to validity. This helped uncover the latent aspects associated with all procedural indicators and, sometimes, even citation indicators.

Although the patent system is quite heterogeneous, the participants' views about the realities in the patent system have been somewhat coherent. This is different from participants in qualitative research related to attitudinal or behavioural research which can produce different accounts of the same reality. In my case, absence of these problems made the mixed methods approach less susceptible to the weaknesses of the qualitative approach. On the other hand, patent databases represent data that are facts or are documentation of the events that actually happened. In contrast, data from surveys are subject to many kinds of biases and errors related to interpretation of survey questions.

5.1.2 **Cross-sectional data**

Cross-sectional data refers to data collected over a certain snapshot of time. This data may not account for differences within groups of observations or over periods of time. Heteroskedasticity is an inherent limitation of cross-sectional data. Heteroskedasticity, refers to variables having largely different variances within groups inside the sample. For example, patents of big firms usually are part of bigger families, while individual patent owners may not have enough resources to build big patent families. Patent family size as a variable might predict a dependent variable of interest differently for different entities.

A number of measures are taken to counter the limitations of cross-sectional data. All analysis is done for patents only from the European Patent Office and in a certain technology field. This significantly reduces variations among the sample as we are dealing with approximately the same kind of patents. The regressions are done after controlling for patent value (forward citations), technical breadth (number of technical classes) and type of applicant (firm, individual or university/government research institute). In certain regressions (explained later for settlements), standard errors are clustered at the group level.

It is possible that once an industry is selected for analysis there are still subjective differences between the types of patents. For example, pharmaceutical patents can be separated into categories like combinations, use, formulation, process, and dosage (Howard, 2007). There are bound to be variations in applicant strategy and litigation propensity in these different types of patents. These differences are however beyond the scope of this dissertation.

5.2 Data collection and analysis

The primary source of patent information for all the studies linked to this dissertation has been EPO's PATSTAT database (PATSTAT, 2015). PATSTAT is built primarily for statistical patent analysis. Information is structured in relational tables and SQL queries are required to extract data from it. Appendix B and C provide the overview of tables in PATSTAT. EPO collects data from various patent offices and compiles them in relational tables. It is updated bi-annually. Typical information for a patent application contained in PATSTAT includes application country, references received and made, technical classification, family information, inventor and assignee information, title and abstract.

Recently introduced European Patent Register extension for PATSTAT is used to obtain procedural information of EPO patents. The EP register documents all procedural aspects that an application undergoes along with the communication between examiner and applicant. Status information (e.g. granted, refused, pending), procedural information (e.g. accelerated examination, amendments, etc), opposition and opponent information have been extracted from EP register.

Data on patent litigation in Europe is compiled by two studies, presented in Graham and van Zeebroeck (2014) and Cremers *et al.* (2016). The resulting database is a set of patent litigation cases filed in the four main European patent jurisdictions (France, Germany, Netherlands, and UK) over a nine-year period (2000 to 2008). According to estimates, the cases represent as many as 80% of the patents litigated in Europe (Cremers *et al.*, 2016). Typical case information available was date of case filing, patent(s) involved, name of parties, type of case, result, etc. The patents involved in the case also contained a match with PATSTAT application ids.

The litigated patents were compared to a closely matched sample of non-litigated patents. This was done by extracting all the granted patents at the EPO during the time window of litigated patents in the sample (1981 to 2006). From this list of granted patents, one non-litigated patent was picked for every litigated patent that belonged to the same application year and having one same IPC class. This exercise was done to prepare a control sample that was used to compare litigated patents with non-litigated patents. A similar exercise was undertaken for matching opposed patents at the patent office with unopposed patent grants. Detailed matching procedure and treatment of national patents with EPO equivalents is described in Publication 5.

Eighteen formal semi-structured interviews were conducted with experts to collect views on the patent system and substantiate results. Each interview was recorded and a text transcript was validated by the interviewees themselves. The average length of an interview was 80 minutes. Eleven interviews were used purely for developing theory on patent life cycle. Different experts along the patenting process were interviewed and the details are provided in Publication 1. Overall, the interviews have been invaluable in improving my perspective of the patent system. I have added excerpts from interviews in some of my papers to substantiate the development of hypotheses and understanding the latent aspects of some variables. Many informal discussions in conferences and courses also helped build my understanding of the patent system.

5.2.1 Logistic regression

Since the dependent variables (opposed/not-opposed; litigated/not-litigated; settled/not-settled) are binary, logistic regression model with robust standard errors was used to estimate the likelihood of opposition, litigation, and settlement. A number of patent characteristics are used as controls.

The logistic regression coefficients by default do not measure the change in dependent variable by unit change in independent variable. Marginal effects are computed to study the exact amount of change in dependent variable caused by the independent variables. Marginal effects pertaining to the logistic regressions are computed but not shown in the results. This is because I do not wish to study how much the dependent variable changes with changes in independent variable. The results are not meant to be interpreted in a causal way but to test our theory and hypotheses.

The unit of analysis for regressions studying opposition and litigation is a patent grant. For studying settlements, regressions are carried out at case level. This is because one patent might be involved in several cases, each having a different settlement outcome. A single case may also involve multiple patents but their settlement outcomes can be coded as settled or non-settled (a binary variable). Since the independent variables are the procedural patent characteristics, the standard errors were clustered at the patent level involved in a case.

6 Results and discussion

This section summarizes the results from five selected publications, in light of the research questions introduced earlier. Some of the results stretch beyond the purview of the research questions but I found them necessary somehow for the discerning reader. The publications are not necessarily summarized in a specific order. The following sub-sections are based on the concepts and constructs introduced earlier in the dissertation. I have added an extra section on my unpublished work related to differences between patents involved in infringement and invalidity lawsuits.

6.1 The innovation life cycle

The basic premise of this dissertation is that patents are not one-shot actions. They follow a life cycle of their own which is strongly linked to the life cycle of the corresponding innovation. Publication 1 is a compilation of findings from 11 semi-structured interviews. The objective was to compare the views of various experts about the concept of *patent value* and the relevance of *patent value indicators*. Research question 1 seeks to answer *"how are patent value indicators related to the life cycle of innovations".* The list of interviewees presented in Table 3 represented different stages in the innovation life cycle that are divided among the following five categories.

1. Inventors (Professors owning patents; R&D managers applying for patents)
2. Technology transfer office personnel (University and small-medium firm level)
3. Patent attorneys (Individuals filing and maintaining patents on behalf of clients)
4. Patent consultants (Individuals involved in advice and/or transaction of patents)
5. Patent examiners (Individuals reviewing patentability at patent offices)

Table 3 Interviewee details

Serial	Designation	Category	Years of Experience
1	Professor, Lappeenranta University of Technology	Inventor	More than 20 years
2	Professor, Lappeenranta University of Technology	Inventor	More than 30 years
3	R&D Manager, Industrial Firm	Inventor	More than 20 years
4	Project Coordinator, Lappeenranta University of Technology	Technology Transfer professional	More than 10 years
5	Development Personnel, Foundation for Finnish Inventions	Technology Transfer professional	More than 10 years
6	Former Director, National Board of Patents and Registration of Finland	Patent Consultant	More than 30 years
7	Private Technology Consultant	Patent Consultant	More than 20 years
8	Patent Attorney, Software	Patent Attorney	More than 10 years
9	IPR Specialist, Independent	Patent Attorney	Less than 10 years
10	Senior Patent Examiner, National Board of Patents and Registration of Finland	Patent Examiner	Less than 10 years
11	IP communication specialist, National Board of Patents and Registration of Finland	Patent Examiner	More than 10 years

Research question 1 is answered in Table 4 where views of different stakeholders regarding complementary market-based indicators are tabulated. Commercialization of innovation has a lot to do with market forces that influence decisions of inventors. In this regard, patents are not an end in themselves but complement various market forces at various points in time.

Table 4 Value indicators during different stages

Innovation Stage	**Value Indicators**	
	Patent Based	**Market Based**
Idea		— Market Potential
Invention announcement		— Market reports — Theoretical estimate
Discussion about patentability	— Preliminary novelty search	— No. of competitors — Potential Market Size — No. of alternate solutions — No. of patents possible to infringe — No. of products patent can be applied
Patent application (priority filing)	— Patenting route — Applicant references (if any) — No. of independent claims. — Text of claims — History of success of applicant	— Experience of patent attorney — Past success of applicant — Working prototype
Foreign filing (12 months)	— Family size	— Countries chosen
Search report	— Citation categories (X's, Y's, A's) — No. of IPC fields — No. of claims found novel or carrying inventive step	— Likelihood of grant: Examiners comments
Publication (18 months)	— No. of Claims — No. of backward citations — Text of claims — Citation categories — No. of IPC — No. of IPC of backward citations	— Negotiation of investments and licenses
Examination	— Accelerated examination requests — Third party observations — Divisional filings — Amendments	— Complementary assets — Approvals and regulatory framework
Opposition (if any)	— Opposition event raised — Opposition survival	
Grant	— Forward citations	— Readiness of invention for commercial purposes — Filing trademarks

The overall objective of the first research stage was to explore patent value indicators throughout this life cycle. This was achieved by looking at detailed procedural information of patents filed at the European Patent Office (EPO). While publication 1 sets the foundation for such an exercise. Detailed usage of relevant patent value indicators with an appreciation towards their availability in time is shown in Publications 4 and 5. Publication 4 separates citations introduced in a patent document during different stages of the patent life cycle. Publication 5 uses various interactions of applicants and their rivals with the patent office.

6.2 The concept of patent value

The ideas presented by the interviewees about patent value had a lot to do with their daily scope of work. For example, attorneys considered text of claims as the most important indicator of value as their job required drafting of patent claims in the broadest way possible. Inventors and technology transfer personnel, who were involved in the early stages of inventions, emphasized more on complementary assets and market based indicators as representative of patent value. Interviewees who had experience with buying or selling patents did consider forward citations to enhance patent value. Patent examiners were best placed to evaluate both the technical and commercial aspects of a patent. They were aware of the various patent value indicators produced by academia but did not regard them relevant at a case by case level. We viewed the overall finding as value lying in the eyes of the beholder.

The overall result favoured *family size*, *incidence of dispute*, and *patenting route* as the strongest indicators of patent value. This was followed by *forward citations* and *patent renewals*. The rest were not considered very important by the interviewees. There was near unanimous vote on the strongest patent being the one that survived an opposition or court litigation.

The experts liked the treatment of patents on a case by case basis. This is unlike patent statistics researchers who use patent based measures with aggregated datasets. When applied at the individual patent level, it was found that the overall impact of these indicators was indeed small (Gambardella *et al.*, 2008).

The PCT route was also considered to be indicative of patent value. Experts associated selection of PCT route to be indicative of seriousness of the applicant and global nature of markets. This was also why patent family size was considered important.

The chief goal of economists and policy makers is to ensure that the patent system serves its purpose of encouraging innovation and social welfare. While they are interested in making policies for social welfare, they should be aware of the private incentives that drive different stakeholders in the innovation life cycle.

6.3 Use of Cooperative Patent Classification

Publication 2 explores the use of recently introduced Cooperative Patent Classification (CPC) system in retrieving data for patents in the field of climate change mitigation technologies. Cooperative Patent Classification (CPC) is a bilateral system that is developed jointly by the EPO and USPTO. It combines the best classification practices from the two offices. The format of CPC is very similar to the ubiquitous International Patent Classification (IPC) system, but with a greater level of granularity. CPC consists of roughly 250,000 sub-groups to define technical inventions as opposed to just 70000 sub-groups in the IPC system.

Moreover, CPC is a very recent development. It came in force from 1st January 2013. The USPTO phased out their United States Patent Classification (USPC) system in January 2015. The EPO and the State Intellectual Property Office (SIPO) of China have signed a Memorandum of Understanding to enhance their co-operation. SIPO will strive to classify all new patent documents in all technical fields according to CPC guidelines from 2016. CPC is already being used by more than 45 patent offices worldwide. (Blackman, 2013)

Another interesting aspect of the CPC over IPC is the extra section *Y* to classify documents in new technology fields and inventions that encompass multiple technical fields. Especially, the *Y02* class collects a wide range of technical fields associated with climate change mitigation technologies. This new tagging scheme is made by qualified EPO examiners who have technical expertise in patent classification and search. Classes in section *Y* are not assigned intellectually but done algorithmically by using a combination of classes and keywords. (Veefkind, 2012)

Data retrieval using CPC

Data retrieval of patents in the field of "wind power" was first carried out using the IPC sub-class F03D. This sub-class has been used by a number of previous studies to retrieve wind power patents (WIPO, 2009; Braun, *et al.*, 2010; Johnstone, *et al.*, 2010). The result of this data retrieval process was then compared to a sample of wind power patents obtained by using CPC sub-groups Y02E 10/70 – 766.

The results indicate that more wind power patents could be retrieved using the CPC classification. Two tests confirmed that the "extra" patents produced by CPC search over IPC search indeed belonged to the wind industry. They belonged to top players active in the wind power business and belonged to technical fields closely linked to wind power. The results were similar for patents from EPO, USPTO and SIPO. Sample results tabulated below (Table 5).

Table 5 Wind industry patents sample from Europe, United States and China (filing year between 2001 and 2010)

Jurisdiction	No. of wind power patents using CPC	No. of wind power patents using IPC	Match between samples
EP	4866	4189	4066
US	6152	4671	4133
CN	5939	5295	5122

The sample of relevant wind industry patents, as obtained by the CPC, were 16% higher than those obtained by the IPC for EPO patents, 32% higher for US patents, and 12% for Chinese patents.

6.4 Measures of encroachment and hindrance

As part of the second research question, Publication 2 carries out a detailed citation analysis after isolating the most relevant wind power patents. The jurisdiction was restricted to EPO patents. Application filing date was chosen between 2001 and 2010. Furthermore, top eight applicants were selected who had at least 100 patent applications during the selected time window. Six players were European (seen also as leading firms in Lehtovaara, *et al.* (2014)) and two players, GE Wind and Mitsubishi, were foreign. The citations made among the selected top players were further separated into "overlapping" and "non-overlapping" citations. Two measures are introduced based on "overlapping citations" among competing firms.

Measure of encroachment indicates the *vulnerability* of a patent portfolio. It is the ratio of all *X* and *Y* citations made to competitors over all *X* and *Y* citations made. Its value ranges between 0 and 1. A value closer to 1 indicates a high overlap of claims with competitors' portfolios. The results are shown in Table 6. Measure of encroachment is based on backward citations as shown in Figure 12.

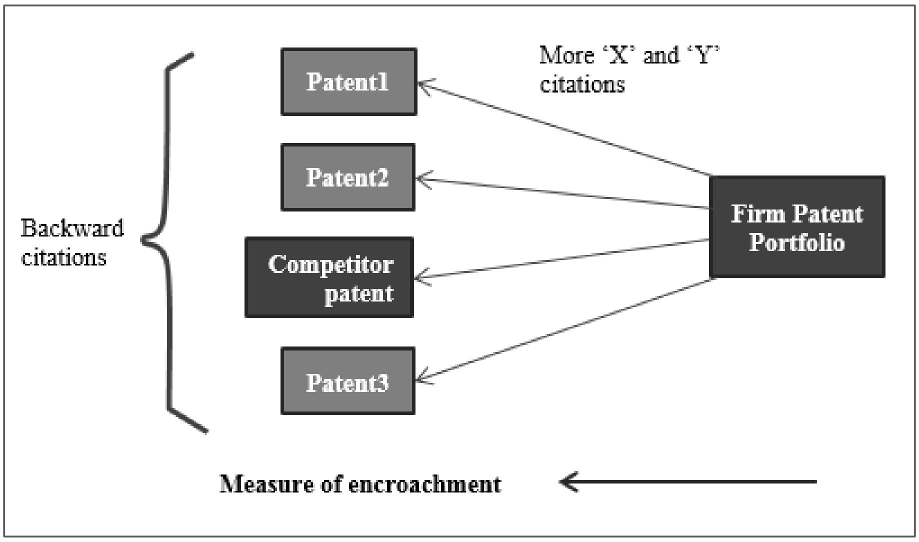


Figure 12 Measure of Encroachment

$$\text{Measure of encroachment} = \frac{\sum 'X' and\ \ 'Y' cit. to\ competitors}{\sum All\ \ 'X'\ and\ 'Y' cit. made}$$

Measure of hindrance indicates the *blocking power* of a firm's patent portfolio. Forward citations are used to compute it (Figure 13). It is the ratio *X* and *Y* citations received from competitors to all *X* and *Y* citations received. The value of measure of hindrance also ranges between 0 and 1. A value closer to 1 indicates a greater blocking power of a firm's patent portfolio. The results for the chosen firms are shown in Table 6.

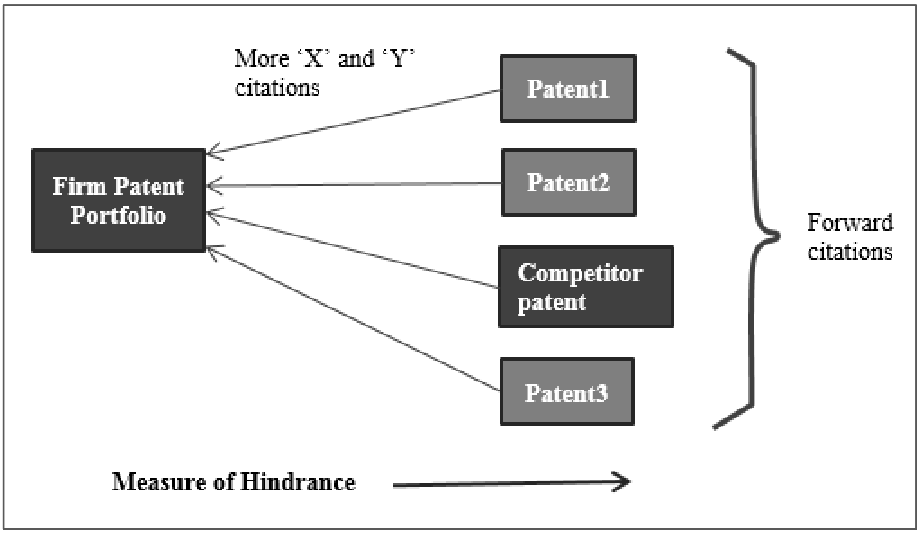


Figure 13 Measure of Hindrance

$$\text{Measure of hindrance} = \frac{\sum 'X' and\ \ 'Y' cit. from\ competitors}{\sum All\ \ 'X'\ and\ 'Y' cit. received}$$

Table 6 *X* and *Y* citations with the measure of encroachment (MOE) and measure of hindrance (MOH). Wind power applications from 2001 to 2010

Firm Name	Backward citations		Forward citations		MOE	MOH
	Total X, Y	Total X, Y to competitors	Total X, Y	Total X, Y from competitors		
GE Wind	1253	370	527	238	0.30	0.45
Vestas	647	170	173	56	0.26	0.32
Siemens	1236	313	235	75	0.25	0.32
Enercon	623	110	161	73	**0.18**	0.45
Mitsubishi	163	59	80	42	0.36	**0.53**
REpower	444	166	120	58	0.37	0.48
Nordex	224	86	61	25	0.38	0.41
LM Glasfiber	288	92	42	16	0.32	0.38

The above results correspond to Research Question 2: *How can we measure technological overlap among competing firms?* Based on the above table, Enercon has made the least number of blocking citations to competitors. Mitsubishi has the strongest portfolio relative to competitors in terms of blocking power. We see that this kind of analysis is better than measuring pure citation counts. Not only do we know what kind of citations were made, but also to whom they were made. This kind of value weighing of citations is significantly better than present approaches of patent portfolio analyses.

Unsurprisingly, results from Publication 4 show that the wind power industry shows signs of concentration of innovation. The top ten players hold more than 46% of all patents in the field. Presence of Universities and government funded research is virtually non-existent as they hold less than 2% of the patents (Table 7). The number of NPL citations in wind power patents was around 5.5% that was seen to be far below other industries. This was backed up by examiner interviews who held the view that innovations in the wind industry were more ‘practical’ than other industries, hence, explaining a lack of fundamental research.

Table 7 Share by ownership (European wind power patents 2001-2010) Source: PATSTAT, 2015

Category	**Count**	**% ownership**
Big players	2326	46.6
Small players	1936	38.8
Individuals	603	12.1
Universities	51	1.0
Govt./Non-profit	39	0.8
Unknown	36	0.7
Total	**4991**	**100**

Furthermore, patent oppositions in the European wind power industry have seen a steep rise. The numbers have nearly doubled every two years since 2004. Figure 14 shows the number of oppositions raised. The results are taken one step further by creating a *who-opposed-whom* matrix and found almost all oppositions featuring one big player (Table 8).

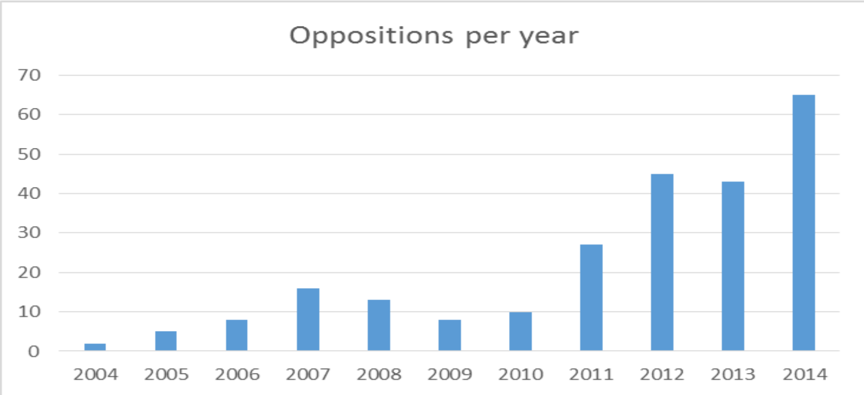


Figure 14 Number of EPO oppositions raised per year

Table 8 Who-Opposed-Whom matrix

	Opponents											
Applicants	ENERCON	GAMESA	GE WIND	LM GLASFIBER	MITSUBISHI	NORDEX	REPOWER	SIEMENS	SUZLON	VESTAS	OTHER	**Total**
ENERCON		1				2	**6**	**8**		4	1	**22**
GAMESA										1	1	2
GE WIND	2					1	1	2		4	3	13
LM GLASFIBER	2		1					2		2		7
MITSUBISHI											1	1
NORDEX	2	1						1	1	2	1	8
REPOWER	**11**				1	1		**6**		5	4	**28**
SIEMENS	8		1	2		1	2			**7**	3	**24**
SUZLON	2											2
VESTAS	**10**	3		3		2	2	**7**			2	**29**
OTHER	7		3				1	5		7	12	35
Total	**44**	5	5	5	1	7	12	**31**	1	**32**	28	171

6.5 Landscape on financial innovation

The measures developed in the previous publication are used in the context of financial innovation. This publication is a chapter in a book titled “Innovation in Financial Services: A dual ambiguity” – edited by Anne-Laure Mention and Marko Torkkeli. Financial services, or financial method patents are part of a larger field called *business methods*. Granting of software and business method patents are part of a contentious debate among IP policy makers. While they are more commonly granted in the USPTO, the EPO looks at them with scepticism (Laub, 2006; Komulainen and Takalo, 2011).

Conventionally, most innovations from financial services were not considered eligible for patent protection (Lerner, 2006). The increased importance of IP management is further confirmed by Lerner (2010) who provides evidence that financial services patents are being litigated at a much higher rate than patents in general. These issues are mainly studied in the context of USPTO patents. This chapter explores the landscape of business method patents in Europe with a focus on financial services.

Nature of financial innovation

Financial services is a new industry in the context of IP management. Lerner (2002) empirically found examiners’ limited exposure to finance research and patents, and hence their failure to cite academic research. Bader (2007) used a single case study of Swiss Reinsurance Company (Swiss Re) to show how financial services companies are beginning to systematically manage their innovation through patents. Swiss Re is one of the first European financial services firm that created its own patent department. Financial innovations are easily imitable and their diffusion across institutions is fast (Roberts and Amit, 2003).

The top players who are filing patents in this field have less experience than players dominating other business method patents. Innovation in financial services has a lot to do with building products by involving the user. Successful products have rarely been built around strong intellectual property rights. Licensing, as a tool for appropriability, has still not matured fully due to complications due to pricing and antitrust laws. (Kumar and Turnbull, 2006)

Main results

The growth in EPO patents filed in the field of business methods is decreasing (Figure 15). The surge after 1999 is known to be because of the famous *State Street* suit decision by the United States board of appeals that rendered methods of doing business eligible for patenting.

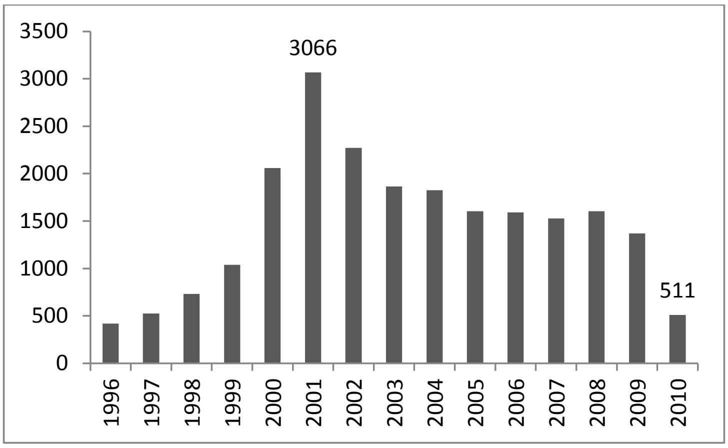


Figure 15 EPO patent applications filed in IPC class 'G06Q'

The following table presents the type of citations made by firms in the sector “finance, insurance and tax” of business method patents. Relative to other business methods, this field cited unusually low number of references. I have explored this phenomenon in another paper. Most of the patents held by firms in Table 9 have been marked by EPO “no search” which is a guideline in place to discourage non-patentable subject matter. Very few, or none, of the patents held by these firms are successful (Kapoor and Mention, 2015). Siemens, a multi-industry conglomerate, was an anomaly in Table 9 as most of their overlapping citations were made to patents in other industries.

Table 9 Measure of encroachment (Finance, insurance and tax patents)

Firm name	**Total ‘A’ citations**	**Total ‘X’ and ‘Y’ citations**	**‘X’ and ‘Y’ to same field**	**Measure of encroachment**
Espeed	7	22	15	0,68
Trading Tech	9	24	18	0,75
SAP AG	3	33	7	0,21
Swiss Re	6	24	12	0,50
Accenture	1	0	0	--
CME	0	5	5	1,00
Goldman Sachs	4	17	9	0,53
Bank of America	8	10	4	0,40
Siemens AG	22	21	2	0,10
OMX Technology	10	13	9	0,69
Average	**7,67**	**18,78**	**9,00**	**0,54**

6.6 Timing and type of citations

Publication 4 uses the wind power patents collected using the CPC classification. To the best of my knowledge, this paper carries out the most detailed citation analysis on European patents till date. Citations of EPO patents are separated based on type (patent or non-patent literature), origin (whether a reference was presented by the applicant, included during initial search or during substantive examination) and type (overlapping or non-overlapping based on citation categories). The citation analysis also accounts for references in international search reports for foreign patents entering the EPO. Table 10 presents the descriptive statistics of all the variables used in the study.

Table 10 Descriptive statistics. Wind power patents in Europe (2001-2010)

	Variable	**N**	**Mean**	**S.D.**	**Min**	**Max**
Scope	Technical classes	4991	2.691	1.826	0	22
	Number of claims	4991	7.336	7.968	0	77
Type of reference	NPL references	4991	0.355	1.197	0	37
	Patent references	4991	6.111	3.988	0	88
Nature of reference	X references	4991	2.029	2.276	0	18
	Y references	4991	0.924	1.641	0	15
	A references	4991	2.242	2.310	0	31
Origin of reference	Applicant	4991	1.208	2.696	0	118
	European Search Report	4991	2.480	2.715	0	35
	International Search Report	4991	3.423	3.390	0	33
	Examiner	4991	0.1000	0.565	0	9
	Third Party Observation	4991	0.0285	0.368	0	9
Filing route	PCT (international)	4991	0.438	-	0	1
	PCT (EPO)	4991	0.177	-	0	1
	Euro direct	4991	0.385	-	0	1
Dependent variables	isGranted	2545	0.545	-	0	1
	isOpposed	1094	0.225	-	0	1

This effort is undertaken to predict two very important events in the life cycle of a patent, namely, a *grant*, and if any, an *opposition*. Detailed citation characteristics were compared between patents that were granted (successful) and those that were unsuccessful (refused, revoked or abandoned) patents. Similar characteristics were compared for granted patents that were opposed, against granted patents that were unopposed (after the nine month opposition window). Citation characteristics are extracted from EPO's PATSTAT database, and application status information (like refusal, revocation, opposition, etc.) was retrieved from European Patent Register extension for PATSTAT.

Tables 11 - 12, and the discussion that follows, answer Research Question 3: *Can citation type and timing explain the likelihood of grant and opposition?*

Table 11 Regression models for likelihood of grant

	Variables	(1) Grant	(2) Grant	(3) Grant	(4) Grant PCT	(5) Grant EURO
Scope	Technical classes	0.467*** (0.0967)	0.544*** (0.0982)	0.557*** (0.0973)	0.597*** (0.137)	0.560*** (0.155)
	Number of claims	0.332*** (0.0831)	0.432*** (0.0851)	0.419*** (0.0843)	0.337*** (0.115)	0.390*** (0.140)
Interaction term (type and nature of citations)	NPL – *X*			-0.0200 (0.0168)		
	NPL – *Y*			-0.0023 (0.0200)		
	NPL – *A*			0.000733 (0.0119)		
	PAT – *X*			-0.007*** (0.00178)		
	PAT – *Y*			-0.0050** (0.00253)		
	PAT – *A*			0.000819 (0.00107)		
Nature of citation	*A* citations		0.262*** (0.0622)			
	X citations		-0.230*** (0.0603)			
	Y citations		-0.241*** (0.0673)			
Type of citation	Patent citations	0.380*** (0.0736)				
	NPL citations	0.149 (0.106)				
Origin of citation	Applicant citations				0.582*** (0.103)	0.813*** (0.113)
	International Search				-0.558*** (0.163)	
	European Search				-0.657*** (0.133)	-1.260*** (0.195)
	Examiner citations				0.0545 (0.257)	1.436*** (0.416)
	Third party obs.				1.074 (0.789)	-0.504 (0.544)
	Constant	-1.920*** (0.256)	-1.512*** (0.242)	-1.382*** (0.229)	0.225 (0.408)	0.119 (0.475)
	Observations	2,545	2,545	2,545	1,357	1,087
	Pseudo R^2	0.0237	0.0337	0.0249	0.0575	0.0949
	Log likelihood	-1713	-1695	-1711	-853.1	-681.8

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 12 Regression models for likelihood of opposition

	Variables	Opposed	Opposed	Opposed	Opposed PCT	Opposed EURO
Scope	Technical classes	-0.0939 (0.168)	-0.0682 (0.168)	-0.0726 (0.169)	-0.107 (0.217)	0.0834 (0.272)
	Number of claims	0.298** (0.146)	0.306** (0.146)	0.283* (0.146)	0.301* (0.177)	0.258 (0.284)
Interaction term (type and nature of citations)	NPL – *X*			0.0518* (0.0309)		
	NPL – *Y*			0.0105 (0.0360)		
	NPL – *A*			0.0379 (0.0244)		
	PAT – *X*			0.00156 (0.00378)		
	PAT – *Y*			0.000877 (0.00567)		
	PAT – *A*			-0.013*** (0.00460)		
Nature of citation	*A* citations		-0.349*** (0.130)			
	X citations		0.0351 (0.119)			
	Y citations		-0.0517 (0.128)			
Type of citation	Patent citations	0.0344 (0.166)				
	NPL citations	0.799*** (0.165)				
Origin of citation	Applicant citations				0.126 (0.151)	0.152 (0.192)
	International Search				0.0469 (0.270)	
	European Search				-1.212*** (0.469)	-0.235 (0.336)
	Examiner citations				-0.649* (0.386)	0.522 (0.488)
	Third party obs.				0.929 (0.614)	1.505 (1.033)
	Constant	-2.086*** (0.515)	-1.548*** (0.460)	-1.747*** (0.428)	-1.102 (0.765)	-1.767* (0.917)
	Observations	1,094	1,094	1,094	658	436
	Pseudo R^2	0.0240	0.0133	0.0219	0.0307	0.0115
	Log likelihood	-569.1	-575.3	-570.3	-342.4	-227.2

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

On the context of citations, some citations were clearly more important than others in determining grant and opposition. Blocking citations made to patents (type *X* and *Y* references) had a highly significant role in impeding grant, but did not seem to have any effect on the likelihood of opposition. Non-blocking citations made to patents (type *A*) did not affect the chances of grant but were highly significant in pre-empting opposition. NPL citations of the category *X*, however few, were seen to significantly increase the chances of facing an opposition.

Over 90% of the references were added during the search phase. Granted patents had a significant number of references provided by the applicant themselves compared to unsuccessful patents. Overall, a more extensive search report (international or European), led to lower chances of grant. PCT applications were less prone to opposition if they had substantial number of references supplemented during the European search and examination phase.

The overall results show that incidence of grant and opposition have a non-fortuitous relationship with timing and type of citations added to patent documents. These citation indicators can act as early signals for impending grants or oppositions. The findings with citation origin are exploratory and first of its type for European patents. More research is needed to see their relevance in other technology fields. For example, rare events like third party observations might be relevant in the pharmaceutical industry as public interest groups keep watch on proceedings of patent applications.

6.7 Procedural indicators and patent litigation

Publication 5 makes use of a unique dataset of European patent litigations in four most important jurisdictions (UK, Germany, France and Netherlands). *Litigated* patents are compared to a closely matched set of *non-litigated* patents. The effort is undertaken for patents in the field of chemicals and drugs. A host of patent characteristics were compared as part of an exploratory data analysis. A set of most important procedural patent characteristics are isolated across the patent life cycle.

The hypotheses were developed around a careful examination of the literature for our variables of interest. In addition, theory of litigation and settlement were used from Chapter 4 of this dissertation. The latent aspects of each variable were discussed with a patent attorney and other online law firm sources. Table 13 presents the hypotheses formulated along with their empirical support.

Table 13 Hypotheses developed along with empirical support

	Hypothesis	Result
H1	*Controlling for patent value, patents with fewer claims are less subject to legal challenges.*	Supported for opposition, not for litigation
H2	*Applications that are part of a large divisional chain are more likely to be involved in legal challenges, but their association with settlements is a priori unclear.*	Supported
H3	*Clarification of validity in the form of amendments will lead to a lower likelihood of legal challenges.*	Supported
H4	*Information about patent validity revealed during earlier prosecution (i.e. opposition) will increase the likelihood of litigation but also of a subsequent settlement.*	Supported
H5	*When the validity of a patent is discussed before court, settlement is less likely to occur.*	Supported
H6	*Foreknown interest of third parties and the applicant's haste are more likely to lead to opposition and litigation, but their effect on settlements is a priori unclear.*	Supported

The data preparation process unearthed the heterogeneity in the European patent system despite having a central patent office in the form of EPO. The final sample of litigated patents consisted of 1052 EPO patent grants. Some of the litigated patents were national office patents whose EPO equivalents were used for the analysis. Parties who wish to enforce or invalidate patents also face lot of barriers in the current litigation system. Some of the challenges typically faced are high costs, language barriers, and risk of diverging verdicts across countries. In this regard, policy makers are yet to agree on the long due Unified Patent Court (UPC) whose verdicts will be held across jurisdictions.

Table 14 presents the results of logistic regression analysis with EPO opposition, European litigation, and settlement of suit as dependent variables. The four core controls used are listed at the bottom of the table. This is followed by two sub-sections that answer Research Questions 4 and 5 respectively.

Table 14 Logistic regression results

VARIABLES	(1) Opposed	(2) Opposed	(1) Litigated	(2) Litigated	(3) Litigated	(1) Settlement	(2) Settlement	(3) Settlement	(4) Settlement
Number of claims		0.126*** (0.02)		-0.327*** (0.07)			0.24 (0.15)		
Number of divisionals		0.628*** (0.04)		1.460*** (0.14)			0.030 (0.18)		
Third-Party Obs.		2.065*** (0.13)		1.231*** (0.39)			0.309 (0.58)		
Accelerated Exam Req.		0.722*** (0.06)		0.887*** (0.19)			-0.299 (0.26)		
Patent is amended		-0.137*** (0.03)		-0.210 (0.19)			0.896** (0.45)		
Validity is challenged in proceedings								-0.545*** (0.20)	
Patent has been opposed (and survived)	--	--			1.295*** (0.13)				0.898*** (0.21)
Number of cases	--	--	--	--	--	-0.067* (0.04)	-0.083** (0.04)	-0.0571 (0.04)	-0.072* (0.04)
Age at litigation	--	--	--	--	--	-0.064*** (0.02)	-0.049** (0.02)	-0.061*** (0.02)	-0.045** (0.02)
Forward citations	0.537*** (0.01)	0.473*** (0.01)	0.614*** (0.06)	0.513*** (0.07)	0.522*** (0.06)	0.175 (0.11)	0.117 (0.13)	0.155 (0.11)	-0.014 (0.12)
Number of IPC	-0.506*** (0.02)	-0.580*** (0.02)	-0.282*** (0.08)	-0.453*** (0.08)	-0.299*** (0.08)	0.022 (0.15)	-0.021 (0.17)	0.009 (0.15)	0.010 (0.16)
Assignee company	0.240*** (0.05)	0.253*** (0.05)	-0.490*** (0.16)	-0.663*** (0.17)	-0.523*** (0.17)	0.120 (0.28)	-0.082 (0.28)	0.140 (0.30)	0.131 (0.27)
Assignee univ/govt	-0.259*** (0.06)	-0.321*** (0.06)	-0.661*** (0.20)	-0.935*** (0.21)	-0.695*** (0.21)	-0.268 (0.38)	-0.304 (0.38)	-0.156 (0.41)	-0.286 (0.39)
Constant	0.397 (0.06)	0.173*** (0.07)	0.537*** (0.20)	1.613*** (0.25)	0.439** (0.21)	0.136 (0.37)	-0.530 (0.47)	-0.266 (0.38)	-0.274 (0.35)
Observations	50,986	50,986	2,034	2,034	2,034	683	683	683	683
Pseudo R^2	0.0347	0.0508	0.0430	0.117	0.0835	0.0494	0.0665	0.0596	0.0770
Log Likelihood	-34112	-33545	-1349	-1245	-1292	-427.5	-419.8	-422.9	-415.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.7.1 Actions and reactions of parties

Research Question 4 states: *What factors drive the actions and reactions of parties during the patent life cycle?* One of the main findings from Publication 5 is that parties continuously update their beliefs about the strength of their case as *new information* unfolds. The emphasis is on new information since we see that old information becomes less powerful in predicting subsequent events (As measured by regression coefficients based on marginal effects and Pseudo R^2 values of different models). A submission of accelerated examination request signals value to third parties who are then highly likely to oppose the patent to get it invalidated at the patent office stage. If a patent is granted despite submission of third party observations, it is challenged at the opposition stage. Applicants make use of divisional applications when there is an uncertainty regarding the exact nature of rights that will be valuable. More important patents are usually part of a big chain of divisional patent applications.

6.7.2 Drivers of litigation and settlement

This section sets out to answer Research Question 5: *How can we explain the incidence and outcome of European patent litigation?* A typical litigated patent was found to be a relatively small and focussed patent, *within a complex chain of divisional applications*. Chemical and pharmaceutical industries usually have long testing and approval procedures. Patents are filed in a broad and vague fashion for a range of molecules or compounds, until the most promising ones can be identified. This leads to broad filings which have been shown to exist disproportionately in these industries (Archontopoulos *et al.*, 2007; Zeebroeck *et al.*, 2009).

Patents involved in litigation were indeed more valuable than the non-litigated control sample (value as proxied by five-year forward citations at family level). In unreported regressions, our procedural variables (accelerated examination requests, third party observations, divisional applications) were more potent in explaining the incidence of litigation than citations.

Regarding settlement, it was found that anything that adds weight to the validity of a patent helped reduce uncertainty, and hence enable parties to settle. Amendments and survival of EPO opposition were two variables that helped clarify the validity of a patent and hence encouraged settlements. Conversely, when the validity of a patent comes under scrutiny, settlement becomes less likely. This is seen in our analysis that cases in which patent validity was challenged are significantly less likely to settle.

6.8 Infringement versus invalidity

I would like to end the empirical part of this dissertation with a dialogue on the characteristics patents involved in infringement and invalidity type cases. The following discussion sets out to answer Research Question 6: *Are there differences between patents in infringement and invalidity cases?*

Results from Publication five have found that infringement type suits are much more likely to settle than invalidity types (at least for the chemical and pharmaceutical industries). This is mainly because it is easy to identify if a chemical or pharmaceutical composition comprises (or infringes) the subject matter of the patent in question. Both litigants therefore agree on the *expected outcome* of the case. This, in turn, leads to higher chances of settlement.

Pure invalidity cases are few because third parties usually do not have enough incentives to attack a patent unless there is a direct conflict. When faced with an infringement claim, a defendant typically has two counterarguments, in the form of non-infringement and counter-invalidity. Most invalidity challenges are an outcome of a counterclaim to an infringement suit. Ford (2013) presents theoretical arguments that favor non-infringement as a counterclaim over counter-invalidity. To prove invalidity, the defendant will have to prepare clear and concise evidence that might include a prior art search. Moreover, the preparation of the counter-invalidity argument may have to be done within a time limit as the case remains pending. In an infringement suit, the defendant will typically have better access to information about their allegedly infringing product, while the patent holder (plaintiff) will have better access to information regarding the underlying technology and prior art (Meurer, 1989). Another reason why defendants may not choose counter-invalidity is that a successful invalidity challenge renders the patent right as a public good (Farrell and Merges, 2004). This means that any competitor can use the technology without infringement or royalties, thus reducing the benefit of privileged players (patent holders and licensees) in a market economy. This again reduces the incentive to invalidate a patent and encourages mutual settlement of a dispute. Table 15 below shows the breakup in our sample.

Table 15 Total cases and case type (Source: Publication 5)

Total cases	Only infringement cases	Only invalidity cases	Both infringement and invalidity cases
893	549	109	235

I ran the regressions within the sample of litigated patents in order to compare infringement versus invalidity suits. The regression output (Table 16) shows that invalidity patents are significantly weaker than patents involved in infringement suits. Moreover, there are certain differences in the type of references they make. Patents involved in invalidity suits lack *A* citations (backward references that are non-blocking in nature) and make more *X* and *Y* citations (references that are blocking in nature). Patents involved in invalidity suits are also seen to be belonging to larger divisional chains. No differences are seen in terms of procedural variables.

Table 16 Logistic regression - Invalidity versus Infringement cases

	(1)	(2)	(3)	(4)
VARIABLES	Invalidity	Invalidity	Infringement	Infringement
Forward citations	-0.0545*** (0.0158)	-0.055*** (0.0158)	0.0397*** (0.0124)	0.0365*** (0.0127)
Number of technical classes	0.0061 (0.0103)	0.008 (0.0106)	0.0018 (0.00951)	0.0069 (0.00991)
Number of claims	-0.0077 (0.00670)	-0.0088 (0.00677)	0.0039 (0.00572)	0.0052 (0.00571)
Size of divisional chain	0.161*** (0.0411)	0.163*** (0.0419)	-0.121*** (0.0383)	-0.131*** (0.0392)
NPL - *A citations*		0.072 (0.0826)		-0.180** (0.0718)
NPL - *X citations*		-0.142* (0.0807)		0.103 (0.0738)
NPL - *Y citations*		-0.117 (0.109)		-0.058 (0.0994)
PAT - *A citations*		-0.200*** (0.0633)		0.256*** (0.0576)
PAT - *X citations*		0.170*** (0.0633)		0.0056 (0.0596)
PAT - *Y citations*		0.153** (0.0740)		0.0083 (0.0709)
X citations	0.019 (0.0265)		0.0045 (0.0252)	
Y citations	0.037 (0.0403)		0.0022 (0.0386)	
A citations	-0.090*** (0.0325)		0.082*** (0.0285)	
Constant	-0.847*** (0.166)	-0.894*** (0.177)	0.32** (0.152)	0.096 (0.160)
Observations	1,039	1,039	1,039	1,039
Pseudo R^2	0.0353	0.0462	0.0216	0.0324
Log Likelihood	-560.7	-554.4	-652.1	-644.9

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

7 Conclusion

This dissertation is an attempt to advance the field of patent statistics. We live in a pro-patent era as firms make substantial efforts in the management of their technology portfolios. Patent databases have been improving with time by becoming bigger and faster. Intelligence can be drawn from these databases even before a patent is granted by the patent office. Patent departments of firms are monitoring their competitors' patents and so are the investors. This is relevant in a world where product life cycles are shortening and diffusion of information is seamless. The patent system itself is under pressure as the numbers of applications grow. New technological fields like software and business methods are slowly opening up for patenting that requires the patent system to evolve.

Consequently, this dissertation *first* explored patent value indicators throughout the life cycle of a patent application. This was done by means of interviews with experts who were part of the innovation life cycle. Publication 1 presents the views of these patent value indicators along with the corresponding market-based measures available during different stages of technology commercialization. Publication 5 presents hypotheses on certain procedural instruments used by applicants and their rivals. Latent aspects, or the thought processes, behind actions and reactions of parties are uncovered in order to build hypotheses.

The *second* task was to look at firm competition in the form of technological overlap. Studying technological overlap is the key to understanding the friction between parties as the boundaries of a patent right are often fuzzy. Boundaries and scope of a patent are determined by examiners who assess each claim based on prior art, in light of the patentability criteria established by the patent system. They build a list of prior art and assign relevance to them based on the effect they have on the boundaries and scope of a patent. This means that all citations are not similar. Citations of the blocking type are used to study technological overlap between top wind power firms. Measures are introduced that can show *blocking power* and *vulnerability* of patent portfolios at the firm level and industry level.

Patent disputes are usually a result of technological overlap in shared markets. The *third* aim was to delve into the dynamics of patent disputes in Europe. Using patent information in different stages of the patent life cycle, drivers that lead to disputes and their settlement are unearthed. The importance of uncertainty during the patent life cycle is uncovered. It is the presence of uncertainty that influences many of the choices made by applicants and third parties. A typical patent that ends up in court is a relatively small and focussed patent, but exists within a chain of divisional applications. Uncertainty over patent validity is one of the biggest impediments towards dispute settlement.

7.1 Managerial implications

Measures of encroachment and hindrance introduced in this dissertation are useful for managers to assess their technological portfolios relative to their competitors. Use of citation categories can be extended to identifying potential infringement at individual patent level. A landscape analysis based on citation categories is also helpful in scouting for potential collaborators. Since skilled examiners assign categories to citations they are a fairly good resource to identify closely related patents. Relevance of citations deserves greater attention of researchers and practitioners alike. Most patent landscaping tools offering citation analysis do not separate citations according to type that leaves out important information potentially useful for practitioners.

By studying the impact of procedural indicators on litigation, this dissertation validates procedural indicators as a strong proxy for commercial patent value (as proxied by an incidence of litigation). In unreported comparisons, procedural indicators explained the incidence of litigation better than citation indicators based on regression model fit and R^2 values. Stakeholders interested in commercial value of patent applications may look into the self-selection of important patents by patentees and their rivals through patent office actions. Since procedural indicators are strong predictors of disputes, results can contribute toward developing models for patent litigation insurance.

Research into competition and disputes can have some policy implications at the industry level and for the patent system. One of the objectives of patent offices should be to reduce the amount of uncertainty during patent pendency and beyond grant. We saw that uncertainty during pendency likely drove some of the actions and reactions of patentees and their rivals. In face of an uncertain commercial and technical scope of their inventions, applicants file multiple divisional applications to isolate the most important (perhaps litigious) part of their applications. This leads to patent office overload along with uncertainty for competitors who are kept guessing about the exact extent of claims that might be allowed. The EPO tried to address the issue of divisional applications by introducing a 2 year moratorium on filing divisional applications from the date of the first examination report. This was later rescinded in April 2014 due to apparent pressure and lobbying from patent applicants and their representatives. In praise for the EPO opposition system, we saw that its outcome significantly reduces uncertainty, which in turn leads to higher likelihood of settlement. Courts usually do not overturn a decision of the opposition division. Parties are aware of this and usually settle among themselves as there is no risk of divergent expectations. In this regard, it is possible that more certainty can be introduced by pre-grant measures rather than post-grant opposition. The answer to reduced uncertainty could be found in encouraging amendments and third party observations. Early decision on acceptance or refusal for straightforward cases can help reduce the number of pending applications. The EPO is indeed looking at achieving pre-grant certainty for all stakeholders as they have ambition to produce search reports with opinion within 6 months[8].

7.2 Main limitations

Patents are not the only way of exploiting technological innovation. Secrecy, lead time advantages, complementary protection with copyrights and trademarks, and other auxiliary industrial competencies are important to drive innovation and growth. In this regard, there are inherent limitations in using only patents to study an industrial organization.

Cross-sectional nature of the data is another inevitable limitation of this dissertation. I have discussed some of the measures undertaken to alleviate this limitation in the chapter on research methods. However, still some concerns remain pertaining to type of patents.

Patent litigation happens primarily in the shadow of infringement. Many instances of infringement might be unobservable as they are not spotted or ignored (for fear of litigation costs). In similar vein, instances of patent invalidity show up only when a third party is directly affected by it. As a result, an element of selection bias impairs any study with respect to patent disputes.

7.3 Future research

As the work on this dissertation comes to an end, I have more ideas than ever before. I will briefly list down some topics that I intend to delve into in one form or the other.

7.3.1 Divisional applications

Divisional applications are a unique phenomenon. In one of my papers, I have proposed that they be looked with suspicion. Patents that are part of a large chain of divisionals are overwhelmingly more likely to be opposed or litigated. Qualitative interviews behind the exact drivers of filing divisional applications and their relationship with technology commercialization could be a useful area to explore. It might be useful to explore if patentees use this procedural instrument in fairness, and how it affects the invalidity of a patent within a divisional chain.

7.3.2 Business method patents

Despite the scepticism of EPO in granting purely method-based inventions, business methods are going to continue to test the boundaries and patience of the European patent system. Griliches (1990) referred to the patent system as a "slow moving standard". But innovation is hardly something that can be controlled. Rate of innovation is faster than

[8] http://www.ippropatents.com/ippropatents/IPPro_Patents_issue_11.pdf, p. 20.

ever. New industries are coming up as product life cycles are becoming shorter. In this regard, new subject matter will slowly become mainstream. Just how good that will be for the innovation system and society altogether is a subject worth studying.

7.3.3 Cooperative Patent Classification

Cooperative Patent Classification (CPC) is a new classification scheme that is built on European Classification (ECLA) and US patent classification (USPC) schemes. It was introduced on 1st January 2013. It has now caught on with USPTO phasing out their USPC in 2015 and China (SIPO) beginning to tag patents in certain technology fields following CPC guidelines since 2016. It is by far the most technically refined classification scheme based on IPC (International Patent Classification) till date. Besides being more technically refined, one of the biggest advantages for patent researchers is the CPC section *Y*. Section *Y* refers to "general tagging of new technological developments; general tagging of cross-sectional technologies spanning over several sections of the IPC; technical subjects covered by former USPC cross-reference art collections [XRACs] and digests". Patent searching for new technologies, especially related to climate change mitigation technologies (Y02 class), produce much broader and relevant results. My own research has confirmed CPC to be better than IPC in retrieving wind power patents (please see Publication 2 for more details). CPC seems to be the way forward in terms of classification research. Patent researchers might be better off in their searches in using CPC over other technical classification schemes.

7.3.4 Unified Patent Court (and Brexit)

The heterogeneity in the European civil court system prompted policy makers to create a Unified Patent Court (UPC) that will have exclusive jurisdiction over European patents (and European patents with unitary effect) with a pan-Europe authority. Under the unitary system, applicants can file a single EPO patent, and if granted, see it have immediate effect across all relevant states and pay a single renewal fee. Applicant behaviour in the new system might be expected to change as few courts will have exclusive power over the continent. This will call for further research into the behaviour of innovators in the new system. The inception for such a specialized forum has been marred by resistance from some members of the European Union (EU). In addition, a recent Brexit vote that leads to UK leaving the EU will further complicate matters and push the inception date further[9].

7.3.5 Responsible innovation

Emergence of complex product industries like smartphones pose a different challenge to the existing patent system. The patent system works well for discrete product industries like pharmaceuticals where one, or few patents are needed per product. It is usually easy

[9] UPC and Brexit Q&A: http://www.bristowsupc.com/brexit/

to identify infringement as composition of products can be ascertained fairly accurately. The scope of patent claims is also usually well defined. As opposed to discrete products, smartphones require the use of hundreds, or even thousands of patented technologies to make the final product ready for consumers. The patents are owned by different entities and might be having unclear scope with regards to their validity. To account for these challenges, the ICT industry in general has instruments like standardization, patent pools and cross licensing to prevent conflicts between stakeholders (Bekkers, *et al.*, 2002). There is, thus, a proliferation of patents in the ICT industry (Hall and Ziedonis, 2001) and applicants resort to the use of strategic patenting to empower themselves in negotiations (Blind and Thumm, 2004; Bekkers and West, 2009; Berger, *et al.*, 2012).

In view of these developments there is a push by research funding agencies towards the concept of responsible innovation (Stilgoe, *et al.*, 2013; European Commission, 2016). The framework for responsible innovation encompasses many areas like ethics of research, public and stakeholder dialogue, foresight of adverse impacts, and the like. There is need for further research in estimating the societal impact of the patent system related to different industries, particularly ICT. Further work can investigate how innovation in this industry can engage the participation of social sciences and humanities.

7.3.6 Markets for technology

In order to avoid costly disputes and reduce transaction costs, market players are coming together with alternatives to dispute resolution. Markets for technologies are seen as a potential way to lower barriers to entry and encourage healthy competition (Arora, *et al.*, 2001). Patent pools and cross-licensing agreements are becoming more popular in technologies with cumulative innovation (Shapiro, 2001; Lerner and Tirole, 2004; Layne-Farrar and Lerner, 2011). Potential new appropriability frameworks around open-source innovation are becoming popular. The Open Innovation Network is a great example of patent aggregation to defend the open source Linux operating system and promote technology products based on it[10]. More research is surfacing related to private-collective innovation models or patent commons (Alexy and Reitzig, 2013; Hall and Helmers, 2013; Wen, *et al.*, Forthcoming).

7.4 Personal note

My own learning from the journey of a doctoral candidate is much more than is contained in this book. I have met with different challenges while applying patent analysis methods in different technologies. Other fields I have worked on are engine waste heat recovery, crystallization using ultrasound, thermal management systems in power electronics and most recently, patents related to ICT industries. Each field has its own idiosyncrasies related to patent classification, keywords, applicant strategies, etc. Along with

[10] See for example a foundation that protects the Linux open-source framework by allowing patents to be used to make products around the Linux framework: http://www.openinventionnetwork.com/about-us/

understanding the nuances of patent databases I also understood the various traps, sometimes unavoidable, that are part of this field.

I have built and refined many SQL queries in PATSTAT. For example, it is easy to overestimate non-patent citations in PATSTAT if queries are not designed to cleanse references to search reports and other examiner comments. Interested researchers are welcome to contact me related to PATSTAT queries, especially related to citations.

There were various lines of research I pursued that led me nowhere, only to be eventually abandoned. One of them was my paper on patent portfolio efficiency analysis using data envelopment analysis (DEA). I understood the difficulty in matching R&D data with PATSTAT assignees as a result. Some research has, however, done advanced work on these topics now[11]. Studying the long pendency of financial methods applications will still remain in my future agenda. Enduring long, and sometimes frustrating, and sometimes unfair, journal review processes also made me aware about the research process in general. Only when I was asked to be a referee myself for two articles at the end of my PhD that I became more appreciative of the difficulties of editors and reviewers in the whole research process.

Overall, I found it more and more difficult to answer important research questions using patent data alone. Since patents themselves are only signs, it is best to measure another economic or managerial variable using the help of patent information. My recommendation to patent analysts will be to keep samples small by restricting jurisdiction and industry field. I would also refer to the Journal of Management article by Deepak Somaya (Somaya (2012)) for a review on where the field of patent strategy is heading.

[11] http://risis.eu/wp-content/uploads/2014/08/Poster-CIB-Final.pdf; http://datasets.risis.eu/metadata/cib

References

Akers, N. (2000). The European patent system: An introduction for patent searchers. *World Patent Information*, 21(4), pp. 309-315.

Alcácer, J. and Gittelman, M. (2006). Patent Citations as a Measure of Knowledge Flows: The Influence of Examiner Citations. *The Review of Economics and Statistics*, 88(4), pp. 774-779.

Alcácer, J., Gittelman, M., and Sampat, B. (2009). Applicant and examiner citations in U.S. patents: An overview and analysis. *Research Policy*, 38(2), pp. 415–427.

Alexy, O. and Reitzig, M. (2013). Private–collective innovation, competition, and firms' counterintuitive appropriation strategies. *Research Policy*, 42(4), pp. 895-913.

Allison, J., Lemley, M., Moore, K., Trunkey, D. (2004). Valuable patents. *Georgetown Law Journal* 92; 435. *George Mason Law & Economics Research Paper* No. 03-31; UC Berkeley Public Law Research Paper No. 133. Available at SSRN: http://ssrn.com/abstract=426020

Archontopoulos, E., Guellec D., Stevnsborg N., van Pottelsberghe de la Potterie B., van Zeebroeck N. (2007). When small is beautiful: Measuring the evolution and consequences of the voluminosity of patent applications at the EPO. *Information Economics and Policy*, 19(2), pp. 103–132

Arora, A., Fosfuri, A. and Gambardella, A. (2001). Markets for Technology and their Implications for Corporate Strategy. *Industrial and Corporate Change*. 10 (2), pp. 419-451.

Bader, M., (2007). Managing intellectual property in the financial services industry sector: learning from Swiss Re. *Technovation*, 28(4), pp.196–207.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 17(1), pp. 99-120.

Baron, J. and Delcamp, H. (2012). The private and social value of patents in discrete and cumulative innovation. *Scientometrics*, 90(2), pp. 581- 606.

Bebchuk, L. (1984). Litigation and settlement under imperfect information. RAND *Journal of Economics*, 15(3), pp. 404–415.

Bekkers, R., Verspagen, B. and Smits, J. (2002). Intellectual property rights and standardization: the case of GSM, *Telecommunications Policy*, 26(3–4), pp. 171-188

Bekkers, R. and West, J. (2009). The limits to IPR standardization policies as evidenced by strategic patenting in UMTS, *Telecommunications Policy*, 33(1–2), pp. 80-97

Berger, F., Blind, K. and Thumm, N. (2012). Filing behaviour regarding essential patents in industry standards, *Research Policy*, 41(1), pp. 216-225.

Bessen, J. and Meurer, M. (2005). The Patent Litigation Explosion. *Boston Univ. School of Law Working Paper No. 05-18*. Available Online: https://papers.ssrn.com/sol3/Papers.cfm?abstract_id=831685

Bessen, J. and Meurer, M. (2006). Patent Litigation with Endogenous Disputes. *American Economic Review*, 96(2), pp. 77-81.

Bessen, J. and Hunt, R. (2007). An Empirical Look at Software Patents. *Journal of Economics & Management Strategy*, 16(1), pp. 157–189.

Bessen, J. (2008). The value of U.S. patents by owner and patent characteristics. *Research Policy*. 37(5), pp. 932-945.

Blackman, M. (2013). News on classification, *World Patent Information*, 35(4), pp. 328-329

Blind, K. and Thumm, N. (2004). Interrelation between patenting and standardisation strategies: empirical evidence and policy implications, *Research Policy*, 33(10), pp. 1583-1598

Blind, K., Edler, J., Frietsch, R. and Schmoch, U. (2006). Motives to patent: Empirical evidence from Germany, *Research Policy*, 35(5), pp. 655–672.

Blind, K., Cremers, K. and Mueller, E. (2009). The influence of strategic patenting on companies' patent portfolios, *Research Policy*, 38(2), pp. 428-436

Braun, F., Schmid-Ehmcke, J. and Zloczysti, P. (2010). Innovative activity in Wind and Solar technology: empirical evidence on knowledge spillovers using patent data. *CEPR Discussion Paper No. DP7865*. Available at SSRN: https://ssrn.com/abstract=1640387.

Burrell, G. and Morgan, G. (1979). Social paradigms and organizational analysis: Elements of the sociology of corporate life. *Heinemann: London*.

Calderini, M. and Scellato, G. (2004). Intellectual property rights as strategic asset: the case of European patent opposition in the telecommunications industry. *CESPRI Working Paper n. 158. University Bocconi*.

Callaert, J., Looy, B., Verbeek, A., Debackere, K. and Thijs, B. (2006). Traces of Prior Art: an analysis of non-patent references found in patent documents. *Scientometrics* 69, pp. 3-20.

Caviggioli, F., Scellato, G. and Ughetto, E. (2013). International patent disputes: Evidence from oppositions at the European Patent Office. *Research Policy*, 42(9), pp. 1634– 1646

Cincera M. 2011. Déterminants des oppositions de brevets. *Revue économique*, 62, pp. 87–99

Cohen, W., Nelson, R. and Walsh, J. (2000). Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not). *NBER Working Paper No. 7552*, Available online: http://www.nber.org/papers/w7552

Comino, S. and Manenti, F. (2015). Intellectual Property and Innovation in Information and Communication Technology (ICT). *JRC Science and Policy Report*, Luxembourg, Publications Office of the European Union Available Online: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC97541/jrc97541.pdf

Cotropia, C., Lemley, M. and Sampat, B. (2013). Do applicant patent citations matter? *Research Policy* 42(4), pp. 844–854.

Crampes, C. and Langinier, C. (2002). Litigation and settlement in patent infringement cases. *The RAND Journal of Economics*, 33(2), pp. 258–274.

Cremers, K., Ernicke, M., Gaessler, F., Harhoff, D., Helmers, C., McDonagh, L., Schliessler, P. and van Zeebroeck, N. (2013). Patent Litigation in Europe. *ZEW - Centre for European Economic Research Discussion Paper No. 13-072*. Available at SSRN: http://ssrn.com/abstract=2333617

Cremers, K., Ernicke, M., Gaessler, F., Harhoff, D., Helmers, C., McDonagh, L., Schliessler, P. and van Zeebroeck, N. (2016). Patent litigation in Europe. *European Journal of Law and Economics*, pp. 1–44.

Czarnitzki, D., Hussinger, K. and Leten, B. 2011. The market value of blocking patent citations. *Discussion paper no. 11-021, ZEW: Center for European economic research*.

Ernst, H. (2003). Patent information for strategic technology management. *World Patent Information*, 25(3), pp. 233-242.

European Commission. (2016). Responsible research and innovation, Web resource: Available online: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation [Last accessed: 19.9.2016]

European Patent Office. (2013). Guideline for Examination, Claims comprising technical and non‑technical features. Available online: http://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_vii_5_4.htm [last accessed: 26.08.2016]

European Patent Office, PATSTAT database. Autumn 2015 version.

Farrell, J., and Merges, R. (2004). Incentives to Challenge and Defend Patents: Why Litigation Won't Reliably Fix Patent Office Errors and Why Administrative Patent Review Might Help. *Berkeley Technology Law Journal*, 19(3), pp. 943-970.

Fischer, T. and Leidinger, J. (2014). Testing patent value indicators on directly observed patent value — An empirical analysis of Ocean Tomo patent auctions, *Research Policy*, 43(3), pp. 519-529.

Ford, R. (2013). Patent invalidity versus noninfringement. 99 *Cornell Law Review* 71; *University of Chicago Coase-Sandor Institute for Law & Economics Research Paper No. 670; University of Chicago Public Law Working Paper No. 454*. Available at SSRN: http://ssrn.com/abstract=2256207

Frietsch, R. and Schmock, U. (2010). Transnational patents and international markets, *Scientometrics*, 82(1), pp. 185-200.

Futia, C. (1980). Schumpeterian Competition. *The Quarterly Journal of Economics*, 94(4), pp. 675-695.

Gambardella, A., Giuri, P. and Luzzi, A. (2007). The market for patents in Europe. *Research Policy*, 36(8), pp. 1163–1183.

Gambardella, A., Harhoff, D. and Verspagen, B. (2008). The value of European patents. *European Management Review*, 5(2), pp. 69–84.

Gilbert, R. and Newbery, D. (1982). Preemptive Patenting and the Persistence of Monopoly. T*he American Economic Review*, 72(3), pp. 514-526.

Graham, S., Hall, B., Harhoff, D. and Mowery, D. (2002). Post-Issue Patent Quality Control: A Comparative Study of US Patent Re-examinations and European Patent Oppositions. *National Bureau of Economic Research. Cambridge, MA. NBER Working Paper 8807*.

Graham, S. and Harhoff, D. (2006). Can Post-Grant Reviews Improve Patent System Design? A Twin Study of US and European Patents. *CEPR Discussion Paper No. 5680*. Available at: http://ssrn.com/abstract=921826

Graham, S. and van Zeebroeck, N. (2014). Comparing patent litigation across Europe: A first look. *Stanford Technology Law Review 17*; pp. 655–708. Available at SSRN: http://ssrn.com/abstract=1924124 or http://dx.doi.org/10.2139/ssrn.1924124

Graham, S. and Vishnubhakat, S. (2013). Of Smart Phone Wars and Software Patents, *Journal of Economic Perspectives*, 27(1), pp. 67-85.

Graham, S. and Harhoff, D. (2014). Separating patent wheat from chaff: Would the US benefit from adopting patent post-grant review? *Research Policy*, 43(9), pp. 1649-1659.

Griliches, Z. (1957). Hybrid Corn: An Exploration in the Economics of Technological Change. *Econometrica*, 25(4), pp. 501-522

Griliches, Z. (1990). Patent Statistics as Economic Indicators: A Survey. *NBER Working Paper 3301*. Available Online: http://www.nber.org/papers/w3301

Guellec, D. and van Pottelsberghe, B. (2000). Applications, grants and the value of patent, *Economics Letters*, 69(1), pp. 109-114.

Guellec, D. and Van Pottelsberghe de la Potterie, B. (2002). The Value of Patents and Patenting Strategies: Countries and Technology Areas Patterns. *Economics of Innovation and New Technology*, 11(2), pp. 133-148.

Hall, B. (2009). Business and Financial Method Patents, Innovation, and Policy. *Scottish Journal of Political Economy*, 56(4), pp. 443- 473.

Hall, B., Jaffe, A. and Trajtenberg, M. (2001). The NBER Patent Citations Data File: Lessons, Insights, and Methodological tools. Cambridge: The MIT Press. *NBER Working Paper no. 8498*.

Hall, B., Graham, S. and Harhoff, D. (2003). Prospects for Improving U.S. Patent Quality via Post-grant Opposition. *NBER Working Paper No. 9731*. Available Online: http://www.nber.org/papers/w9731

Hall, B., Jaffe, A. and Trajtenberg, M. (2005). Market value and patent citations. *The RAND Journal of Economics*, 36(1), pp. 16-38

Hall, B. and Ziedonis, R. (2001). The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995. *The RAND Journal of Economics*, 32(1), pp. 101-128.

Hall, B. and Helmers, C. (2013). Innovation and diffusion of clean/green technology: Can patent commons help? *Journal of Environmental Economics and Management*, 66(1), pp. 33-51.

Harhoff, D., Scherer, F. and Vopel, K. (2003). Citations, family size, opposition and the value of patent rights, *Research Policy*, 32(8), pp. 1343-1363

Harhoff, D. and Reitzig, M. (2004). Determinants of opposition against EPO patent grants—the case of biotechnology and pharmaceuticals. *International Journal of Industrial Organization*, 22(4), pp. 443–480.

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

Holgersson, M. (2013). Patent management in entrepreneurial SMEs: a literature review and an empirical study of innovation appropriation, patent propensity, and motives. *R&D Management*, 43(1), pp. 21–36.

Howard, L. (2007). Use of Patents in Drug Life cycle Management. *Journal of Generic Medicines*. 4(3), pp. pp. 230-236.

Hunt, R., Simojoki, S. and Takalo, T. (2009). Intellectual property rights and standards setting in financial services: the case of the single European payments area, in Anderloni, L., Llewellyn, D.T. and Schmidt, R.H. (Eds.): Financial Innovation in Retail and Corporate Banking, pp. 170–198, *Edward Elgar, Cheltenham*.

Jell, F. (2012). Patent filing strategies and patent management – An empirical study, *Springer Gabler publications*.

Jerak, A. and Wagner, S. (2006). Modeling probabilities of patent oppositions in a Bayesian semiparametric regression framework. *Empirical Economics* 31(2), pp. 513–533.

Johnson, J. (2014). Defensive publishing by a leading firm. *Information Economics and Policy*, 28, pp. 15-27.

Johnstone, N., Hascic, I. and Popp, D. (2010). Renewable energy policies and technological innovation: evidence based on patent counts. *Environmental and Resource Economics*, 45(1), pp. 133-155.

Kapoor, R. and Mention, A-L. (2015). Patenting financial innovation in Europe. *2015 Portland International Conference on Management of Engineering and Technology (PICMET), Portland, OR, USA*, pp. 1071-1077.

Komulainen, M. and Takalo, T. (2011), Does State Street Lead to Europe? The Case of Financial Exchange Innovations. *European Financial Management*, 19(3), pp. 521-557.

Kostylo, J. (2008). Commentary on the Venetian Statute on Industrial Brevets (1474), in Primary Sources on Copyright (1450-1900), *eds L. Bently & M. Kretschmer*, www.copyrighthistory.org

Kuhn, T. (1962). The Structure of Scientific Revolutions. *University of Chicago Press*.

Kumar, P. and Turnbull, S. (2006). Patenting and licensing of financial innovations, *Working paper, July, CT Bauer College of Business, University of Houston*.

Lanjouw, J. and Schankerman, M. (1997). Stylized Facts of Patent Litigation: Value, Scope and Ownership, National Bureau of Economic Research, *NBER Working Paper No. 6297*, Available online: http://www.nber.org/papers/w6297

Lanjouw, J. and Schankerman, M. (2001). Characteristics of patent litigation: A window on competition. *The RAND Journal of Economics*, 32(1), pp. 129–151.

Lanjouw, J. and Schankerman, M. (2004). Protecting Intellectual Property Rights: Are Small Firms Handicapped? *The Journal of Law & Economics*, 47(1), pp. 45-74.

Laub, C. (2006). Software Patenting: Legal Standards in Europe and the US in view of Strategic Limitations of the IP Systems. *The Journal of World Intellectual Property*, 9(3), pp. 344–372.

Layne-Farrar, A. and Lerner, J. (2011). To join or not to join: Examining patent pool participation and rent sharing rules. *International Journal of Industrial Organization*, 29(2), pp. 294-303.

Lazaridis, G. and van Pottelsberghe de la Potterie, B. (2007). The rigour of EPO's patentability criteria: An insight into the "induced withdrawals". *World Patent Information*. 29(4), pp. 317-326.

Lehtovaara, M., Karvonen, M., Kapoor, R., Kässi, T. and Pyrhönen, J. (2014). Major factors contributing to wind power diffusion. *Foresight*, 16(3), pp. 250 – 269.

Lemley, M. (2001). Rational Ignorance at the Patent Office. *Northwestern University Law Review*, 95(4). Available at SSRN: http://ssrn.com/abstract=261400

Lemly, M. and Shapiro, C. (2005). Probabilistic patents. *Journal of Economic Perspectives*, 19(2), pp. 75–98.

Lerner, J. (1994). The Importance of Patent Scope: An Empirical Analysis. *The RAND Journal of Economics*, 25(2), pp. 319-333.

Lerner, J. (1995). Patenting in the Shadow of Competitors. *The Journal of Law & Economics*, 38(2), pp. 463-495.

Lerner, J. (2002), Where Does State Street Lead? A First Look at Finance Patents, 1971 to 2000. *The Journal of Finance*, 57(2), pp. 901–930.

Lerner, J. (2006). The New New Financial Thing: The Origins of Financial Innovations. *Journal of Financial Economics*, 79(2), pp. 223-255.

Lerner, J. (2010). The litigation of financial innovations. *Journal of Law and Economics*, 53(4), pp. 807–831.

Lerner, J. and Tirole, J. (2004). Efficient Patent Pools. *American Economic Review*. 94(3), pp. 691-711.

Levin, R., Klevorick, A., Nelson, R., Winter, S., Gilbert, R., & Griliches, Z. (1987). Appropriating the Returns from Industrial Research and Development. *Brookings Papers on Economic Activity*, 1987(3), 783-831

List, J. (2010). An A to X of patent citations for searching. *World Patent Information* 32(4), pp. 306-312.

Mansfield, E. (1986). Patents and Innovation: An Empirical Study. *Management Science*, 32(2), pp. 173-181.

Merges, R. and Nelson, R. (1990). On the Complex Economics of Patent Scope. *Columbia Law Review*, 90(4), pp. 839-916.

Meurer, M. (1989). The Settlement of Patent Litigation. *The RAND Journal of Economics*, 20(1), pp. 77-91.

Meurer, M. and Bessen, J. (2005). Lessons for Patent Policy from Empirical Research on Patent Litigation. *Lewis & Clark Law Review*, 9(1), pp. 1-27. *Boston Univ. School of Law Working Paper No. 05-22*

Michel, J. and Bettels, B. (2001). Patent citation analysis. A closer look at the basic input data from patent search reports. *Scientometrics* 51(1), pp.185–201.

Nalebuff, B. (1987). Credible pre-trial negotiation. *The RAND Journal of Economics*, 18(2), pp. 198–210.

Narin, F. and Olivastro, D. (2006). Linkage between patents and papers: An interim EPO/US comparison. *Scientometrics*, 41(1-2), pp. 51-59.

Nemet, G. and Johnson, E. (2012). Do important inventions benefit from knowledge originating in other technological domains? *Research Policy*, 41(1), pp. 190-200

OECD, (2005). OECD Science and Technology Policy, 2005, Available online: http://www.oecd.org/sti/sci-tech/35428822.pdf [last accessed: 31.08.2016]

OECD. (2009). OECD Patent Statistics Manual, *OECD Publishing*.

Pakes, A. and Schankerman, M. (1984). The rate of obsolescence of patents, re-search gestation lags, and the private rate of return to research resources. In: Griliches, Z. R&D, Patents, and Productivity. *University of Chicago Press, Chicago*, pp. 73–88.

Pakes, A. (1986). Patents as options: some estimates of the value of holding European patent stocks. *Econometrica*, 54(4), pp. 755–784.

PATSTAT. (2015). Patent Statistical Database, Autumn 2015 Edition.

Peteraf, M. (1993). The cornerstones of competitive advantage: A resource-based view. *Strategic Management Journal*, 14(3), pp. 179–191.

Pitkethly, R. (1997). The valuation of patents: A review of patent valuation methods with consideration of option based methods and the potential for further research. *Oxford Intellectual Property Research Centre*. Available online: http://users.ox.ac.uk/~mast0140/EJWP0599.pdf

Priest, G and Klein, B. (1984). The selection of disputes for litigation. *The Journal of Legal Studies*, 13(1), pp. 1–55.

Putnam, J. (1996). *The value of international patent rights*. Doctoral dissertation. Yale University, New Haven, CT.

Régibeau, P. and Rockett, K. (2010), Innovation cycles and learning at the patent office: Does the early patent get the delay? *The Journal of Industrial Economics*, 58(2), pp. 222–246.

Reitzig, M. (2004). Improving patent valuations for management purposes—validating new indicators by analyzing application rationales. *Research Policy*, 33(6-7), pp. 939-957.

Reitzig, M. and Puranam, P. (2009). Value appropriation as an organizational capability: the case of IP protection through patents. *Strategic Management Journal*, 30(7), pp. 765–789.

Roberts, P.W. and Amit, R. (2003). The dynamics of innovative activity and competitive advantage: the case of Australian retail banking, 1981 to 1995, *Organization Science* 14(2), pp. 107–122.

Rosenberg, N. (1974). Science, Invention and Economic Growth. *The Economic Journal*, 84(333), pp. 90-108.

Sapsalis, E., van Pottelsberghe de la Potterie, B. and Navon, R. (2006). Academic versus industry patenting: An in-depth analysis of what determines patent value. *Research Policy*, 35(10), pp. 1631-1645.

Saunders, M., Lewis, P. and Thornhill, A. (2009). Research methods for business students. *Pearson Publishers*, Fifth Edition.

Scherer, F. (1982). Demand-Pull and Technological Invention: Schmookler Revisted. *The Journal of Industrial Economics*, 30(3), pp. 225-237.

Scherer, F. and Harhoff, D. (2000). Technology policy for a world of skew-distributed outcomes, *Research Policy*, 29(4–5), pp. 559-566

Scotchmer, S. (1991). Standing on the Shoulders of Giants: Cumulative Research and the Patent Law, *Journal of Economic Perspectives*, 1(5), pp. 29-41.

Shapiro, C. (2001). Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting, Book Chapter In: Innovation Policy and the Economy, Volume 1, Edited by: Adam B. Jaffe, Josh Lerner and Scott Stern. *MIT Press*, pp. 118-150.

Shepherd, C. and Challenger, R. (2013), Revisiting Paradigm(s) in Management Research: A Rhetorical Analysis of the Paradigm Wars. *International Journal of Management Reviews*, 15(2), pp. 225–244.

Somaya D. (2003). Strategic determinants of decisions not to settle patent litigation. *Strategic Management Journal* 24(1), pp. 17–38.

Somaya, D. (2012). Patent Strategy and Management: An Integrative Review and Research Agenda, *Journal of Management*, 38(4), pp. 1084-1114.

Sterlacchini, A. (2016). Patent oppositions and opposition outcomes: evidence from domestic appliance companies. *European Journal of Law and Economics*. 41(1), pp 183–203.

Stilgoe, J., Owen, R. and Macnaghten, P. (2013). Developing a framework for responsible innovation, *Research Policy*, 42(9), pp. 1568-1580.

Swanson, K. (2014). The Surprisingly Engrossing History of Patent Examiners. *History of Innovation. Web based resource,* Available online: http://www.slate.com/blogs/browbeat/2016/10/27/the_charlie_and_lola_halloween_special_and_it_s_the_great_pumpkin_charlie.html

Teece, D. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15(6), pp. 285-305.

Trajtenberg, M. (1990). A Penny for Your Quotes: Patent Citations and the Value of Innovations, *RAND Journal of Economics*, 21(1), pp. 172-187.

van de Kuilen, A. (2013). Successful European oppositions: Analysis for the patent information professional. *World Patent Information*, 35(2), pp. 126-129.

Van Pottelsberghe de la Potterie, B. (2011), The quality factor in patent systems, *Industrial and Corporate Change*, 20(6), pp. 1755-1793.

van Zeebroeck, N. and van Pottelsberghe, B. and Guellec, D. (2009). Claiming more: The increased voluminosity of patent applications and its determinants. *Research Policy*, 38(6), pp. 1006–1020.

van Zeebroeck, N. and van Pottelsberghe, B. (2011a). The vulnerability of patent value determinants. *Economics of Innovation and New Technology*, 20(3), pp. 283-308.

van Zeebroeck, N. and van Pottelsberghe, B. (2011b). Filing strategies and patent value. *Economics of Innovation and New Technology*, 20(6), pp. 539-561.

Veefkind, V., Hurtado-Albir, J., Angelucci, S., Karachalios, K. and Thumm, N. (2012). A New EPO classification scheme for climate change mitigation technologies. *World Patent Information*, 34(2), pp. 106–111.

Webb, C., Dernis, H., Harhoff, D. and Hoisl, K. (2005). Analysing European and international patent citations: a set of EPO patent database building blocks. *OECD STI Working Paper 2005/9*, OECD Publishing.

Wen, W., Ceccagnoli, M., Forman, C. (Forthcoming). Opening up IP Strategy: Implications for Open Source Software Entry by Start-Up Firms. *Management Science*.

WIPO. (2009). Patent-based technology analysis report - alternative energy. World Intellectual Property Organization. Last Accessed: 27.10.2016, Available Online: http://www.wipo.int/export/sites/www/patentscope/en/programs/patent_landscapes/documents/landscape_alternative_energy.pdf

WIPO, 2009, internet document, available online: http://www.wipo.int/export/sites/www/wipo_magazine/en/pdf/2010/wipo_pub_121_2010_01.pdf, last accessed: 11.04.2016

Appendix A: Sample search report

Europäisches Patentamt
European Patent Office
Office européen des brevets

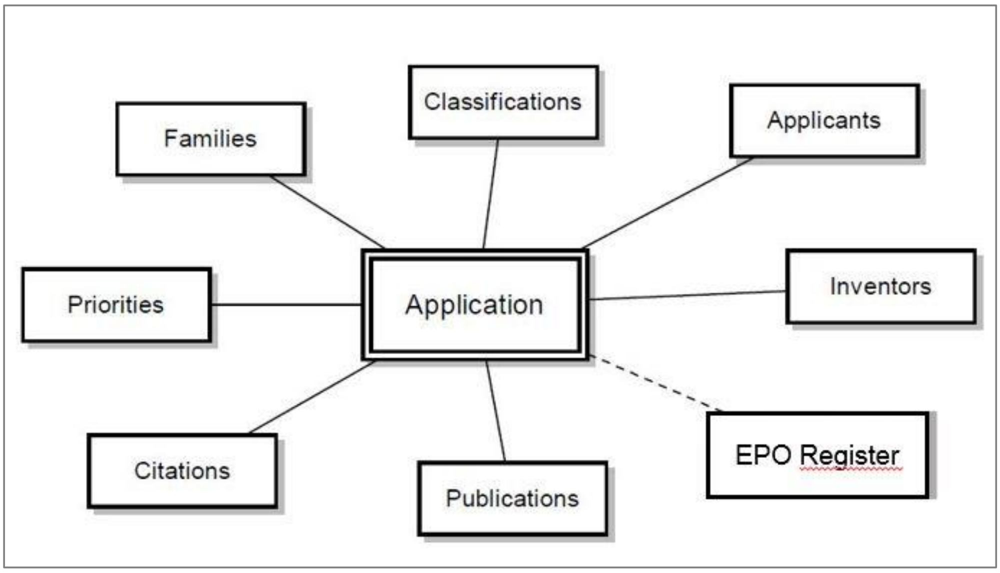
EUROPEAN SEARCH REPORT

Application Number
EP 14 18 1068

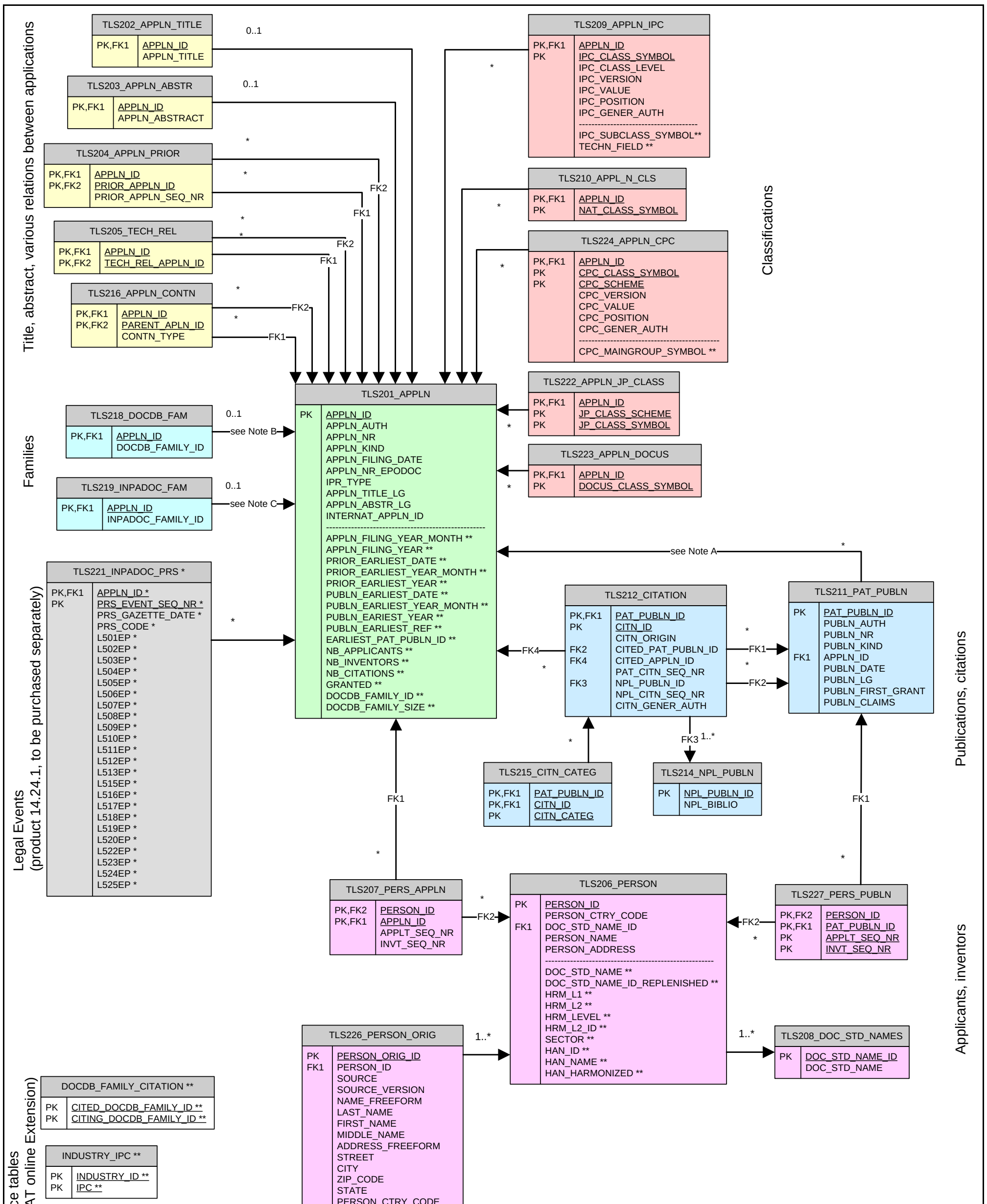
DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 146 090 A2 (REPOWER SYSTEMS AG [DE] REPOWER SYSTEMS SE [DE]) 20 January 2010 (2010-01-20)	1,4-6,8	INV. B66C23/20 F03D1/00
Y	* the whole document * -----	2	
A	EP 2 147 885 A1 (GEN ELECTRIC [US]) 27 January 2010 (2010-01-27) * abstract; figures * -----	1,4,6-9	
Y	WO 2005/031159 A1 (NEG MICON AS [DK]; PEDERSEN BJARNE [DK]) 7 April 2005 (2005-04-07)	2	
A	* abstract; figures * -----	1,4,6-9	

Appendix B: PATSTAT basic model



Appendix C: PATSTAT detailed model



Key for tables and column names:

* **Product 14.24.1: Worldwide Legal Status** (to be purchased separately)

** **PATSTAT online Extension only** see http://www.epo.org/searching/subscription/patstat-online.html

Part II

Publication I

Kapoor, R., Karvonen, M., and Kässi, T.

Patent value indicators as proxy for commercial value of inventions

International Journal of Intellectual Property Management
Vol. 6, Issue 3, pp. 217-232, 2013

Patent value indicators as proxy for commercial value of inventions

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Abstract: This paper presents a theoretical analysis of patent value as perceived by different stakeholders in the innovation lifecycle. Data is collected using semi-structured interviews with inventors, technology transfer personnel, patent attorneys, consultants and examiners. Views are presented for the most common patent value indicators. A value indicator framework is developed for different stages in the patenting procedure. The paper contributes to a better understanding of value determinants' impact on the value of patent rights. Results indicate that different value indicators are perceived differently by various stakeholders. More robust indicators can be developed by combining market data and customer knowledge.

Keywords: patent value indicators; patent value; patent valuation; patent research.

Reference to this paper should be made as follows: Kapoor, R., Karvonen, M. and Kässi, T. (2013) 'Patent value indicators as proxy for commercial value of inventions', *Int. J. Intellectual Property Management*, Vol. 6, No. 3, pp.217–232.

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Tuomo Kässi holds an MSc in Technical Physics and in Economics. He wrote his doctoral thesis in industrial engineering and management. He has worked in research and development, sales, marketing and as director of machinery production and consultant in industry for 25 years before entering his academic career. His research interests are in technology management, innovation and strategy.

1 Introduction

Patent statistics is an active area of research which has produced myriad patent-based value indicators. From the traditional citation-based indicators (Hall et al., 2001; Trajtenberg et al., 1997) to the more recent indicators based on litigation data (Graham et al., 2002; Harhoff et al., 2003; Reitzig, 2004), the field continues to evolve. 'Value' can bear different definitions depending on the perspectives of various stakeholders. Researchers can be interested in the science and technology potential of an invention, while a technology manager might be interested in how much licensing income the invention can generate. Top managers may see value lying in the expansion possibilities which an invention can bring, while lawyers and patent strategists may find value in how damaging a patent can be to a competitor. The actual value of a patent in monetary terms is known only when a patent right is sold, licensed or litigated with damages.

The term 'patent value' has several different meanings as well. Trajtenberg (1990) draws a clear distinction between private and social value of inventions. The social value represents the total net value created by the patent for social welfare. The concept of private value takes into account value added for the owner, and is defined as the discounted flows of revenue generated by the patent over its lifetime. Zeebroeck and Pottelsberghe de la Potterie (2011) highlight the conceptual difference between determinants and indicators of patent value. One should distinguish between the value of a patent itself and the value of the underlying invention. In the literature three main lines of work have been followed by researchers to estimate the 'private' economic value of patents (OECD, 2009):

1 surveys asking inventors (owners) about the economic value of their patents (e.g., Scherer et al., 2000)

2 analysing bibliographic data from the patenting procedure

3 estimating value from market and financial data (Chen and Chang, 2010; Hall et al., 2005).

The second approach attempts to cast light on patent value by using patent information provided by bibliographic sources (publications, search reports, opposition, etc.) which can be correlated with the value of patents. This approach has frequently been combined with the first and third approaches to validate the versatility of an indicator in determining value. Studies have proven the validity of statistical patent value indicators in retrospection rather than for prediction. For example, studies have used the price of patents, value given by the inventor (Gambardella et al., 2008) or auction prices of buyers (Mathew et al., 2012; Nair and Mathew, 2012), and then compared patent characteristics to validate the patent value indicators. Our analysis found out that while these indicators might be associated with the actual patent value in retrospect, they have little predictive power when the patent is new or unproven.

Another highlight of the second approach is the macroscopic treatment associated with the patent data. These value indicators are significantly correlated to the market value of firms holding patent stocks (Hall et al., 2005). However, when applied at the individual patent level (Gambardella et al., 2008), it was found that the overall impact of these indicators was small, thus leaving a large scope in refining traditional patent value indicators and developing new ones. The interviews have been an attempt to bring a micro level perspective to the notion of patent value indicators. The respondents present some idiosyncrasies based on the nature of work they are involved with.

This study regards the valuable contribution of the patent statistics literature, and pits them against the ideas of various stakeholders involved in the patenting process. The main purpose of this paper is to understand the views of various stakeholders in the innovation lifecycle regarding commonly used patent value indicators. The views presented were also used to develop a framework to identify value determinants during the initial stages of the patent lifecycle. The framework contains all the market-based indicators which can complement the patent-based indicators depending on the innovation stage. This area of work is largely still at the research stage, and many of the value determinants reported here are being debated among experts.

The remainder of the paper is divided thus: Section 2 summarises the existing literature on patent value indicators. Section 3 illustrates the methodology and information about the experts interviewed. The results are presented in Section 4 followed by an analysis of results in Section 5. Section 6 concludes and lays down areas for future research.

2 Patent value literature

Patent data has been historically used in determining technology change (Griliches, 1990). Multiple studies have used patent data along with market value of firms and R&D expenditures to develop innovation efficiency indicators (Griliches, 1981; Hall et al., 2005; Pakes, 1985). Studies have also suggested inconsistencies in traditional patent value determinants (Zeebroeck and Pottelsberghe de la Potterie, 2011) along with findings on what part of patent value can be determined by the most common value indicators (Baron and Declamp, 2010; Czarnitzki et al., 2011; Gambardella et al., 2008). These have been supplemented by Hagedoorn and Cloodt (2003), who encourage the use of multiple patent value indicators to determine patent value.

Patents which receive more citations than the average are more likely to be renewed (Putnam, 1996). Fallah et al. (2011) propose that early forward citations can lead to future citations in the patent lifespan. Subtle nuances of the examination process have been highlighted by Harhoff and Wagner (2009) and also in the results section of this article. The references which go into the search report and eventually in the published application are controlled by the examiner and can give useful insights into the value potential of an application.

A set of patents filed in several countries which are related to each other and protect the same invention is generally known as a patent family. It has been shown (Lanjouw, 1998; Putnam, 1996) that the size of a patent family, measured as the number of jurisdictions in which a patent grant has been sought, and the survival span of patents, i.e., the time from application to non-renewal or expiration, are highly correlated. This can be explained by the fact that obtaining and maintaining a larger patent family is more expensive. Organisations looking to maintain large patent families in different jurisdictions must associate a greater commercial value to their patents. One drawback of using patent families is the timeliness of the data in question. For United States Patents and Trademarks Office (USPTO) the average time between application and grant of a patent is 35 months, but can reach 44 months. This means that complete statistics on patent families is not available until three years of the date of interest.

Each granted patent is technically classified by specific technology areas of the invention. It is a hierarchical way of assigning the category to which a patent belongs and is known as international patent classification (IPC) classes. Number of IPC classes attributed to a patent application has been used as a proxy for the scope, and hence the market value of a patent (Lerner, 1994). It has also been argued in the literature that IPC classes have little or no association with the value of the patent rights (Harhoff et al., 2003; Lanjouw and Schankerman, 1997).

According to Lanjouw and Schankerman (1998), more valuable patents belonging to the same technology area are more likely to be involved in litigation. In addition, new technology areas were more active in litigation and that corporate patents are more likely to be involved in litigation than individually owned patents. It was also conclusively proven by Harhoff et al. (2003) that litigated patents have a higher than average value and patents which survived opposition were particularly high in value.

Table 1 Main value indicators

Indicator	*Rationale*	*Main limitations*
Patent grant	Limited legal protection if not granted	Not very informative (large share: about 60% of patent applications are granted); USPTO: 95% are granted.
Forward citations	Technological importance; impact on further technology developments.	Timeliness (availability over time), interpretation
Backward citations	Extent to which the patent makes use of the existing prior art	Cannot explain technical value from social value
Number of claims	Breadth of the technology claimed by the patent holder	Can be used more to explain about the invention than enhancing scope.
Family size	Costly to have protection in different jurisdictions; sign of market potential of an invention	Representatives issues; large share of patent applications are international

Source: Adapted from Baron and Delcamp (2012), OECD (2009) and Neuhäusler et al. (2011)

Table 1 Main value indicators (continued)

Indicator	*Rationale*	*Main limitations*
Number of inventors	Proxy the cost of an invention (cost of research)	Rough measure which treats inventors equally; need for complementary information of the inventors.
Generality (dispersion of cited patents over technology classes)	Patent has an impact in a wide range of technological fields.	Highly dependent on the classification system and varies in consistency between patent offices.
Originality (dispersion of citing patents over technology classes)	Invention learns from a broad set of technologies making it more likely to be patented.	Highly dependent on the classification system and varies in consistency between patent offices.
Renewals	Increasing cost of maintaining a patent	Timeliness, influence of technology life cycles, renewal rates different across technologies.
Opposition	Market value of a patent. Costs and risks associated with legal disputes.	Timeliness, very small share (about 5% in EPO); how to detect mutual settlements.
Litigation	Costs and risks associated with legal disputes.	Timeliness, very small share, friendly settlements are frequent, data availability.

Source: Adapted from Baron and Delcamp (2012), OECD (2009) and Neuhäusler et al. (2011)

Some authors have used the probability of getting a patent granted (Guellec and Pottelsberghe de la Potterie, 2000), while others have relied on whether the patents have churned out high-tech start-ups (Shane, 2001). Furthermore, there are studies which have regarded the accelerated examination request by applicants (Reitzig, 2004). In the process, we observed that less attention has been paid to value patents early in their life, albeit for rational reasons related to data availability. The macroscopic view also dismissed subtle nuances related to the patenting system and contextual inconsistencies. In wake of the skewness in the value of patents and the mixed performance of various indicators in determining value; this paper intends to contribute to the debate on patent value indicators by systematically comparing different stakeholder view to value determinants in the literature. Table 1 presents the most common value indicators along with their rationale and limitations.

3 Data collection and methodology

The data for the research is collected using eleven semi-structured interviews in Finland. The participants belonged to five categories in the innovation lifecycle:

1 inventors (academic and R&D)

2 technology transfer office (TTO) personnel

3 patent consultants

4 patent attorneys (PAs)

5 patent examiners.

All participants were senior professionals in their respective fields and have dealt with in numerous patent applications in their careers. The structured part of the interview included views regarding traditional patent value indicators like forward citations, backward citations, patent family size, number of claims, IPC, renewals and opposition proceedings. The unstructured part included thoughts and opinions based on the individual nature of work of the participants. The interview time ranged between 60 and 145 minutes with an average length of 80 minutes per interview. Interviewee designation along with their level of experiences is tabulated below (Table 2).

Table 2 Interviewee information

Serial	*Designation*	*Category*	*Years of experience*
1	Professor, Lappeenranta University of Technology	Inventor	More than 20 years
2	Professor, Lappeenranta University of Technology	Inventor	More than 30 years
3	R&D manager, industrial firm	Inventor	More than 20 years
4	Project coordinator, Lappeenranta University of Technology	Technology transfer professional	More than 10 years
5	Development personnel, Foundation for Finnish Inventions	Technology transfer professional	More than 10 years
6	Former director, National Board of Patents and Registration of Finland	Patent consultant	More than 30 years
7	Private technology consultant	Patent consultant	More than 20 years
8	PA, software	PA	More than 10 years
9	IPR specialist, independent	PA	Less than 10 years
10	Senior patent examiner, National Board of Patents and Registration of Finland	Patent examiner	Less than 10 years
11	IP communication specialist, National Board of Patents and Registration of Finland	Patent examiner	More than 10 years

The methodology follows a deductive approach which makes use of existing literature in the field of patent value indicators and then regards views of different stakeholders in the innovation lifecycle. In quantitative studies, the most frequently used determinants are the number of forward patent citations, the number of backward patent citations, and the geographical scope for protection (Sapsalis et al., 2006). We considered these along with concepts of opposition procedures, number of claims and IPC classification to be the most common indicators in the literature. The interview results are condensed into the views related to patent value indicators in the results section.

4 Results and analysis

4.1 Respondent work profiles

4.1.1 Inventors

Inventors in academia and industry present a different notion towards intellectual property. Companies have a professional way of dealing with intellectual property through their patent departments. The patent departments handle most of the interaction with PAs and devising a strategy for IP. Universities do not have a proven setup for the same.

The university inventors worked on projects funded by government grants or by industry collaborations. While, almost all inventions based on industry funded research are utilised, the same was not the case for free research. Sometimes, if an invention is not taken seriously due to lack of prospective customers, the researcher forgets about it and moves on to something else. As far as value is concerned, at this stage the inventor is not very analytical about the value of the invention. The invention comes from a certain need. The inventors are in discussions with the customers and somehow the knowledge accumulates and we have a hunch that there is potential.

4.1.2 TTO personnel

The main task of TTO personnel is to screen research activities and exploit potential opportunities. The respondents we interviewed were taking care of university-based inventions. The university TT professionals research markets and look for incubators in an early stage. Patent is not applied for if there are no interested customers due to lack of funds. The range of negotiation in patent value is very large due to the scarcity of information in the early stages of an invention. In their observation, inventors have an unrealistic picture of their own invention and have a tendency to overestimate the value potential.

> "… Earlier our focus was to see whether the idea is patentable, but nowadays, we are turning our focus toward identifying business potential …"

4.1.3 Patent attorneys

The most important deliverable for a PA is the drafting of patent claims along with novelty searches. In terms of patent value, they believe that it is only the text of the claims which matters. In their view, if matters have to be settled in the court, the decisions are made solely on the scope of the patent right as delineated by the text of the claims.

4.1.4 Patent examiners

Examiners work independently in the Finnish Patent Office. The head of department checks the initial invention as it arrives and assigns an examiner based on an internal classification system. Examiners have access to patent databases which are more updated than the ones available to PAs and other patent professionals. This gives them an edge in making prior art searches. The examiners claimed that backlogs do not affect the quality of the examination process in Finland. They give the same amount of time and effort, irrespective of the backlog situation. Based on the backlog situation, the examiners sometimes concentrate on national phase patents and sometimes on PCT patents. In Finland, there are no priority-based examinations or green channels for accelerating the examination process. Discussion between the inventors or their representative PAs with the patent examiners is usually done through e-mail. The examiners need to have everything documented in case of future problems. Face to face meetings are rare between the applicants and the examiners. With various exceptions, it usually takes ten months to get the first office action from the Finnish Patent Office. In examiners' view, a lot can be said about the value of a patent based on the history of the applicant. Small inventors usually take on the National route in Finland.

The examination process is crucial from the point of view of patent statisticians. Discrepancies and non-standard processes in the examination processes can lead to publication of inconsistent data in the patent databases. Our findings regarding the examination process revealed that the Finnish patent office is very standardised in its processes and has strict quality controls. Patent consultants highlighted that this may not be the case in some other countries where examiners do not have as much independence as Finland. There may also be less strict quality checks which could result in discrepancies in assigning literature, IPC, citation categories, etc.

4.1.5 Patent consultants

Patent consultants hold a more strategic view of the patenting procedure. They help clients in advising about the patenting route and strategy with respect to timeline and international applications. In their view, a good PA can add extra value to the patent application with experience in the art of drafting claims. It is possible to ruin a good invention by poorly drafting claims, so choice of PA is important in filing a patent. PAs can also work with the inventor to explain who the early stage buyers can be for the given technology. Stetson method[1] has been used occasionally in arriving at a certain cost for a patent.

Consultants' view regarded buyers' ability and willingness to pay for an invention the sole determinant of patent value during sale.

4.2 Outlook of various experts related to the most common patent value indicators

4.2.1 Citations

At the stage of patent filing there can be some analysis done based on the references provided by the applicants or their PAs. The interviews revealed that more applicants and their PAs refrain from citing any prior art at the time of filing the patent.

From the experiences of a PA it is difficult to assess value based on the prior art submitted by the applicant.

> "…Traditionally there were more citations submitted by the applicant during patent filing. Nowadays, more and more clients do not want any references in their patent applications. It is not possible to distinguish patent value based on whether the applicant submits prior art or not. Sometimes, prior art given by an applicant is incorrect prior art…"

Backward citations, as a patent value indicator can be useful only after the examiner makes the search report available. In USPTO, the applicants are obliged to disclose any prior art believed to be relevant to the invention as a duty of candor (OECD, 2009). It has been found that the examiners still did most of the work related to prior art by supplementing or completely modifying the list of prior art given by the applicant (Alacer et al., 2009). Patents have also been granted by the USPTO which had no prior art submitted by the applicant.

Participants who were acquainted with the concept of citation categories had contrasting opinions regarding the same. We asked them to shed light on three main citation categories, namely, X, Y and A. Related documents assigned X in the search report indicate a clear similarity between the claimed invention and the cited document's contents. Y refers to documents which can be combined by a person skilled in the art to develop a concept as claimed by the patent applicant. Documents ascribed A refer to records which define the state of the art but no aspect of the document can challenge the claimed invention. Appendix A carries the definition of less used citation categories as well as the main categories X, Y and A (OECD, 2009). The examiners conceded that there can be difference of opinion among them in assigning a citation category. Sometimes, applications might come from the EPO or another priority country where the search report is already made by another examiner.

The examiners do not start from scratch in these cases and mostly supplement the records from previous search reports. The views of examiners in estimating citation categories as representative of patent value are interesting.

> "…It [patent] might be very limited on technical part if you have X's and Y's, but maybe it is good for doing business. Value still depends on the markets. The nature of citations is more important than the amount of them… If you have a lot of A's then it can mean that you are in a new territory. It may be the case that there is no point of inventing in this region as there is no market. So even if you find a tiny place in the existing scope of invention coverage (more X's and Y's) it can mean more value."

PA's view dismissed citation categories to bear any association with patent value. The categories provided by the examiner in the search report are meant to be a reference to the applicant to suitably modify the nature of claims. The documents cited in the search report are not necessarily the ones which will be eventually cited in the patent application. The nature of categories is not very important post grant.

Forward citation was considered a strong indicator of potential value by only one of the eleven respondents. Patent examiners are of the opinion that a patent with a large number of citations from future patents can be a very 'interesting' patent but not necessarily valuable. Technology transfer professionals dismissed forward citations as an academic concept and they do not think buyers are interested in it for making purchase decisions. The proponents of forward citation as a patent value indicator upheld that it is an indicator of value as it will be difficult for the competitor to fight against the original patent. Patent thickets are made in this way to achieve a slice of cake of a certain technology field.

> "…The original invention is the same and there is small change in different patent applications in different countries making it hard for the competitors to break through the type of claims…"

4.2.2 Patent family size

The respondents maintained their reservations for contextual inconsistencies, but overall agreed that a larger family size can make a patent more valuable in the same technology field. Technology transfer personnel and patent consultants admitted that the process of finding a buyer starts quite early in the patent lifecycle and generally the family size cannot grow much by that time. The buyers also would like to purchase the rights when there is still chance to choose the countries of interest in furthering the application. This is a stage where both buyer and seller face a trade-off. If the buyer is willing to buy the technology at this stage, it would mean that he/she really wants it despite the fact that the patent is not granted and hence not valid at the particular stage. If the buyer is unsure about the invention, he/she will insist that the transaction be made only when the patent is granted leaving the seller to make the necessary payments related to furthering the foreign applications.

The choice of markets was considered more important by the respondents. R&D managers' view considered patenting in China risky. They thought that extending the patent to China can even reduce value as there is not appropriate protection guaranteed there. There is a risk of divulging too much information at an early stage. Somehow, the choice of countries should be associated with the market potential of the countries.

4.2.3 Number of claims

There was near unanimous agreement among the participants that number of claims was not as important as their text.

> "…In most cases however, it is not possible to have a broad scope with just one claim and so the number of claims do have an impact on patent value and its final chances to survive opposition. With more claims, there may be cases when you lose one of the claims to the examiner but the rest remain. Strength of the claim is more important than the number of claims…"

Two interviewees however thought that it could be used as a small proxy for strengthening negotiations related to IP sale. The responses emphasised a few notable things. Having a high number of independent claims can broaden the scope of an invention. The dependent claims are, however, only descriptive and are more about understanding the invention than defining its scope. Another revelation was that the applicants are increasingly encouraged by patent examiners, consultants and attorneys to apply multiple patents with the same invention rather than having one broad patent with too many claims. Examiners and attorneys maintained that there is a shift from complicated claims in the past to conciseness and quality. In view of patent consultants, the value of a patent can be determined based on whether it has been drafted by a competent PA.

4.2.4 Litigation

Previous research has used an assumption that litigation is an expensive proposition which makes it rare and parties indulging in it have faith in the value of the invention in question. Our results proved to differ from the above logic in three different ways. The first view from the university technology transfer office suggests that if a patent has been challenged, it is harder to sell as the buyer might be careful regarding future litigation.

Patent consultants and examiners highlighted the second view, that of litigation being standard practice in certain industries. In such cases, a formal value is not analysed before opposing a patent. Finally, the examiners went on to add that litigation may not always be an expensive proposition for the plaintiff. It is one way to make money by means of extracting licensing fees from the defendant for possible overlap with the plaintiff's claims.

> "…It is also that patents are opposed post grant and not post publication. This is to ensure that the litigant cannot modify the claims which satisfy the opposition…"

Counter arguments related to litigation as a value indicator came from PAs who maintained that opposition is a standard procedure in certain industries. They also held a view that shorter technology lifecycle time correlated to the number of instances of opposition. If the technology lifecycle time is short, for example in the software industry, the technology is already old by the time the patent is granted. This leads to fewer cases of opposition and correspondingly more instances of cross-licensing in the software industry.

The inventors did not have any concrete opinions about opposition as a proxy for patent value due to lack of involvement with the litigation process. Only one patent consultant regarded patents which have survived opposition to be the ultimate test of value.

4.2.5 International patent classifications

It was largely accepted by the respondents, with minor variations, that a varied IPC can enlarge the scope of a patent. Patent consultants preferred to know 'which' IPC classes along with the number of IPC classes. PAs and technology transfer professionals viewed the main IPC section as important and the subclasses not so important (see Appendix), i.e., the number of first digit IPC codes can be more important than more number of four digit IPC classes. Combining two traditional fields increased value for an invention. Patent examiners, however, reserved their doubts regarding number of IPC classes being an indicator of patent value.

> "…If there is a window fastener which can be used in different industries, then IPC is just based on the fastening system. The IPC is assigned for the technology area and not on the number of markets it can be used. The class is there but it does not define the scope of market use."

It was also found through patent consultants and examiners that IPC classification depended a lot on the idiosyncrasies of the patent examiners. Some patent examiners usually assigned more than one IPC class as a reference for another person viewing the application on where to look further and find more information.

4.3 Inferred value determinants during different stages

The value determinants which surfaced during the interviews are tabulated below (Table 3) as patent-based and market-based. The market-based indicators act as complementary indicators to the patent-based indicators. This framework can be used for determining patent value during different stages in the innovation lifecycle.

Table 3 Value determinants during various stages

Innovation stage	*Value indicators*			
	Patent-based		*Market-based*	
Idea			1	Market potential
Invention announcement			1	Market reports
			2	Theoretical estimate
Discussion about patentability	1	Preliminary novelty search	1	No. of competitors
			2	Potential market size
			3	No. of alternate solutions
			4	No. of patents possible to infringe
			5	No. of products patent can be applied
Patent application (priority filing)	1	Patenting route	1	Experience of patent attorney
	2	Applicant references (if any)	2	Past success of applicant
	3	No. of independent claims.	3	Working prototype
	4	Text of claims		
	5	History of success of applicant		
Foreign filing (12 months)	1	Family size	1	Countries chosen
Search report	1	Citation categories (fewer X's, Y's more A's)	1	Likelihood of grant: examiners comments
	2	Initial no. of IPC fields		
	3	No. of claims found novel or carrying inventive step		
Publication (18 months)	1	No. of claims		
	2	No. of backward citations		
	3	Text of claims		
	4	Citation categories		
	5	No. of IPC		
	6	No. of IPC of backward citations		
Opposition (if any)	1	Opposition event raised		
	2	Opposition survival		
Grant	1	Forward citations	1	Readiness of invention for commercial purposes

5 Discussion

The perspectives which came forward during the interviews had a lot to do with the daily scope of work of individuals. For example, inventors and technology transfer personnel had little interest toward forward citation as an indicator as they never had to deal with inventions which had reached a stage post-grant and multiple renewals (in most cases). PAs displayed an excessive attachment to claims as it was part of their most important work profile. Examiners, with their technical expertise and experience with handling many patent applications, were best placed to evaluate both the technical as well as commercial aspect of a patent. They were appreciative of the various indicators churned out by academic research but were equally dismissive of them at the time of contextual inconsistencies. Patent consultants showed shrewdness in aspects related to patenting strategy. They were adept at knowledge related to quickness of office action in various patent offices, patenting fees, patent trolls and prospective buyers.

The views related to patent value indicators were tabulated (Table 4) to find out which indicators were considered to be more associated to patent value. We assigned 0 (zero) if the interviewee thought the indicator had no predicting ability in determining patent value, 1 (one) if a mild ability to predict value was understood and 2 (two) if the indicator was thought to determine patent value strongly. For cases where there was no certain reply or the interviewee did not know about the value indicator, we assigned (--).

Table 4 Summarised weighted opinions

Value indicator	*Ability to predict value (0 – none, 1 – mild, 2 – strong)*												
	IN	*IN*	*IN*	*TT*	*TT*	*PA*	*PA*	*PC*	*PV*	*PE*	*PE*	*Sum*	*Mean*
Forward citations	--	--	1	0	--	1	0	1	2	1	1	7	0.88
Backward citations	--	--	0	0	--	--	0	--	2	--	--	2	0.50
Citation categories	--	--	--	--	--	--	0	--	--	1	0	1	0.33
Number of claims	0	--	1	1	--	0	0	1	1	0	0	4	0.44
Family size	1	--	0	2	--	2	1	2	2	--	2	*12*	*1.50*
IPC	0	--	--	--	--	0	1	1	1	0	0	3	0.43
Litigation	--	--	0	1	--	2	1	1	2	1	2	*10*	*1.25*
Patenting route	--	--	--	2	--	--	--	1	2	1	2	*8*	*1.60*
Renewal	--	--	0	0	--	1	--	1	--	--	2	4	0.80

The overall view seemed to consider family size, litigation and patenting route as the most important indicators of patent value. Forward citations and renewals generated mild interest among the interviewees and the rest were not considered important in patent valuation. Zeebroeck and Pottelsberghe de la Potterie (2011) revealed that forward citations, family size, opposition and renewals are the four patent value indicators which have been consistently found to be positively associated with patent value. In the same study, it was found that the literature has proven filing strategies (in our case patenting route) to be among the most stable determinants of patent value. In this regard, our results conform to the findings of existing literature.

6 Conclusions and future work

The results highlighted a few untouched loopholes in the most commonly used value indicators. For example, litigation is a standard procedure in the battle of IPR amongst corporate giants. This puts into question the very fact that it is not always the more valuable patents which are challenged. Stakeholder views were delineated for a better idea about what goes on in their work profile and how they regard the academic patent value indicators. Table 3 features some complementary non-patent-based indicators during different stages of the patenting process which can be used along with patent-based indicators to get more authentic results from future research. The micro level view of the patent value indicators can refine the results from macro level statistical research. We also tried to highlight the role of examiners in the patenting process and how variations in the examination philosophy of different patent offices can lead to noise in statistical research.

The overall findings revealed a mild aversion towards the traditional patent value indicators as proxies for economic value of patents. The results contribute to the existing state of the art in the field of patent value indicators. A framework of patent value indicators in the context of the innovation stage is presented which can be used effectively to evaluate patent applications. The emphasis has been in determining patent value for relatively new patents and some new indicators are cited for the same. The use of traditional patent value indicators as determinants of patent cost is still questionable. One PA summarised the idea of patent valuation.

> "…you need a patent attorney for reading the claims and a financial manager who understands the business area to estimate the value of patents."

It is to be noted that the valuation of patents filed and patents granted are very different in nature. If a patent has reached grant stage, it can be said that the picture is a lot clearer than a patent still in the application stage. The inventor would already have figured out the commercial use of the new technology or would have possibly agreed upon transfer rights with a potential customer.

6.1 Future research scope

Since valuation deals with forecasting the future, some speculative assumptions are inevitable in estimating value. Any new indicators or combination of indicators will be welcome as long as they enable a better understanding of the situation, and thus patent value. Novel methods of combining market forecast data with fresh patents data can also improve our understanding of industry trends (Kapoor et al., 2012). Future research can be aimed at addressing the issue of combining the patent value indicators with economic and financial data to generate accurate estimates of patent value. The commonly used patent value indicators are still only good for relative valuation of patent stocks. Text of claims came out to be an important indicator from the experts. More text mining-based analysis can churn out useful indicators in the domain. The most important industry methods to evaluate individual patents are based on cost, income and market approaches (Pitkethly, 1997). There is a need to merge the traditional indicators with economic methods for the valuation of individual patents.

References

Alacer, J., Gittelman, M. and Sampat, B. (2009) 'Applicant and examiner citations in U.S. patents: an overview and analysis', *Research Policy*, Vol. 38, No. 2, pp.415–427.

Baron, J. and Delcamp, H. (2010) *Patent Quality and Value in Discrete and Cumulative Innovation*, pp.1–30, Cerna Working Paper Series, MINES ParisTech.

Baron, J. and Delcamp, H. (2012) 'The private and social value of patents in discrete and cumulative innovation', *Scientometrics*, Vol. 90, No. 2, pp.581–606.

Chen, Y. and Chang, K. (2010) 'The relationship between a firm's patent quality and its market value – the case of US pharmaceutical industry', *Technological Forecasting and Social Change*, Vol. 77, No. 1, pp.20–33.

Czarnitzki, D., Hussinger, K. and Leten, B. (2011) *The Market Value of Blocking Patent Citations*, ZEW – Centre for European Economic Research Discussion Paper No. 11-02.

Fallah, M.H., Fishman, E. and Reilly, R.R. (2011) 'Forward patent citations as predictors of patent valuation', *International Journal of Intellectual Property Management*, Vol. 4, No. 3, pp.165–178.

Gambardella, A., Harhoff, D. and Verspagen, B. (2008) 'The value of European patents', *European Management Review*, Vol. 5, No. 2, pp.69–84.

Graham, S.J.H., Hall, B.H., Harhoff, D. and Mowery, D.C. (2002) *Post-Issue Patent Quality Control: A Comparative Study of US Patent Re-examinations and European Patent Oppositions*, NBER Working Paper 8807, National Bureau of Economic Research, Inc.

Griliches, Z. (1981) 'Market value, R&D and patents', *Economics Letters*, Vol. 7, No. 2, pp.183–187.

Griliches, Z. (1990) *Patent Statistics as Economic Indicators: A Survey*, NBER Working Paper Part I.

Guellec, D. and Pottelsberghe de la Potterie, B. (2000) 'Applications, grants and the value of patents', *Economics Letters*, Vol. 69, No. 1, pp.109–114.

Hagedoorn, J. and Cloodt, M. (2003) 'Measuring innovative performance: is there an advantage in using multiple indicators?', *Research Policy*, Vol. 32, No. 8, pp.1365–1379.

Hall, B.H., Jaffe, A. and Trajtenberg, M. (2001) *Market Value and Patent Citations: A First Look*, Economics Department Working Paper E00-277, University of California.

Hall, B.H., Jaffe, A.B. and Trajtenberg, M. (2005) 'Market value and patent citations', *RAND Journal of Economics*, Vol. 36, No. 1, pp.16–38.

Harhoff, D. and Wagner, S (2009) 'The duration of patent examination at the European Patent Office', *Management Science*, Vol. 55, No. 12, pp.1969–1984.

Harhoff, D., Scherer, F.M. and Vopel, K. (2003) 'Citations, family size, opposition and the value of patent rights', *Research Policy*, Vol. 32, No. 8, pp.1343–1363.

Kapoor, R., Karvonen, M., Lehtovaara, M. and Kässi, T (2012) 'Patent value indicators: case of emerging wind energy markets', *Technology Management for Emerging Technologies (PICMET), Proceedings of PICMET '12*.

Lanjouw, J.O. (1998) 'Patent protection in the shadow of infringement: simulation estimations of patent value', *Review of Economic Studies*, Vol. 65, No. 4, pp.671–710.

Lanjouw, J.O. and Schankerman, M. (1997) *Stylized Facts of Patent Litigation: Value, Scope and Ownership*, NBER Working Paper Series, NBER, Cambridge, MA.

Lanjouw, J.O. and Schankerman, M. (1998) *Patent Suits: Do They Distort Research Incentives?*, Centre for Economic Policy Research, London, CEPR Working Paper Series, No. 2042.

Lerner, J. (1994) 'The importance of patent scope: an empirical analysis', *RAND Journal of Economics*, Vol. 25, No. 2, pp.319–333.

Mathew, M., Mukhopadhyay, C., Raju, D. and Nag, D. (2012) 'An analysis of patent pricing', *Decision*, Vol. 39, No. 1, pp.28–39.

Nair, S.S. and Mathew, M. (2012) 'The dynamics between forward citations and price of singleton patents', *Technology Management for Emerging Technologies (PICMET), Proceedings of PICMET '12*.

Neuhäusler, P., Frietsch, R., Schubert, T. and Blind, K. (2011) *Patents and Financial Performance of Firms – An Analysis Based on Stock Market Data*, Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis No. 28.

OECD (2009) *OECD Patent Statistics Manua*.

Pakes, A. (1985) *Patents, R and D, and the Stock Market Rate of Return*, NBER Working Paper No. 786.

Pitkethly, R. (1997) *The Valuation of Patents: A Review of Patent Valuation Methods with Consideration of Option Based Methods and Potential for Future Research*, Judge Institute Working Paper WP21/97.

Putnam, J. (1996) *The Value of International Patent Rights*, PhD thesis, Yale University, Yale.

Reitzig, M. (2004) 'Improving patent valuations for management purposes: validating new indicators by analyzing application rationales', *Research Policy*, Vol. 33, Nos. 6–7, pp.939–957.

Sapsalis, E., Pottelsberghe de la Potterie, B. and Navon, R. (2006) 'Academic versus industry patenting: an in-depth analysis of what determines patent value', *Research Policy*, Vol. 35, No. 10, pp.1631–1645.

Scherer, F.M., Harhoff, D. and Kukies, J. (2000) 'Uncertainty and the size distribution of rewards from technological innovation', *Journal of Evolutionary Economics*, Vol. 10, No. 1, pp.175–200.

Shane, S. (2001) 'Technological opportunities and new firm creation', *Management Science*, Vol. 47, No. 2, pp.205–220.

Trajtenberg, M. (1990) 'A penny for your quotes: patent citations and the value of innovations', *RAND Journal of Economics*, Vol. 21, No. 1, pp.172–187.

Trajtenberg, M., Henderson, R. and Jaffe, A. (1997) 'University versus corporate patents: a window on the basicness of invention', *Economics of Innovation and New Technology*, Vol. 5, No. 1, pp.19–50.

Zeebroeck, N. and Pottelsberghe de la Potterie, B. (2011) 'The vulnerability of patent value determinants', *Economics of Innovation and New Technology*, Vol. 20, No. 3, pp.283–308.

Notes

1 Stetson-Harrison method is a general way of pulling out numerical values from a hat. The method involves no analysis but a random number is chosen which comes out of a hat.

Appendix

Citation category	*Description*
X	Particularly relevant documents when taken alone (a claimed invention cannot be considered novel or cannot be considered to involve an inventive step)
Y	Particularly relevant if combined with another document of the same category
A	Documents defining the general state of the art
O	Documents referring to non-written disclosure
P	Intermediate documents (documents published between the date of filing and the priority date)
T	Documents relating to theory or principle underlying the invention (documents which were published after the filing date and are not in conflict with the application, but were cited for a better understanding of the invention)
E	Potentially conflicting patent documents, published on or after the filing date of the underlying invention
D	Document already cited in the application (provided by the applicant)
L	Document cited for other reasons (e.g., a document which may cast doubt on a priority claim)

Publication II

Kapoor, R., Karvonen, M., Ranaei, S. and Kässi, T.

Patent portfolios of European wind industry: New insights using citation categories

World Patent Information
Vol. 41, No. 1 pp. 4-10, 2015

World Patent Information 41 (2015) 4–10

Contents lists available at ScienceDirect

World Patent Information

journal homepage: www.elsevier.com/locate/worpatin

Patent portfolios of European wind industry: New insights using citation categories

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ARTICLE INFO

Article history:
Available online 27 February 2015

Keywords:
Intellectual property
Patent portfolios
Citation categories
Cooperative patent classification
Wind power

ABSTRACT

This study explores the use of citation categories assigned by patent examiners to study overlap of patent portfolios among top wind power firms. Cooperative Patent Classification (CPC) is used to obtain a sample of wind industry patents. CPC is shown to be better than the International Patent Classification for identifying patents relevant to the wind power industry. Results show high inter-firm citation among the top wind industry players that can suggest concentration of innovation. The results can be useful for patent analysts, technology managers and policy makers.

1. Introduction

A patent contract requires inventors to disclose their inventions to the public, in return for protection against their unsolicited use. The incentive for inventors is the temporary monopoly for the use of their invention. The public, on the other hand, gets to see how the invention works and have a chance of improving it. The details of the disclosure of inventions are stored systematically in worldwide patent databases. In addition to the full text, claims, inventor/applicant information of the inventions, data on technical classifications and citations added by examiners are also available in patent databases. This data has given rise to the field of patent statistics that can be used to predict the scientific and technological activities of firms, industries and nations.

Patent data has been used for various purposes, such as competitor monitoring [1], patent quality assessment [2,3], scanning potential co-operators or acquisition targets [4,5], technology lifecycle forecasting [6,7], and so on. As a field, patent statistics has grown briskly in line with a rapid increase of patents filed worldwide and the availability of improved patent databases. Researchers have produced a myriad of patent value indicators to determine the value potential of patents.

Of the many patent value indicators, citation-based indicators are the most common among researchers. Patent citations are used because the value of patent counts is severely limited by the large variance in the significance of individual patents. References made to previous patents are called backward citations, and references received from future patents are called forward citations. Cumulative and knowledge transfer indicators use backward citations, and impact-type indicators are based on forward citations [e.g. [8]]. The advantages and disadvantages of using patent citations are extensively discussed in Ref. [2]. For example, a long accumulation process of forward citations restricts their use in the evaluation of very recent innovations. Studies [3,9] have also shown that there is a lack of consistency in results based on citation analysis due to the idiosyncrasies of various patent offices worldwide. Using backward citations as a value determinant has provided ambiguous results [10,11]. One limitation related to citation analysis has been that citation counts have been considered rather than the nature of citations. This has led the authors to believe that there is some scope in refining citation-based indicators and the insights that can be obtained from them.

A worldwide increase in patent filings has also been characterized by marginal inventions with broad and/or overlapping claims. Building patent fences and blocking competitors are some of the new strategic motives of patenting [12]. In light of these trends, the nature of citations accumulated by the European Patent Office (EPO) examiners can offer insights into studying trends related to overlapping and blocking. This paper uses the citation categories formed by the EPO examiners to weigh the relevance of citations made in patent search reports. The value weighing of citations can lead to more refined usage of patent citations in determining the

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http://dx.doi.org/10.1016/j.wpi.2015.02.002
0172-2190/

value potential of patent portfolios. The analysis is based on the proposition that the portfolios of patents that receive a larger share of 'X' and 'Y' citations from other patents are more valuable than others [13].

The contribution of the paper is two-fold. The research first explores the use of Co-operative Patent Classification (CPC) in analyzing wind power patents in Europe and other countries. The results show that better sampling can be done using the CPC than the International Patent Classification (IPC), especially for US patents in the wind industry. Secondly, two measures are introduced, the measure of encroachment and the measure of hindrance. These measures use citation categories to study the overlap in the patent portfolios of the top players in the European wind industry. The results indicate high inter-firm citing among the top players.

The research on citation categories is exploratory, and the case study approach is used to obtain the results. The developed indexes are used in evaluating the competitive landscape of the European wind power industry. Currently, wind power technology is one of the fastest growing renewable energy technologies, and it has been intensively studied from the policy perspective [14,15], technological perspective [16,17] and combinations of these [18]. The key drivers for the growth of the wind energy market are the increasing global demand for energy, environmental concerns due to climate change, and economic considerations, as the cost of energy (CoE) generation by wind power can be predicted quite well. However, wind power is still in the accelerating stage of its lifecycle [19,7] and requires various support schemes in order to be competitive among the alternative energy sources [20]. Since the beginning of this century, we have seen that the patenting activity within this particular technology has drastically increased [e.g. [21]]. In patent–based studies, retrieval of wind industry patents has been typically based on the International Patent Classification (IPC) code 'F03D', which stands for 'wind motors' [22,23,18]. Dubaric et al. [7] have utilized the European Classification (ECLA), which is based on IPC but has an additional 66,000 subdivisions, being thus more precise and systematic. With the help of ECLA, the present authors were able to analyze systematically the lifecycle of subtechnologies like regulation, rotor form and pitch adjusting. A recent study reported that there are significant differences between volumes of patenting in the wind industry against the quality of these applications. This could lead to increased cost of litigation in the future [24]. The study further goes on to indicate that there could be a greater concentration of patents among the bigger players with litigation costs expected to escalate to $1 billion by 2020. In light of these trends, intellectual property will become even more valuable in the wind industry, which can generate interest among the stakeholders.

Section 2 sheds light on the theory of patent classification and citations. Section 3 introduces the data and empirical analysis based on sampling of wind industry patents. This is followed by the methodology of using citation categories to build a measure of hindrance and a measure of encroachment. Section 4 presents the results of the citation category analysis. Discussions and conclusions follow in Section 5.

2. Theory of patent citations and classification

2.1. Patent citation analysis

The history of citations in patents dates back to 1947 when examiners in United States Patent and Trademarks Office (USPTO) began citing the references considered during the examination process [25]. Forward citations can be used to assess the technological impact of innovations and thus the economic importance of patents. In the measurement of patent quality [26,27,3], citations received have been used as a proxy of the impact of technology. Backward citation analysis can potentially provide insights into the exploration process of new technologies or radical search behavior [28,29]. The idea behind utilizing backward citations as a value determinant is in the assumption that combinations and knowledge transfer from other technological domains would lead to more valuable patents [30]. Studies have combined forward and backward citations with the technical classification of patents to obtain measures of the originality and generality of patents [31,10]. In Europe, applicants are not obliged to add references to their patent applications. The patent examiners are primarily in charge of adding technical classification and citations.

2.1.1. Citation categories

The presented analysis makes use of the citation categories that are assigned to patent references by the examiners of the European Patent Office (EPO). The EPO examination guidelines [32] require all documents cited in the search report to be identified by a certain letter or a combination of letters where appropriate. The search report is made public by the EPO examiners with the publication after 18 months of the patent filing. After a patent is filed and all the administrative formalities are complete, the first step for the patent examiner is to judge the novelty and inventive step of the invention. This is done by a prior art search, and the relevant references are cited in the search report. Each reference that is cited in the search report is assigned a citation category. Citation categories are a useful way of assigning relevance to a cited document in terms of its impact on the claims of the patent application.

Two main citation categories are considered in this research, X and Y. Documents marked 'X' in search report references indicate a clear similarity between the claimed invention and the contents of the cited document. 'Y' refers to documents that can be combined with other documents by a skilled person to develop a concept similar to the claimed invention. Documents ascribed 'A' refer to records which define the state of the art, but no aspect of the document can challenge the inventiveness of the claimed invention. Table 1 includes the definitions of less used citation categories, as well as the main categories X, Y and A.

The search report is prepared by the examiner to make the applicant aware of the chances of a successful patent grant. Knowledge of search reports is a pre-requisite for carrying out citation analysis. Michel and Bettels [33] present some intricacies of citation categories and other factors related to the heterogeneity of

Table 1
Description of commonly used citation categories [8].

Citation category	Description
X	Particularly relevant documents when taken alone (a claimed invention cannot be considered novel or cannot be considered to involve an inventive step)
Y	Particularly relevant if combined with another document of the same category
A	Documents defining the general state of the art
O	Documents referring to non-written disclosure
P	Intermediate documents (documents published between the date of filing and the priority date)
T	Documents relating to theory or principle underlying the invention (documents which were published after the filing date and are not in conflict with the application, but were cited for a better understanding of the invention)
E	Potentially conflicting patent documents, published on or after the filing date of the underlying invention
D	Document already cited in the application (provided by the applicant)
L	Document cited for other reasons (e.g. a document which may cast doubt on a priority claim)

patent offices. Cited documents categorized as 'X' are considered to be particularly relevant and can potentially damage the chances of a patent grant if the claims are not suitably modified. This notion has been seconded by a study on the economic value of R&D intensive firms in the US, Europe and Japan [34]. An owner of a patent that receives 'X' citation from another patent can be in a position to challenge the validity of certain claims of the citing patent. The research on citation categories is still in a nascent stage, and our objective is to introduce its use in evaluating patent portfolios.

2.2. Cooperative patent classification

The patent literature is an extensive source of information, together with European Patent Offices' Espacenet offering access to more than 80 million patent documents worldwide. It is important to search this large amount of information efficiently to identify the patentability of a patent's subject matter. Montecchi et al. [35] highlight some of the drawbacks of keyword-based search, such as different official languages, inaccurate terminology, and inconsistent detail level in the patent description. Patent classification is a useful way to overcome these drawbacks by categorizing patents according to the technology field they belong to. Different patent classification practices are adopted by different patent offices worldwide. Wolter [36] has explored some of the world's major patent classification schemes.

The Cooperative Patent Classification (CPC) system, in force from 1 January 2013, is a bilateral system which has been jointly developed by the European Patent Office (EPO) and the United States Patents and Trademarks Office (USPTO). It combines the best classification practices of the two offices. It is largely based on the European Classification (ECLA) system formerly used by the EPO. With over 250,000 subgroups, as opposed to 70,000 subgroups in the International Patent Classification (IPC), CPC is the most refined of IPC-based systems.

The USPTO plans to phase out their current United States Patent Classification (USPC) system from January 2015. Over 8 million US patents already have CPC classes assigned to them. On 4 June 2013, the EPO and the State Intellectual Property Office (SIPO) of China signed a Memorandum of Understanding (MoU) to enhance their co-operation. The SIPO will now start classifying its newly published patent applications in some selected fields into the CPC, and will from January 2016 strive to classify new inventions in all technical areas according to the CPC. The CPC is already used by more than 45 patent offices worldwide [37].

The CPC classification is divided into nine sections, as opposed to eight sections in the IPC. Sections A-H have the same taxonomy as that of the IPC, albeit with more refined classes, sub-classes, groups and sub-groups. The extra section is named Y, defined as: "General tagging of new technological developments; general tagging of cross-sectional technologies spanning over several sections of the IPC; technical subjects covered by former USPC cross-reference art collections [XRACs] and digests".

The new Y02 classification scheme collects a wide spectrum of technical fields associated with climate change mitigation technologies in one convenient location. The new tagging scheme is made by the qualified EPO examiners who have both technical expertise and are experts in patent classification and search. Classes in section Y are not assigned intellectually by examiner but algorithmically by automated search using a combination of classes and keywords [38].

2.2.1. CPC and wind energy patents

The CPC identifies wind energy patents using the main group Y02E 10/70. Similar to the IPC, it also classifies patents using the sub-class F03D, but at greater level of detail than IPC. While the F03D taxonomy refers to the technical aspects of the inventions related to wind industry, the Y02E 10/70 taxonomy mostly refers to the association of the invention with various components of the wind energy solution. Table 2 lists the taxonomy of the IPC subclass F03D and CPC main group Y02E 10/70. The list is not exhaustive, but it shows the differences in the classification schemes. We provide empirical evidence in Section 3 that shows that better sampling of wind industry patents can be done by using the CPC sub-groups 'Y02E 10/70 to 10/766' (henceforth referred as 'Y02E 10/7*') than the IPC sub class 'F03D'.

3. Method and data

3.1. Comparing samples using CPC and IPC

A number of previous studies [21–23] have used the IPC sub class F03D to obtain a patent data sample for analysis related to the wind power industry. The search was made with the EPO PATSTAT database using both the IPC (F03D) and CPC (Y02E 10/7*) to return wind industry patents. The time span chosen for the analysis was 2001–2010.

The analysis was carried out to compare patents filed through the European Patent Office (EPO), United States Patents and Trademarks Office (USPTO) and Chinese Patent Office (SIPO). The comparison is presented in Table 3 below. For example, the search results with CPC gave a total of 4866 unique patent applications filed with the EPO as opposed to 4189 unique patent applications using the IPC class 'F03D'. The two samples had a match of 4066 applications. This means that 97.1% of the EP patent applications classified as 'wind industry' patents by the IPC (F03D) were also

Table 2
Taxonomy of IPC and CPC [adapted [39,40]].

IPC main/sub groups	Description	CPC main/sub groups	Description
F03D 1/00	Wind motors with rotation axis substantially parallel to the air flow entering the rotor	Y02E10/72	Wind turbines with rotation axis in the wind direction
F03D 1/02	Having a plurality of rotors	Y02E10/721	Blades or rotors
F03D 1/04	Having stationary wind-guiding means, e.g. with shrouds or channels	Y02E10/722	Components or gearbox
F03D 1/06	Rotors	Y02E10/723	Control of turbines
F03D 5/00	Other wind motors	Y02E10/725	Generator or configuration
F03D 5/02	The wind-engaging parts being attached to endless chains or alike	Y02E10/726	Nacelles
F03D 5/04	The wind-engaging parts being attached to carriages running on tracks or alike	Y02E10/727	Offshore towers
F03D 5/06	The wind-engaging parts swinging to and fro, not rotating	Y02E10/728	Onshore towers

Table 3
Wind industry samples from Europe, the United States and China (2001–2010).

Jurisdiction	No. of wind energy patents using CPC	No. of wind energy patents using IPC	Match between samples	% match of sample with IPC
EP	4866	4189	4066	97.1
US	6152	4671	4133	**88.5**
CN	5939	5295	5122	96.7

classified as being 'wind industry' by the CPC (Y02E 10/7*). For US patents, the match percentage was low, indicating that many patents that are considered to be related to 'wind industry' by the CPC were not assigned the IPC class F03D by the examiners.

Patents related to climate change mitigation technologies (CCMTs) usually belong to many areas of technology and may not fall under one single classification section. IPC and ECLA classifications are thus susceptible for incomplete results. CPC employs a structured retrieval and identification of patent documents related to CCMTs. The Y02 classification scheme collects CCMT related documents that could be present in all sections A–F of IPC. This probably accounts for the greater number of wind industry patents obtained from using the CPC class Y02E 10/7* than the IPC sub-class F03D [38].

Table 4 below shows that overall, more patents are classified as being 'wind industry' by the CPC than the IPC. The analysis was continued to find whether these extra patents (those classified as wind industry by the CPC and not the IPC) belonged indeed to the wind power industry. Table 4 lists the top IPCs of the extra patents that were assigned to the CPC class 'Y02E 10/7*' but not to the IPC class 'F03D'.

The findings presented in Table 4 reveal that most of the wind industry patents not classified into the IPC sub class F03D belong to the IPC class 'H02' which stands for "Generation, conversion, or distribution of electrical power". IPC subclasses like 'F03B' and 'F01D' are identified as being 'related to wind technology' [22]. The IPC class 'E04H 12/00' deals with "Towers; Masts, poles; Chimney stacks; Water-towers; Methods of erecting such structures". World Intellectual Property Organization (WIPO) Green Inventory [46] identifies the IPC sub-group 'H02K 7/18' as belonging to the wind industry and indicating "Structural association of electric generator with mechanical driving motor". The list of related IPC classes suggests that the extra patents classified as 'wind industry' by the CPC are indeed related to the wind industry.

Further doubt is removed by Table 5 that carries the top applicant counts for the 'extra' applications classified as "wind energy" by the CPC but not by the IPC. The names of applicants are top wind industry players, confirming that the applications are related to the wind power industry.

We thus consider the CPC sub-groups 'Y02E 10/7*' to be of better use in the sampling of wind industry patents for carrying out patent analysis. This is true especially in the case of US patents, which have approximately 32% more patents classified in the CPC than IPC (see Table 3 for the match and difference in numbers).

Table 4
Related IPC of patents not classified in F03D but classified as Y02E 10/7*.

EP		US		CN	
IPC	Count	IPC	Count	IPC	Count
H02J 3/38	62	H02P 9/04	238	H02J 3/38	189
H02K 7/18	49	E04H 12/00	68	H02K 1/27	56
H02K 1/27	33	F03B 13/00	60	H02P 9/00	44
H02P 9/00	27	F01D 5/14	60	H02J 3/18	28
F03B 17/06	21	H02K 7/18	54	H02K 7/18	25

Table 5
Top applicant counts of patents not classified as F03D but classified as Y02E 10/7*.

EP		US		CN	
Applicant name	Count	Applicant name	Count	Applicant name	Count
Siemens	109	General Electric	220	General Electric	101
General Electric	78	Vestas	113	Vestas	42
Vestas	69	Mitsubishi Heavy Ind	49	Siemens	42
Enercon	16	Siemens	39	Mitsubishi Heavy Ind	14
REpower	15	REpower	29	REpower	11
Mitsubishi Heavy Ind	12	LM Glasfiber	24	Sany Electric Co Ltd	10
LM Glasfiber	8	Gamesa	19	Shenzhen Academy Of Aerospace	10
Nordex	7	Nordex	19	Qi Yamei	7

3.2. Citation category analysis

For carrying out citation category analysis, the jurisdiction was restricted to 'EP' patents. About 30 patent authorities are now assigning categories references [[41] p. 17]. We chose EP patents only since it lends consistency to citation analysis that suffers from variations in examiner practices in different patent authorities. Also, our focus being the European wind industry made EPO patents the most relevant. The data for the case companies was collected using the EPO PATSTAT database. PATSTAT contains bibliographic data supplied to the EPO by over 90 countries [42]. PATSTAT is available in the form of a relational database setup and is built for the purpose of statistical analysis.

The time span of the analysis was 2001–2010. We did not consider the latest patents because of the property of right truncation of forward citations, which means that there is not enough time for future patents to cite the most recent ones. Patent applications before 2001 were not considered in order to nullify the effect of different lifespans of organizations. REpower is a relatively young company (founded in 2001), which would have resulted in variations in patent counts if patents before 2001 were considered. Enercon patents were searched by the owner 'Wobben Aloys' following the transfer of all Enercon shares to the Aloys Wobben Foundation [43]. Due to multiple naming formats at various patent offices, obtaining a true count of patent applications of firms is a difficult job. PATSTAT, to some extent, has had a name harmonization effort that merges the applications of various subsidiaries of firms into a single entity. We, however, manually merged some of the anomalies in creating our firm specific datasets. For example, 'Wobben Aloys' and 'Wobben Properties GMBH' were merged to obtain Enercon patents; 'Gen Electric', 'GE Wind Energy Norway AS', 'GE Wind Energy LLC' were merged to get GE Wind patents.

Two main citation categories were considered, X and Y. Related documents assigned 'X' in the search report indicate a clear similarity between the claimed invention and the contents of the cited document. 'Y' refers to documents which can be combined by a person skilled in the art to develop a concept as claimed by the patent applicant.

3.2.1. Measure of encroachment

Backward citations of all the patents in the dataset were found next. The backward citations thus obtained were divided into two categories: ones made to competitors and ones made to others. Only patent citations were considered in the X, Y citation analysis, thus disregarding all non-patent literature cited. The backward

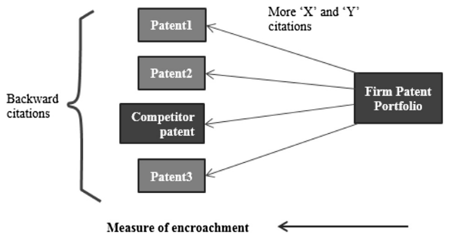

Fig. 1. Measure of encroachment.

citation data was further narrowed into only the X and Y backward citations made by the focal firm. The X and Y backward citations would refer to documents that can potentially challenge the validity of certain claims of the focal patent. The X and Y backward citations thus obtained were again split into the ones made to competitors and ones made to others. The measure of encroachment is depicted in Fig. 1.

The measure of encroachment can indicate the vulnerability of the patent portfolio in terms of the level of overlap with competitor portfolios. We define the measure of encroachment of the case firm as the ratio of 'X' and 'Y' citations made to competitors to all 'X' and 'Y' citations made.

$$\text{Measure of encroachment} = \frac{\sum' X' \text{ and } 'Y' \text{ cit. to competitors}}{\sum All\ 'X' \text{ and } 'Y' \text{ cit. made}}$$

The measure of encroachment can take any value between 0 and 1. A value closer to one indicates that the focal company is vulnerable to their competitors while a value closer to zero is desirable.

3.2.2. *Measure of hindrance*

The measure of hindrance is based on forward citations. Similar to our backward citation analysis, the incoming citations were separated into 'citations by competitors' and 'citations by others'. If the firms received 'X' or 'Y' references from future patents they can be seen to hinder or block subsequent patents. The measure of hindrance is depicted in Fig. 2.

We define the measure of hindrance of the case firm as the ratio of 'X' and 'Y' citations received from competitors to all 'X' and 'Y' citations received.

$$\text{Measure of hindrance} = \frac{\sum' X' \text{ and } 'Y' \text{ cit. from competitors}}{\sum All\ 'X' \text{ and } 'Y' \text{ cit. received}}$$

The measure of hindrance can take any value between 0 and 1.

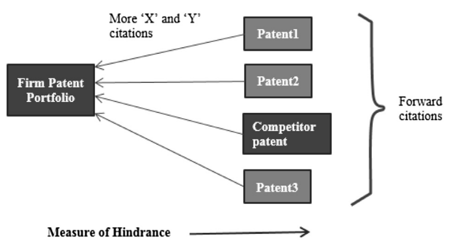

Fig. 2. Measure of hindrance.

Table 6
Patent count and citation data.

Firm name	Patent count	Backward citations		Forward citations	
		Total	% to competitors	Total	% from competitors
GE Wind	498	1366	17.3	1606	**44.4**
Vestas	480	1005	22.0	467	35.3
Siemens	406	2085	26.6	768	33.1
Enercon	254	972	**7.3**	776	**46.1**
Mitsubishi	160	158	20.3	210	**46.2**
REpower	186	803	**31.0**	414	**43.7**
Nordex	94	463	**35.9**	176	39.8
LM Glasfiber	126	568	27.3	114	38.6

Table 7
'X' and 'Y' citations with the measure of hindrance (MOH) and measure of encroachment (MOE).

Firm name	Backward citations		Forward citations		MOE	MOH
	Total X, Y	Total X, Y to competitors	Total X, Y	Total X, Y from competitors		
GE Wind	1253	370	527	238	0.30	0.45
Vestas	647	170	173	56	0.26	0.32
Siemens	1236	313	235	75	0.25	0.32
Enercon	623	110	161	73	**0.18**	0.45
Mitsubishi	163	59	80	42	0.36	**0.53**
REpower	444	166	120	58	0.37	0.48
Nordex	224	86	61	25	0.38	0.41
LM Glasfiber	288	92	42	16	0.32	0.38

A value closer to one indicates that the focal company has an edge over its competitors by virtue of being able to block their patents or acquire royalties and licensing income.

4. Results

A sample of 4866 EP patents was selected for carrying out the analysis based on citation categories. Top eight patenting firms were shortlisted for the same. Table 6 presents the patent counts along with details of the forward and backward citations of the firms. Enercon's patents had the lowest share of backward references to competitors while Nordex and REpower had the highest shares of references made to competitors. It should be noted here that competitors for a firm are the rest of the firms that feature in the list of the eight firms selected for analysis. The overall data suggests that there is a lot of inter-citing among competing firms in the wind industry. For Mitsubishi, a high 46.2% of their forward citations come from the other seven firms in the list.

The forward and backward citation data was further broken into X and Y citation categories. As mentioned in section two, 'X' and 'Y' references in an application can indicate a document that can damage the validity of certain claims of the application. A larger share of 'X' and 'Y' backward citations made to competitors can be seen as encroachment. A larger share of 'X' and 'Y' forward citations received from competitors can be seen as blocking power or hindrance. Enercon had the lowest value (0.18) for the measure of encroachment (MOE), which can indicate more fundamental research (see Table 7). The measure of hindrance (MOH) values was the highest for Mitsubishi and lowest for Vestas and Siemens.

5. Discussion and conclusion

The results suggest that Enercon's performance is the strongest among its competitors. Its performance in both indicators is good, making its portfolio least encroaching and having a high blocking power. Despite being a relatively small player in the list, REpower has a high blocking power and a competent portfolio [44]. High inter-firm citation is observed, which can be seen as concentration of innovation among the top firms in the industry. This can pose challenges to tier two and three firms in the industry who have to be wary of the freedom-to-operate aspect of their patent portfolios. New entrants have to carry out analysis before making decisions to import/export goods that could possibly infringe on others' patents. The insights from our results concur with a recent report in the Wind Power Monthly [24] that predicts a rise in litigation costs in the wind power industry. The general trend in the wind industry seems to be of marginal inventions and overlapping claims.

The analysis made in the study established the Cooperative Patent Classification (CPC) as a better alternative to the International Patent Classification (IPC) in identification of wind industry patents. The CPC was found to be especially useful in analyzing US wind industry patents. The sample of relevant wind industry patents, as obtained by the CPC, were 16% higher than those obtained by the IPC for EPO patents, 32% higher for US patents, and 12% for Chinese patents. Patent-based measures, the measure of hindrance and the measure of encroachment were introduced in the research using EPO patent citation category data. These indicators offered insights related to overlapping claims within patent portfolios of the European wind industry.

As pointed out above, a search report is usually published along with the patent full text 18 months after filing. This is the earliest date from which patents are made available to the public and any kind of patent analysis can be carried out. The citation categories can thus be considered to be early stage patent value indicators as opposed to some other patent value indicators that suffer from timeliness (e.g. patent family size, forward citations, grant, etc.). This benefit is also seen as a problem. As the patent application progresses through with examination and reaches closer to grant, some of the X and Y references are no longer valid. The applicant is encouraged to modify the claims suitably with regard to the references in the search report. A patent that contained overlapping claims during the time of publication can be modified during examination to be made suitable for grant. The use of citation categories is contentious in the regard that once a patent is granted, it does not matter what the search report looked like. In retrospect, however, the search report data is interesting because we know that X and Y citations *were* made. A larger share of X and Y citations in search reports can indicate an important business area where the stakes are high. Applicants take their chances because even a small inventive step in a patent grant can be commercially useful. In this regard, we can infer that high inter-firm X and Y citations are an indication of high stakes in the wind industry in coming years.

Future research in this area can aim at competitor analysis in different industries using the same template. This will help in comparing the results from one industry to another and provide a frame of reference for drawing insights. The proposed methodology can be applied in creating macro level indicators for studying technology overlap in various industries. One limitation when using count based indices for macro level analyses is that there can be a bias related to multiple family members being cited by applications. The use of 'X' and 'Y' citations received can be a better method to identify the core patents of a firm. There is room for research in the usage of 'A' citations in patent analysis. 'A' references usually refer to documents that describe the state-of-art that is relevant to the patent application. This could be used as an indicator for exploring knowledge flows at a more basic science level. There are very few studies [13,34] based on citation categories, and the present study can attract more attention of researchers towards this potential patent value determinant. The use of opposition and litigation data along with citation categories can be useful in the testing and validation of citation category -based indicators. Another potential future work could be to separate the citations further by their nature and motives, for example by either examiner-cited or applicant-cited references [45]. In the ongoing research, the patent citation categories are developed further identify overlap of the portfolios of competitors, thus enabling judgments related to licensing, technology transfer and potential acquisition targets. This kind of a tool can be useful for technology managers and patent analysts, as well as policy makers.

Acknowledgment

The paper is an extended version of the IEEM 2013 conference paper in Bangkok, and the authors would like to express their gratitude for the essential feedback and constructive comments of anonymous reviewers. We would also like to thank the Innovation Management department of Lappeenranta University of Technology for the funding and research infrastructure provided for carrying out this research.

References

[1] Ernst H. Patent information for strategic technology management. World Pat Inf 2003;25:233–43.
[2] Griliches Z. Patent statistics as economic indicators: a survey. J Econ Literature 1990;28:1661–707.
[3] Hall B, Jaffe A, Trajtenberg M. Market value and patent citations. Rand J Econ 2005;36:16–38.
[4] Breitzman A, Thomas P. Using patent citation analysis to target/value M&A candidates. Res Technol Manag 2002;45:28–36.
[5] Fabry B, Ernst H, Langholz J, Köster M. Patent portfolio analysis as a useful tool for identifying R&D and business opportunities – an empirical application in the nutrition and health industry. World Pat Inf 2006;28:215–25.
[6] Andersen B. The hunt for S-shaped growth paths in technological innovation: a patent study. J Evol Econ 1999;9:487–526.
[7] Dubaric E, Giannoccaro D, Bengtsson R, Ackermann T. Patent data as indicators wind power technology development. World Pat Inf 2011;33:144–9.
[8] OECD patent statistics manual. OECD Publishers; 2009.
[9] Griliches Z. R&D and productivity: the econometric evidence. NBER; 1998.
[10] Hall B, Jaffe A, Trajtenberg M. The NBER patent citations data file: lessons, insights, and methodological tools. 2001. NBER Working Paper No. 8498 Cambridge MA.
[11] Zeebroeck N, van Pottelsberghe B. The vulnerability of patent value determinants. Econ Innovation New Technol 2011;20:283–308.
[12] Grimpe C, Hussinger K. Pre-empted patents, infringed patents and firm's participation in markets for technology. Res Policy 2014;43:543–54.
[13] Harhoff D, Wagner S. The duration of patent examination at the european patent office. Manag Sci 2009;55:1969–84.
[14] Saidur R, Islam M, Rahim N, Solagi K. A review on global wind energy policy. Renew Sustain Energy Rev 2010;14:1744–62.
[15] Simmie J. Path dependence and new technological path creation in the Danish wind power industry. Eur Plan Stud 2012;20:753–72.
[16] Sahin A. Progress and recent trends in wind energy. Prog Energy Combust Sci 2004;30:501–43.
[17] Islam M, Mekhilef S, Saidur R. Progress and recent trends of wind energy technology. Renew Sustain Energy Rev 2013;21:456–68.
[18] Popp D, Hascic I, Medhi N. Technology and diffusion of renewable energy. Energy Econ; 33:648–662.
[19] Dismukes J, Miller L, Bers J. The industrial life cycle of wind energy electrical power generation ARI methodology modeling of life cycle dynamics. Technol Forecast Soc Change 2009;76:178–91.
[20] Daim T, Harell G, Hogaboam L. Forecasting renewable energy production in the US. Foresight 2012;14:225–41.
[21] World Intellectual Property Organization. Patent-based technology analysis report – alternative energy. 2009.
[22] Braun F, Schmid-Ehmcke J, Zloczysti P. Innovative activity in wind and Solar technology: empirical evidence on knowledge spillovers using patent data. Grasp Work Pap 2010;3:1–28.
[23] Johnstone N, Hascic I, Popp D. Renewable energy policies and technological innovation: evidence based on patent counts. Environ Resour Econ 2010;45:133–55.
[24] Smith P. Patent litigation to rise. Wind Power Mon Rep August 2013 [www-document]. [accessed 07.06.13]. Available at: http://www.windpowermonthly.com/article/1209660/patent-litigation-rise.
[25] List J. An A to X of patent citations for searching. World Pat Inf 2010;32:306–12.

[26] Trajtenberg MA. Penny for your quotes: patent citations and the value of innovations. Rand J Econ 1990;21:172–87.
[27] Harhoff D, Scherer F, Vopel K. Citations, family size, opposition and the value of patent rights. Res Policy 2003;32:1343–63.
[28] Jaffe A, Trajtenberg M, Fogarty M. Knowledge spillovers and patent citations: evidence from a survey of inventors. Am Econ Rev 2000;90:215–8.
[29] Lukach R, Plasmans J. Measuring knowledge spillovers using patent citations: evidence from the Belgian Firm's data. 2002. CESifo Working Paper No. 754.
[30] Nemet G, Johnson E. Do important inventions benefit from knowledge originating in other technological domains? Res Policy 2012;41:190–200.
[31] Trajtenberg M, Henderson R, Jaffe A. University versus Corporate patents: a Window on the Basicness of invention. Econ Innovation New Technol 1997;5:19–50.
[32] European Patent Office. Guidelines for examination in the European Patent Office, 2010. [www-document]. [accessed 07.06.13]. Available at: http://documents.epo.org/projects/babylon/eponet.nsf/0/7ffc755ad943703dc12576f00054cacc/$FILE/guidelines_2010_complete_en.pdf.
[33] Michel J, Bettels B. Patent citation analysis. A closer look at the basic input data from patent search reports. Scientometrics 2001;51:185–201.
[34] Czarnitzki D, Hussinger K, Leten B. The market value of blocking patent citations. Discussion paper no. 11–021. ZEW: Center for European Economic Research; 2011.
[35] Montecchi T, Russo D, Liu Y. Searching in cooperative patent classification: comparison between keyword and concept-based search. Adv Eng Informatics 2013;27:335–45.
[36] Wolter B. It takes all kinds to make a world – some thoughts on the use of classification in patent searching. World Pat Inf 2012;34:8–18.
[37] Blackman M. News on classification. World Pat Inf 2013;35:328–9.
[38] Veefkind V, Hurtado-Albir J, Angelucci S, Karachalios K, Thumm N. A New EPO classification scheme for climate change mitigation technologies. World Pat Inf 2012;34:106–11.
[39] WIPO International. Patent classification official publication. 2014 [accessed March 2014], Available online: http://web2.wipo.int/ipcpub/#refresh=page.
[40] European Patent Office. Cooperative patent classification (CPC). 2015 [accessed March 2014], Available online: http://worldwide.espacenet.com/classification?locale=en_EP.
[41] WIPO. Survey concerning citation practices in industrial property offices, Handbook on industrial property information and documentation. 2008 [accessed: January 2015], Available Online: http://www.wipo.int/export/sites/www/standards/en/pdf/07-09-01.pdf.
[42] EPO Worldwide patent statistical database, October 2013 edition.
[43] Enercon. Enercon news, ENERCON owner to transfer company shares to the Aloys Wobben Foundation. 2012 [Accessed September 2013], Available online: http://www.enercon.de/en-en/1850.htm.
[44] Kapoor R, Karvonen M, Kässi T. Patent portfolio efficiency using data envelopment analysis: case of wind power market. Hong Kong: IEEE International Conference on Industrial Engineering and Engineering Management; 2012.
[45] Alcacer J, Gittelman M, Sampat B. Applicant and examiner citations in U.S. patents: an overview and analysis. Res Policy 2009;38:415–27.
[46] WIPO, IPC Green inventory, [Accessed: March 2014], Available online: http://www.wipo.int/classifications/ipc/en/est/.

Publication III

Kapoor, R.

Intellectual property and appropriability regime of innovation in financial services

Book chapter in: Innovation in Financial Services: A Dual Ambiguity
Edited by Anne-Laure Mention and Marko Torkkeli
Cambridge Scholar Publishing

Publication IV

Kapoor, R., Karvonen, M., Mohan, A. and Kässi, T.

Patent citations as determinants of grant and opposition: case of European wind power industry

Technology Analysis & Strategic Management
Vol. 28, Issue. 8 pp. 950-964, 2016

Technology Analysis & Strategic Management

ISSN: 0953-7325 (Print) 1465-3990 (Online) Journal homepage: http://www.tandfonline.com/loi/ctas20

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TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT, 2016
http://dx.doi.org/10.1080/09537325.2016.1180358

Patent citations as determinants of grant and opposition: case of European wind power industry

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ABSTRACT
The grant of a patent and filing of an opposition are important events in the lifecycle of a patent. This paper tests the influence of backward citations on the likelihood of a patent grant and, if any, an opposition. Since all citations are not alike, detailed analysis is done by assessing type, nature and origin of citations in European search reports and, where needed, international search reports. The nature of citations, blocking or non-blocking, is found to have a significant impact on the likelihood of a patent being granted. The effect of citations originating during different stages of patent pendency is also explored in this study. For practitioners, the study provides a landscape of the European wind industry that is characterised by popularity of the PCT route, dearth of non-patent citations and dominance of bigger actors. For academics, the study offers novel opportunities to utilise citation based indicators.

ARTICLE HISTORY
Received 21 October 2015
Revised 18 February 2016
Accepted 14 April 2016

KEYWORDS
Patent citations; patent opposition; patent value; wind power

1. Introduction

In the patent statistics literature, a grant is indicative of patent value while an opposition is considered an even more definitive sign of value (Guellec and Pottelsberghe 2000; Harhoff, Scherer, and Vopel 2003). On average, a typical European patent grant occurs five years after filing, while opposition from third parties occurs almost six years after filing of the patent.[1] A grant is possible when a patent application survives the rigorous search for prior art that establishes the primary patentability criteria of novelty and inventiveness. Prior art, or backward patent references,[2] thus play an important role in determining the outcome of the patent examination process.

Opposition to a successful patent is an indication of the commercial stakes associated with an invention (Hall et al. 2003). The opposition procedure is a structure that acts as a corrective post-grant mechanism. A European Patent Office (EPO) patent is a bundle of national patents that are effective once validated in individual member states. A central opposition can be made at the EPO by any third party within a period of nine months after the publication of grant. Opposition is the only procedure that can invalidate an EPO patent centrally. Once the time period of nine months has elapsed, a patent has to be challenged through legislative courts in individual member states. The costs associated with pursuing patent litigation in courts can be significantly higher than the EPO opposition procedure (Graham and Harhoff 2006; Lee, Song, and Park 2013).

The lengthy pendency periods between a patent application, the grant of a patent and the filing of opposition offer many opportunities to study events during the different stages of the patent examination process. Our central research aim is to test the influence of backward citations on the likelihood of a patent grant and, if any, a patent opposition. By definition, backward citations are available early in the lifecycle of a patent application. The patent examiner compiles a list of backward citations

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by reviewing prior art against the claims made in the application. The importance of prior art does not end with the granting of a patent. Their use continues in determining the outcome of opposition cases as claims are interpreted in light of prior art. In this paper, we have carried out detailed citation analysis of European wind power patents. Citations are classified according to type (references to patents or non-patent literature (NPL)); nature (blocking or non-blocking citations based on citation categories); and origin (whether a reference was presented by the applicant, included during initial search or added during substantive examination). For incoming foreign applications, we extracted citations from international search reports to get a more comprehensive coverage[3] of citations added to European patents.

Previous research related to determinants of EPO oppositions (Graham et al. 2002; Jerak and Wagner 2006) have shown valuable patents being more susceptible to opposition; with forward citations, EPO designated states and patent claims as value proxies. Other studies have tested the likelihood of an opposition based on geographical origin (Caviggioli, Scellato, and Ughetto 2013) and size of firms (Calderini and Scellato 2004). The usage of intellectual property varies by industry and firm size (Jensen and Webster 2006; Holgersson 2013). Applicant strategies and examiner practices may thus lead to different characteristics of patents in different industries (Blind, Cremers, and Mueller 2009). For example, oppositions among large incumbent firms are significantly lower than average in the telecommunications industry as a result of retaliation risk (Calderini and Scellato 2004). In contrast, no such variations are observed in the plant biotechnology industry (Schneider 2011).

Among studies that have made use of backward citations are Reitzig (2004) and Harhoff and Reitzig (2004) who studied the explanatory power of early stage patent characteristics in predicting European patent oppositions in chemical, biotechnology and pharmaceutical industries. In this study, we have taken the case of European wind power industry to test our citation based indicators. Wind power industry is unique in a way that it has seen a steady increase in patenting while still being dominated by few top players. Along with the increase in patenting (Braun, Schmid-Ehmcke, and Zloczysti 2010), there has also been evidence of large number of overlapping claims (Kapoor et al. 2015). Smith (2013) postulates that increased concentration of patents among the bigger actors can lead to an escalation of litigation costs. In light of these trends, determination of likelihoods of a patent grant and opposition can be important for the stakeholders in wind industry. Wind power has been intensively studied from the policy perspective (Simmie 2012; McDowall et al. 2013), technological perspective (Sahin 2004; Islam, Mekhilef, and Saidur 2013) and a combination of these (Popp, Hascic, and Medhi 2011). Some authors claim that wind power is still in the accelerating stage of its lifecycle (Dismukes, Miller, and Bers 2009; Dubaric et al. 2011).

Along with oppositions, and unlike previous research, we have tested the impact of backward citations on patent grants. This allows us to explain why some variables, like blocking citations, significantly influencing a grant may be pre-empting opposition. Backward citations are analysed in a comprehensive manner by testing also the impact of when a citation originates during pendency. Our results include various descriptive insights, like the large number of pending applications, who-opposed-whom analysis and institutional share of patent ownership.

2. Literature review and research setting

In this section we review the literature related to the patent variables used in our study. Some expectations are then drawn regarding the influence of various patent characteristics on the likelihood of grant and opposition.

2.1. Patent scope

Patent examiners build a list of prior art based on a claim by claim analyses. There is, thus, a strong relationship between patent claims and citations. The fee structure for claims set by the EPO seeks to discourage voluminous patents. There is no fee for up to 15 claims. There is a higher fee per claim from the 16th claim, and an even higher fee after the 50th claim. Despite the fee structure, there has been an increase in the number of claims per patent at the EPO over the years (Van Zeebroeck, van Pottelsberghe, and Guellec 2009), owing partially to the popularity of the Patent Co-operation Treaty (PCT) route and harmonisation of drafting practices according to the US system. In the literature, a higher number of claims has been associated with broader scope and has been found to be related with patent value (Lerner 1994; Lanjouw and Schankerman 2004).

While claims define the legal scope of a patent, the number of International Patent Classification (IPC classes) is indicative of the technical scope (Lerner 1994). However, it has also been argued in the literature that the number of IPC classes has little correlation with the value of patent rights (Harhoff, Scherer, and Vopel 2003). We expect therefore:

(a) Broader legal scope (as indicated by number of claims) is associated with higher likelihood of grant and, if any, a subsequent opposition
(b) Broader technical scope (as indicated by number of IPC classes) enables a higher likelihood of grant but may not have an impact on impending opposition

2.2. Backward references

Backward citation analysis can potentially provide insights into the exploration process of new technologies (Jaffe, Trajtenberg, and Fogarty 2000; Rosenkopf and Nerkar 2001) and linkages between science and commercialisation (Berbegal-Mirabent and Sabate 2015). The idea behind utilising backward citations as a value determinant is in the assumption that combinations and knowledge transfer from other technological domains lead to more valuable patents (Nemet and Johnson 2012). Citations can be made either to patent documents or to NPL comprising of research articles, internet links, books, magazines and the like. The results of using backward citations as a value determinant have, however, provided ambiguous results (Hall, Jaffe, and Trajtenberg 2001; Van Zeebroeck 2011). More backward citations would require an applicant to circumvent more prior art before establishing novelty. On the other hand, more prior art can indicate more extensive combinations of knowledge leading to inventions of higher quality. Hence:

(a) More science-based citations facilitate the grant of a patent and increase the chances of opposition.
(b) More patent citations facilitate the grant of a patent and increase the chances of opposition.

Due to the ambiguous nature of theoretical background related to backward citations, we created an interaction term between backward citations and citation categories (next section).

2.3. Citation categories

EPO examination guidelines (EPO 2010) require examiners to categorise the impact of prior documents on each claim of the patent application. The impact of a citation is denominated by a letter or combination of letters (see Table 1). *X*, *Y* and *A* are by far the most used categories. Cited documents assigned *X* indicate a clear similarity between the claimed invention and the contents of the cited document. *Y* refers to documents that can be combined with other documents by a skilled person to develop a concept similar to the claimed invention. Documents ascribed *A* refer to citations that define the state of the art, but are not in conflict with the claimed invention. In simpler terms, an *X* reference indicates overlapping claims with a previous document; a *Y* reference means a combination of multiple *Y* documents can anticipate the claims of the patent being examined; and an *A* reference mostly defines the state of the art. Thus, *X* and *Y* references can

Table 1. Most common citation categories.

Citation category	Description
X	Particularly relevant documents when taken alone
Y	Particularly relevant if combined with another document of the same category
A	Documents defining the general state of the art
O	Documents referring to non-written disclosure
P	Documents published between the date of filing and the priority date
T	Documents cited for a better understanding of the invention, published after the filing date
E	Potentially conflicting patent documents, published on or after the filing date
D	Document provided by the applicant
L	Document cited for other reasons

Source: OECD (2009).

be considered as blocking citations that can anticipate claims and *A* citations are non-blocking in nature.

Our conversations with patent examiners revealed that three or more *Y* references associated to a claim can be seen as inventive. Previous literature (Harhoff and Wagner 2009; Czarnitzki, Hussinger, and Leten 2011) has combined *X* and *Y* references and called them blocking citations. '*A*' references are usually added by examiners if they are considered useful for the applicant when modifying claims. While *A* references mostly do not have any effect on the claims of the document, this is not always so. In some cases, *A* references are so close to a patent document that it can make it very difficult for an applicant to circumvent other *X* and *Y* references cited in the search reports.

We summarise our interpretation of the various categories thus: *X* and *Y* references represent significant obstacles that need to be circumvented by the applicant. The effect of *X* and *Y* citations on opposition is more complex. The presence of a large number of conflicting documents can indicate a hot technology area, which can lead to higher chances of opposition. In another argument presented during our discussions with examiners, more *X* and *Y* citations in search reports can result in significant limitations being imposed on a patent which can pre-empt opposition. Harhoff and Reitzig (2004) use large number of blocking citations as proxy for information asymmetry and hence greater likelihood of opposition. '*A*' references, on the other hand, do not impede the grant of a patent and can be seen as unlikely to generate opposition. The expected impact of citation categories is summarised below:

(a) Large number of non-blocking citations (as measured by counts of *A* citations) facilitate the grant of a patent and reduce likelihood of opposition.
(b) Large number of blocking citations (as measured by counts of *X* and *Y* citations) hinder the grant of a patent and increase likelihood of opposition.

2.4. Citation origin

A typical timeline of a European patent and a foreign (PCT) patent entering EPO is depicted in Figure 1. Most citations are added during the search phase. Where necessary, these search reports can be supplemented by the examiner and/or by third party observations during pendency. Previous studies on US patents (Alcácer, Gittelman, and Sampat 2009; Cotropia, Lemley, and Sampat 2013) have noted differences in the relevance of citations originating from applicants and examiners.

In this study we have considered five different 'origin' of citations. EPO patent applications can be either Euro-direct (applications filed directly to the EPO) or international applications filed under the PCT.[4] For Euro-direct applications, examiners prepare a search report from scratch. For international applications, EPO examiners usually have access to an international search report that has been prepared by the office from where the application is incoming. Sometimes, EPO examiners add new

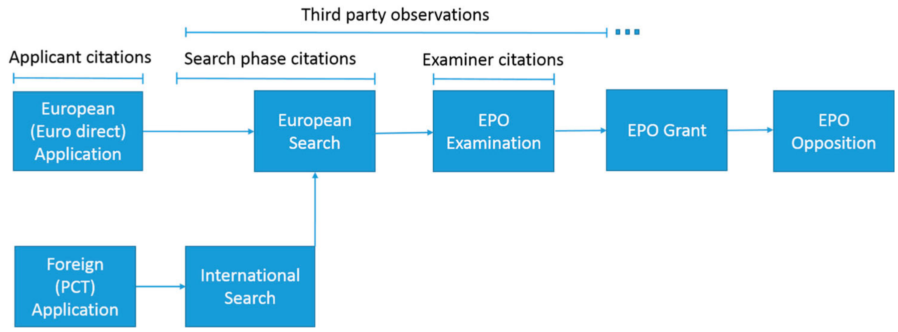

Figure 1. EPO patent application: simplified timeline.

references to those already found in the international search report. Typically, a Euro-direct application will contain only 'European Search Report' and a PCT application will contain both 'International Search Report' and 'European Search Report'. Owing to these differences, we have presented separate regression models for these two filing routes. More references in the search report make it harder for an applicant to 'invent around' and obtain a patent grant. When considering the impact on opposition, more references in the search report could limit patent scope enough to 'pre-empt' opposition. Thus:

(a) More comprehensive search reports (as measured by counts of citations added during European and international search) reduce the likelihood of both grant and opposition.

The references provided by the applicant, *and* added to the search report are considered as applicant citations. After the search phase a patent undergoes a substantive examination process. This is where the examiner assigned for handling the patent application can add references if necessary.

According to article 115 of the European Patent Convention, any third party is allowed to present observations concerning the patentability of the invention to which the patent relates. EPO is obliged to forward all such observations to the patent applicant. This is a rare but interesting event. According to Akers (1999), 'As a possible disincentive to the filing of observations, it should be realized that observations could give an applicant forewarning of a competitor's interests'. From a strategic point of view, some third parties may refrain from filing observations as it could disclose their future actions and gives a chance for the patent applicant to modify the application in light of the new references added. We note our expected association of examiner and third party citations thus:

(a) Examiner citations can hinder both grant and future oppositions.
(b) Third party observations hinder grant and increase the likelihood of future oppositions.

3. Data collection and sample preparation

The data for this study were obtained from EPO PATSTAT and European Patent Register databases (April 2015 versions). Detailed citation analysis was possible with PATSTAT and information like current status and oppositions were extracted from the European Patent Register. Sampling of wind power patents was done using the Cooperative Patent Classification (CPC) classes Y02E 10/70 to Y02E 10/766 (referred to as Y02E10/7*). The CPC class Y02E10/7* proved to be a better alternative to the IPC class F03D as it returned a more comprehensive coverage of patents relevant to the wind power industry (Kapoor et al. 2015).

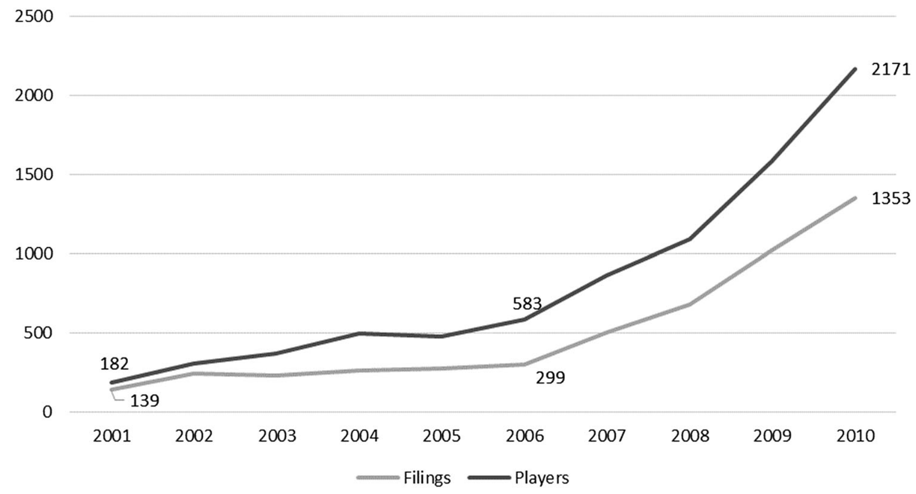

Figure 2. Counts of patents filed and unique assignees per year.

The time period chosen for the analysis was a snapshot of patent applications filed between 2001 and 2010. CPC class Y02E10/7* returned 4991 European (EP) patent applications filed during this time period. We did not consider recent patent applications because of publication lags and, hence, unavailability of current status and opposition information. PATSTAT was used to obtain counts of patent and non-patent citations. The NPL citations in PATSTAT were cleaned to remove irrelevant references such as examiner comments and references to earlier search reports. Figure 2 shows a brisk increase in the number of patents filed after 2006. Also seen, is a rise in number of new entrants in the industry.

The latest status information for our sample of 4991 applications was extracted from the European Patent Register. The register identified 4105 'published' applications that had valid status information. The results are tabulated below.

On excluding the pending applications we found the grant rate a little over 54% and the rate of opposition close to 10%. (This figure is slightly higher than the long-term opposition rate of 8.1% for EP patents reported by Reitzig (2004)) For our regression analysis we use successful patents (1384 applications) as 'granted' patents and unsuccessful patents as our control sample (1161 applications). We obtained a list of applications that were opposed from European Patent Register (246 applications). This list comprised all applications that have been amended or revoked, in addition to applications subjected to the opposition procedure and some granted patents (Table 2, last column). The control sample for opposed patents were applications with the status 'No opposition within time limit' (848 applications).

A large share of pending documents is also observed in Table 2. There are various reasons why applicants may deliberately keep their patents pending (Palangkaraya, Jensen, and Webster 2008; Blind, Cremers, and Mueller 2009; Jell 2012). Pending patents create uncertainty among competitors regarding which claims might eventually be granted. This large share of pending applications is worth noting, although, for furthering our analysis, we focused on successful and unsuccessful applications.

4. Empirical findings and discussions

4.1. Ownership characteristics

We used the OECD HAN (OECD 2015) tables to cleanse assignee names of duplicates and compile figures related to the ownership characteristics of patents. The top ten patent owning firms were

Table 2. Status information from European Patent Register.

Status information	Count	%	Opposed count
Unsuccessful			
Deemed to be withdrawn	956	23.3	0
Refused	24	0.6	0
Withdrawn	159	3.9	0
Revoked	22	0.5	22
Subtotal	1161	28.3	22
Pending			
Examination in progress	519	12.6	0
Examination requested	902	22.0	0
Published	139	3.4	0
Subtotal	1560	38.0	0
Successful			
Grant intended	127	3.1	0
No opposition within time limit	848	20.7	0
Granted	383	9.3	198
Opposition rejected	12	0.3	12
Opposition procedure closed	8	0.2	8
Maintained in amended form	6	0.1	6
Subtotal	1384	33.7	224
Total	4105	100	246

classified as big players and all other 'companies' were assumed to be smaller players.[5] The list further comprised of individuals, universities and government/non-profits. Where necessary, we manually removed anomalies in assignee names. For example, Enercon patents were searched using the assignee 'Wobben Aloys' and 'Wobben Properties GMBH'. Patents that were co-owned by companies and individuals were treated as belonging to 'companies'. The top ten firms (who we call big players) and ownership shares are shown in Tables 3 and 4 respectively.

For our sample of patents filed between 2001 and 2010, we observed an increase in the number of oppositions filed (Figure 3).

Of the 246 patents opposed we found opponent information for 171 of them. A who-opposed-whom matrix is presented in Table 5. Almost all oppositions feature at least one big player. This finding is interesting in-light of findings by Kapoor et al. (2015) who found top wind power players having considerable overlap among their portfolios based on the share of blocking citations made to competitors. Since our overall results do not show blocking citations to be significantly affecting incidence of opposition, we infer that blocking citations made to competitors maybe more relevant than ones made to others.

4.2. Descriptive statistics

Table 6 presents descriptive statistics from our sample of 4991 observations. Since pending patents were removed from our analysis, regressions with grants had 2545 observations (1384 successful and

Table 3. Application counts of top firms.

Firm name	Patent count
General Electric	493
Vestas Wind	480
Siemens AG	413
Enercon	262
REpower	186
Mitsubishi	159
LM Glasfiber	125
Nordex Energy	95
Gamesa	80
Suzlon Energy	33

Table 4. Share by ownership type.

Category	Count	Ownership (%)
Big players	2326	46.6
Small players	1936	38.8
Individuals	603	12.1
Universities	51	1.0
Govt./Non-profit	39	0.8
Unknown	36	0.7
Total	4991	100

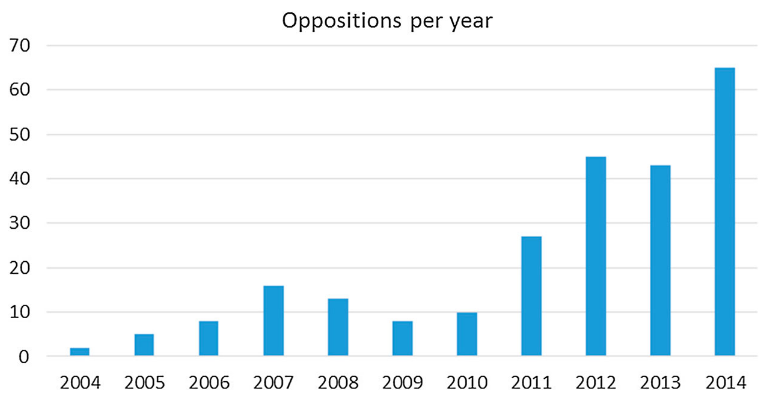

Figure 3. Oppositions raised.

1161 unsuccessful applications) and opposition regressions had 1094 observations (246 opposed and 848 unopposed applications).

According to our data, NPL comprises 5.5% of the citations added to patents. To put this into context, average NPL citations in all EP applications are close to 12% and can go as high as 60% in the field of biochemistry (Michel and Bettels 2001, 197). These findings were corroborated by our discussion with examiners, who suggest that wind industry patents are more ‘practical’ in nature and have, thus, fewer NPL citations.

The PCT route was seen as more preferred by applicants, with roughly 44% PCT applications (2185) originating from international offices and 18% PCT applications filed at the EPO (885 applications). The remaining 1921 (38%) were filed directly at the EPO. The mean values of citation origin indicate that most references are added during the search phase and only few citations originate from examiner and third party observations.

The number of claims and technical classes is zero on some occasions. This finding is a result of non-republished Euro-PCT patents and cases where the number of claims is not known in PATSTAT. In our data there was only one application that had missing IPC classes so we ignored it. Missing values in ‘number of claims’ were imputed by creating a linear regression model on data where ‘number of claims’ was not missing. We used this model to ‘predict’ values of missing ‘number of claims’ from other patent characteristics.

4.3. Regression analysis

Since our dependent variables ‘isGranted’ and ‘isOpposed’ were binary, we used logistic regression to test the influence of our predictor variables. Five models were finalised to test the influence of predictor variables on likelihood of grant and opposition. We included the scope variables of IPC and claim counts in all models as core controls. Analysis of origin of citations was separated for PCT

Table 5. Who-opposed-whom.

	Opponents											
Applicants	ENERCON	GAMESA	GE WIND	LM GLASFIBER	MITSUBISHI	NORDEX	REPOWER	SIEMENS	SUZLON	VESTAS	OTHER	Total
ENERCON		1				2	**6**	**8**		4	1	**22**
GAMESA										1	1	2
GE WIND	2					1	1	2		4	3	13
LM GLASFIBER	2		1					2		2		7
MITSUBISHI											1	1
NORDEX	2	1						1	1	2	1	8
REPOWER	**11**				1	1		**6**		5	4	**28**
SIEMENS	8		1	2		1	2			**7**	3	**24**
SUZLON	2											2
VESTAS	**10**	3		3		2	2	**7**			2	**29**
OTHER	7		3				1	5		7	12	35
Total	**44**	5	5	5	1	7	1	**31**	1	**32**	28	171

Table 6. Descriptive statistics.

	Variable	*N*	Mean	SD	Min	Max
Scope	Technical classes	4991	2.691	1.826	0	22
	Claims	4991	7.336	7.968	0	77
Type of reference	NPL references	4991	0.355	1.197	0	37
	Patent references	4991	6.111	3.988	0	88
Nature of reference	X references	4991	2.029	2.276	0	18
	Y references	4991	0.924	1.641	0	15
	A references	4991	2.242	2.310	0	31
Origin of reference	Applicant	4991	1.208	2.696	0	118
	European search report	4991	2.480	2.715	0	35
	International search report	4991	3.423	3.390	0	33
	Examiner	4991	0.1000	0.565	0	9
	Third party observation	4991	0.0285	0.368	0	9
Filing route	PCT (international)	4991	0.438	–	0	1
	PCT (EPO)	4991	0.177	–	0	1
	Euro-direct	4991	0.385	–	0	1
Dependent variables	isGranted	2545	0.545	–	0	1
	isOpposed	1094	0.225	–	0	1

and Euro-direct patents since there are different timelines and procedures for these filing routes. All count variables were used in log (count+1) form to normalise the effect of right skewness of the variables. The likelihood of grants is presented in Table 7.

Legal and technical scope is seen to be highly influential in predicting grant. Granted patents were characterised by higher patent citations. Citation categories have a significant impact on the likelihood of a grant. While blocking patent citations (*X* and *Y*) impede a grant, non-blocking (*A*) citations increase the likelihood of a grant. An interaction term was created as a cross product of citation type and citation categories. The effect of backward citations comes mainly from blocking citations made to patents. These references seriously hinder the chances of a successful patent.

In our regression model 5, we removed 101 rows of data that had zero references in their European search reports. This accounted for the bias that could have crept in by applications that were abandoned or withdrawn before the search phase. More comprehensive European and international search reports impede the chances of a grant. Successful patents featured higher number of applicant citations for both PCT and Euro routes. Euro-direct patent grants had a higher number of references added by the examiner which, we think, is because many unsuccessful applications do not reach examination stage.

The likelihood of oppositions is presented in Table 8.

Number of claims was significantly higher for opposed patents than for unopposed patents. Interesting to note are the negative sign in the coefficients of technical scope that suggest more opposition for more focused patents.

NPL references, however few, have a highly significant impact on the incidence of opposition. Or more specifically, NPL citations assigned to the *X* category made the patent application more susceptible to being challenged. One argument for this relationship is the increased chances of invalidity challenges owing to overlapping claims with scientific references.

Higher number of *A* references in a patent reduces the chances of opposition, while there is no significant impact of blocking citations on the incidence of opposition.[6] As mentioned earlier, one explanation for this finding is that the presence of *X* and *Y* citations can reduce the potency of a patent at the grant stage, thus pre-empting opposition.

Oppositions to PCT patents are less likely when citations are added in later stages of a PCT application (European search and examiner additions). Origin of citations does not prove to be significantly affecting oppositions to Euro-direct patents. Third party observations, despite being a rare occurrence in the wind industry, bear positive coefficients but significant only at 13% significance level.

Table 9 summarises our results.

Table 7. Regression models for likelihood of grant.

	Variables	(1) Grant	(2) Grant	(3) Grant	(4) Grant PCT	(5) Grant EURO
Scope	Technical classes	0.467***	0.544***	0.557***	0.597***	0.560***
		(0.0967)	(0.0982)	(0.0973)	(0.137)	(0.155)
	Number of claims	0.332***	0.432***	0.419***	0.337***	0.390***
		(0.0831)	(0.0851)	(0.0843)	(0.115)	(0.140)
Interaction term (type and nature of citations)	NPL – *X*			−0.0200		
				(0.0168)		
	NPL – *Y*			−0.00230		
				(0.0200)		
	NPL – *A*			0.000733		
				(0.0119)		
	PAT – *X*			−0.0072***		
				(0.00178)		
	PAT – *Y*			−0.00504**		
				(0.00253)		
	PAT – *A*			0.000819		
				(0.00107)		
Nature of citation	*A* citations		0.262***			
			(0.0622)			
	X citations		−0.230***			
			(0.0603)			
	Y citations		−0.241***			
			(0.0673)			
Type of citation	Patent citations	0.380***				
		(0.0736)				
	NPL citations	0.149				
		(0.106)				
Origin of citation	Applicant citations				0.582***	0.813***
					(0.103)	(0.113)
	International search				−0.558***	
					(0.163)	
	European search				−0.657***	−1.260***
					(0.133)	(0.195)
	Examiner citations				0.0545	1.436***
					(0.257)	(0.416)
	Third party obs.				1.074	−0.504
					(0.789)	(0.544)
	Constant	−1.920***	−1.512***	−1.382***	0.225	0.119
		(0.256)	(0.242)	(0.229)	(0.408)	(0.475)
	Observations	2545	2545	2545	1357	1087
	Pseudo R^2	0.0237	0.0337	0.0249	0.0575	0.0949
	Log likelihood	−1713	−1695	−1711	−853.1	−681.8

Note: Standard errors in parentheses; ***$p < .01$; **$p < .05$; *$p < .1$

5. Conclusion

Managing the lifecycle of a patent application consumes significant firm resources. Researchers and managers spend considerable time in dealing with patent office actions, examiner comments and opposition cases. In this study we have concentrated on patent grants and oppositions as key events in the lifecycle of a patent. We find, empirically, a relationship between patent citations and the likelihood of grants and opposition in European wind industry patents. These citation indicators can act as early signals for impending grants or oppositions.

Our specific findings show that NPL citations comprise only 5.5% of all citations in wind power patents. The patent landscape analysis has shown a rise in patent opposition in the wind industry, which is becoming dominated by top players. The 'who-opposed-whom' matrix presented reveals that top players are heavily involved in mutual oppositions. In light of almost 50% patents owned by big firms, smaller players need to carry out adequate due diligence before entering European markets. An interesting finding in our study is related to as many as 40% patents filed between 2001 and 2010 that are still pending. Pending patents represent uncertainty in the innovation

Table 8. Regression models for likelihood of opposition.

	Variables	(1) Opposed	(2) Opposed	(3) Opposed	(4) Opposed PCT	(5) Opposed EURO
Scope	Technical classes	−0.0939	−0.0682	−0.0726	−0.107	0.0834
		(0.168)	(0.168)	(0.169)	(0.217)	(0.272)
	Number of claims	0.298**	0.306**	0.283*	0.301*	0.258
		(0.146)	(0.146)	(0.146)	(0.177)	(0.284)
Interaction term (type and nature of citations)	NPL – *X*			0.0518*		
				(0.0309)		
	NPL – *Y*			0.0105		
				(0.0360)		
	NPL – *A*			0.0379		
				(0.0244)		
	PAT – *X*			0.00156		
				(0.00378)		
	PAT – *Y*			0.000877		
				(0.00567)		
	PAT – *A*			−0.0130***		
				(0.00460)		
Nature of citation	*A* citations		−0.349***			
			(0.130)			
	X citations		0.0351			
			(0.119)			
	Y citations		−0.0517			
			(0.128)			
Type of citation	Patent citations	0.0344				
		(0.166)				
	NPL citations	0.799***				
		(0.165)				
Origin of citation	Applicant citations				0.126	0.152
					(0.151)	(0.192)
	International search				0.0469	
					(0.270)	
	European search				−1.212***	−0.235
					(0.469)	(0.336)
	Examiner citations				−0.649*	0.522
					(0.386)	(0.488)
	Third party obs.				0.929	1.505
					(0.614)	(1.033)
	Constant	−2.086***	−1.548***	−1.747***	−1.102	−1.767*
		(0.515)	(0.460)	(0.428)	(0.765)	(0.917)
	Observations	1094	1094	1094	658	436
	Pseudo R^2	0.0240	0.0133	0.0219	0.0307	0.0115
	Log likelihood	−569.1	−575.3	−570.3	−342.4	−227.2

Note: Standard errors in parentheses; ***$p < .01$; **$p < .05$; *$p < .1$.

system, and there could be strategic reasons why applicants deliberately want to delay decision-making events. The question of the effect of pending patents could provide researchers with an interesting area of future research. In this context, research on divisional patent applications may be of particular interest.

Legal (number of claims) and technical scope (number of IPC classes) show a strong positive relationship with the likelihood of a grant of a patent. Building an interaction term between type of citation and citation categories shows that most of the effect of backward citations come from blocking citations (the ones indicating overlapping claims). The use of citation categories deserves greater attention as they can offset the use of pure citation counts with relevance of each citation. We also see that categories assigned to citations are strong predictors of grants. Citations of a blocking nature weaken the scope of a patent and pre-empt opposition and non-blocking patent citations significantly reduce the likelihood of facing an opposition. Future research related to citation categories could valuably test their influence on the outcome of opposition cases.[7]

Table 9. Summary of results.

	Variables	Impact on grant Expected	Impact on grant Actual	Impact on opposition Expected	Impact on opposition Actual	Remarks
Legal and technical scope	IPC classes	+	+	+/−	−/+	Confirmed; coeff negative for opposition
	Claims	+	+	+	+	Confirmed
Citation type	NPL references	+	+/−	+	+	Not significant for grant; confirmed for opposition
	Patent references	+	+	+	+/−	Confirmed for grant: not significant for opposition
Citation category	*A* references	+	+	−	−	Confirmed
	X references	−	−	+	+/−	Confirmed for grant: not significant for opposition
	Y references	−	−	+	−/+	Confirmed for grant: not significant for opposition (negative coeff)
Citation origin	Applicant citations	+/−	+	+/−	+/−	Granted patents tend to have higher applicant citations
	European search report	−	−	−	+/−	Confirmed for grant
	International search report	−	−	−	−	Confirmed
	Examiner citations	−	+/−	−	−/+	No reliable effect
	Third party observations	−	+/−	+	+/−	Impact on opposition significant at 13% level

Our findings related to citation origins are exploratory and more research is needed to test their impact in other technology fields. Rare events like third party observations might be relevant in pharmaceutical industry where there are public interest groups who keep watch on proceedings of a patent application. The theoretical part also highlights some strategic aspects of when parties choose to exercise (or not) the option of third party observations. Search reports can provide valuable insights into the future of a patent application. More comprehensive search reports are seen in our study to obstruct the grant of a patent and pre-empt opposition.

Unfortunately, despite restricting our sample to a single jurisdiction, the citation analysis in our study has some limitations. The importance of PCT patents cannot be ignored in the wind industry and this has led us to treating citations coming from various search authorities with equal status. For this reason, we have separated our analysis related to citation origins into PCT and non-PCT patents. Controlling for the exact effects of the various search authorities remains a future area of research. Another limitation stems from the lack of availability of data showing the changes made to a patent application during pendency. In this regard, the degree to which citation categories affect changes to an application is not studied.

Notes

1. Our wind industry data revealed an average grant lag of 4.7 years and average opposition lag of 5.5 years.
2. We have used the phrases ‘prior art’, ‘backward patent citations’, ‘backward patent references’, sometimes just ‘citations’, interchangeably in this paper.
3. For more details about European and international citations for EPO patents please refer to Webb et al. (2005).
4. PCT applications can also be filed at the EPO. In this case EPO generates the international search report too. See Table 6 for detailed shares of filing routes in our sample.
5. Some firms like ABB are financially big conglomerates but they feature in the list of ‘small players’ because they own fewer wind power patents than other players.
6. This result is different from Harhoff and Reitzig (2004), 472, who found positive relationship between *X* citations and incidence of opposition for biotechnology and pharmaceutical patents.
7. Some efforts have been made to use patent characteristics as determinants of opposition outcomes by Sterlacchini (2016).

Acknowledgements

We would like to thank Lappeenranta University of Technology for funding this research as part of patent studies in climate change mitigation technologies. We are also grateful for the insights provided by two anonymous referees.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Akers, N. J. 1999. "The European Patent System: An Introduction for Patent Searchers." *World Patent Information* 21: 135–163.

Alcácer, J., M. Gittelman, and B. Sampat. 2009. "Applicant and Examiner Citations in U.S. Patents: An Overview and Analysis." *Research Policy* 38 (2): 415–427.

Berbegal-Mirabent, J., and F. Sabate. 2015. "Balancing Basic and Applied Research Outputs: A Study of the Trade-Offs Between Publishing and Patenting." *Technology Analysis & Strategic Management* 27 (10): 1143–1158.

Blind, K., K. Cremers, and E. Mueller. 2009. "The Influence of Strategic Patenting on Companies' Patent Portfolios." *Research Policy* 38 (2): 428–436.

Braun, F., J. Schmid-Ehmcke, and P. Zloczysti. 2010. "Innovative Activity in Wind and Solar Technology: Empirical Evidence on Knowledge Spillovers using Patent Data." *Grasp Working Paper* 3: 1–28.

Calderini, M., and G. Scellato. 2004. *Intellectual Property Rights as Strategic Asset: The Case of European Patent Opposition in the Telecommunications Industry*. CESPRI Working Paper no. 158. University Bocconi.

Caviggioli, F., G. Scellato, and E. Ughetto. 2013. "International Patent Disputes: Evidence from Oppositions at the European Patent Office." *Research Policy* 42 (9): 1634–1646.

Cotropia, C. A., M. A. Lemley, and B. Sampat. 2013. "Do Applicant Patent Citations Matter?" *Research Policy* 42 (4): 844–854.

Czarnitzki, D., K. Hussinger, and B. Leten. 2011. *The Market Value of Blocking Patent Citations*. Discussion paper No. 11–021, ZEW. Center for European Economic Research.

Dismukes, J., L. Miller, and J. Bers. 2009. "The Industrial Life Cycle of Wind Energy Electrical Power Generation ARI Methodology Modeling of Life Cycle Dynamics." *Technological Forecasting and Social Change* 76 (1): 178–191.

Dubaric, E., D. Giannoccaro, and R. Bengtsson, and T. Ackermann. 2011. "Patent Data as Indicators Wind Power Technology Development." *World Patent Information* 33: 144–149.

European Patent Office. 2010. Guidelines for Examination in the European Patent Office, April 2010. [www-document]. Accessed August 8. http://documents.epo.org/projects/babylon/eponet.nsf/0/7ffc755ad943703dc12576f00054cacc/$FILE/guidelines_2010_complete_en.pdf.

Graham, S. J. H., B. H. Hall, D. Harhoff, and D. C. Mowery. 2002. *Post-issue Patent "Quality Control": A Comparative Study of US Patent Re-examinations and European Oppositions*. NBER Working Paper 8807.

Graham, S., and D. Harhoff. 2006. *Can Post-Grant Reviews Improve Patent System Design? A Twin Study of US and European Patents, Governance and the Efficiency of Economic Systems*. Discussion Paper No. 38.

Guellec, D., and van B. Pottelsberghe. 2000. "Applications, Grants and the Value of Patent." *Economics Letters* 69 (1): 109–114.

Hall, B., S. Graham, D. Harhoff, and D. Mowery. 2003. *Prospects for Improving US Patent Quality via Post-grant Opposition*. NBER working paper 9731.
Hall, B. H., A. B. Jaffe, and M. Trajtenberg. 2001. *The NBER Patent Citations Data File: Lessons, Insights, and Methodological tools*. NBER Working Paper No. 8498. Cambridge, MA.
Harhoff, D., and M. Reitzig. 2004. "Determinants of Opposition Against EPO Patent Grants—The Case of Biotechnology and Pharmaceuticals." *International Journal of Industrial Organization* 22 (4): 443–480.
Harhoff, D., F. Scherer, and K. Vopel. 2003. "Citations, Family Size, Opposition and the Value of Patent Rights." *Research Policy* 32 (8): 1343–1363.
Harhoff, D., and S. Wagner. 2009. "The Duration of Patent Examination at the European Patent Office." *Management Science* 55 (12): 1969–1984.
Holgersson, M. 2013. "Patent Management in Entrepreneurial SMSs: A Literature Review and an Empirical Study of Innovation Appropriation, Patent Propensity, and Motives." *R&D Management* 43 (1): 21–36.
Islam, M., S. Mekhilef, and R. Saidur. 2013. "Progress and Recent Trends of Wind Energy Technology." *Renewable and Sustainable Energy Reviews* 21: 456–468.
Jaffe, A., M. Trajtenberg, and M. Fogarty. 2000. "Knowledge Spillovers and Patent Citations: Evidence from a Survey of Inventors." *The American Economic Review* 90 (2): 215–218.
Jell, F. 2012. *Patent Filing Strategies and Patent Management – An Empirical Study*. Wiesbaden: Gabler Verlag.
Jensen, P., and E. Webster. 2006. "Firm Size and the Use of Intellectual Property Rights." *The Economic Record* 82 (256): 44–55.
Jerak, A., and S. Wagner. 2006. "Modeling Probabilities of Patent Oppositions in a Bayesian Semiparametric Regression Framework." *Empirical Economics* 31: 513–533.
Kapoor, R., M. Karvonen, S. Ranaei, and T. Kässi. 2015. "Patent Portfolios of European Wind Industry: New Insights Using Citation Categories." *World Patent Information* 41: 4–10.
Lanjouw, J., and M. Schankerman. 2004. "Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators." *The Economic Journal* 114 (495): 441–465.
Lee, C., B. Song, and Y. Park. 2013. "How to Assess Patent Infringement Risks: A Semantic Patent Claim Analysis Using Dependency Relationships." *Technology Analysis & Strategic Management* 25 (1): 23–38.
Lerner, J. 1994. "The Importance of Patent Scope: An Empirical Analysis." *Rand Journal of Economics* 25 (3): 319–333.
McDowall, W., P. Ekins, S. Radosevic, and L. Zhang. 2013. "The Development of Wind Power in China, Europe and USA: How Have Policies and Innovation System Activities Co-evolved?" *Technology Analysis & Strategic Management* 25 (2): 163–185.
Michel, J., and B. Bettels. 2001. "Patent Citation Analysis. A Closer Look at the Basic Input Data from Patent Search Reports." *Scientometrics* 51 (1): 185–201.
Nemet, G., and E. Johnson. 2012. "Do Important Inventions Benefit from Knowledge Originating in Other Technological Domains." *Research Policy* 41 (1): 190–200.
OECD, HAN Database. 2015, April. http://www.oecd.org/sti/inno/oecdpatentdatabases.htm
OECD Patent Statistics Manual. 2009. *OECD Publishing*.
Palangkaraya, A., P. H. Jensen, and E. Webster. 2008. "Applicant Behaviour in Patent Examination Request Lags." *Economics Letters* 101 (3): 243–245.
Popp, D., I. Hascic, and N. Medhi. 2011. "Technology and the Diffusion of Renewable Energy." *Energy Economics* 33 (4): 648–662.
Reitzig, M. 2004. "Improving Patent Valuations for Management Purposes—Validating New Indicators by Analyzing Application Rationales." *Research Policy* 33 (6–7): 939–957.
Rosenkopf, L., and A. Nerkar. 2001. "Beyond Local Search: Boundary-Spanning Exploration, and Impact in the Optical Disk Industry." *Strategic Management Journal* 22 (4): 287–306.
Sahin, A. 2004. "Progress and Recent Trends in Wind Energy." *Progress in Energy and Combustion Science* 30 (5): 501–543.
Schneider, C. 2011. "The Battle for Patent Rights in Plant Biotechnology: Evidence from Opposition Filings." *Journal of Technology Transfer* 36 (5): 565–579.
Simmie, J. 2012. "Path Dependence and New Technological Path Creation in the Danish Wind Power Industry." *European Planning Studies* 20 (5): 753–772.
Smith, P. 2013. "Patent Litigation to Rise." *Wind Power Monthly*, 29 August 2013. Accessed October 10. http://www.windpowermonthly.com/article/1209660/patent-litigation-rise
Sterlacchini, A. 2016. "Patent Oppositions and Oppositions Outcomes: Evidence from Domestic Appliance Companies." *European Journal of Law and Economics* 41 (1): 183–203.
Van Zeebroeck, N. 2011. "The Vulnerability of Patent Value Determinants." *Economics of Innovation and New Technology* 20 (3): 283–308.
Van Zeebroeck, N., B. van Pottelsberghe, and D. Guellec. 2009. "Claiming More: The Increased Voluminosity of Patent Applications and its Determinants." *Research Policy* 38 (6): 1006–1020.
Webb, C., H. Dernis, D. Harhoff, and K. Hoisl. 2005. *Analysing European and International Patent Citations: a Set of EPO Patent Database Building Blocks*. OECD STI Working Paper 2005/9. OECD Publishing.

Publication V

Kapoor, R., and van Zeebroeck, N.

The laws of action and reaction: on determinants of patent disputes in European chemical and drug industries

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Available online: http://econpapers.repec.org/paper/ictwpaper/2013_2f235144.htm

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THE LAWS OF ACTION AND REACTION: ON DETERMINANTS OF PATENT DISPUTES IN EUROPEAN CHEMICAL AND DRUG INDUSTRIES

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The laws of action and reaction: on determinants of patent disputes in European chemical and drug industries

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Abstract

Patent disputes are important events for patentees, their competitors, and society. Using a unique dataset of patent disputes in Europe, we estimate their likelihood and outcome based on the choices and actions of parties during patent prosecution. We build our hypotheses using classical models of litigation and settlement, namely, divergent expectations, asymmetric stakes, and informational asymmetries. Our results suggest that parties are involved in a dynamic bargaining game throughout the lifecycle of a patent. They use procedural instruments at their disposal to achieve certainty, and continuously update their beliefs about the strength of their case as new information is revealed. Uncertainty over scope and validity triggers third-party actions to eliminate blocking patents, while patentees use divisionals and amendments to isolate valuable parts of their applications before quickly bringing them to court. Defendants may retaliate by challenging the validity of patents as a counterclaim before court, bringing more uncertainty and thus impeding settlement. The main policy implication is that specific patent procedures (e.g., third-party observations and amendments) might be exploited to reduce uncertainty and improve the validity of patents. These should be encouraged, while bulky patents followed by long chains of divisionals should be regarded with a degree of suspicion.

Keywords: *Patent Litigation, Opposition, Patent System, Patent Value, Patent Strategy, European Patent Office*

1. Introduction

The enforcement or cancellation of patents may yield or destroy millions, perhaps billions, of euros in revenues for their holders, particularly in discrete product industries like chemicals and pharmaceuticals. The validity and enforceability of patents are therefore very intense battlefields for firms and their lawyers. Consequently, patent reviews (such as oppositions) and litigation over patent infringement or cancellation have been widely studied in the economics literature (Graham and van Zeebroeck, 2014). These efforts have contributed to our understanding of the main factors driving the demand for litigation or affecting the likelihood of patent disputes to settle: divergent expectations, asymmetric stakes, and information asymmetries. Most of these efforts have looked at patent litigation like one-shot actions that start with a claim filing before a court (e.g., Lanjouw and Schankerman, 2004). The roots of legal conflicts may, however, be developing as soon as a patent is filed, and a court filing may be viewed as a failure of the parties to resolve their conflict earlier. Consequently, early signs of tensions—revealed by the patentee's actions during the patenting process or by counteractions by third parties—may provide advanced notice of future legal challenges and may help understand why such disputes resolve before going to court or not. In this paper, we investigate the sources of patent litigation as they uncover during the patenting process. We analyze the actions of patentees and their opponents throughout the patent proceedings and assess their impact on future legal disputes.

Our analysis focuses on the chemical and pharmaceutical industries in Europe. These industries are research intensive, and their business models rely heavily on patents for value appropriation (Levin et al., 1987; Arundel and Kabla, 1998; Cohen et al. 2000). In addition, technology development cycles and times to market are considerably longer in these industries, largely due to regulatory testing and approval procedures (Howard, 2007). This means that patents are applied for years before the patented product or process makes its way to the market. As the technology and business opportunities unfold, patentees develop a better sense of where the true value of their inventions lie. Patents in these fields often endure lengthy granting processes and can even remain in pendency for a decade (van Zeebroeck, 2011).

The theoretical framework of this study relies on earlier models of litigation and settlement (Priest and Klein, 1985; Nalebuff, 1987). We use these frameworks to shed new light on different stages in patent disputes and strategic factors predicting developments in a dispute. Data on opposition and litigation of European patents are compared over a set of observables (mainly revealed during the examination phase) against a random control group. Research on patent litigation in Europe has been comparatively limited until recently, due to the fragmented nature of the European litigation system and the resulting lack of case information available. We thereby extend earlier findings on the determinants of patent opposition and litigation in Europe (Harhoff and Reitzig, 2004; Reitzig, 2004; Cremers et al., 2016) with recently disclosed data.

Our results indicate that the seeds of patent disputes can already be observed in applicant and third party actions during patent office proceedings. We observe that the typical litigated patent is a relatively small and focused patent within a chain of divisional filings. Furthermore, requests for accelerated examination are extremely strong predictors of future challenges. These two results suggest that patentees use divisionals to isolate and extract the most valuable (and litigious) part of their application once they are determined and ready to litigate. In turn, offensive actions against a pending patent (i.e., third-party observations) betray the eagerness of other firms to prevent a patent from being granted and therefore also strongly indicate future legal challenges. Oppositions and amendments to patents during the proceedings then act as catalysts to strengthen and clarify the validity of patents. Overall, our results show the dynamic strategic games played by patentees and other players in their environment, highlighting a game of actions and reactions until the case reaches its end (through settlement or court adjudication). Parties continuously update their beliefs as new information is unveiled. Throughout this game, uncertainty over patent validity appears to be a critical obstacle to dispute resolution.

2. Enforcement of patents in Europe

The patent system encourages public disclosure of inventions in return for a temporary monopoly over their use. The inventor's private value lies in the monopoly pricing of the patented product, while the societal value comes from the openness of patent information that enables anybody to learn and improve an invention. Many researchers have debated the tradeoffs faced by innovators and the optimal incentive systems to encourage innovation (Gilbert and Shapiro, 1990; Scotchmer, 1991; Lanjouw and Lerner, 1997; Wright, 1999). In a competitive economy, it is noteworthy that patents offer only passive rights to their owners. The onus of defending their rights, thus, lies with the patent holders (Crampes and Langinier, 2002; Harhoff and Reitzig, 2004). Disputes related to patented inventions serve the dual purpose of defending innovators' rights and purging the patent system of erroneous or low-quality grants.

In Europe, patent challenges either can take place at the patent office (during opposition) or as national lawsuits pursued by the parties.[1] A European Patent Office (EPO) patent is a bundle of national patents that are effective once validated in individual member states. A central opposition can be made at the EPO by any third party within a period of nine months after grant. An opposition is the only procedure that can invalidate an EPO grant centrally. Once the nine months have elapsed or the opposition procedure is formally closed, a patent can only be challenged through legislative courts in the individual member states.[2] The costs associated with pursuing patent litigation in courts can be significantly higher than the central EPO opposition procedure.[3]

Once filed, a European patent first undergoes a search for prior art, which results in a search report. The search report and application are usually published within 18 months. In the second stage, the application may proceed to a substantive examination phase before being granted or refused. Figure 1 shows a simplified timeline of a European patent application. We refer to a patent dispute as any incidence of opposition and/or litigation. Settlement refers to a settlement agreement between the parties after a dispute is brought to a national court for litigation. Opposition, litigation, and settlement form the set of dependent variables in this study.

[1] Europe has recently adopted the principle of a centralized forum and procedure for patent litigation called the Unified Patent Court (UPC). The UPC is still in its inception stage and not yet active. The present study focuses on patent litigation in a period that precedes this development. For the context of the present paper, patent litigation in Europe was still governed by national courts with exclusive jurisdiction.
[2] This will only remain true until the Unified Patent Court will come into force.
[3] While the cost of filing an opposition at the EPO is only €785 (2016 figures), the total cost of opposition for each party can be between €10,000 to €25,000, including attorney fees and other indirect costs (Graham and Harhoff, 2006). Litigation costs can be much higher. WIPO (2009) estimates a minimum cost of £350,000 for a typical lawsuit in the UK.

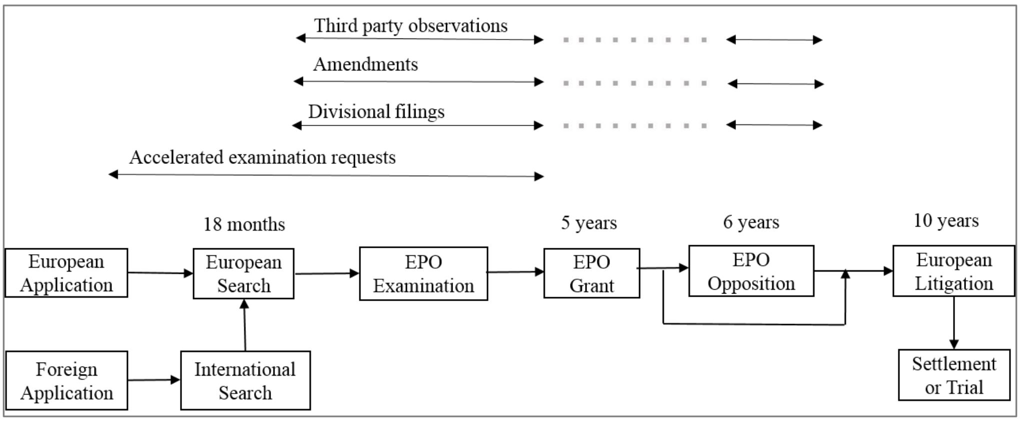

Figure 1. *Simplified timeline of EPO patents (average lags in years)*

2.1 Opposition

After obtaining a grant, applicants usually have three months to submit translations and complete other formalities in individual member states that constitute the "validation" of an EPO grant. Even as the applicants undergo formal procedures to obtain patent rights, their grants are not written in stone just yet. Any third party may file an opposition to an EPO grant up to nine months after the grant publication. The EPO opposition procedure is in place to act as a corrective post-grant mechanism. The procedure constitutes first-instance proceedings and appeal proceedings. There are three possible outcomes of the opposition procedure: (i) revocation, (ii) amendment, and (iii) maintenance.[4] Along with the appeal proceedings, the opposition procedure can sometimes last up to four years. This window of uncertainty is detrimental to patent holders because it undermines the incentives to make additional investments before the patent's validity is established.

Previous research related to determinants of EPO oppositions (Graham et al., 2002; Harhoff et al., 2003; Jerak and Wagner, 2006; Cincera, 2011) showed that valuable patents are more susceptible to opposition. Reitzig (2004) and Harhoff and Reitzig (2004) used early-stage patent characteristics to predict European patent oppositions in chemical, biotechnology, and pharmaceutical industries. Other studies have tested the likelihood of an opposition based on geographical origin (Caviggioli et al., 2013) and size of firms (Calderini and Scellato, 2004).

2.2 Litigation

Post grant, an EPO patent comes under the purview of national courts in individual countries where the patent is valid. The litigation system in Europe is very heterogeneous. Patent proprietors face a difficult task in enforcing their European patents. The same applies to third parties who wish to invalidate a European patent in different countries. Some of the challenges typically faced by litigants are high costs, language barriers, and risk of diverging verdicts. Forum shopping is thus a common practice (Moore, 2001), where litigants take advantage of differences between national courts in terms of damages awarded, historical trends, speed of verdict, and interpretation of case law. As a result, the process of setting up a specialized court called the Unified Patent Court (UPC) is

[4] Evidence suggests all outcomes are equally likely as a result of the opposition procedure (van de Kuilen, 2013 p. 126)

currently underway. A good discussion of the most important courts and their structural differences is presented in Cremers et al. (2016) and Graham and van Zeebroeck (2014).

Empirically, litigation has been found to be the ultimate test of patent value (Allison et al., 2004). Lanjouw and Schankerman's (2001) study was among the first to identify variations across patents in their likelihood of being litigated. They used a sample of litigated patents in the United States and compared patent and ownership characteristics with a control group of similar non-litigated patents. They reported that only some 6.3 patents (involved in 10.7 cases) were involved in litigation per thousand patents between 1980 and 1984.[5]

2.3 Settlement

We study the determinants of settlements for only those patents that were brought to a court for litigation. Many disputes are settled during pre-trial negotiations (before litigation) that are unobservable. The very fact that litigation occurs is a sign of non-settlement. Thus, when we study the determinants of litigation, we are also studying the determinants of failure of pre-trial negotiations. Of the few patents that end up being litigated, even fewer go to trial. The parties usually settle before incurring a sizable chunk of legal expenses.

Interestingly, the determinants of pre-trial non-settlement (or litigation) are not the same as those of non-settlement in court. The following section describes the prior literature on disputes and settlements.

3. Theoretical framework

Priest and Kline (1984) have paved the foundations for an economic theory of litigation. At the core of this theory is the choice parties face between litigating and cooperating over patent validity and infringement. This choice is strongly affected by the presence of uncertainty. There are two inherent sources of uncertainty associated with patents: commercial significance and definition of validity and scope. Uncertainty generates divergent expectations, which prevent parties from cooperating (Priest and Kline, 1984). Asymmetric stakes (Meurer, 1989; Siegelman and Waldfogel, 1999; Lanjouw and Lerner, 1997) and informational asymmetry (Bebchuk, 1984) are the two other prominent obstacles to cooperative solutions. Asymmetric stakes occur when the resolution of a dispute affects one party more than the other beyond the monetary amount of the resolution. Informational asymmetry refers to a situation wherein one party has some private information that can help them make a better assessment of the expected outcome. Empirical work based on these models by Somaya (2003) has identified "strategic stakes" of the parties as the primary reason for non-settlement in disputes related to research medicines.

Enforcement of patents is a bargaining process. Parties usually reach a mutual agreement before it is necessary to go to court. Nalebuff (1987) presented a model wherein pre-litigation settlement is influenced by the credibility of a plaintiff's threat to litigate. Figure 2 presents Nalebuff's simple theoretical model.

[5] Patents in the field of drugs and health feature a much higher litigation rate of 20 patents per 1000

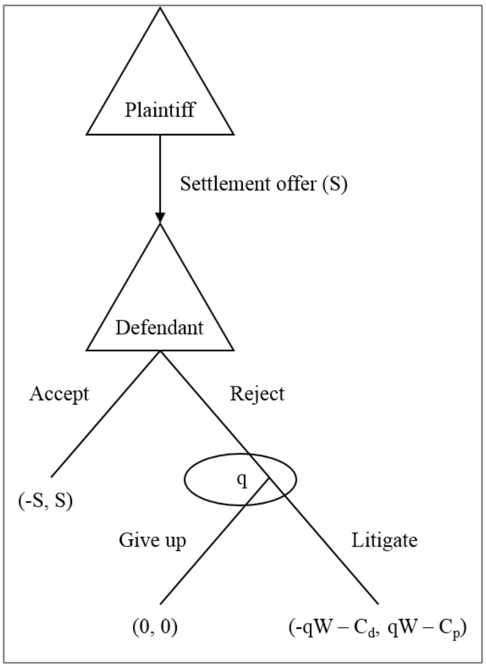

Figure 2. Game tree of bargaining and outcome. Source: Nalebuff (1987)

W refers to the total size of plaintiff injury; *q* refers to the defendant's liability in the total injury *W*. Alternatively, *q* can be assumed to be the probability of plaintiff victory with defendant being fully liable. C_p and C_d capture the costs of plaintiffs and defendants respectively. The figures in brackets refer to the respective loss of defendant and gain of plaintiff in the event of a plaintiff victory. Should a trial lead to plaintiff victory, the defendant loss is $–qW – C_d$ and corresponding plaintiff gain is $qW – C_p$. If the plaintiff's settlement offer S is rejected, the choice to follow through with litigation will depend upon their estimate of *q* (uncertainty surrounding the strength of the case) and the size of stakes *W*. Litigation will be prudent only if $qW > C_p$.

Our empirical framework uses these litigation and settlement models over the entire lifespan of patents and shows what kinds of actions bring the parties closer to, or farther from, a settlement. By studying the effects of our procedural measures on litigation and settlement, we show that parties update their beliefs continuously as new information is revealed (and hence also update *q* in the model above).

In this paper, our focus is primarily on the uncertainty surrounding patent scope and validity, using various patent and procedural features of the EPO to assess them. We further investigate whether the urgency of parties has any influence on the likelihood and outcome of future disputes. These different dimensions are discussed in the following paragraphs to develop our hypotheses.

3.1 Uncertainty over scope

If parties opt into a dispute based on prior information about the scope of the focal patent, uncertainty about the patent scope should increase the likelihood of legal challenges. We rely on claim counts and divisional applications to proxy for the uncertainty over the scope of patents.

<u>*Claims*</u>

Despite a general increase in claim counts within patent filings throughout the world (see e.g. Archontopoulos et al. (2007)), patents vary widely in size, from just one or a few claims to thousands of them in a single application. Intuitively, more claims should be associated with a broader scope of protection, although dependent claims may also be used to narrow down the scope of other claims. It is however safe to argue that a larger number of claims will be harder to navigate and fully grasp. How could one fully assess the scope of patent that is made of hundreds of different claims? Larger patents are therefore associated with more uncertainty around the exact scope of a patent document. This is particularly relevant in the chemicals and pharmaceuticals industry, where patents are often drafted at a very early stage to cover a whole range of molecules or compounds until the most promising one(s) can be identified. Archontopoulos et al. (2007) and van Zeebroeck et al. (2009) have shown that very large patents are disproportionately found in this industry. Hypothesis 1 therefore reads as follows:

Hypothesis 1*: Controlling for patent value, patents with fewer claims are less subject to legal challenges.*

<u>*Divisional applications*</u>

Divisional applications are used to isolate a "surer" part of the application or to proceed with the examination of the application in several parts following parallel tracks. According to Rule 36 of the European Patent Convention (EPC), an applicant may file a divisional application at the EPO as long as the parent application is pending, i.e., not granted, refused, or revoked. The usual reason for filing a divisional application is that the parent application does not satisfy the requirements as to the unity of invention and the applicant is not content with limiting it. Applicants can sometimes identify new and independent protection features emanating from the same subject matter that can be filed as "divisionals."

From a strategic point of view, divisional applications are usually filed immediately ahead of the office actions, for example, imminent rejection. *"It has thus been popular to file a divisional application on the day before oral proceedings are being held at the EPO. In case the oral proceedings should end with a rejection of the patent application, the applicant in question has really not lost any rights as then he has a pending divisional application which could have the same content as the originally filed application, and which subsequently is prosecuted in its own course of examination."*[6] Applicants may use divisional applications as means of understanding what subject matter will be allowed as a patent right for a perceptibly important invention. As a result, third parties may be kept in uncertainty over the exact nature of rights granted to an invention. Divisionals are therefore expected to proxy for uncertainty around the scope of a patent; likewise, claims.

[6] http://www.patentgruppen.com/news/archive/new-rules-epo---divisional-applications.aspx. Last accessed on July 15, 2015.

Besides the usual grounds of "insufficiency of disclosure" and "non-patentable subject matter" to file oppositions at the EPO, third parties may also challenge subject matter extension of divisional applications as grounds for invalidation. Divisional applications are harder to invalidate in court because their subject matter is interconnected with other applications. This gives the patent holder greater confidence against possible invalidity, thus making the threat to litigate credible. The nine-month opposition window gives third parties a useful opportunity to invalidate such patents immediately. Our second hypothesis thus derives as follows:

***Hypothesis 2**: Applications that are part of a large divisional chain are more likely to be involved in legal challenges.*

3.2 Uncertainty over validity

The two main issues that are discussed in most legal challenges over patents are their equivalence (i.e. does the defendant infringe on the patent or not) and their validity (are the patents valid in the first place). Any source of uncertainty over the latter should therefore feed divergent expectations and push the parties closer to the courts. On the contrary, any action that adds more confidence or clarity around a patent's validity should reduce the risk of divergent expectations and hence pull the parties away from courts. We look at patent validity from three different perspectives, which we introduce in the following section: has the focal patent been amended before grant (as discussed below, most amendments are meant to clarify and strengthen the application to facilitate its grant)? Has the patent survived an opposition challenge (i.e. has the patent's validity been reviewed by an opposition board)? And is the validity of the focal patent discussed in court?

<u>*Patent amendments*</u>

We used the European Patent Register database to check for patents that have events related to their amendment. Any amendment made to the description or claims is recorded in the register. As per article 123 of the EPC, these amendments are those made by applicants of their own volition. The amendments may not, in any way, extend beyond the subject matter of the filed application, which is usually formulated in broad and vague fashion. Our discussions with experts have revealed that amendments are usually made in a restrictive way to clear the way for a grant. Amendments should therefore clarify (hence reduce uncertainty over) the patent's validity, hence hypothesis 3:

***Hypothesis 3:** Clarification of validity in the form of amendments will lead to a lower likelihood of legal challenges.*

<u>*Post-grant opposition*</u>

Post-grant oppositions are interesting in at least two respects. First, they form one kind of legal challenge (an invalidity action in this case), which we consider in our empirical analysis. The literature has established a strong link between patent value and opposition (Harhoff et al., 2003), suggesting that oppositions themselves occur because of the higher stakes involved. Second, they act as catalysts, reducing uncertainty over the validity of patents. Should a patent resist an opposition procedure before the EPO, it will exit the challenge with much more certainty over its validity.

An incidence of opposition should thus be associated with higher stakes and a significant reduction in uncertainty over the patent's validity. In such circumstances, the patent holder's threat to litigate is more credible, owing to their updated belief about the validity of their patent. This should make them more likely to initiate litigation against an alleged infringer. Once the suit makes its way to court, the outcome of opposition is generally known before the parties and judges. The parties should therefore be better aware of patent validity (reducing divergent expectations) and thus become more likely to reach a settlement, as observed by Graham et al. (2012). In this regard, patent amendments play a similar role. This is summarized in hypothesis 4.

Hypothesis 4*: Information about patent validity revealed during earlier prosecution (i.e. opposition) will increase the likelihood of litigation but also of a subsequent settlement.*

Case type

Typically, patent litigation will involve either an infringement or an invalidity suit. Correspondingly, plaintiffs make either an infringement or an invalidity claim. Infringement-type disputes are most common; hence, plaintiffs are usually patent holders themselves. Of the few invalidity suits, most occur as an outcome of an infringement claim. This happens when a defendant counterclaims invalidity of a patent when charged with infringement of the said patent.

Patent litigation literature suggests that lack of pure invalidity suits is a result of low incentives for third parties to invalidate a patent (Farrell and Merges, 2004). Most patents' validity is not challenged because it is simply not worth spending legal expenses on patent grants that have little or no commercial significance. In addition, given the availability of opposition proceedings in Europe and the costs associated with the national scope of invalidity challenges before courts, pure invalidity challenges are less likely.

When faced with an infringement claim, a defendant typically has two counterarguments, in the form of non-infringement and counter-invalidity. Ford (2013) presents theoretical arguments that favor non-infringement as a counterclaim over counter-invalidity. To prove invalidity, the defendant will have to prepare clear and concise evidence that might include a prior art search. Moreover, the preparation of the counter-invalidity argument may have to be done within a time limit as the case remains pending. In an infringement suit, the defendant will typically have better access to information about their allegedly infringing product, while the patent holder (plaintiff) will have better access to information regarding the underlying technology and prior art (Meurer, 1989). Another reason why defendants may not choose counter-invalidity is that a successful invalidity challenge renders the patent right a public good (Farrell and Merges, 2004). This means that any competitor can use the technology without infringement or royalties, thus reducing the benefit of privileged players (patent holders and licensees) in a market economy. This again reduces the incentive to invalidate a patent and encourages mutual settlement of a dispute. We presume a pure invalidity or a counter-invalidity suit to be associated with greater uncertainty than a pure infringement case, thus leading expectations to diverge further. Hence, hypothesis 5.

Hypothesis 5*: When the validity of a patent is discussed before court, settlement is less likely to occur.*

3.3 Urgency

We next investigate the effect that a sense of urgency has on the likelihood and outcome of patent challenges. Specifically, we examine whether the haste of the parties to obtain a grant or prevent a patent from being issued are predictive of future challenges, and whether legal challenges started in a haste are more or less likely to be settled. Two procedural features of the examination procedures at the EPO enable us to observe this: third-party observations and requests for accelerated examination.

Third-party observations

We extracted citation data from PATSTAT and disaggregated them based on origin. Although a vast majority of citations included in EPO patents are generated during the search phase, they are sometimes suggested by third parties. According to article 115 of the EPC, any third party is allowed to present observations concerning the patentability of an invention. The EPO is obliged to forward all such observations to the patent applicant. The usual grounds on which third parties can file such observations include lack of novelty, lack of clarity or sufficiency of disclosure, and/or unallowable amendments. Such observations are a rare but interesting event. They are the first evidence that third parties are interested in an application or even potentially vexed by it. We interpret such observations as indicative of an invention's market value and the presence of stakeholders with conflicting interests. Gambardella et al. (2007) used third-party observations made for EPO patents as a measure of "economic value of technology." They found that patents characterized by third-party observations were more likely to be licensed.

According to Akers (2000, p. 313), "*As a possible disincentive to the filing of observations, it should be realized that observations could give an applicant forewarning of a competitor's interests. There may be other commercial reasons for not taking the opportunity of filing observations. Accordingly, the absence of observations by a third party should not be taken as an indication that other relevant disclosures do not exist in the public domain, or that they are not well known to those in the relevant technical field.*" Given the risk to which third parties expose themselves (i.e., forewarning the patentee about the embarrassment that their application causes them), such observations should therefore be indicative of higher stakes involved for third parties (to justify the risk-taking) and therefore be highly predictive of future disputes. One might argue in particular that if the third-party observations are not sufficient to prevent the patent from being granted, the chances are particularly high that the third party will challenge the patent's validity in an opposition procedure.

Our data does not allow us to note whether the parties presenting observations during pendency are also the ones involved in opposition. We have reason to believe that this may not always be so. Presenting observations during pendency may allow the applicant to modify the patent as long as it is in the pre-grant stage. This may not be desirable for a competitor, who would rather choose the post-grant opposition procedure over pre-grant observations.

Accelerated examination requests

According to EPO examination guidelines, an accelerated examination can be requested by the applicant at any time. In the event of such a request, the EPO does its best to issue the first examination report in less than three months. There are two classic reasons for expediting the patent prosecution process. One is to obtain a patent right and prevent infringement by a potential infringer. The other is to obtain a patent grant quickly to negotiate investments and licenses. These two reasons suggest that accelerated examination requests capture (i) the applicant's quest to achieve greater certainty related to their patent's validity and (ii) their belief that the invention is close to commercialization. Practitioners we interviewed indicated that there is a general agreement in the profession that such requests should only be used in cases of necessity and with care, because overloading the patent office with such requests would simply make it impossible for the office to honor them all and would therefore neutralize this procedural facility. Given the extra costs associated with this procedure and the self-selection applicants submit themselves to, accelerated examination requests could signal value to third parties (hence increasing the likelihood of opposition) and increase the likelihood of applicants to litigate once the patent is granted. Not many researchers have used accelerated examination requests in an empirical setting, but Reitzig (2004) has confirmed that such requests are associated with patents of higher value. The impact of accelerated examination requests on opposition has also yielded positive and significant results in Jerak and Wagner (2006).

According to the theory, higher stakes should be associated with lower chances of reaching a settlement. However, accelerated examination requests and third-party observations not only indicate the stakes but also convey a sense of urgency, suggesting that, in both cases, at least one party is in a rush to reach a resolution to the latent dispute (by obtaining a patent grant or preventing a patent from being granted). Such haste may play in favor of a settlement. Hypothesis 6 therefore remains an empirical question.

Hypothesis 6: *Foreknown interest of third parties and the applicant's haste are more likely to lead to opposition and litigation, but their effect on settlements is a priori unclear.*

4. Data and empirical strategy

We estimate the incidence and outcome of legal challenges over European patents. We achieve this by matching each litigated (resp. opposed) patent with a random control patent that has not been litigated (resp. opposed). Incidences of opposition and litigation are regressed at the patent level on a set of observables. For the set of litigated patents whose outcome was known, we then regress the likelihood of their reaching a settlement (compared with going all the way to court adjudication) on the same observables.

We use several control variables to account for externalities that can influence our dependent variables (incidences of opposition, litigation, and settlement). Five-year forward citation counts (computed at the family level) are used to control for patent value. Number of IPC classes are introduced to control for technological breadth. We also control for the type of applicant (company, university or public research institution, and individuals). Individual assignees are used as a reference in the regression models, so that we compare the coefficients of companies and university/government assignees against individuals. For settlement regressions, we use "number of cases" and "age at litigation" as additional case-controls.

Our core data comes from two main sources. PATSTAT and EPO Patent Register provided us with patent characteristics, opposition proceedings, and detailed counts of citations. Litigation data comes from two datasets, presented in Graham and van Zeebroeck (2014) and Cremers et al. (2016), respectively. The resulting database is a set of patent litigation cases filed in the four main European patent jurisdictions (France, Germany, the Netherlands, and the UK) over a nine-year period (2000 to 2008). According to estimates, the cases represent as many as 80% of the patents litigated in Europe (Cremers et al., 2016). Using OST classification,[7] which includes seven broad industry categories linked to International Patent Classification at the four-digit level, we isolated applications in the field of chemicals and pharmaceuticals. To harmonize our analysis and expand the coverage of patent characteristics, we kept only EPO applications and EPO equivalents of various national patents involved in lawsuits. Thus, any case information of a litigated German patent was attributed to its EPO equivalent. After cleaning and matching to PATSTAT, we ended up with 1052 EP patent applications: the "litigated" sample. We then looked up PATSTAT for all "EP" applications filed between 1981 and 2007 (the time window of the patents litigated in our sample) in the same OST classification scheme. This exercise gave us a list of 325,510 granted patents, of which 26,852

[7] Observatoire des sciences et techniques, indicateurs de science et de technologies: edition 2010, at 507, http://www.obs-ost.fr/sites/default/files/R10_Complet_1.pdf (downloaded on September 10, 2010)

opposed patents formed our "opposed" sample. From this same list of 325,510 grants, and corresponding to each "opposed" and "litigated" patent, we randomly selected a control patent with similar IPC class and application year.

Since our dependent variables are binary (opposed/not-opposed; litigated/not-litigated; settled/not-settled), we use a logit model with robust standard errors to estimate the likelihood of opposition, litigation, and settlement, controlling for a number of patent and case characteristics.

Our unit of analysis is an EPO patent grant. However, given that some patents are involved in multiple suits and those suits may have different outcomes, we run our settlement regressions at the patent-case level (in which case, the standard errors were clustered at the patent level). Settlement information was extracted for 798 patents (excluding cases in the Netherlands for which settlement information was unavailable). We also removed cases that did not have a verdict or were awaiting verdict to compare only settled and not-settled cases (with verdict infringed, revoked, not infringed, or other).

Table 1. *Total cases and case type*

Total cases	Only infringement cases	Only invalidity cases	Both infringement and invalidity cases
893	549	109	235

Table 2 presents the descriptive statistics of our sample.

Table 2. *Descriptive statistics*

	VARIABLES	N	mean	sd	min	max
Explanatory patent variables	Number of claims	55,184	14.62	10.98	0	422
	Count of divisionals	55,184	0.174	0.657	0	23
	Patent is amended	55,184	0.102	0.302	0	1
	Accelerated examination request	55,184	0.0314	0.174	0	1
	Third-party observations	55,184	0.0145	0.119	0	1
Core controls	Forward citations (families – 5 year)	55,184	1.856	3.161	0	127
	Number of IPC classes	55,184	7.799	6.930	1	166
	Assignee is company	55,184	0.917	0.276	0	1
	Assignee is individual (used as reference)	55,184	0.0421	0.201	0	1
	Assignee is university/govt./non-profit	55,184	0.0584	0.234	0	1
Dependent variables	Patent is Opposed	55,184	0.487	0.4998	0	1
	Patent is Litigated	55,184	0.019	0.137	0	1
Case-controls	Number of cases	892	1.453	1.461	1	25
	Age at litigation	805	10.14	5.727	-0.81	26.84
Explanatory case variables	Invalidity claim (patent-case pairs)	744	0.379	0.485	0	1
	Infringement claim (patent-case pairs) (used as reference)	744	0.911	0.284	0	1
Dependent variable	Settled (patent-case pairs)	744	0.349	0.477	0	1

We were able to obtain reliable litigation case characteristics for 892 patents from our sample of 1052 EP litigated patents. Cases and patents had an *m* x *n* relationship. A single patent might be involved in multiple cases and a single case might involve multiple patents. The 892 patents whose case information was available were involved in 969 cases. Table 1 presents the number of infringement and invalidity cases after we removed 76 cases that were litigated for reasons other than infringement or invalidity.

A small part of our sample had zero claims. This is a result of non-republished Euro-PCT patents and cases where the number of claims is not known in PATSTAT. We ignored this anomaly because it affected only 0.38% of our sample.

Companies were assignees of almost 92% applications. Institution type was obtained from the PATSTAT Harmonized Applicant Names extension (OECD, 2015).

Our measure of divisional applications was based on the sum of immediate parent and child applications related to a grant. This variable captures whether a patent was part of a complicated chain of divisional applications. Fewer than 18% were part of divisional chains in our sample.

Amendments were made to roughly 10% of our entire sample. Accelerated examination request and third-party observations are seen only for 3% and 1.5% patents, respectively.

Case data was more erratic for different case characteristics. Proper case information was available for 892 of our sample of 1052 litigated patents. On average, one patent was involved in 1.45 distinct cases. Information regarding the name of parties involved in a suit was even harder to come by. We could match only 550 patents of our sample of 1052 litigated patents. An average patent had 3.25 litigants who were part of suit proceedings. Age at litigation was computed as the difference between the date of first suit in which the patent was involved and the filing date of the patent. An average suit occurred 10.14 years after the date of filing.

As mentioned earlier, the full sample comprised 26,852 opposed patents, which were compared to a similar number of non-opposed controls, and 1052 litigated patents that were compared to the same number of non-litigated controls. Summary statistics suggest that chances of settlement is roughly 35%. This may be an understatement because cases that have a different verdict may also settle in due course. Anecdotal evidence from our discussions with patent attorneys suggested settlement in 90% of the cases, but the figures vary substantially across countries (see, e.g., Cremers et al., 2016).

All count variables were treated in log form in our regressions. To deal with zero values in count variables, we treated them as log(count+1).

5. Results

Regressions results

The results from our logit regressions are presented in Table 3. Two models are estimated for opposition: first with the set of core controls and second after including the procedural variables. Litigation regressions consisted of three models, two similar to opposition and the third for estimating the influence of post-grant opposition on litigation. Regressions estimating the likelihood of settlement comprised four models, the first with core controls and case-controls, the second estimating the influence of procedural variables, the third testing the influence of case type, and the fourth including the incidence of post-grant opposition as an explanatory variable.

Our results confirm and add to prior literature in similar industries. Companies were overwhelmingly more likely to be involved in oppositions than individuals. This is not the case with litigation, where individuals are significantly more likely to be represented in the litigated sample than the non-litigated sample (consistent with findings of Lanjouw and Schankerman, 2004). The absolute number of individuals involved in litigation, however, remains low.

Table 3. *Logit regression results*

VARIABLES	(1) Opposed	(2) Opposed	(1) Litigated	(2) Litigated	(3) Litigated	(1) Settlement	(2) Settlement	(3) Settlement	(4) Settlement
Number of claims		0.126*** (0.02)		-0.327*** (0.07)			0.24 (0.15)		
Number of divisionals		0.628*** (0.04)		1.460*** (0.14)			0.030 (0.18)		
Third-Party Obs.		2.065*** (0.13)		1.231*** (0.39)			0.309 (0.58)		
Accelerated Exam Req.		0.722*** (0.06)		0.887*** (0.19)			-0.299 (0.26)		
Patent is amended		-0.137*** (0.03)		-0.210 (0.19)			0.896** (0.45)		
Validity is challenged in proceedings								-0.545*** (0.20)	
Patent has been opposed (and survived)	--	--			1.295*** (0.13)				0.898*** (0.21)
Number of cases	--	--	--	--	--	-0.067* (0.04)	-0.083** (0.04)	-0.0571 (0.04)	-0.072* (0.04)
Age at litigation	--	--	--	--	--	-0.064*** (0.02)	-0.049** (0.02)	-0.061*** (0.02)	-0.045** (0.02)
Forward citations	0.537*** (0.01)	0.473*** (0.01)	0.614*** (0.06)	0.513*** (0.07)	0.522*** (0.06)	0.175 (0.11)	0.117 (0.13)	0.155 (0.11)	-0.014 (0.12)
Number of IPC	-0.506*** (0.02)	-0.580*** (0.02)	-0.282*** (0.08)	-0.453*** (0.08)	-0.299*** (0.08)	0.022 (0.15)	-0.021 (0.17)	0.009 (0.15)	0.010 (0.16)
Assignee company	0.240*** (0.05)	0.253*** (0.05)	-0.490*** (0.16)	-0.663*** (0.17)	-0.523*** (0.17)	0.120 (0.28)	-0.082 (0.28)	0.140 (0.30)	0.131 (0.27)
Assignee univ/govt	-0.259*** (0.06)	-0.321*** (0.06)	-0.661*** (0.20)	-0.935*** (0.21)	-0.695*** (0.21)	-0.268 (0.38)	-0.304 (0.38)	-0.156 (0.41)	-0.286 (0.39)
Constant	0.397 (0.06)	0.173*** (0.07)	0.537*** (0.20)	1.613*** (0.25)	0.439** (0.21)	0.136 (0.37)	-0.530 (0.47)	-0.266 (0.38)	-0.274 (0.35)
Observations	50,986	50,986	2,034	2,034	2,034	683	683	683	683
Pseudo R^2	0.0347	0.0508	0.0430	0.117	0.0835	0.0494	0.0665	0.0596	0.0770
Log Likelihood	-34112	-33545	-1349	-1245	-1292	-427.5	-419.8	-422.9	-415.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Patents selected for dispute (opposition and/or litigation) are characterized by a significantly higher number of forward citations. Forward citation has repeatedly been proven as an indicator of patent value in the patent statistics literature. The outcome of the dispute, however, did not depend on patent value as measured by forward citations.

All procedural indicators that proxy for information revealed during the examination phase are predictive of future legal challenges, but none of them (to the notable exception of amendments) have any influence on the likelihood of a settlement. On the contrary, further sources of uncertainty during proceedings (e.g. when the validity of the patent is challenged as part of a court trial) reduces the chances of a settlement, whereas disclosure of the outcome of a post-grant validity challenge (i.e. opposition) makes a settlement considerably more likely. These results are consistent with our main assumption that legal challenges are affected by prior information, and that the information revealed during the proceedings is used by the parties to update their beliefs, thereby reducing information asymmetries and divergent expectations.

H1: In line with hypothesis 1, our results indicate that broader or unfocused patents (i.e., containing more claims) are significantly more likely to be opposed by third parties. This supports our hypothesis that third parties target invalidation of broad patents at the opposition stage. However, by contrast, they are associated with a significantly lower likelihood of litigation, controlling for patent value and technical scope. In this case, the data suggest that greater certainty over patent scope is associated with a greater confidence on the part of the patent holder, increasing his expectation of a positive outcome of an infringement action.

This finding is contrary to Lanjouw and Schankerman (2004), who found a significant positive relationship (at the 0.01 level) between number of claims and probability of litigation for a sample of US patent cases. We interpret this difference to derive from the differences between the USPTO and EPO systems. USPTO patents are characterized by more claims than EPO patents (Archontopoulos et al., 2007). A post-grant review at the USPTO is much more expensive than an EPO opposition procedure. Until recently, petitioners have used the US court system to make invalidity challenges. This makes US litigation more akin to the EPO opposition procedure. In contrast, our estimates do not suggest any systematic relationship between claim counts and settlements.

H2: A bigger chain of divisionals is positively associated with both opposition and litigation. The size of a divisional chain increased the likelihood of an opposition and litigation by 7.6 and 13.6 percentage points, respectively (marginal effects). Besides the argument of an important commercial space being covered by divisional filings, the effect on oppositions can also be because divisional filings that extend beyond the subject matter of the “originally filed application” are valid grounds for revocation during opposition. The high likelihood of litigation also supports our hypothesis that the patent holder is ready to litigate after isolating the most valuable part of the original claims. Once the legal action is started, however, the parties have already updated their beliefs accordingly, and hence a settlement is not going to become more or less likely until new information is disclosed.

H3: Amendments during pendency have a pronounced negative effect on the likelihood of facing an opposition (the coefficient is significant at a 1% statistical level). To the best of our knowledge, we have not seen any previous studies that have used EPO amendments in an empirical setting. Amendments are typically made to the description and/or claims of the application. Unfortunately, we cannot discern from the data available as to the amendments’ nature. Clarifying the description can insure against “sufficiency of disclosure” arguments during opposition and limiting the claims can help prevent challenges to the application’s novelty. In both cases, it seems like amendments contribute to greater certainty of the patent’s validity and therefore reduce the chances of an invalidity challenge. In contrast, they have no effect on the incidence of infringement actions, but positively affect the chances of reaching a settlement. These results therefore suggest that amendments lead to fewer disputes.

H4: The long-term opposition rate at the EPO is about 8% (Harhoff et al., 2003). By contrast, 32% of the litigated patents in our study were opposed earlier by third parties at the EPO. An incidence of opposition was found to increase the likelihood of litigation by 28.8% points (estimated with a standard error of 2.6% points). Oppositions first reveal that higher stakes are involved for the parties, as argued in our theoretical framework. If a third party challenges a patent in an opposition, it suggests at the least that the patent, as granted, creates enough embarrassment to justify the costs and risks associated. This suggests both the importance and asymmetry of the stakes, which play in favor of future litigation. By the time a court has to make an assertion about the claims in a case, however, the EPO will have heard the parties and rendered its decision on the opposition in most instances (most courts in Europe would stay their judgment in a patent case, pending an EPO opposition's outcome). When the opposition outcome is revealed to the parties, they update their beliefs about the validity of the patent and the chances to reach a settlement increase as a result.

H5: We have used "infringement case" as a reference in the regression model with case type. Table 3 shows that actions involving an invalidity component are much less likely to settle than infringement actions. It is the lingering uncertainty over a patent's validity that appears as the major cause of non-settlement in our results. The literature (Lemley and Shapiro, 2005) has conceptualized patents as probabilistic rights that confer a right upon patent holders to *try* to exclude others from infringing. Failure to settle in invalidity suits may also be because of the anti-competitive nature of settlement with licenses (Shapiro, 2003).

There are a number of other arguments in favor of this result. In particular, courts usually operate under the presumption of validity. This encourages settlement of infringement cases. Moreover, in chemical and pharmaceutical industries, it is easier to identify if a composition or compound infringes a patented invention (lack of divergent expectations).

H6: The strong relationship of accelerated examination requests and third-party observations with opposition and litigation indicates that such haste to speed up the granting process is highly predictive of future challenges. Marginal effects for these logit regression models show that an incidence of *third-party observation* and *accelerated examination requests* increase the likelihood of opposition by 27 and 21 percentage points, respectively. However, no relationship is observed between these measures and the likelihood of a settlement. The urgency of the parties to enter into a legal challenge does not seem to affect the odds of reaching a settlement whatsoever. This is somewhat counterintuitive, in the sense that if parties are so impatient to enforce or challenge their rights, one may assume that they are also eager to resolve their latent dispute. It therefore suggests that urgency does not necessarily dictate faster resolution or easier negotiation. To some extent, this is consistent with the abovementioned view that settlements are primarily influenced by new information that is disclosed after the legal challenges are filed, enabling the parties to update their beliefs.

The results are summarized in table 4.

Table 4. *Summary of results*

	Hypothesis	Result
H1	*Controlling for patent value, patents with fewer claims are less subject to legal challenges.*	Supported for opposition, not for litigation
H2	*Applications that are part of a large divisional chain are more likely to be involved in legal challenges, but their association with settlements is a priori unclear.*	Supported
H3	*Clarification of validity in the form of amendments will lead to a lower likelihood of legal challenges.*	Supported
H4	*Information about patent validity revealed during earlier prosecution (i.e. opposition) will increase the likelihood of litigation but also of a subsequent settlement.*	Supported
H5	*When the validity of a patent is discussed before court, settlement is less likely to occur.*	Supported
H6	*Foreknown interest of third parties and the applicant's haste are more likely to lead to opposition and litigation, but their effect on settlements is a priori unclear.*	Supported

The key result from estimating the likelihood of settlements is the importance of case characteristics over patent and procedural characteristics as predictors. The introduction of case characteristics improved the model fit, which suggests that case-specific characteristics are much stronger in predicting a settlement outcome than patent and procedural characteristics. Again, this is most likely due to patent and procedural characteristics being known to the parties when the case is filed. Thus, parties are unable to further update their beliefs or reduce stakes or information asymmetries.

Specifically, we observe that the age of a patent at litigation significantly affects the likelihood of a settlement. The earlier a patent is litigated in its life, the more likely is its settlement. Inventions in chemical and drugs industries usually pay off late in the lifecycle of patents. The last few years of patent protection may be the most important for firms from the appropriability point of view. This possibly leads to the phenomenon of "asymmetric stakes" between the parties and thus a lower incentive to settle during the later stages. Settlement is also less likely when a patent is involved in multiple cases. Our discussions with patent attorneys revealed that parties are unwilling to settle and wait for court adjudication if they have already spent substantial resources in the enforcement of their patent.

6. Conclusion

Patent disputes are an important issue because they consume significant firm resources. Equally important are the welfare costs that derive from weak or invalid patents. In this study, we have used the European patent examination and litigation system to investigate how stakeholders are involved in a bargaining game during the entire lifecycle of a patent. Firm strategies in chemical and drugs industries are heavily involved in tackling uncertainty during the early stages of the innovation process. The actions of applicants and third parties are indicative of an ongoing struggle to achieve greater certainty during the innovation lifecycle. The relationship of these actions with selection and outcome of patent disputes is thus non-fortuitous.

Applicants tend to file broad applications when they are unsure about the exact appropriability conditions related to their invention. Broad applications give way to multiple divisionals and/or limitations induced by amendments. Furthermore, accelerated examination requests are used when the patentee is looking to clarify validity fast, to commercialize or litigate. Third parties may file observations during pendency or open post-grant opposition proceedings against patents with conflicting commercial interests. If these fail, defendants may retaliate by challenging the validity of patents as a counterclaim before a court. All these procedural instruments cogently predict legal challenges, in line with the classical theoretical framework of selection of disputes.

Our results provide suggestive evidence of this dynamic bargaining game between parties. Parties vie to achieve greater certainty related to their inventions, and actions of one party lead to updated beliefs of the other. Incidentally, we also observe that the haste of parties to enforce or challenge a patent right is not predictive of the outcome of the resulting dispute. We rather observe that uncertainty over the validity of a patent seems to be the biggest impediment to settlements. Given that most empirical work related to patent litigation has been done in the context of US litigation, our study also contributes to the scant empirical evidence available so far on European patent litigation.

The results speak to at least three bodies of literature. First, they extend earlier findings on patent value by offering new early-stage observables that are predictive of patent value as revealed by future legal challenges. Specifically, third-party oppositions and pre-grant amendments are highly indicative of patent value. Second, they shed light on the inner dynamics of patent disputes by uncovering early-stage interactions between patentees and third parties, which are highly predictive of future legal challenges and their outcome. Third, they speak to the literature on the design and policy of patent systems, by highlighting some potential positive or adverse consequences of specific legal or procedural arrangements (e.g., divisionals).

In terms of policy, the main implication of these results is that specific patent procedures (e.g., third-party observations and amendments) might be leveraged to help reduce uncertainty and information asymmetries. This can improve the validity of patents. Results from our sample show third party observations were submitted for only 1.5% patents. Since these patents were highly likely to be involved in future disputes, it shows that TPOs were filed only for very contentious patents whose pendency was being monitored. Interviews with practitioners revealed that they prefer filing a post-grant opposition to submitting observations during pendency. This is mainly because TPOs rarely lead to non-grant. Moreover, the EPO is not obliged to take any action or let the submitter know whether their observations were taken into consideration. Amendments were more common, with about 10% patents in our sample undergoing some form of amendment during prosecution. This instrument deserves more attention of researchers and policy makers as they significantly reduced the likelihood of opposition and encouraged settlements. Patent offices and policy makers may want to consider encouraging the use of such provisions whenever suitable.

However, policy makers should also be very much concerned about any potential misuse of the procedures (e.g., when large patents are used to hide the true invention and divisionals are issued to keep non-patentable subject matter alive forever). In this regard, the EPO had attempted to rein in the abuse of divisional applications by limiting the application of divisionals to 24 months after the original filing. This was later repealed.[8] Applicants can now file divisionals anytime during pendency but with a twist of paying progressively increasing fee for each generation of divisional filing.

[8] https://www.epo.org/news-issues/news/2013/20131018.html, last accessed on August 9, 2016.

It comes as good news from our study that opposition proceedings are associated with a greater chance of a future dispute's settlement. Courts usually do not annul the verdict of EPO's opposition division[9] and that seems to be known to the parties. However, our analysis deals with only those patents that successfully survived the opposition procedure (as only those patents found themselves in court). Opposition proceedings can last up to 4 years and are associated with uncertainty over the validity of a patent. This uncertainty can be detrimental to the inventors who look for opportunities to make further investments and commercialize their inventions. In this regard, the EPO can look to reduce uncertainty by encouraging the use of TPOs and amendments. This, in turn, can pre-empt opposition.

For patent holders and IP practitioners, our results point at the lower hazard of invalidity challenges that are faced by smaller or more focused patents. This should encourage them to draft (or amend) their patents in a more concise and focused way to reduce their chances of being attacked.

The limitations in our analysis come mainly from the data (cross-sectional, with limited firm observables) and the well-known limitations of resting on patent data in innovation studies (in particular, the fact that litigation can only be observed in the shadow of infringement). In addition, the fragmentation of the patent litigation system in Europe makes cross-country comparisons more difficult. Nonetheless, we see potential in the procedural features of the European patent system to provide advanced notice of future legal challenges and worthy subjects of analysis to better understand the dynamic interactions between patentees, examiners, and third parties, with a view toward the continuous improvement of the patent system to better support innovation and serve society.

[9] Courts usually work under the "presumption of validity" (See, e.g., Cremers, et al., 2014)

References

Akers NJ. 2000. The European patent system: An introduction for patent searchers. World Patent Information 21; 4; 309-315.

Allison JR, Lemley MA, Moore KA, Trunkey DR. 2004. Valuable patents. Georgetown Law Journal 92; 435. George Mason Law & Economics Research Paper No. 03-31; UC Berkeley Public Law Research Paper No. 133. Available at SSRN: http://ssrn.com/abstract=426020

Allison JR, Lemley MA, Schwartz DL. 2014. Understanding the realities of modern patent litigation. Texas Law Review 92; 1769.

Arundel A, Kabla I. 1998. What percentage of innovations are patented? Empirical estimates for European firms. Research Policy 27;2; 127–141

Archontopoulos E, Guellec D, Stevnsborg N, van Pottelsberghe de la Potterie B, van Zeebroeck N. 2007. When small is beautiful: Measuring the evolution and consequences of the voluminosity of patent applications at the EPO. Information Economics and Policy 19;2; 103–132

Bebchuk LA. 1984. Litigation and settlement under imperfect information. RAND Journal of Economics 15;3; 404–415.

Calderini M, Scellato G. 2004. Intellectual property rights as strategic asset: The case of European patent opposition in the telecommunications industry. CESPRI Working Paper n. 158. University Bocconi.

Caviggioli F, Scellato G, Ughetto E. 2013. International patent disputes: Evidence from oppositions at the European Patent Office. Research Policy 42;9; 1634–1646

Cincera M. 2011. Déterminants des oppositions de brevets. Revue économique 62; 87–99

Cohen W, Nelson R, Walsh J. 2000. Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not). NBER Working Paper No. 7552. Available at: http://www.nber.org/papers/w7552

Crampes C, Langinier C. 2002. Litigation and settlement in patent infringement cases. The RAND Journal of Economics 33;2; 258–274.

Cremers, K., Gaessler, F., Harhoff D., Helmers, C. 2014. Invalid but infringed? An analysis of Germany's bifurcated patent litigation system. Max Planck Institute for Innovation and Competition Research Paper No. 14-14.

Cremers K, Ernicke M, Gaessler F, Harhoff D, Helmers C, McDonagh L, Schliessler P, van Zeebroeck N. 2016. Patent litigation in Europe. European Journal of Law and Economics 1–44,

European Patent Office. 2010. Guidelines for examination in the European Patent Office, 2010.

Farrell J, Merges RP. 2004. Incentives to challenge and defend patents: Why litigation won't reliably fix patent office errors and why administrative patent review might help. Berkeley Technology Law Journal 19;3; 943–70.

Ford RA. 2013. Patent invalidity versus noninfringement. 99 Cornell Law Review 7; University of Chicago Coase-Sandor Institute for Law & Economics Research Paper No. 670; University of Chicago Public Law Working Paper No. 454. Available at SSRN: http://ssrn.com/abstract=2256207

Gambardella A, Giuri P, Luzzi A. 2007. The market for patents in Europe. Research Policy 36;8; 1163–1183.

Graham S, Harhoff D. 2006. Can post-grant reviews improve patent system design? A twin study of US and European patents. CEPR Discussion Paper No. 5680. Available at SSRN: http://ssrn.com/abstract=921826

Graham, S., Marco, A., van Zeebroeck, N. (2012). Patently Informative: Strategy and Information in Patent Litigation across Countries. Unpublished working paper, presented at the 2nd ZEW-SEEK Conference, Mannheim, March 2012.

Graham S, van Zeebroeck N. 2014. Comparing patent litigation across Europe: A first look. Stanford Technology Law Review 17; 655–708. Available at SSRN: http://ssrn.com/abstract=1924124 or http://dx.doi.org/10.2139/ssrn.1924124

Harhoff, D., Scherer FM, Vopel K. 2003. Citations, family size, opposition and the value of patent rights, Research Policy 32;8; 1343–1363.

Gilbert R, Shapiro C. 1990. Optimal patent length and breadth. The RAND Journal of Economics 21;1; 106–112.

Harhoff D, Scherer FM, Vopel K. 2003. Citations, family size, opposition, and the value of patent right s. Research Policy 32; 1343–1364

Harhoff D, Reitzig M. 2004. Determinants of opposition against EPO patent grants—the case of biotechnology and pharmaceuticals. International Journal of Industrial Organization 22;4; 443–480.

Howard L. 2007. Use of patents in drug lifecycle management. Journal of Generic Medicines: The Business Journal for the Generic Medicines Sector 4; 230–236.

Jerak A, Wagner S. 2006. Modeling probabilities of patent oppositions in a Bayesian semiparametric regression framework. Empirical Economics 31; 513–533.

van de Kuilen A. 2013. Successful European oppositions: Analysis for the patent information professional. World Patent Information 35;2; 126–129

Lanjouw J, Lerner J. 1997. The enforcement of intellectual property rights: A survey of the empirical literature. NBER Working Paper Series, No. 6296.

Lanjouw J, Schankerman M. 2001. Characteristics of patent litigation: A window on competition. The RAND Journal of Economics 32;1; 129–151.

Lanjouw J, Schankerman M. 2004 Protecting intellectual property rights: Are small firms handicapped? The Journal of Law and Economics 47;1; 45–74.

Lemly MA, Shapiro C. 2005. Probabilistic patents. Journal of Economic Perspectives 19;2; 75–98.

Levin RC, Klevorick AK, Nelson R, Winter SG. 1987. Appropriating the returns from industrial research and development. Brookings Papers on Economic Activity 3; 783–820.

Michael M. 1989. The settlement of patent litigation. The RAND Journal of Economics 20;1; 77–91.

Moore KA. 2001. Forum shopping in patent cases: Does geographic choice affect innovation? North Carolina Law Review 79. Available at SSRN: http://ssrn.com/abstract=262333

Nalebuff B. 1987. Credible pretrial negotiation. The RAND Journal of Economics 18;2; 198–210.

OECD. HAN Database, April 2015. Available online: http://www.oecd.org/sti/inno/oecdpatentdatabases.htm

Priest G, Klein B. 1984. The selection of disputes for litigation. The Journal of Legal Studies 13;1; 1–55.

Reitzig M. 2004. Improving patent valuations for management purposes—validating new indicators by analyzing application rationales. Research Policy 33; 6-7; 939-957.

Scotchmer S. 1991. Standing on the shoulders of giants: Cumulative research and the patent law. Journal of Economic Perspectives 1;5; 29–41.

Shapiro C. 2003. Antitrust limits to patent settlements. RAND Journal of Economics 34;2; 391–411.

Siegelman P, Waldfogel J. 1999. Toward a Taxonomy of Disputes: New Evidence through the Prism of the Priest/Klein Model. The Journal of Legal Studies 28; 1; 101-130.

Somaya D. 2003. Strategic determinants of decisions not to settle patent litigation. Strategic Management Journal 24;1; 17–38.

Sternitzke C. 2010. Knowledge sources, patent protection, and commercialization of pharmaceutical innovations. Research Policy 39;6; 810–821.

Sternitzke C. 2013. An exploratory analysis of patent fencing in pharmaceuticals: The case of PDE5 inhibitors. Research Policy 42;2; 542–551.

Trajtenberg M. 1990. A penny for your quotes: Patent citations and the value of innovations. Rand Journal of Economics 21;1; 172–187.

Van Zeebroeck N, van Pottelsberghe de la Potterie B. 2011. Filing strategies and patent value. Economics of Innovation and New Technology 20;6; 539–561.

Van Zeebroeck N, van Pottelsberghe de la Potterie B, Guellec D. 2009. Claiming more: The increased voluminosity of patent applications and its determinants. Research Policy 38;6; 1006–1020.

Webb C, Dernis H, Harhoff D, Hoisl K. 2005. Analysing European and international patent citations: A set of EPO patent database building blocks. OECD STI Working Paper, OECD Publishing.

WIPO. 2009. Internet document, available online: http://www.wipo.int/export/sites/www/wipo_magazine/en/pdf/2010/wipo_pub_121_2010_01.pdf, last accessed: 11.04.2016

Wright DJ. 1999. Optimal patent breadth and length with costly imitation. International Journal of Industrial Organization 17; 3; 419–436.

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