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Jussi Heikkilä

Empirical Analyses of European Intellectual Property Rights Institutions

JYVÄSKYLÄN YLIOPISTO

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ABSTRACT

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This dissertation consists of introduction chapter and five empirical studies on European intellectual property rights institutions. Chapters 2, 3 and 4 are micro-level studies and the perspective shifts to macro-level in Chapters 5 and 6. Chapters 2, 3, 5 and 6 analyze two-tiered patent systems and Chapter 4 focuses on design rights.

Chapter 2 analyzes the choice between patent and utility model protection among German firms. The results indicate that larger firms are more likely to use both protection methods and that a short life cycle of products and services is associated with an increased likelihood to use utility models.

Chapter 3 analyzes the role of utility models in patent filing strategies. It is documented that most European utility models are used to protect inventions only nationally. The study provides suggestive evidence that utility models play also a role in international patent filings. The results indicate that patent filings at European Patent Office (EPO) with national utility model priority filings are of lower quality than those with patent priorities.

Chapter 4 analyzes the role of design rights in competition and innovation in the Finnish sauna heater industry. We document events, which provided the industry participants with learning opportunities about the scope of design rights. Evidence suggests that the scope of design rights evolved dynamically as more designs were introduced and that uncertain design rights may have fostered entrepreneurial optimism.

Chapter 5 analyzes the effect on aggregate patenting activity when a country shifts from a two-tiered patent system to a single-tiered patent system. Using synthetic control method it is found that the abolition of the Dutch short-term patent system did not cause a constant decrease in the level of patenting.

Chapter 6 analyzes the sorting induced by two-tiered patent systems in European countries. Second tier patents are chosen for more marginal inventions and more often by individual applicants in comparison to regular patents. The ratio of second tier patents to regular patents is highest in technology fields in which the average quality of inventions protected with regular patents is lowest. The evidence regarding quality differences between regular patents in single-tiered and two-tiered patent systems is ambiguous.

Although there still exists no evidence that two-tiered patent systems boost innovation activity in advanced economies, this thesis has demonstrated that a two-tiered patent system may serve as a screening instrument. The main implication is that future patent research should take into account second tier patents or, at least, be explicit whether they are included in patent statistics or not.

Keywords: intellectual property right, patent, utility model, second tier patent, two-tiered patent system, design right, self-selection, European Single Market

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Article 4. pp. 190–234
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Article 5. pp. 235–288
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CONTENTS

CHAPTER 1: INTRODUCTION

Technological progress and innovations are the sources of our increasing standard of living in the long run. Intellectual property rights (IPR) institutions are important innovation policy instruments, which affect the rate and direction of technological progress and innovation activity. This thesis takes a European perspective on IPR institutions and focuses, in particular, on two-tiered patent systems and design rights. In the European Single Market, member states have their own national IPR legislations, which create transaction costs to businesses. In this complex IPR environment, there is a risk that large, experienced and resource-abundant incumbent firms have the upper hand relative to small, young and financing-constrained firms. Hence, there is a need for harmonization of national institutions. Rigorous empirical evidence can assist policy makers to find a satisficing path of harmonization.

There exists very little empirical evidence on the functioning of two-tiered patent systems and design rights systems. The analyses of this thesis blend economic analysis and innovation study approaches in trying to address this research gap. The aim is to provide policy-relevant research results and promote evidence-based IPR policy in Europe and elsewhere. In particular, the analyses shed light on the relationship between patent and second tier patents and how decision-makers learn the boundaries of uncertain design rights. The studies utilize comprehensive and detailed IPR registry data and contribute to more systematic empirical evaluation of two-tiered patent systems and design right systems.

The introductory chapter is structured as follows. Sections 1.1 motivates why innovation institutions are an important research topic from an economic perspective. Section 1.2 provides definitions and explains the relevant IPR concepts. Section 1.3 reviews briefly the fragmented European IPR landscape. Section 1.4 outlines the theoretical framework of the thesis. Section 1.5 presents an overview of the chapters. Finally, conclusions, policy implications and avenues for future research are discussed in section 1.6.

1.1 Institutions for innovation

"Throughout history, institutions have been devised by human beings to create order and reduce uncertainty in exchange."

Douglass North (1991, p.97)

"[The U.S. patent system] was exceptional in recognizing that it was in the public interest that patent rights, like other property rights, should be clearly defined and well enforced, with low transaction costs."

Khan & Sokoloff (2004, p.400)

"Institutions like the patent system or the Small Business Innovative Research (SBIR) grants program are themselves ideas. These institutions have evolved over time to promote an efficient allocation of resources, but it is almost surely the case that better institutions – better ideas – are out there to be discovered."

Charles Jones (2005, pp. 1087–1088)

By definition, institutions are "the humanly devised constraints that structure political, economic and social interaction" (North, 1991, p. 97). Since innovations are the key to our increasing standard of living (Solow, 1957; Aghion & Howitt, 2009), creating appropriate institutions to incentivize innovations is at the core of innovation policies around the world. Due to knowledge spillovers (Foray, 2004; Bloom et al., 2013), which are a positive externality of innovation investments, agents allocate less resources to innovation activity than is socially desirable (Arrow, 1962). Policy makers have several instruments to internalize these positive externalities and to affect the rate and direction of innovation (Wright, 1983; Scotchmer, 2004; Jones, 2005). IPRs are one of these. Both existing theoretical and empirical economics of IPR analyses have focused mainly on patent systems. Patents create innovation incentives (Machlup & Penrose, 1950; Scotchmer, 2004), promote the diffusion of technical knowledge (Ordover, 1991; Foray, 2004), direct technological change (Moser, 2005) and promote efficient division of innovative labor (Arora et al., 2001).

Although the long run global trend has been harmonization and strengthening of national IPR systems (Siebeck et al., 1990; Ginarte & Park, 1997; Sakakibara & Branstetter, 2001; Gallini, 2002; Moser, 2005; Qian, 2007; Park, 2008; Lerner, 2009; Prud'homme, 2017), there still exist significant differences in legislation and practices across countries. Sometimes institutional heterogeneity is beneficial, as countries in different development phases may require different levels of IPR protection (Siebeck et al., 1990; Dutfield & Suthersanen, 2005; Kim et al., 2012; Prud'homme, 2017). When countries shift from technological catching-up, i.e. imitation, phase to innovation phase, they tend to strengthen their IPR systems (Kim et al., 2012; Prud'homme, 2017). However, national heterogeneity is not beneficial when it mainly creates entry barriers and increases transaction costs, for instance, makes it harder for innovative SMEs to enter new markets or for individual inventors to license their inventions across borders.

Indeed, IPR policy and competition policy are strongly intertwined (Aghion et al., 2005; Aghion et al., 2015): Empirical evidence suggests that it is important to decrease barriers to product market entry in order to promote innovation-led competition (Aghion et al., 2009). Optimal IPR policy is, thus, to a large extent about finding a satisficing balance between the concurrent efforts to maximize innovation incentives and to minimize deadweight loss due to market power created by exclusive IP rights.

1.2 Patents, second tier patents and design rights

IPRs are temporary and territorial rights to exclude others from the commercial use of the protected subject. A patent can be granted to a technical invention that satisfies patentability requirements, which are novelty, inventiveness (non-obviousness in the U.S.) and industrial applicability. Exclusive rights create monopoly power, which enables patent owners to appropriate the returns from their R&D investments. In the absence of IPR protection there would be less incentives to invest in R&D and commercialization of inventions since competitors could imitate successful inventions immediately after their disclosure. Thus, a patent is a contract between the patent owner and the society: the patent owner gets a temporary exclusive right (currently maximum term is standardized to 20 years[1]) and the invention is described in patent register in such a detail that others can carry it out (Denicolò & Franzoni, 2004).

Patent statistics have been used in economic research for a long time as proxies for inventive activity and knowledge creation (Sokoloff, 1988; Griliches, 1990; Hall & Harhoff, 2012) but second tier patents and design rights (definitions below) are much less studied. There are several potential reasons for this. First, patent data have been much more available in comparison to data of other IP protection methods. Second, another important factor is that second tier patent and design right systems are less harmonized than patent systems. Third, the U.S., which patent system has traditionally been the most actively studied both theoretically and empirically (Hall & Harhoff, 2012; Eckert & Langinier, 2014), does not have a second tier patent system.

Design rights have got relatively little attention in the economics of IPR literature until recently (Filitz et al., 2015). Design rights, also known as design patents (in the U.S.) or industrial design rights, are temporary rights to exclude others from commercially exploiting the protected design. In other words, designs do not protect technical inventions but just the product's aesthetic aspects. Existing empirical evidence suggests the importance of design right protection varies across industries (Filitz et al., 2015) but in most cases they are considered to be of low importance (Arundel, 2001; Moultrie & Livesey, 2014; Lim et al., 2014; Galindo-Rueda & Millot, 2015).

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[1] Some exceptions exist for the maximum duration of patent protection, for instance, Hatch-Waxman Act (see Izhak, Saxell & Takalo, 2016).

A two-tiered patent system refers to a patent system, in which the patent office offers regular patents and alternatively some other type of patent protection to applicants, who want to protect their technical inventions (Lemley et al., 2005; Atal & Bar, 2014). Following Atal & Bar (2014), we refer to regular patent systems occasionally as "single-tiered patent systems" to stress their distinction to two-tiered patent systems. Recent theoretical contributions have considered a two-tiered patent systems that consist of a combination of a regular patent and a "gold-plate" patent, which is more costly, has possibly been more thoroughly examined and has, hence, a higher probability of validity (Lemley et al., 2005; Atal & Bar, 2014). However, in practice, these other types of patents in existing two-tiered patent systems are actually "second tier patents" (Janis, 1999; Kingston, 2001), most often utility models (UM) or short-term patents. For the sake of consistency, in this thesis the term "second tier patents" is used as an umbrella term for utility models, short-term patents, utility certificates, consensual patents, petty patents and innovation patents.

Second tier patents lie between patents and design rights (Janis, 1999; Suthersanen, 2006). In comparison to patents, their maximum term of protection is typically shorter (6–10 years), inventive step requirement is lower, application and renewal fees are lower and the grant is faster (Janis, 1999; Kingston, 2001; Beneito, 2006; WIPO, 2008, p. 17; Kim et al., 2012; Filitz et al., 2015; Rutenberg & Mwangi, 2017). Thus, second tier patents provide flexibility to national protection of technical inventions and "try to repair some of the faults in the regular patent system" (Kingston, 2001 p. 412).[2] Johnson (2002) analyzed the interaction of "technology acquisition forms" (R&D and licensing) in the creation of new intellectual capital using Brazilian firm-level data and found larger firms to rely more on patents and less on UMs. Beneito (2006) was also among the first to distinguish between patents and UMs as innovation output measures: She showed with Spanish firm-level data that patents are associated with in-house R&D and UMs are associated with external R&D. Empirical evidence exist that lower tier patent systems have different effects in countries in different development phases (Kim et al., 2012). Japan, South Korea, Taiwan and China have successfully used UM systems in technological catching-up (Maskus & McDaniel, 1999; Kim et al., 2012; Prud'homme, 2017). Hamdan-Livramento and Raffo (2016) find UMs to be chosen for inventions that are less valuable. Table 1 summarizes some key dimensions in which patents, second tier patents and design rights differ from each other.

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[2] A quote from Janis (1999, pp.152–152) further highlights the flexibility in designing second tier patent systems: "Second tier protection has been considered a backwater of intellectual property. For example, the TRIPs agreement dutifully establishes minimum substantive standards for each of the major intellectual property regimes but fails explicitly to mention second tier protection leaving WTO member countries free to formulate or reject second tier protection regimes as they see fit. The Paris Convention includes second tier protection in its definition of the categories of industrial property, but, apart from extending national treatment and priority to second tier patents, it establishes no important benchmarks for this form of protection." See Section 1.3 for brief discussion on the Paris Convention and the TRIPS agreement.

TABLE 1 Comparison of selected dimensions of IPR types

	Patent	Second tier patent	Design right
Country-specific equivalents	Utility patent, Patent of invention	Utility model, Utility certificate, Petty patent, Innovation patent, Short-term patent	Industrial design right, Design patent (U.S.)
Subject matter	Technical solution	Technical solution. Varies across countries. Typically process inventions excluded.	Design / Aesthetic aspect of a product
Maximum term of protection	20 years	6-15 years	10-25 years
Inventive step requirement	Yes	Typically lower than for patents	Must be new to an informed user
Novelty requirement	Global	Global. Previously local/national in some countries	Global. Previously local/national in some countries
Examination	Typically substantive examination	Typically registration process, less stringent than for patents	Typically registration process
Publication lag from filings/Secrecy period	18 months	Varies. Typically published when registered	Varies. Typically published when registered
Grant lag	Typically years	Typically weeks or months	Typically months
Administrative fees	Vary across countries	Typically lower than for patents	Typically lower than for patents
Grace period	Varies. Not in Europe	Varies	Varies
Level of international harmonization	Moderate	No	Low
Supranational filing routes and procedures in the European Single Market	EPO grants European patents which can be validated in EPO member states	"Community utility model" proposal suspended	EUIPO grants Registered Community Designs

Notes: Information collected from European Commission (1995), Suthersanen (2006), Prud'homme (2014), Radauer et al. (2015), webpages of national patent offices and WIPO Lex database.

There is an important "demarcation" between special exceptions within a regular patent system and an actual second tier patent system. These exceptions, which, as such, are not sufficient conditions for the institution to be called a second tier patent system, include differentiated fees for small-entity applicants, differentiated application and/or examination processes and differentiated speed in obtaining protection. For instance, in the U.S., small entities have lower application fees for patents but the system is not considered as a two-tiered patent system. There are also possibilities to hasten the speed of application process within some regular patent systems ("fast track examination", e.g., patent prosecution highway), which however, is not sufficient condition for the system to be second tier patent system. There is no agreed definition for a second tier patent system, but one possible way to distinguish second tier patent systems from "exceptions within patent systems" is to consider all systems, for which the 1) scope of patent protection is limited (e.g., length), or 2) the inventive step requirement is lowered or 3) the enforceability is limited (e.g. no assumption of validity), as second tier patent systems.

Despite the fact that there exists no empirical evidence on the benefits of two-tiered patent systems in advanced economies, UM systems are considered to be desirable in widely used patent rights index of Ginarte & Park (1997) and further developed by Park (2008). The index measures the strength of protection and assigns higher values to countries, which provide UM protection. As a consequence a country can never reach the maximum points unless it offers UM protection. The argument to give additional points for providing a UM system is that presence of UM system "helps to distinguish which of developing countries provide relatively stronger protection" (Ginarte & Park, 1997). However, their index says nothing about the desirability of UMs in advanced economies and whether other types of second tier patent protection systems (e.g., short-term patents) are considered as equivalent to UMs. More recently Saint-Georges & van Pottelsberghe (2013) developed a novel quality index for patent system but the index does not take into account second tier patent systems.

Finally, the internal structure of patent families has been a neglected topic until recently (Martínez, 2011; Dechezleprêtre et al., 2017). Even less is known about the role of second tier patents in patent filing strategies. To my knowledge Cao (2015) and Cao et al. (2016) are the only studies that have considered the role of UMs in international patent filing strategies (see also Radauer et al., 2015). They looked at pairs ("dyads") of Chinese UMs and U.S. patents and Chinese patents and U.S. patents and found that applicants with the preference for faster protection tend to choose Chinese UMs instead of patents.

1.3 European intellectual property rights institutions

"Differences in intellectual property laws have a direct and negative impact on intra-Community trade and on the ability of enterprises to treat the common market as a single environment for their economic activities."

European Commission's White Paper
on Completing the Internal Market. (1985, p. 37)

"Member States are basically free to design utility model systems as they will, provided the measures they take are not a means of arbitrary discrimination or a disguised restriction on trade between Member States." (p. 34)

"Patent law and utility model law both set out to protect technical inventions, so that friction between the two systems cannot be ruled out." (p. 76)

European Commission's Green Paper
on The Protection of Utility Models in the Single Market (1995)

"The fragmentation of the IPR landscape in the EU has implications for Europe's growth, job creation and competitiveness. Licensing transactions are impaired by high costs, complexity and legal uncertainty for creators, users and consumers."

European Commission's Communication
A Single Market for Intellectual Property Rights (2011, p.6)

The quotes above demonstrate that despite significant harmonization efforts, the progress is slow and European IPR landscape remains fragmented (Guellec & van Pottelsberghe, 2007; European Commission, 2011; European Commission, 2015). Table 2 presents selected formal IPR institutions that affect national IPR policies in contracting countries and highlights the differences in institutions — that is, in "the rules of the game" (North, 1991), across European countries. In 1883, Paris convention established the national treatment principle in IPR filings and ruled that foreign residents should be treated the same ways as national residents in IPR protection (Guellec & van Pottelsberghe, 2007; Webster et al., 2014). Since then several international treaties and multilateral agreements have further harmonized IPR protection in Europe and globally: European Patent Convention (EPC), signed in 1973 in Munich, provided patenting standards for Europe and was the beginning of European Patent Office (EPO). By 2011, the initial set of seven EPO member states had extended to its current 38 member states. World Intellectual Property Organization's (WIPO) Patent Cooperation Treaty (PCT) signed in 1970 (effective since 1978) and Patent Law Treaty in 2000 together with World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in 1994 have aimed to harmonize and integrate national IPR systems. Translation costs related to patenting in the EPO member states were reduced as a consequence of London agreement (in force since 2008; see van Pottelsberghe & Mejer, 2010; Gazzola & Volpe, 2014).

TABLE 2 The integration of European IPR systems

	Paris Convention	EU	EPO	PCT	TRIPS	Patent Law Treaty	Two-tiered patent system	Registered community design
Belgium	1884	1952	1977	1981	1995		1987-2008	2003
France	1884	1952	1977	1978	1995	2010	1968	2003
The Netherlands	1884	1952	1977	1979	1995	2010	1995-2008	2003
Italy	1884	1952	1978	1985	1995		1934	2003
United Kingdom	1884	1973	1977	1978	1995	2006		2003
Spain	1884	1986	1986	1989	1995	2013	1929	2003
Portugal	1884	1986	1992	1992	1995		1940	2003
Switzerland	1884		1977	1978	1995	2008		
Sweden	1885	1995	1978	1978	1995	2007		2003
Norway	1885		2008	1980	1995			
Denmark	1894	1973	1990	1978	1995	2005	1993	2003
Germany	1903	1952	1977	1978	1995		1891	2003
Austria	1909	1995	1979	1979	1995		1994	2003
Hungary	1909	2004	2003	1980	1995	2008	1992	2004
Poland	1919	2004	2004	1990	1995		1924	2004
Romania	1920	2007	2003	1979	1995	2005	2008	2007
Finland	1921	1995	1996	1980	1995	2006	1992	2003
Bulgaria	1921	2007	2002	1984	1995		1993	2007
Luxembourg	1922	1952	1977	1978	1995			2003
Greece	1924	1981	1986	1990	1995		1988	2003
Ireland	1925	1973	1992	1992	1995	2012	1992	2003
Turkey	1925		2000	1996	1995		1995	
Liechtenstein	1933		1980	1980	1995	2009		
Monaco	1956		1991	1978				
San Marino	1960		2009	2004				
Iceland	1962		2004	1995	1995			
Cyprus	1966	2004	1998	1998	1995			2004
Malta	1967	2004	2007	2007	1995			2004
Slovenia	1991	2004	2002	1994	1995	2005	1992	2004
Croatia	1991	2013	2008	1998	1995	2005	1992	2013
Macedonia	1991		2009	1995	2003	2010		
Republic of Moldova	1991			1991	2001	2005	1994	
Serbia	1992		2010	1997		2010	2004	
Bosnia-Herzegovina	1992			1996		2012		
Czech Republic	1993	2004	2002	1993	1995		1992	2004
Slovakia	1993	2004	2002	1993	1995	2005	1992	2004
Latvia	1993	2004	2005	1993	1999	2010		2004
Estonia	1994	2004	2002	1994	1999	2005	1994	2004
Lithuania	1994	2004	2004	1994	2001	2012		2004
Albania	1995		2010	1995	2000	2010	2009	
Andorra	2004							
Montenegro	2006				2012	2012		

Note: Information gathered from official websites of the EPO, EU and WIPO. The years refer to years, in which contracts entered into force. In case of EPO, some countries have been "extension states" already before their accession (see EPO's webpage for more information). Republic of Moldova has been a validation state of patents granted by the EPO since November 2015. All remaining errors are mine and highlight the challenges in acquiring information about European IPR institutions.

Some European countries have two-tiered patent systems while others do not (European Commission, 1995; Suthersanen, 2006; Prud'homme, 2014; Radauer et al., 2015). Several European countries introduced second tier patent protection systems during 1990s and 2000s despite there exists no systematic empirical evidence on their benefits in advanced economies. European Commission (1995) suggested establishing "a community utility model" in 1995, but the EU member states abandoned the project in 2001 as they wanted to focus on the adoption of "a community patent" (European Commission, 2002). The Netherlands and Belgium reversed the trend of the diffusion and adoption of two-tiered patent systems when they abolished short-term patent systems in 2008 and 2009, respectively. A recent report finds that European UMs are not mainly used to protect "minor inventions by small inventors", but rather they have "turned into an auxiliary tool of savvy IP professionals, who use it in specific national contexts to overcome shortcomings of the patent system" (Radauer et al., 2015, p. 182). Also Australia has recently considered abolition of its innovation patent system (Productivity Commission, 2016) which is the local second tier patent system and equivalent to European UM systems.

The European Union's Office for the Harmonization of the Internal Market (OHIM, the predecessor of the European Union Intellectual Property Office (EUIPO)) started to register community designs on the 1st April 2003. Initially the protection was available for EU15 member states but after 2004, 2007 and 2013 enlargements of the EU it is currently available for 28 EU member states. Registered community designs are only one alternative for design protection in addition to design rights granted by national patent offices and the "unregistered community design protection (Filitz et al., 2015). The unregistered community design provides automatic protection against copying for new and individual designs for three years from the date of disclosure in the EU (Filitz et al., 2015).

It is likely that country-specific institutional differences affect competition and innovation within the European Single Market (Aghion et al., 2015). Transaction costs caused by institutional differences are a nuisance in the European Single Market (European Commission, 1985, 2011). Small firms and individual inventors are likely to be disadvantaged in a market with dozens of national IPR legislations. The problem is further compounded by language barriers: information about national institutional peculiarities is primarily available only in domestic languages and patenting requires translations of patent documents into national languages (Harhoff et al., 2009; van Pottelsberghe & Mejer, 2010; Gazzola & Volpe, 2014). The information asymmetries between experienced incumbents and new entrants are almost inevitable and, presumably, several young and small firms have boundedly rational managers when IPR issues are concerned.

Recently, evidence-based policy has gained momentum also in the context of IPR policy (e.g., Hargreaves, 2011). Improved access to IPR data has concurrently taken the empirical evaluation of IPR institutions to new levels. EPO has formulated "patent information policies" and made efforts to barrier-free access to patent information (e.g., Edfjäll, 2008). EPO's Worldwide Patent Statistics Database, PATSTAT, has been available for researchers since 2006 (Martínez, 2011; de Rassenfosse et al., 2014). However, due to differences in national institutions (see Table 2), analyses of national European IPR systems are inevitably case studies by nature. Their findings may not be directly generalizable to other countries. It should be kept in mind that IPR systems are only one instrument of innovation policy and their interaction and complementarity with other innovation policy instruments — and other institutions in general — affects the national rate and direction of innovative activity. Despite these inherent limitations on external validity, objective evidence is required in designing better IPR policies and in preventing regulatory capture of policy makers and patent offices by specific interest groups. Patent systems must also be protected from self-interested bureaucrats (Niskanen, 1968; Gans et al., 2004; Picard & van Pottelsberghe, 2013) and agency problems should be taken into account (Langinier & Marcoul, 2009; Schuett, 2013a; Kim & Oh, 2017). Increasing transparency and open access to IPR data enables constant review of the functioning of European IPR institutions, may help to overcome risks of regulatory capture and, first and foremost, to harmonize European IPR systems in a satisficing manner.

On 23 June 2016, the harmonization of IPR systems in the European Single Market encountered a new setback when British people voted in a referendum to leave the EU ("Brexit"). A comprehensive analysis of the effects of Brexit on the harmonization of IPR systems in the European Single Market is out of the scope of this thesis, but it is certain that it creates adverse uncertainty to owners of European IPRs (see e.g., Arnold et al., 2017).

1.4 Theoretical framework

The key theoretical frameworks of this thesis are 1) patent quality and value (Chapters 3, 5 and 6), 2) the sorting induced by two-tiered patent systems (Chapters 2, 3, 5 and 6) and 3) uncertain IPRs and their consequences on belief formation, innovation and competition (Chapter 4). In this section, they are discussed briefly.

1.4.1 IPR quality and value

Existing studies considering IPR quality and value have focused almost solely on patents while measurement of quality and value of second tier patents and design rights has been neglected. Here, we review briefly the prior literature on patent quality and value and evaluate the usefulness of traditional patent-based indicators for second tier patents. It is important to analyze how the choice between single-tiered and two-tiered patent system could be associated with patent quality.

Patent value can be seen as a distinct concept from patent quality, which is discussed below, although patent value depends on patent quality. Patent value can be private or social. A patent is a right to exclude others from commercially using the protected invention and the private value of this exclusive right can be measures as the discounted expected returns from having the patent right or pending patent application. The expected returns are not necessarily related to the commercialization of the underlying invention, in which case one way to measure the patent's value would be to calculate how much the expected discounted returns from the commercialization of the patent protected invention exceed the expected discounted returns from the commercialization of the invention in the absence of patent protection (free imitation). A patent right may have also value, for instance, as a means to attract financiers, in licensing the invention and in blocking or pre-empting competitors from entering the market (while not commercializing the patented invention). Moreover, the value of a single patent depends on its complementarity with the IPR portfolio of its owner (cf. Gambardella et al., 2017). Patent value has been studied using surveys of patent owners (e.g., Harhoff et al., 2003; Giuri et al., 2007; Gambardella et al., 2008) and analysing owners' decisions in payment of renewal fees (Pakes, 1986; Schankerman & Pakes, 1986, Bessen, 2008; Grönqvist, 2009). To my knowledge, there exist no surveys on the value of second tier patents or design rights.

Social value of a patent right is more complex to measure. The possibility to protect a novel technical invention with a patent right creates incentives to invest in R&D. New products and processes that are the output of these patent-incentivised R&D investments promote social welfare. A patent right has also social value, since the document must contain description of the invention, so that a person skilled in the art is able to replicate the invention. This disclosure function of the patent system promotes diffusion of technical knowledge, cumulative innovation, more efficient division of innovative labor and social welfare. On the other hand, a patent, as a right to exclude others from commercialization, creates deadweight losses during its term of protection as its owner may have market power in pricing its patent protected inventions above competitive prices. In addition, patents, which boundaries are unclear, create uncertainty which may hinder R&D investments of competitors and, therefore, reduce social welfare. The net of these multiple effects is the social value of a patent right. Both private and social values of a patent depend on multiple dimensions of patent quality, which are next discussed.

Patent quality is an ambiguous concept, which has been used inconsistently in prior literature with various meanings (de Rassenfosse & Jaffe, 2014). Therefore, it is important to define explicitly what is meant by patent quality in each specific context. Generally, patent quality may refer either to 1) the legal quality created by a patent's reliability as an enforceable property right, 2) to the economic value created by the patent (discussed above) or 3) to the technological quality or impact of the underlying invention (cf. Burke & Reitzig, 2007; Frietsch et al., 2010; Squicciarini et al., 2013). Legal quality, economic value and technological quality of a patent are all mutually related. Moreover, quality of a single patent and quality of a a patent system are distinct concepts. For instance, van Pottelsberghe (2016, p. 1763) defines quality of a patent system as as "the extent to which patent systems comply with their own patentability conditions in a transparent way". Saint-Georges & van Pottelsberghe (2013) uses a similar definition.

Legal quality depends on how well the patent document, in particular, the patent claims, are drafted. Claims define the scope (or "breadth") — that is, the boundaries, of the exclusive right. The higher the legal quality of a patent, the higher the likelihood that the patent is valid and can be enforced against infringers (Burke & Reitzig, 2007; van Pottelsberghe, 2011; de Saint-Georges &

van Pottelsberghe, 2013; Picard & van Pottelsberghe, 2013; Harhoff, 2016). On the other hand, an ambiguously drafted patent, which "legal quality" is uncertain, may deter entry of competitors and be in that sense economically valuable (cf. Farrell & Shapiro, 2008). In the context of legal quality of patents, patents are sometimes called strong or weak referring to high and low likelihood of validity, respectively. Furthermore, invalid patents or patents that have been granted to inventions that do not satisfy patentability requirements are frequently referred to as "bad patents" (Lemley et al., 2005; Caillaud & Duchêne, 2011; Schuett, 2013a; Atal & Bar, 2014; de Rassenfosse & Jaffe, 2014). Technological quality or impact of a patent depends on how the invention is described in the patent document and to what extent future inventions are related to the invention. Thus, technological quality is, in particular, a measure of knowledge spillovers and the social value of the invention. Economic value of a patent depends on the legal quality of the patent and on the patent owner's ability to monetize the patent (e.g., by enforcing the patent against infringers or by licensing the patent). Table 3 presents a non-exhaustive list of indicators which operationalize different dimensions of patent quality and value. The table also points out certain limitations regarding the application of these measures to second tier patents.

Given that several patent offices offer a menu of patents that differ in various characteristics, it is expected that, due to self-selection, the quality of patents and UMs differs systematically. This thesis contributes to existing literature by analysing value of second tier patents and how two-tiered patent systems affect the quality of regular patents (Chapters 3, 5 and 6).

TABLE 3 Examples of patent quality and value indicators

Measure	Legal quality	Invention value	Technological quality	Examples of articles using the measure	Logic	Potential shortcomings if applied to second tier patents
Grant status	X	X	X	Guellec and van Pottelsberghe de la Potterie (2000, 2002)	Granted patent has satisfied patentability requirements. Patenting process is often a negotiation process. Granted patent hence suggests that the applicant has invested time and effort into the patenting process.	Most second tier patents are granted. In several jurisdictions there is no examination of second tier patents but the "grant" is just a registration process.
Payment of renewal fees ("patent life")		X		Pakes (1986), Schankerman & Pakes (1986), Lanjouw et al. (1998)	Payment of the renewal fees indicates that the expected profit from keeping the patent in force is higher than the renewal fee.	Renewal fees are only a small share of patenting costs since patent attorney costs (e.g. drafting, translation) are much larger. Renewal fees for second tier patents are typically even lower in comparison to patents.
Accelerated examination request		X		van Zeebroeck & van Pottelsberghe (2011)	Hastened process may indicate that the invention is valuable and needs fast protection.	Accelerated edamination is used is some European countries but not in others.
Grant lag		X		Harhoff and Wagner (2009), Régibeau and Rockett (2010)	Applicants want to get faster protection for more valuable inventions.	Typically there is no substantive examination for second tier patents and grant/registration lags are much shorter compared to patent.
Number of claims	X			Lanjouw & Schankerman (2004)	Claims define the boundaries of the right to exclude.	Number of claims information is not always available for all patent offices. In some jurisdictions, second tier patents can have only a single claim.
Forward citations		X	X	Trajtenberg (1990), Harhoff et al. (2003)	The more significant the protected technical invention, the more forward citations it will receive.	Language barriers hinder forward citations to second tier patents. National citation practices vary across national patent offices decreasing comparability of forward citations across countries.
Generality		X	X	Trajtenberg et al. (1997)	Generality index of a patent is higher when it receives forward citations from several patent classes/technological fields. High generality is assumed to indicate a widespread impact on subsequent inventions.	Most second tier patents do not receive forward citations and generality index cannot be calculated.
Patent family size		X		Putnam (1996), Harhoff et al. (2003)	The larger the patent family, the higher are patent protection related costs. Administrative costs and translation costs must be paid at each national patent office.	Most second tier patent families are singletons (patent family size is one)
PCT route		X		van Zeebroeck & van Pottelsberghe (2011)	PCT route is an ambigous indicator. It can either signal that applicant is searching broad international protection or that she is uncertain about the commercial potential of the invention and uses the PCT route to flexibly postpone patenting.	Second tier patents are less often used as members of PCT filings relative to patents
Timespan between the first and the last filing of a patent family		X		Dechezleprêtre et al. (2017)	Timespan is positively associated with patent family size.	Most second tier patents are singletons (patent family size is one), for which timespan is zero.
Second tier patent priority in patent family		X	X	Cao (2015), Cao et al. (2016)	Second tier patents have typically lower inventive step requirement and may therefore be a signal of incremental invention.	
Post-grant opposition	X	X		Harhoff et al. (2003)	Patents which are upheld in opposition process are particularly valuable.	Oppositions are rare for patents (< 10% of granted patents are opposed; see Harhoff et al. 2003) and probably even rarer for second tier patents.
Individual applicant	X		X	Bessen (2008)	Individual applicants have less resources to buy IPR expert services (e.g., for drafting the patent document and claims).	Second tier patents are motivated to be especially suitable for individual applicants as cheaper and simpler alternative.
Number of inventors		X		Sapsalis et al. (2006), Breitzman & Thomas (2015)	Number of inventors is a proxy for R&D inputs/inventive labor costs.	Number of inventors is more often missing for second tier patents compared to patents.

Notes: The crosses indicate that the indicators are appropriate measures for the patent quality dimension(s).

1.4.2 Patent menus as sorting mechanisms

Patent system design affects the average quality and value of patent applications and granted patents (van Pottelsberghe, 2011; Eckert & Langinier, 2014). Patent systems are *de facto* sorting mechanisms (Mas-Colell et al., 1995; Salanié, 2005) in the context of mechanism design and optimal contracts (Scotchmer, 1999; Cornelli & Schankerman, 1999; Hopenhayn & Mitchell, 2001; Encaoua et al., 2006; Schuett, 2013b; Schankerman & Schuett, 2016).[3] Suppose there is asymmetric information: a patent applicant knows better the quality and characteristics of her invention than the patent office. Sorting (alternatively, self-selection or screening) refers to the setting, where an uninformed patent office offers a menu of differentiated patent types (patents and second tier patents) and an applicant selects its profit maximizing option. The choice to apply for a patent or the choice between alternative protection methods — a patent, a second tier patent or a design right — signals something about the type of the applicant or applicant's invention.

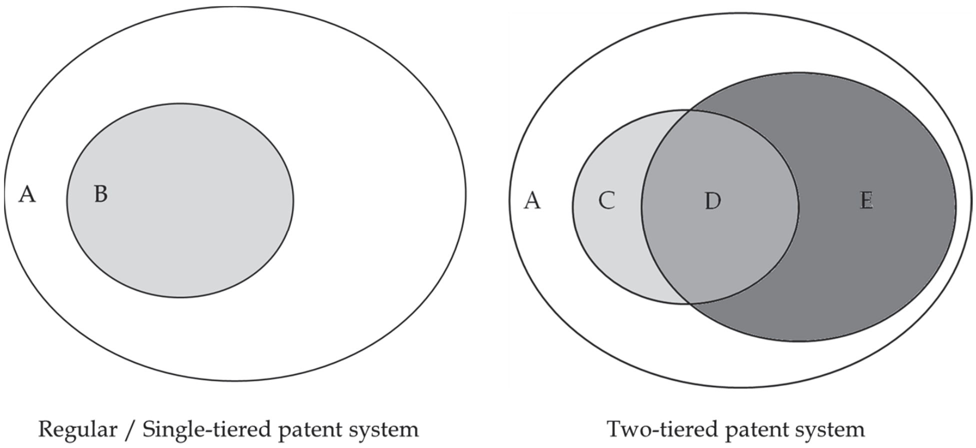
In the simplest case the patent office offers patent protection for inventions that satisfy patentability requirements and applicants self-select to use or not to use patents. As a consequence, there are patent-protected and not-patent-protected technical inventions in the market. The propensity-to-patent literature has a long tradition in analysing this simple choice and characteristics that are associated with patenting decisions (e.g., Cohen et al., 2000; Arundel & Kabla, 1998; Heger & Zaby, 2013; Holgersson, 2013; Hall et al., 2014). Scotchmer (1999) and Cornelli & Schankerman (1999) went a step further and showed that patent renewal fees can also be understood as screening mechanisms: more valuable inventions are worth to be protected for longer time and the patent office can improve welfare by offering a menu of patents with differentiated lengths and fees. Hopenhayn & Mitchell (2001) argued that the patent office can use more efficiently patent breadth and length as screening instruments in comparison to renewal fees. Kou et al. (2013) analyzed the role of non-obviousness requirement of patents as a screening instrument and argued that raising the non-obviousness threshold can alleviate adverse selection: inefficient innovators are discouraged from doing research while efficient innovators can signal the quality and value of their invention to financiers. Atal & Bar (2014) showed that patent applicants can use different types of patents (regular and "gold-plated") as signalling devices and that the self-selection of applicants in a two-tiered patent system may increase the average (legal) quality of patents. Recently, Schankerman and Schuett (2016) constructed a model to analyze the interactions between patent screening instruments (examination intensity, application and

[3] Objective functions of patent offices are not known to a researcher. While the incentives of self-funding patent offices may not be optimal for welfare maximization (Gans et al. 2004; Picard & van Pottelsberghe, 2013), the basic assumption in theoretical modelling of patent system design is that the patent office maximizes social welfare. It is often also assumed that the patent office aims to weed out bad patents, which create negative externalities to good patents (see e.g., Atal & Bar, 2014). In other words, the patent office minimizes also adverse selection.

renewal fees, and post-examination challenges in the courts). They calibrated the model on U.S. patent and litigation data and conducted simulations, which implied that the majority (65–81%) of granted U.S. patents are invalid. It is an empirical question, whether a two-tiered patent system could lead to a more efficient screening of patents.

Figure 1 describes graphically the sets of technical inventions and their subsets of patentable invention in the presence of standard "single-tiered" and two-tiered patent systems.

FIGURE 1 Sets of inventions in single-tiered and two-tiered patent systems



In Figure 1, the space A is the set of all (technical) inventions; B is the set of patentable inventions and a subset of A; C is the set of patentable inventions, which cannot be protected with second tier patents; D is the set of inventions, which can be protected with either regular patents or second tier patents (or both); E is the set of inventions, which can be protected with second tier patents but not with regular patents.

Let i denote an invention, $i \in A$. In case of complete information, the applicants and the patent office would know exactly the types of the inventions. In single-tiered patent system, the patent office would grant patents if $i \in B$ and reject applications otherwise. In a two-tiered patent system, patent office would 1) grant regular patents if $i \in C$ or $i \in D$ and reject regular patent applications otherwise and 2) would grant second tier patents if $i \in D$ or $i \in E$ and reject second tier patent applications otherwise. The profit maximizing applicants know this and choose the alternatives that maximize their expected profits. The extent to which the average quality of regular patents is affected depends on the choices made by applicants for which $i \in D$. The more they choose second tier patents instead of regular patents, the higher is the weight of applications for inventions for which $i \in C$ in defining the average quality of regular patents.

In practice, the information is incomplete. Applicants have beliefs about the type of their inventions and the patent office screens the types of inventions in applications using imperfect examination. Imperfect screening means that there is a non-negligible probability $\varepsilon > 0$ that the patent office makes a mistake, Type II error, and grants a patent in single-tiered patent system if $i \notin B$ and in two-tiered patent system if $i \notin C$ and $i \notin D$. This creates an incentive for applicants, which inventions do not satisfy patentability requirements, to apply for patents. As a consequence, the quality of regular patent applications and patents decreases.

Despite the existing theoretical contributions, very little empirical evidence exists about the role of patent menus as sorting devices. Some empirical studies have found evidence on the selection between patents and UMs (Johnson, 2002; Beneito, 2006, Kim et al., 2012; Cao, 2015; Cao et al., 2016; Hamdan-Livramento & Raffo, 2016) without linking the phenomenon to theoretical patent screening literature. Chapters 2, 3, 5 and 6 aim to shed further light on the sorting induced by two-tiered patent systems and its consequences. Chapters 5 and 6 also link the empirical analyses to theoretical patent screening literature.

1.4.3 Complex IPR systems, uncertain IPRs and bounded rationality

"Thereby I say nothing of my being tired of my life, while I was Patenting my invention. But I put this: Is it reasonable to make a man feel as if, in inventing an ingenious improvement meant to do good, he had done something wrong? How else can a man feel, when he is met by such difficulties at every turn? All inventors taking out a Patent MUST feel so. And look at the expense."

Narrator John in "Poor Man's Tale of a Patent" by Charles Dickens (1850)

"In studying the uncertainty surrounding the patent system, we ultimately are interested not in that uncertainty per se, but rather in the effects of the patent system, and its uncertainty, on innovation, inventors, competition and consumers."

Lemley & Shapiro (2005, p.87)

Ayres & Klemperer (1999) were the first to coin the term "probabilistic patents" (Lemley & Shapiro, 2005) although the probabilistic nature of patents have been acknowledged already in earlier studies (e.g., Meurer, 1989; Choi, 1998). In essence, patents are not iron-clad rights to exclude but a patent provides its owner with a right to try to exclude by asserting the patent in court (Lemley & Shapiro, 2005). The same applies to all IPRs.

Probabilistic IPRs are relatively straightforward to model formally with assumptions about the belief systems and belief updating processes (normally Bayesian updating) of the agents. Common knowledge of game structure and rationality are convenient implicit modelling assumptions (Meurer, 1989; Shapiro, 2010). However, in practice, there is also uncertainty whether all the players know the rules of the game, which complicates the theoretical modelling in several ways. What is the level of bounded rationality and prior beliefs of decision makers that should be assumed? A key element in the context of uncertain IPRs is, therefore, the process how agents learn the rules of the game by using the system ("learning by doing"). How do agents update their beliefs about the scope of IPR protection and about the level of know-how of others in an environment where IPR legislation is in constant flux? It might be, hence, useful to distinguish between probabilistic IPRs and uncertain IPRs when modelling strategic interaction. While "probabilistic IPRs" traditionally refer to objective probabilities of validity that are common knowledge among market participants, "uncertain IPRs" could, instead, refer to subjective beliefs about the validity and infringement probabilities and higher order beliefs that are not common knowledge.

Complex IPR systems confuse both researchers and practitioners. The more complex the institutions, the more time and effort it requires to learn the rules of the game and gain sufficient level of know-how. Correspondingly, the more complex the IPR institutions, the greater the potential uncertainty about the boundaries of property rights and the higher the likelihood that decision makers make decisions under bounded rationality. Since IPR institutions are complex, it is likely that a large share of IPR-related strategic choices are made under bounded rationality and asymmetric information.

There exists a plethora of different meanings for bounded rationality (see e.g., Simon, 1957; Arthur, 1994; Dosi, 1997; Kahneman, 2003) but in this context it means making decisions without full knowledge of IPR institutions. In practice, investing in R&D and commercialization of new innovations is always uncertain and not probabilistic; there is no such thing as common "rational technological expectations" (Dosi, 1997) that are common knowledge. In other words, there is a zero probability that all decision makers assign the same probabilities for the infinite set of technological trajectories at a specific point in time. Uncertainty leaves room for subjective beliefs and self-serving biases (Babcock & Loewenstein, 1997; Miettinen et al., 2012) and may breed optimism. Here, I use optimism to refer to the overly optimistic beliefs of entrepreneurs about their success probabilities in commercialization and in enforcing their IPRs.

Some authors have even argued that entrepreneurial optimism fuelled by uncertain IPRs is essential for technological process (Lovallo & Dosi, 1997; Crouch, 2008; Mokyr, 2009; Åstebro et al., 2014). For instance, Mokyr (2009, p. 353) notes illustratively: "As long as, on average, people were willing to be fooled, a few vastly successful patents would keep hope alive". However, the abolitions of the Dutch and Belgian short-term patent systems were motivated specifically by the legal uncertainty that they created (Prud'homme, 2014; Radauer et al., 2015; Prud'homme, 2017). Indeed, the task to define and implement the optimal — that is, welfare maximizing — level of uncertainty to IPR systems is, in practice, impossible. The key elements and dimensions of uncertain IPRs are the asymmetric know-how of market participants about IPR institutions, their asymmetric beliefs, their higher order beliefs and the dynamic evolution of these belief systems. When IPR institutions are designed excessively complex and unpredictable, they might not "create order and reduce uncertainty in exchange" (North, 1991) but serve as an impediment to innovation activity and shift the competitive advantage to more experienced agents. Large incumbent firms have naturally more resources, accumulated know-how and experience than small and young firms and individual inventors. The latter are, therefore, likely to be disadvantaged in several ways. Obviously, the level of bounded rationality is asymmetric between market participants and, therefore, it is important to study how uncertain IPRs affect competition and rate and direction of innovation within industries. This is the focus of Chapter 4.

1.5 Overview of the chapters

This section summarizes the research questions, employed methods, used data, main findings and scientific contributions of this thesis. Table 4 provides an overview of the studies. In subsections 1.5.1–1.5.5, the chapters are reviewed one by one in more detail and they are linked to relevant prior studies.

TABLE 4 Summary of the studies

Chapter	Research questions	Main unit(s) of analysis	Data and Methods	Main results and scientific contributions
2	What is the relationship between firm size and short life cycles and stated use and importance of patents and utility models?	German firms	Data: Mannheim Innovation Panel 2005 and PATSTAT database (April 2016 edition) Methods: Hypothesis testing with probit and ordered probit models	Short life cycles of products is positively associated with the use and importance of utility models. Firm size is positively associated with the use and importance of utility models.
3	What is the role of utility models in patenting strategies? Do UM priorities convey information about the quality of protected inventions?	European patent families	Data: PATSTAT database (April 2016 edition) Methods: Hypothesis testing with probit models, count data models and duration models	New typology of patent families with utility model members is introduced. European UMs are mainly used to protect inventions nationally but in some countries also as part of international patent filing strategies. EPO filings with UM priorities are of lower quality than EPO filings with patent priorities.
4	Why did the design right filings surge among Finnish sauna heater producers? How did the motives to use design rights evolve over time? Which events offered the decision makers learning opportunities concerning the scope of design right protection?	Finnish sauna heater producers	Data: Transcribed interviews, IPR databases and court case archives. Methods: Mixed methods and triangulation, explanatory and exploratory case study approach	The surge of design right filings was associated with the birth of a new product segment. Documented motives for and outcomes of filing design rights, and how these have changed over time. The scope of design right protection was dynamically evolving. Documented events, which provided learning opportunities about the scope of design rights. Uncertain design rights may induce entrepreneurial optimism.
5	What is the effect of the Dutch two-tiered patent system abolition on patenting activity and quality of patents?	European OECD countries, which are EU members. Dutch patents.	Data: PATSTAT database (April 2016 edition), OECD Methods: Synthetic control method	Abolition led to a temporary decrease in Dutch patenting activity. Abolition did not affect the quality of Dutch patents. One of the first studies to apply synthetic control methods to patent data.
6	Do two-tiered patent systems induce self-selection by applicant and invention type?	Patent systems of EPO members states. Priority and singleton patents and second tier patents filed at patent offices of sample countries.	Data: PATSTAT database (April 2016 edition) Methods: Hypothesis testing with OLS models	Second tier patents are chosen for more marginal inventions and more often by individual applicants in comparison to regular patents. The ratio of second tier patents to regular patents is the highest in technology fields in which the average quality of inventions protected with regular patents is the lowest. Quality differences between regular patents in single-tiered and two-tiered patent systems are ambiguous.

1.5.1 Chapter 2: Need for speed? Exploring the relative importance of patents and utility models among German firms

The second chapter is co-authored with Annika Lorenz and studies German firms' choices between patents and UMs and how they rate the importance of patents and UMs as innovation protection methods.

We use Mannheim Innovation Panel (MIP) 2005 data, which is equivalent to Community Innovation Survey in other EU countries. The data is a firm-level telephone survey conducted in 2005 and considers the time period 2002–2004. MIP survey is conducted every third year but the set of questions may vary year to year. This particular MIP 2005 contained a question, which enabled us to study the association between firms' preference for fast protection and the choice between patents and UMs. Therefore, the study contributes to the economics of patents literature concerning the time dimension of patenting (e.g., Johnson & Popp, 2003; Palangkaraya et al., 2008; Cao, 2015; Cao et al., 2016) as well as to IP strategies literature (e.g., Cohen et al., 2000; Arundel 2001; Hussinger, 2006; Beneito, 2006; Byma & Leiponen, 2009; Thomä & Bizer, 2013; Hall et al., 2014). The functioning of the German UM system is of broader interest, because it has been a benchmark for several second tier patent protection systems around the world.

We estimate biprobit models to analyze associations between firm characteristics and the choice between patents and UMs. The results indicate that larger firms are more likely to use both protection methods. Moreover, a short life cycle of products and services is associated with an increased likelihood to use UMs. The former observation is in line with the view that resource-abundant firms are better positioned to take advantage of all possible IPR protection methods than small and young players. The latter finding indicates that the choice between patents and UMs may be associated with preference for fast protection in addition to the need to protect incremental inventions (cf. Janis, 1999; Johnson, 2002; Beneito, 2006; Suthersanen, 2006; Kim et al., 2012).

1.5.2 Chapter 3: The role of utility models in patent filing strategies: Evidence from European countries

The third chapter is co-authored with Michael Verba and analyses the role of UMs in patent filing strategies. The study contributes to the literature on 1) patent family structures (Martínez, 2011; Dechezleprêtre et al., 2017), 2) international patent filing strategies (e.g., van Zeebroeck & van Pottelsberghe, 2011; Frietsch et al., 2013; Cao, 2015; Cao et al., 2016) and 3) quality of patent-protected inventions (Frietsch et al., 2010; Squicciarini et al., 2013). The study is complementary to Chapter 6, which offers a macro perspective on the quality of patents.

With an extensive patent family data from European countries (EPO's PATSTAT), we explore the structures and characteristics of patent families, which include UMs. A simple typology of patent families with UM members is introduced. We document that the geographical scope of most patent families with UM members is purely national. However, some UMs are members of international and transnational patent families, indicating that they may play some strategic roles in international patent filings strategies.

Analysis of European Patent Office (EPO) patent families suggests that EPO filings with UM priorities are, on average, of lower quality than EPO filings with patent priorities. This implies that the choice between a patent and a UM priority conveys information about the quality of the protected invention. We estimate duration models and find weak evidence that EPO filings with UM priorities generally have shorter filing and grant lags than EPO filings with patent priorities. However, there is heterogeneity between priority filing countries, in particular, between Germany and other countries. The findings highlight that UMs (and other equivalent second tier patents) should be taken into account when structures of patent families and patent filing strategies are analyzed.

1.5.3 Chapter 4: Uncertain design rights and design spillovers: The case of the Finnish sauna heater market

The fourth chapter is co-authored with Mirva Peltoniemi and studies the role of design rights in competition and innovation within a specific industry. The paper contributes to the scarce literature on economics of design rights (Filitz et al., 2015) and explores how industry participants learn the scope of uncertain design rights.

We use case study approach to understand the underlying reasons behind the surge in design right filings in sauna heater industry in 2008. We collect information from various sources and use mixed methods to triangulate and cross-validate our findings. Most importantly, we interviewed nearly the whole population of Finnish sauna heater producers.

We discuss the motives for and outcomes of filing design rights and how these changed over time. We explore the events, which offered the decision makers opportunities to update their beliefs about the scope of design right protection. Collected evidence suggests that uncertain design rights may have fostered entrepreneurial optimism. We also find that the scope of design right protection has been dynamically evolving in the context of sauna heaters: the more designs were introduced to market, the smaller improvements qualified for design right protection and the narrower the scope of existing design rights became.

Policy makers could level the playing field and decrease information asymmetries between experienced and inexperienced players by mandating digital open access to design right databases and existing court cases. However, the expected welfare effects of this libertarian paternalistic policy are contradictory: On one hand, if better informed entrepreneurs are less optimistic, the policy might diminish the excessive entry by unproductive entrepreneurs and improve resource allocation. On the other hand, the social welfare might be affected adversely due to decreased entry of innovative entrepreneurs and due to decreased knowledge spillovers in cumulative innovation.

1.5.4 Chapter 5: The relationship between patent and second tier patent protection: The case of the Dutch short-term patent system abolition

The fifth chapter uses synthetic control method approach (Abadie & Gardeazabal, 2003; Abadie et al., 2010; Abadie et al., 2015) to analyze the association between the amendment of the Dutch Patent Act 1995, which included the abolition of the short-term patent system, in June 2008 and subsequent patenting activity. The study contributes to the broad economics of patents literature, which have estimated the effects of patent policy reforms on patenting and innovation activity (e.g., Sakakibara & Branstetter, 2001; Moser, 2005; Qian, 2007).

What makes the Dutch case especially interesting is that the Netherlands was the first European country to abolish its two-tiered patent system. Previously during the 1990s and 2000s the trend was that increasing number of European countries introduced two-tiered patent systems despite lack of empirical evidence on their benefits. Hence, the abolition of the Dutch short-term patent system reversed the diffusion of second tier patent systems in Europe. The abolition was motivated by the uncertainty, which unexamined short-term patents were claimed to create.

The analysis with synthetic control method indicates that the abolition of the short-term patent institution was associated with a temporary decrease in the level of patent applications. This might indicate that potential short-term patent applicants shifted to apply for normal 20 years patents. The result questions justifications of short-term patent systems in advanced economies: a two-tiered system complicates "the rules of the game" but might not provide any additional boost to innovation in comparison to a normal patent system. No clear effect on the quality of inventions protected with Dutch patents is found.

1.5.5 Chapter 6: Do two-tiered patent systems induce sorting? Evidence from European countries

The sixth and final chapter is co-authored with Michael Verba and studies the screening function of two-tiered patent systems in European countries. We contribute 1) to the mechanism design literature on patent system (Hopenhayn & Mitchell, 2001; Encaoua et al., 2006; Kou et al., 2013; Atal & Bar, 2014) by empirically testing predictions of theoretical patent screening studies and 2) to the patent quality literature (Frietsch et al., 2010; Squicciarini et al., 2013). The analysis is complementary to Chapter 3, which has a more micro perspective on the same topic.

The results suggest that two-tiered patent systems induce self-selection by both invention quality and applicant type. Using EPO's PATSTAT database we document that in European countries second tier patents are chosen for more marginal inventions and more often by individual applicants in comparison to regular patents. We document that the ratio of second tier patents to regular patents is highest in technology fields in which the average quality of inventions protected with regular patents is lowest. We use ordinary least squares regression to analyze the association between country's status of two-tiered patent system and the quality of regular patents. The findings regarding quality differences between regular patents in single-tiered and two-tiered patent systems are ambiguous.

1.6 Concluding remarks, policy implications and avenues for future research

1.6.1 Concluding remarks and policy implications

This thesis provides empirical evidence on the functioning of European two-tiered patent systems and the Finnish design right system. We also tried to narrow the gap between theoretical patent screening and mechanism design literature (e.g., Hopenhayn & Mitchell, 2001; Kou et al., 2013; Atal & Bar, 2014) and empirical studies on the choice between patents and utility models (e.g., Johnson, 2002; Beneito, 2006; Kim et al., 2012; Hamdan-Livramento & Raffo, 2016).

We found evidence that two-tiered patent systems induce sorting. Second tier patents are chosen for more marginal inventions and more often by individual applicants in comparison to regular patents (Chapter 6). On the other hand, we did not find significant difference in the level of patent filings between single-tiered and two-tiered patent systems in the Netherlands (Chapter 5). Hence, there still does not exist evidence that two-tiered patent systems boost innovation activity in European economies and advanced economies, which are near the technological frontier. However, it should be noted that second tier patents (UMs) can play an important role in international patenting and as members of patent families: EPO filings with UM priorities are, on average of lower quality than EPO filings with patent priorities suggesting that UM priorities convey information about the quality of the underlying invention (Chapters 3). The sorting function of two-tiered patent systems may improve the resource allocation at the patent office: if second tier patents are applied for low-quality inventions instead of patents then the backlog of pending patents and grant lags may decrease. In other words, the examiners allocate more time examining on high-quality patents and may grant them faster (cf. Caillaud & Duchêne, 2011).

Patent and second tier patents differ in several dimensions and the difference in the speed of protection is one of the factors, which may affect the self-selection of applicants between patents and second tier patents (Chapters 2 and 3). Quicker-to-obtain UMs and other second tier patents provide flexibility to patent protection and extend the protection term from the front end. The self-selection between patents and second tier patents has implications for the measurement and comparisons of propensity to patent (e.g., Scherer, 1983; Mansfield, 1986; Arundel & Kabla, 1998; Holgersson, 2013; Heger & Zaby, 2013). The propensity-to-patent studies should be transparent and clear about whether second tier patents are included in estimations. Otherwise, the comparability of propensity-to-patent estimates between studies is hampered.

Fritz Machlup (1958, p.80) once noted: "If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it." On the basis of the empirical findings of this thesis, it is difficult to recommend two-tiered patent systems for advanced economies with single-tiered patent systems and equally difficult to recommend abolition of two-tiered patent systems for advanced economies, which have them in place. The essence of institutional path-dependence seems to be that once the prevailing institutional setting has become the status quo, it is increasingly difficult to justify reforms. However, the inefficiency caused by the fragmented and complex IPR landscape in the European Single Market (Guellec & van Pottelsberghe, 2007; European Commission, 2011; European Commission, 2015) is a strong argument in favour of change—be it harmonization of European two-tiered patent systems, introduction of a "community utility model" or abolition of the European second tier patent systems altogether.

At minimum, the functioning of European two-tiered patent systems could be systematically monitored using registry data. The dimensions that can be monitored for regular patents and second tier patents using registry data include 1) relative importance (ratio of second tier patent filings to regular patent filings) 2) quality (e.g., forward citations, patent family size, number of inventors), 3) legal quality (oppositions, litigations), 4) examination stringency (grant rates), 5) speed of protection/backlog (grant lags and pendency times), 6) inclusiveness (the shares of applicant types, e.g., individual and non-individual applicants) and 7) the share of domestic applicants.

The implicit assumption in the economic analysis of IPR systems is that all players know the rules of the game. Anecdotal empirical evidence indicates that this may not be the case (Chapter 4). IPR systems are complex and require expertise, which can be acquired either by buying expert services or by learning by doing. In this type of complex environment, information asymmetries between players are almost inevitable when other players have more accumulated expertise or more resources to acquire IPR expert services. There is a risk that large, experienced and resource-abundant incumbent firms have the upper hand relative to small, young and financing-constrained firms (Chapter 2 and Chapter 4). This institutional setting may hinder competition and cumulative innovation and, thus, lead to welfare losses.

Policy makers in Europe and elsewhere have the instruments to level the playing field and decrease information asymmetries between experienced and inexperienced players. By providing more accurate and clear information about IPR systems they do not hurt more experienced players but may help inexperienced players. This is the essence of libertarian paternalism (Thaler & Sunstein, 2003) and asymmetric paternalism (Camerer et al., 2003). Moreover, courts could provide open access to digitized court case documents so that agents can learn how IPR law is enforced and practiced. Finally, in the European Single Market it is of the utmost importance that the rules of the game are clear to all players and language barriers (Harhoff et al., 2009; van Pottelsberghe & Mejer, 2010; Gazzola & Volpe, 2014) should not create additional impediments to competition and innovation.

1.6.2 Avenues for future research

Most patent analyses have, thus far, ignored the existence of second tier patents. Therefore, replication of existing empirical studies using patent data while taking into account second tier patents in statistical analyses may increase our understanding of the studied phenomena. The empirical analysis of design right systems has been scarce due to the lack of design right registry data sets. EUIPO could enable rigorous design right studies by providing design right registry data set, similar to EPO's PATSTAT, to researchers. Some potential topics for future research include 1) motives to use second tier patents and design rights, 2) the use of second tier patents and design rights in IPR portfolios, 3) the use of second tier patents in defensive publishing and pre-emptive patenting, 4) the role of second tier patents as sources of technical knowledge, 5) the role of second tier patents in allocation of labor at the patent office, 6) how the level of competition affects the choice between patents and second tier patents, 7) the role of second tier patent system as an inclusive institution, 8) the role of patent attorneys' advice on the choice between patents, second tier patents and design rights and, most importantly, 9) what are the welfare effects of two-tiered patent systems and design right systems.

Motives to patent have been studied in prior studies (e.g., Cohen et al., 2000; Blind et al., 2006) but much less empirical evidence exists about the motives to use second tier patents (for exceptions see Björkwall, 2009; Raudauer et al., 2015) and design rights. The investigation of the motives to use second tier patents as part of international patent filing strategies (e.g., PCT filings) remains an interesting topic for future research. It should be noted that national second tier patent institutions vary across countries more than national patent systems. Thus, the motives to file second tier patents are also likely to differ between national patent offices. A related question is what are the roles of second tier patents and design rights in IPR portfolios and how are they associated with the value of patent portfolio (cf. Blind et al., 2009; Gambardella et al., 2017).

The literature on pre-emptive patenting suggests that incumbents apply for patents in order to pre-empt or block others from protecting the invention (Gilbert & Newbery, 1982; Guellec et al., 2012). Another strand of literature discusses defensive publishing (e.g. Henkel & Lernbecher, 2008; Hall et al., 2014) — that is, agents intentionally publish the results of their R&D projects in order to destroy their novelty and, thus, prevent competitors from patenting. Patent filing, which is withdrawn, may be preferred to other forms of defensive publishing since a patent filing "leaves a paper trail" with verifiable date of publication and could be easily found by patent examiners who examine the novelty of inventions (Guellec et al., 2012). An interesting research question is therefore:

Why would applicants choose patent applications instead of second tier patents to pre-empt competitors? How large share of second tier patent filings aim to pre-empt competitors?

On the global level, patent databases contain information on both patents and second tier patents, but the use of these rich information sources and cumulative innovation is hampered by language barriers. In theory, when a second tier patent filing (or a patent filing) is filed and the application is published in digital database, it is possible for every potential innovator to find it and redirect own R&D investments if necessary. As a consequence, efficient use of existing technical knowledge about incremental innovations in patent databases should diminish duplicative R&D investments on re-inventing the wheel. In practice, it is possible that a large share of potential innovators makes R&D and commercialization decisions under bounded rationality by ignoring patent databases as knowledge sources (cf. Arundel & Steinmueller, 1998).[4] Thus, national second tier patents, which are filed in national language, may provide "quasi-secrecy" due to language barriers, pre-empt international competitors from patenting and concurrently protect against imitation.

As mentioned in previous section (1.6.1), second tier patents have the potential to make the allocation of labor more efficient at the patent office. Patent examiners have more time for high-quality inventions when second tier patents are applied for low-quality inventions. Hence, the following hypothesis could be tested in future studies: "The introduction of a two-tiered patent system shortens grant lags and decreases the backlog of pending regular patents". A related topic is the effect of two-tiered patent system on revenue streams of patent offices. Second tier patents are often cheaper alternatives to patents and, therefore, extensive substitution of patents to second tier patents would impact adversely a self-funding patent office's budget.

Prior studies have examined the association between competition and innovation and found an inverted U-shaped relation between the level of competition and the number patent applications (Aghion et al., 2005). To my knowledge, there are not yet studies which have studied the association between competition and second tier patent filings and whether there exist different patterns. It would be interesting to analyze how competing firms in different technology fields start to utilize second tier patents and which motives and patterns of strategic interaction are driving the filing decisions.

The extent to which a second tier patent system is an inclusive institution is a relative straightforward but yet unanswered question. Inclusiveness could be evaluated simply by analyzing the set of applicants before and after the introduction or abolition of a second tier patent system. If after the introduction of the two-tiered patents system there are more new applicants, in particular SMEs and individual inventors, than before, it would be evidence consistent with the second tier patent system being an inclusive institution. A more in-detail analysis would separate first time applicants from "old" applicants. An

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[4] An anonymous IPR expert commented that western patent offices have difficulties in taking into account the constantly increasing number of Chinese UMs.

inclusive second tier patent system would expectedly lead to an increase in first-time applicants. On the other hand, incumbent firms are often more knowledgeable about IPR legislation and the rules of the game. Thus, another important topic for future research is to analyze of whether two-tiered patent systems distort the competition between more knowledgeable and resource-abundant incumbents and resource-constrained and less knowledgeable new entrants.

Many patent, second tier patent and design right applicants, in particular individual applicants, are not initially well-aware of characteristic of these alternative protection methods. Therefore, many of applicants buy services from specialized IPR firms who help, for instance, in drafting applications and in communication between the applicant and the patent office (Wagner, 2006). Also national patent and trademark offices offer services to applicants, including novelty searches, reports on the state of the art, freedom to operate reports, patentability reports, etc. To my knowledge, there exists no empirical evidence on how this advice from IPR attorneys and the patent office impacts the choices of applicants between alternative IPR protection methods, patents, second tier patents and design rights.

Finally, this study did not evaluate the welfare effects of two-tiered patent systems or design right systems. Welfare effects of two-tiered patent systems have been theoretically modelled by Atal & Bar (2014) and, more generally, welfare effects of patent menus have been theoretically modelled, for instance, by Scotchmer (1999), Cornelli & Schankerman (1999) and Hopenhayn & Mitchell (2001). To my knowledge, the welfare effects of design right systems have not been evaluated. Welfare analysis of patent systems must evaluate the balance between incentives to innovate and the diffusion of innovations. Strong and broad IPRs increase incentives to innovate but concurrently inhibit diffusion of innovations as imitators face a higher likelihood of infringement. Second tier patents increase the incentives to develop incremental inventions and short life cycle products but inhibit the diffusion of protected incremental inventions. On the other hand, they contain technical information of incremental inventions in patent databases and, thus, decrease re-inventing the wheel. Having a two-tiered patent system increases the relative appropriability of innovation returns from industries which progress incremental inventions and may therefore affect the direction of innovation (cf. Eswaran & Gallini, 1996; Moser, 2005). This could be investigated by comparing within country changes in R&D investments to industries or technical fields. Presumably, introduction of a second tier patent system increases R&D investments, in particular, in industries and technology fields that rely on incremental inventions. Finally, the uncertainty created by uncertain scope of second tier patents and design rights affects the R&D and commercialization decisions, but the related welfare effects are difficult (or even impossible) to quantify. Whether the benefits of two-tiered patent systems and design right systems exceed the costs remains an unanswered empirical question and is left for future research.

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CHAPTER 2: NEED FOR SPEED? EXPLORING THE RELATIVE IMPORTANCE OF PATENTS AND UTILITY MODELS AMONG GERMAN FIRMS[5]

Abstract

Despite the wide use of two-tiered patent systems (patents and utility models), there is little empirical evidence about how often utility models (UMs) are actually used, what kind of firms use them to protect their intellectual property, and how firms rank them relative to patents. We offer such an analysis using data from Germany. We find that larger firms are more likely to use both protection methods. Moreover, a short life cycle of products and services is associated with an increased likelihood to use UMs. The features and functioning of the German utility model system are of broader interest because it has been a benchmark for several second tier patent protection systems around the world.

[5] This paper is joint work with Annika Lorenz and has been published as Heikkilä, J. & Lorenz, A. 2018. Need for speed? Exploring the relative importance of patents and utility models among German firms. Economics of Innovation and New Technology 27(1), 80–105, https://doi.org/10.1080/10438599.2017.1310794. We thank Cristiano Antonelli, Mika Kortelainen, Ari Hyytinen, Mika Maliranta, Jaana Rahko, Knut Blind, Keld Laursen, Pierre Mohnen, Pia Björkwall and two anonymous referees for valuable comments. Earlier versions of this paper have been presented at the XXXVIII Annual Meeting of the Finnish Economic Association in Pori, the Micro&IO and Econometrics Workshops of the Finnish Doctoral Programme in Economics in Helsinki, at the Jyväskylä University School of Business and Economics breakfast seminar, at the TU Berlin Innovation Research Colloquium and at the Strategic Management Society Conference in Berlin. The financial support from Yrjö Jahnsson Foundation and OP Group Research Foundation is gratefully acknowledged. The authors would like to thank ZEW, Mannheim for sharing the data.

1 Introduction

What kind of institutions and, in particular, systems of intellectual property rights (IPRs) should countries adopt in order to optimize the rate and direction of technological change and innovation? The patent system is arguably one of the most important innovation policy instruments, but its effect on the rate and direction of technological change, productivity growth, and, ultimately, citizens' welfare remains disputable (Mazzoleni and Nelson 1998; Kingston 2001; Moser 2005; Encaoua et al. 2006). Moreover, the importance of the patent system for a country's productivity growth, as an example, may be conditional on the country's level of development (Kim et al. 2012) and its institutions. Thus, it is unclear which type of IPR system is desirable and how its design ought to vary across different institutional contexts. A necessary step, therefore, in the search for an optimal IPR system and combination of innovation policy instruments is to understand the functioning of instruments in a given institutional context. This paper's analysis builds on the premise that understanding why firms in a certain country prefer one IPR over another is at the heart of understanding the functioning of its IPR system.

Since its enactment in 1994, the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement introduced minimum standards for many forms of intellectual property (IP), rendering it the most comprehensive international agreement on intellectual property to date.[6] Despite progressive global harmonization efforts, there are still significant differences across national IPR systems. Some countries, such as Germany, for instance, have a two-tiered patent system comprising a patent and a utility model (UM) system, whereas many other countries have a system consisting of patents only. Additionally, TRIPS defines the minimum standards of patent systems and leaves further room for discretion in designing national patent systems (Suthersanen 2006; Königer 2009; Grosse Ruse-Khan 2012, 2013). However, since there are no international agreements on minimum standards of second tier patent systems, countries may design UM systems as they see fit. Although there are quite a few countries that possess dual-tier patent systems consisting of both patents and UMs, the average number of application is much lower for UMs in contrast to patents. This is mainly due to the distinct characteristics of patents and UMs. Table 1 illustrates some dimensions along which patent and UM protection typically differ.

[6] The Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement is Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization, signed in Marrakesh, Morocco on 15 April 1994. See: https://www.wto.org/english/docs_e/legal_e/27trips_01_e.htm

TABLE 1 Comparison of patent and utility model protection

	Patent	Utility model
Maximum term of protection	20 years	6-15 years
Inventive step requirement	Yes	Typically lower
Novelty requirement	Global	Global or local
Examination at the patent office	Yes	No*
Publication lag from filing	18 months	Some months
Grant lag	Years	Typically months
Process inventions	Yes	No

Notes: In some jurisdictions utility model applications are examined but typically there is just a registration process. Sources of information: WIPO; national patent offices; Janis 1999; Suthersanen 2006; Prud'homme 2014; Radauer et al. 2015.

Based on their distinct characteristics, UMs are usually described as a faster, cheaper, and simpler protection method than patents (e.g., European Commission 1995; Suthersanen 2006, Königer 2009, Radauer et al. 2015; Johnson et al. 2015).[7] As a result, UM systems in advanced economies are often justified by emphasizing their importance to small- and medium-sized enterprises (SMEs) and individual inventors. UM and second tier patent systems have, therefore, been claimed to foster minor inventions, which do not satisfy patentability requirements (Johnson 2002; Beneito 2006; Encaoua et al. 2006; Radauer et al. 2015; Grosse Ruse-Khan 2013). However, empirical evidence for these argued benefits is still scant, if not entirely lacking. For instance, Kim et al. (2012) did not find UM systems to be associated with economic growth in advanced economies.

Although both patents and UMs can be used to protect technical inventions, we currently have a limited understanding of the factors that are associated with the use of these protection methods. Additionally, some studies have investigated patenting strategies of small firms (de Rassenfosse 2012; Holgersson 2013; Maurseth and Svensson 2013) but the strategies to file for UMs remain underexplored. What determines a firm's decision to opt for patents or UMs (or both) and, hence, to choose between these appropriation mechanisms? While insightful, prior theoretical (Anton and Yao 2004; Kultti et al. 2007; Hall et al. 2013) and empirical (Arundel 2001; Hussinger 2006; Hall et al. 2013, 2014; Heger and Zaby 2013) studies have mainly focused on the trade-off between patents and secrecy as IP protection methods. Our paper contributes to the rather limited literature on UMs (reviewed in the next section) by exploring the determinants of firms' decisions to use patents and/or UMs and by identifying firm

[7] UMs are often considered a low cost alternative to patents due to lower administrative and maintenance fees. However, Radauer et al. (2015) point out that the cost savings aspect of UM might be overstated because administrative costs are only a small part of total patenting costs; in practice, patent attorneys are frequently hired to draft applications, and their fees are much higher than administrative application costs. See also van Pottelsberghe and Francois (2009) and Königer (2009).

characteristics that are associated with the use and relative importance of patents and UMs. Inspired by Cao et al. (2014), we focus on the trade-off between UMs, which, arguably, serve as appropriate protection methods for firms with a need to protect their inventions quickly ("need for speed"), and patents, which take more time to obtain, but are more reliable in case of infringement and provide longer-term protection.

Our data come from Germany and allow exploring what kinds of firms use UMs to protect their intellectual property and how firms rank them relative to patents. We have two main findings. First, larger firms are more likely to use both protection methods. On the one hand, the UM system is an inclusive institution by promoting protection of IP among resource-constrained small firms; on the other hand, it concurrently extends the arsenal of IPR methods for large firms. Second, a short life cycle of products and services is associated with an increased likelihood to use UMs. This suggests that UMs do not serve only applicants with incremental inventions, but also applicants in need of quick protection. These findings bear on the debate of the harmonization of IPR systems worldwide, as decision-makers involved in the design of IPR institutions need to understand the effects that two-tiered patent systems have on potential innovators and innovation activity. Such understanding is called for if international harmonization proceeds and, at some point, forces countries to decide whether or not to implement (or maintain) a second tier patent protection system.[8]

The paper is structured as follows: Section 2 reviews the related literature. The German UM system is described in section 3. In section 4, we discuss the possible determinants of the use of patents and UMs and develop testable hypotheses. Data and methods are presented in section 5 and the empirical analysis in section 6. Section 7 concludes.

2 Literature review

Several studies and reports provide historical reviews and information on institutional details and justifications of national UM systems (European Commission 1995; Janis 1999; Suthersanen 2006; Königer 2009; Cummings 2010; Boztosun 2010; Grosse Ruse-Khan 2013; Prud'homme 2014; Radauer et al. 2015; Johnson et al. 2015). These studies and reports highlight three features of UM systems. First, national UM systems vary significantly across countries, as they are not internationally regulated or harmonized. Second, the stated justification of UM systems often refers to creating innovation incentives for SMEs and incremental innovations. Third, a frequently mentioned disadvantage of the UM sys-

[8] In Europe, the harmonization of IPR systems has been a top priority (see European Commission 2011), but national UM systems have been ranked low on the agenda since the European Union member states suspended the proposal for a "community utility model"(European Commission 1995) in March 2000 (European Commission 2002). However, after the unitary patent system is in place and working, it is likely that more attention will be directed to the harmonization of national UM systems.

tems is the legal uncertainty that they create in many jurisdictions as unexamined IP rights (no examination, only a registration process).

While UM systems have received some limited attention among legal scholars (e.g., Janis 1999; Suthersanen 2006; Björkwall 2009; Cummings 2010; Grosse Ruse-Khan 2012, 2013), research on the economics of UMs has been scarcer. In quantitative patent data analyses, it is common to treat UMs as patents (e.g., Hu and Jefferson 2009). Maskus and McDaniel (1999) found the Japanese UM system to have played an important role in the diffusion of technologies. They argue that the primary channels of diffusion were follow-up UM applications for incremental inventions, which built on prior technical knowledge embodied in patent applications. Johnson (2002) analyzes the interaction of "technology acquisition forms" (R&D and licensing) in the creation of new intellectual capital with Brazilian firm-level data. His results indicate that larger firms rely more on patents and less on UMs but otherwise the differences in determinants of patent and UM applications are small. Beneito (2006) focuses on firm-level determinants of patent and UM use in Spanish research and development (R&D) intensive firms. She explicitly assumes patents and UMs to be measures of significant and incremental innovations, respectively, and found the number of patents to be associated with in-house R&D and UMs with contracted R&D. By using Korean data, Kim et al. (2012) show that UMs are positively associated with firm growth when firms are technologically lagging. Kim et al. argue that such firms may use minor innovations protected by UMs as a learning device and as "a stepping stone for developing more patentable inventions later on" (2012, p. 358). Thomä and Bizer (2013) investigate combinations of IP rights utilized by SMEs in Germany using Community Innovation Survey (CIS) data. Although UMs are included in their analysis, Thomä and Bizer (2013) do not extensively discuss their role. It is, nevertheless, notable that, in their sample, SMEs in the "patent-oriented group" also assign a higher importance to UMs. This suggests that UMs are used as an auxiliary (i.e., complementary) protection method by patenting firms as highlighted by Radauer et al. (2015). This is particularly true for some jurisdictions, such as Germany, Finland, and Denmark, where patents and UMs can also be combined under certain conditions. This means that they are not necessarily mutually exclusive or substitutes (Guellec and van Pottelsberghe 2007; Prud'homme 2014; Radauer et al. 2015).

Lemley et al. (2005) further suggest establishing a gold plate patent system to supplement the normal patent system (i.e., two-tiered patent system), and, thus, eliminate bad (low probability of validity) patents in the US. Based on Lemley et al. (2005), Atal and Bar (2014) construct a theoretical model highlighting the role of two-tiered patent systems as signaling (or screening) devices. According to Atal and Bar (2014), introducing a second patent tier can reduce patent applications, decrease the number of bad patents, and increase social welfare: in a single-tiered system bad patents impose negative externalities to holders of "good" (high probability of validity) patents because they negatively affect the overall perception of patent quality. A two-tiered patent system enables screening and self-selection, which diminishes this negative externality.

Importantly, Atal and Bar further claim that “since the two-tiered system can be designed to mimic the best single-tiered system, welfare in an optimal two-tiered system is at least as high as welfare in the optimal single-tiered system” (2014, p. 522).

The disclosure function of the patent system aims to prevent duplication of R&D and allows rapid diffusion of innovations once the patent has expired (Mazzoleni and Nelson 1998; Johnson and Popp 2003; Denicolò and Franzoni 2004; Guellec and van Pottelsberghe 2007; Guellec et al. 2012; Graham and Hegde 2015). Accessible patent information enables other agents, especially competitors, to obtain information on the state of the art and technical advances in their field of technology (Arundel and Steinmueller 1998; van Zeebroeck and van Pottelsberghe 2011). UMs have the potential to further enhance welfare because technical information is published early on and normally much faster than in the case of patents. This means that knowledge spillovers may occur earlier.

3 Institutional framework

3.1 The German utility model system

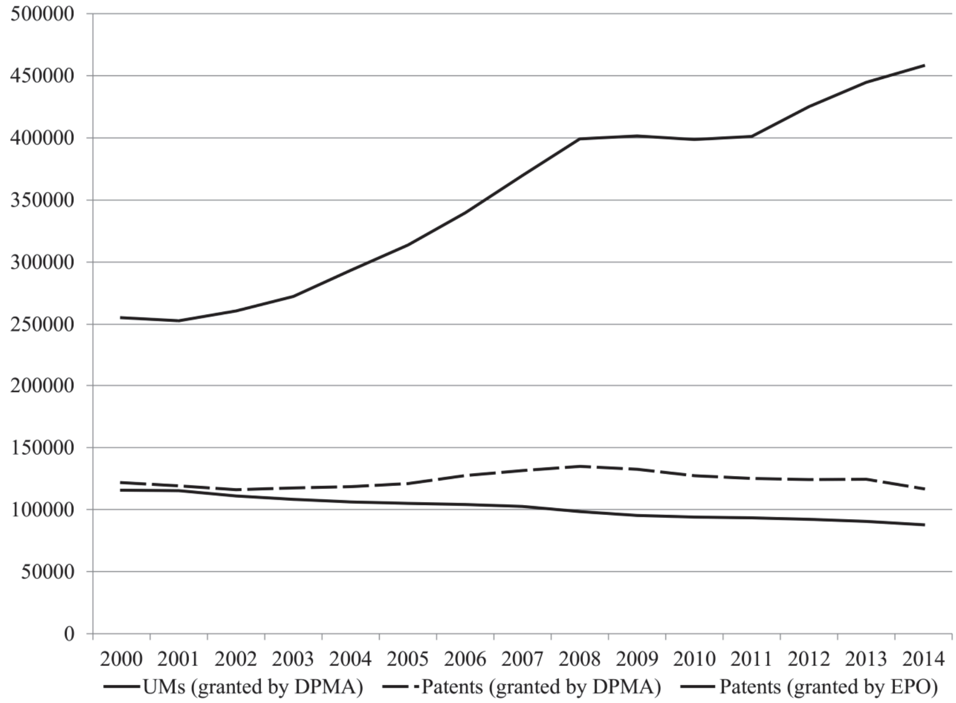
In 1891, Germany introduced a UM system, rendering it the oldest UM system in the world, which is why it is often used as a reference for other countries (Kingston 2001; Guellec and van Pottelsberghe 2007). Initially, the aim of the German UM system was to fill the gap between patents and design rights, i.e., to offer protection for small technical inventions (Janis 1999; Grosse Ruse-Khan 2013). Harhoff et al. (2003), Cremers et al. (2013), and Cremers et al. (2014) provide good descriptions of the German patent system.

German UMs protect technical inventions, including chemical substances, food, and medical products, except processes (manufacturing and working processes, measuring processes, and others). The maximum duration of a patent is 20 years, while a German UM can be extended for a maximum of 10 years. Although the UM is often referred to as a “petty patent” or “small patent”, in Germany the inventive step requirement has been the same for patents and UMs since 2006 (Björkwall 2009; Grosse Ruse-Khan 2013; Prud’homme 2014; Radauer et al. 2015).

Recent statistics on the UMs and patents in force in Germany, granted by the Deutsches Patent- und Markenamt (DPMA), show a slightly decreasing trend (as depicted in Figure 1). Moreover, Figure 2 indicates that the number of UM registrations is declining faster than the number of national patent applications. From 2000 to 2014, UM filings decreased by more than one-third (from 22,440 to 14,805), whereas patent applications increased by 1.7% (from 64,862 to 65,958). In contrast, the number of European Patent Office (EPO) patents granted in Germany has steadily been increasing: from 255,303 in 2000 to 458,042 in

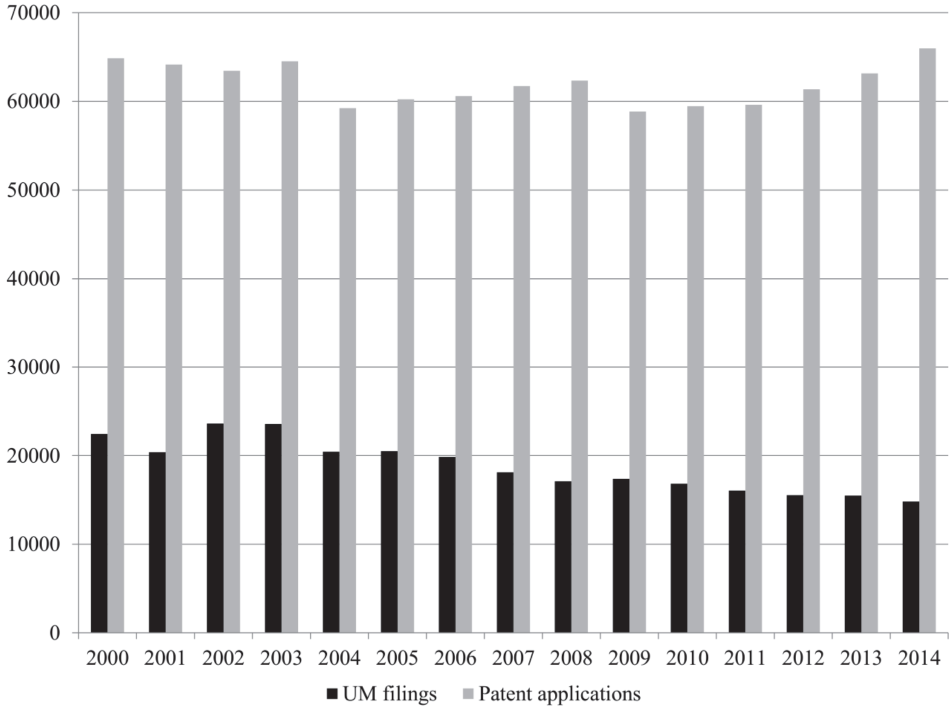
2014 (79.4%). Part of the decrease in UM filings could be explained by the decision of the German Supreme court in 2006 to apply the same inventive step requirement for UMs as for patents.

FIGURE 1 Patents and utility models in force in Germany 2000–2014



Source: DPMA annual reports 2006–2014, available at:
http://www.dpma.de/english/service/publications/annualreports/index.html

FIGURE 2 Patent applications and utility model filings at the DPMA



Source: DPMA annual reports 2006–2014, available at:
http://www.dpma.de/english/service/publications/annualreports/index.html

The German UM system has been designed especially considering the needs of SMEs (Suthersanen 2006; Königer 2009; Grosse Ruse-Khan 2013). The procedure to register a UM at the German patent office is simpler and somewhat cheaper than the procedure to apply for a patent. This is reflected by statements made by the largest IP law firms and patent attorneys, as well as the Industrie-und Handwerkskammer (IHK) in Germany;

> "Due to a lack of examination it is significantly faster and more cost-effective to obtain a utility model, on the other hand, this makes it less legally secure." (IHK München)[9]

> "A utility model is due to the low costs, especially suitable for small and medium-sized businesses (SMEs) as well as for inventions, for which is not yet known whether or how they are economically exploited." (Wittmann and Hernandez, patent attorneys)[10]

[9] https://www.muenchen.ihk.de/de/recht/patentrecht-designschutz/welcher-schutz-fuer-was-/patent-und-gebrauchsmusterrecht Accessed on 28 January 2016.

[10] http://www.whip.de/patentanwalt/gebrauchsmuster_anmelden.html#allgemeine_informationen
Accessed on 28 January 2016.

Additionally, Radauer et al. (2015, pp. 32–33) report six beneficial features of German UMs that stand out in the qualitative feedback from UM users: 1. speed of protection, which makes UMs suitable for products with short life cycles; 2. branching-off a UM from a patent application; 3. protection for minor inventions; 4. grace period; 5. complying with German employee inventions law; and 6. using UMs as a cheap means for publication (create prior art and preserve freedom to operate). Hence, the UM adds flexibility to the German patent system.

3.2 The process of registering a utility model in Germany[11]

The examination and granting of a patent usually take several years. In Germany, the applicants also have the option for deferred examination, i.e., to postpone examination of the patent for a maximum of seven years (Harhoff et al. 2003; Jell et al. 2013; Harhoff et al. 2015). In contrast, a German UM is registered on average within two to four months after filing the application (Radauer et al. 2015), provided the documents filed comply with the provisions of the Utility Model Act (Gebrauchsmustergesetz). The DPMA itself advertises UMs as "the fast IP rights".[12]

Table 2 reports descriptive statistics for German patents and UMs concerning pendency times and publication lags.[13] The mean grant lag of patents and the registration lag of UMs are affected by right-skewed lag distributions as the median lags are considerably shorter than the respective means.[14] From 2000 to 2010, the median grant lag for German patents was 2.8 years, while for UMs, the median registration lag was approximately three months.

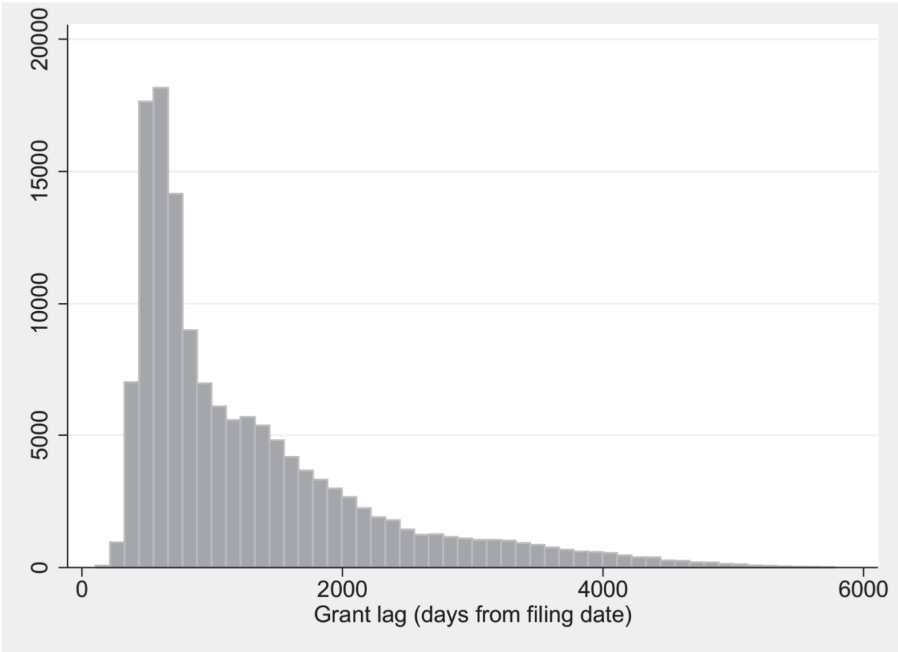
TABLE 2 Publication, registration, and grant lags of patents and utility models

	Observations	Mean	Sd.	Median	Min	Max
Grant/registration lags 2000-2010						
Grant lag of patents	125319	1364.91	970.44	1025	204	5776
Registration lag of utility models	156657	185.07	215.99	107	8	3710
Publication lags 2000-2014						
Patents	578598	540.01	105.50	554	44	5769
Utility models	194242	176.58	203.87	101	3	3553

[11] This section is mainly based on information retrieved from the DPMA's webpage.
[12] http://dpma.de/english/utility_models/index.html Accessed on 25 September 2015.
[13] The source of data is the PATSTAT April 2016 edition. Populations consist of German priority patent and UM filings. PCT applications are excluded.
[14] We report the grant lags for 2000–2010 instead of 2000–2014 due to a truncation problem: the more recent a patent filing is, the more likely it is still pending and does not enter grant lag mean and median calculations. See Figure A.1 in the Appendix.

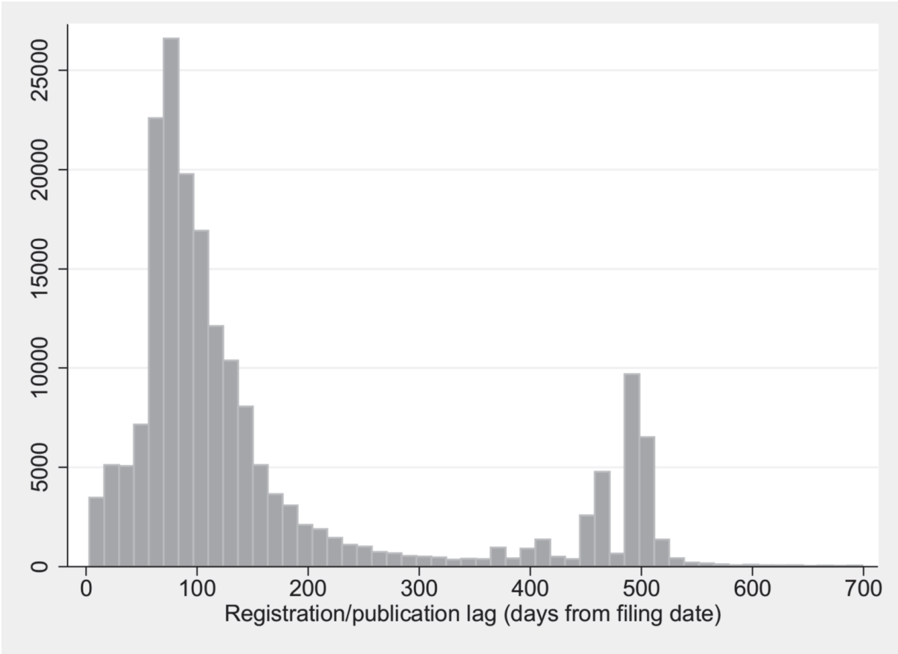
Figure 3 shows the grant lag distribution of patents and Figure 4 the registration lag distribution of UMs. Interestingly, the distribution of UM publication lags is bimodal. As mentioned in the previous section, it is possible to postpone the publication of UMs by 15 months, and Figure 4 suggests that this option is exercised in a considerable number of UM filings.

FIGURE 3 Grant lag distribution of German patents from 2000–2010



Notes: Data source is the PATSTAT 2016 April edition. All priority patents were filed at the German patent office from 2000–2010. PCT filings are excluded.

FIGURE 4 Registration/publication lag distribution of German utility models from 2000–2014



Notes: The data are based on the PATSTAT 2016 April edition and cover all priority UMs filed at the German patent office from 2000–2010. Outliers, UMs with longer than 700 publication lags, are not reported, and PCT filings are excluded.

A major strategic concern in patenting relates to the role of disclosure and the timing thereof. After having filed a patent, the application will be kept secret for 18 months and will then be published. The mean and median publication lags of patents reported in Table 2 are almost exactly 18 months (540 days). The published patent application will be available in the openly accessible DPMAregister database from the first publication date.[15] Figure 5 depicts the publication lags of patents. The 18-month secrecy period does not apply to UMs. Instead, if a UM application does not have any defects, or if the defects have been remedied, the UM is entered into the DPMAregister, and, hence, its contents become public knowledge.[16] For UMs, the publication date is the same as the registration date.

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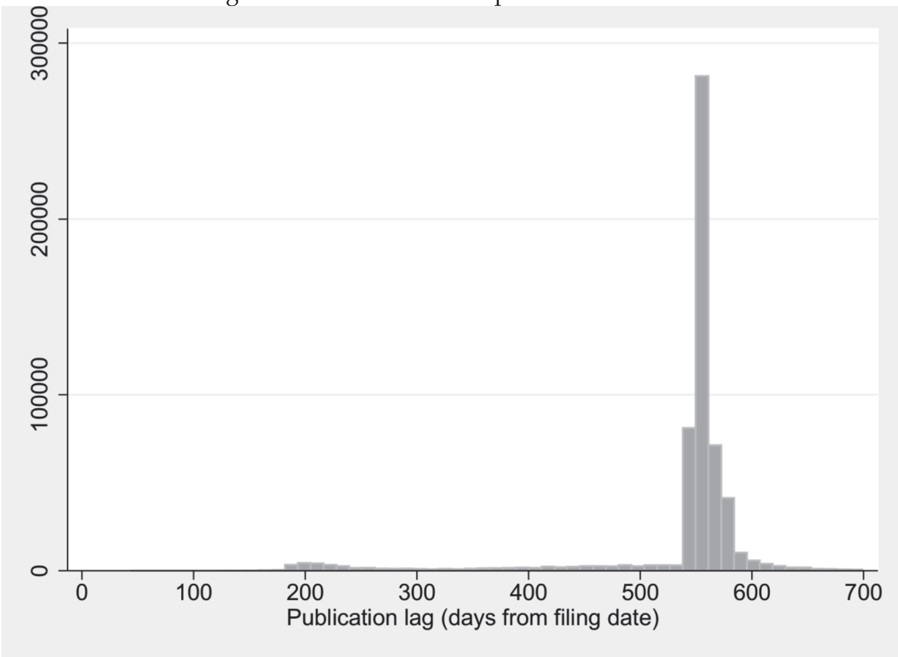
[15] https://register.dpma.de/DPMAregister/Uebersicht?lang=en Accessed on July, 13, 2015.
[16] Upon request, publication of the UM can be postponed for up to 15 months beginning from the filing date, but, of course, protection commences with publication of the UM. See §§ 8 Abs. 1 GebrMG, 49 Abs. 2 PatG. See also: http://www.wh-ip.com/germany/german_utility_model.html Accessed on July 13, 2015. http://www.vo.eu/en/news/item/476/german_utility_model_alternative_to_national_patent Accessed on July, 13, 2015.

FIGURE 5 Publication lag distribution of German patents from 2000–2014



Note: Data source is the PATSTAT 2016 April edition. All priority patents filed at the German patent office from 2000–2014. Outliers, patents with longer than 700 publication lags, are not reported, and PCT filings are excluded.

In Germany, a UM becomes effective upon registration and gives the same right to exclude others from using, producing, and marketing the protected invention as a patent. This makes it a potentially appropriate protection method for inventions whose owner needs quick enforcement against potential imitators. Patent applications, on the other hand, cannot be enforced when they are pending. Thus, while UMs can only be in force for 10 years, the difference in potential effective life (from grant to expiration) compared to patents is decreased by the fast grant.[17] Nonetheless, a UM is an unexamined IP right as it lacks substantive examination: patent examiners at the DPMA do not examine the novelty, inventive step, and industrial applicability of the invention prior to its registration. Therefore, inventors should conduct thorough searches to ensure that the application actually meets the requirements that apply to effective IP rights. Unexamined IP rights comprise inherent legal uncertainty (Suthersanen 2006; Königer 2009; Prud'homme 2014; Radauer et al. 2015). Weak patents may be socially costly as they can create the danger of patent hold-up, lead to costly litiga-

[17] In practice, the duration of most patents is also less than 20 years, since, in many cases, applicants let patents lapse by not paying the renewal fees (Guellec and van Pottelsberghe 2007; Harhoff et al. 2015). Guellec and van Pottelsberghe (2007) report that 50% of patents granted by the EPO lapse within first 10 years and only 8% of EPO patents are renewed until the statutory term.

tions, and induce a vicious cycle of defensive patenting (Farrell and Shapiro 2008; Atal and Bar 2014).

A peculiarity of the German UM system is the novelty grace period: If an inventor applies for a UM registration within six months from the publication of her invention, UM protection is still available (Radauer et al. 2015). The patent systems of the US, Japan, and Canada apply grace periods, but European patent systems have not applied grace periods since the European patent convention was signed in 1973 (Franzoni and Scellato 2010). This means that, in most European patent systems, publication of an invention destroys its novelty and a patent can no longer be granted (Franzoni and Scellato 2010). In Germany the grace period of UMs enables inventors to protect their disclosed inventions with UMs.

Moreover, in Germany, there is the possibility for double granting, i.e., an applicant can protect the same invention with both a patent and a UM (Guellec and van Pottelsberghe 2007; Prud'homme 2014; Radauer et al. 2015). Splitting-off[18] a UM provides protection in the period between patent application and grant, when no or only limited protection is available.[19] By making a respective splitting-off declaration, an applicant may obtain an independent UM application, for which it is possible to claim the priority date from the patent application. Upon registration of the split-off UM, the invention enjoys full protection (a right to injunctive relief and claim for damages), irrespective of the outcome of the patent grant procedure. Hence, with complementary UM protection, it is possible to extend patent protection from the front end. Figure 6 provides an overview of patenting and UM processes in Germany and illustrates the gap in the time dimension of patent protection which the UM protection is filling.

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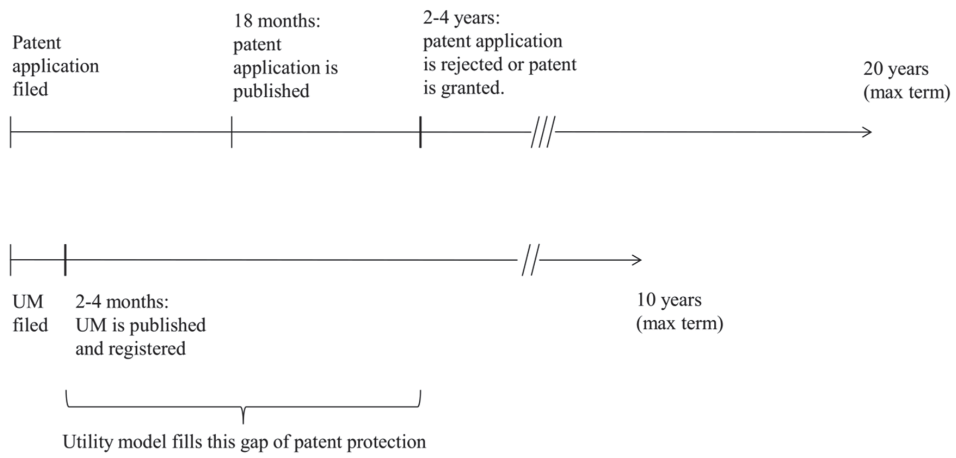
[18] Also referred to as "branching off" by Radauer et al. (2015).
[19] http://dpma.de/english/utility_models/procedure/index.html Accessed on July, 13, 2015.

FIGURE 6 Patenting and UM registration processes in Germany



Although German UMs (and patents) are presumed valid until proven otherwise, the bifurcation principle (infringement and validity of a patent are decided independently by different courts) does not apply to UMs (Cremers et al. 2013; Cremers et al. 2014). In UM disputes, the defendant is allowed to raise the invalidity defense (Cremers et al. 2013), whereas this is not possible in patent suits. Then, cancellation proceedings will clarify whether the UM is actually valid, i.e., that the invention is new and involves an inventive step.[20] The UM infringement suit is then suspended until the resolution of cancellation proceedings.[21]

4 To patent or to register a utility model, or both?

In this section, we discuss the possible determinants of the use of patents and UMs and develop testable hypotheses. The hypotheses are derived from the prior literature and economic theory, but they also mirror the particularities of the institutional context in which the firms in our data operated.

Economic theory suggests that firms' IPR decisions are based on profit maximization and that firms take into account the prevailing IPR institutions when making those decisions. Surveys of patenting firms suggest that firms use patents for different strategic purposes (e.g., preventing imitation, securing freedom to operate (FTO), licensing, signaling capabilities to acquire funding, blocking, and pre-empting), and that these motives may differ by firm size and

[20] http://dpma.de/english/utility_models/procedure/index.html Accessed on September 25, 2015.
[21] Gebrauchsmustergesetz (GebrMG) (adapted on July 31, 2009) §19.

industry (Cohen et al. 2000; Blind et al. 2006; de Rassenfosse 2012; Holgersson 2013). Presumably, the motives to use UMs should be similar to those of patents, as they are also a protection method for technical inventions. The two main differences between the German patents and UMs relate to the speed of protection and to the threshold of obtaining protection. However, the benefits and costs of using patents and UMs are expected to vary depending on firm characteristics. Next, we develop hypotheses concerning the choices between UMs and patents.

4.1 Economies of scale and scope in the use of IPRs

Larger firms can benefit from economies of scale (Cohen et al., 2000) and learning when it comes to filing and using a particular type of IPR. They can spread the fixed costs of IPR activities over a larger number of innovations. In comparison to small firms, established firms have the financial capacity to develop internal R&D capabilities that generate more valuable innovations and, thus, patents with greater economic benefits ("valuable patents") (Johnson 2002; Allison et al. 2004; Harhoff et al. 2003; Hussinger 2006). They also often have an inhouse R&D and/or IP department that is routinized in using the patent system (Hussinger 2006; Wagner 2006; Wang et al. 2009; Grimpe and Kaiser 2010), whereas smaller firms possess fewer resources that they can invest in IP protection (Wernerfelt and Karnani 1987; Byma and Leiponen 2009).

There is no reason to expect that only small firms would use UMs, as it is unclear why large firms would not also want to register UMs to supplement their patent portfolios. Larger firms have the resources to invest in many kinds of R&D projects simultaneously, which increases their chances of discovering protectable inventions (Johnson 2002; Harhoff et al. 2003; Allison et al. 2004). Such inventions can be incremental or more radical. Moreover, larger firms often have more product lines than small firms and, thus, a larger variety of potentially protectable technical inventions. Large firms have more resources and capabilities to utilize many kinds of IPR methods, which may lead to economies of scope. They can protect more valuable inventions with patents and register UMs for less valuable inventions (Beneito 2006). In Germany, it is possible that inventions are protected with both a patent and a UM because the legislation allows double granting (Guellec and van Pottelsberghe 2007; Prud'homme 2014; Radauer et al. 2015), as was explained in the previous section. Hence, the larger a firm is, the more likely it is to have several product inventions, some of which they protect with patents and some with UMs.

Hypothesis 1:
The likelihood to utilize patents and utility models simultaneously in protecting IP increases with firm size.

4.2 Need for speed

The DPMA states that UMs can be granted as quickly as four days after application and that they are typically granted in three to four weeks if a patent attorney is involved and, on average, in three months if no patent attorney is involved (Prud'homme 2014, p. 20). In contrast, Harhoff et al. (2015) report that the average duration of a patent examination at the DPMA was 2.6 years during the period from 1989 to 1996. Table 2 and Figures 3 and 4 in section 3.2 depict the difference in patent grant lag and UM registration lag distributions for the population of German priority filings from 2000–2010. The speed advantage of UMs compared to patents in obtaining protection for technical inventions is considerable and counted in years, rather than months (see Table 2).

Radauer et al. (2015) have recently conducted a survey of UM users in Germany and find fast protection to be the most important motive to register UM among the 47 respondents. Furthermore, Radauer et al. (2015, p.32) report the most useful feature of UMs, which stood out in interviews with IP professionals and UM users, was speed: "Foremost to mention is speed. UMs are granted quickly and can be used particularly well for products that have a short product life cycle." Hence, an important difference between patents and UMs lies in the time dimension of protection: patents offer slower but longer protection, whereas UMs offer fast but shorter protection (Cao 2014). Previous literature has defined the length of the product life cycle (i.e., product lifetime) as the time between a product's introduction and withdrawal from the marketplace (Bayus 1994, 1998).

Particularly in dynamic industries, firms may rely more on informal protection methods, such as lead-time and secrecy, than on the slower patents (Cohen et al. 2000; Arundel 2001; Byma and Leiponen 2009; Thomä and Bizer 2013; Hall et al. 2014). Therefore, we expect firms operating in markets with short life cycles of products and services to be more likely to use UMs and rate a higher importance to UMs relative to patents.

Hypothesis 2a:
Firms reporting to have short life cycles of products and services are more likely to use utility models than other firms are.

Based on the arguments above, we developed a stated preference version of the previous hypothesis:

Hypothesis 2b:
Firms reporting to have short life cycles of products and services assign higher importance to utility models.

It is possible that, in dynamic and fast-moving markets characterized by intense competition, the risk of overlapping invention is higher, irrespective of the life cycle of products. In this situation, firms require strong protection and may, therefore, prefer patents to uncertain UMs. Additionally, firms rarely possess "one patent per product". Hence, even though product life cycles might be short, the underlying patented technology might still be applicable to new products; therefore, it would be rational to patent and protect inventions against competitors. If this reasoning were correct, then the association between short life cycles and the choice of UMs would be confounded.

5 Data and methods

In this section, we present the data for analysis, the choice and construction of dependent and independent variables, and the estimation methods which we apply to test our hypotheses.

5.1 Data sources

We use the Mannheim Innovation Panel (MIP) 2005, MIP2005, which includes the core Eurostat Community Innovation Survey (CIS) questions and a few additional country-specific questions. Previously, Thomä and Bizer (2013) utilized these data to study the innovation protection mechanisms of small German firms. They also provide a detailed description of how the MIP2005 data were collected. The questions in the MIP2005 refer to the three-year period from 2002 to 2004. Thus, the survey considers the period before the 2006 German Supreme Court's decision to abolish the inventive step difference between patents and UMs. As shown in Figure 2, it seems that this legal change led to a slight, but not dramatic, decrease in the level of UM applications. The random sample of German firms is stratified by region, size, and sector. The survey contains information about the perceived business environment and firm characteristics, enabling us to test the developed hypotheses. Most importantly, the questionnaire includes questions about the protection methods that firms used to protect their intellectual property (IP).

5.2 Variables

5.2.1 Dependent variables

We measure how firms use UMs and patents and their stated ranking ("stated preference") of these two methods of IP protection. We, therefore, construct two alternative dependent variables for our empirical analysis.

The relevant questions in the MIP2005 ask whether the respondent firm had used the listed formal protection methods (patent, utility model, design right, trademark and copyright) to protect their IP during past three years.[22] We construct binary variables to indicate the use of patents (P) and UMs:

$$\mathrm{Use}_i^j = \begin{cases} 1, \text{if firm i used protection method j to protect IP 2002} - 2004 \\ 0, \text{otherwise} \end{cases}$$

where j∈{P, UM}.

Conditional on using a specific IP protection method, the respondents were also asked to rate the importance of the respective method on a three-point Likert scale: low importance, medium importance, and high importance. We assume that firms which did not use a specific protection method are considered to assign the lowest possible importance i.e. no importance to the protection method. Hence, we construct the following dependent variable when modelling the stated importance of protection methods in protecting IP:

$$\mathrm{Imp}_i^j = \begin{cases} 0, \text{if } \mathrm{Use}_i^j = 0 \\ 1, \text{if firm i reports j to be of low importance} \\ 2, \text{if firm i reports j to be of medium importance} \\ 3, \text{if firm i reports j to be of high importance} \end{cases}$$

where j∈{P, UM}.

5.2.2 Independent variables of key interest

We measure firm size by logarithm of reported full-time equivalent employees in 2004, log (Employees). Short life cycle of products and services is proxied with a binary variable D (Short life cycle), which obtains value 1, if a firm totally agrees or agrees[23] that in its main market "products/services mature rapidly", and 0 otherwise (cf. Thomä and Bizer 2013). We acknowledge that product and service life cycles differ across industries and that, in the survey, the term "rapidly" is subjectively interpreted. If D (Short life cycle) contains a high measurement error due to subjective interpretations (and, therefore, does not systematically measure how rapidly the products of firms mature and become obsolete), we are less likely to find evidence consistent with Hypotheses 2a and 2b.

5.2.3 Control variables

We control for the following firm characteristics. Firms' R&D investments are controlled for with the total R&D expenditure divided by fulltime equivalent employees. Since higher R&D intensity is likely associated with greater innova-

[22] Question 13.1. (Formale Maßnahmen) in the MIP 2005: "Hat Ihr Unternehmen in den Jahren 2002–2004 eine der folgenden Schutzmaßnahmen für geistiges Eigentum genutzt?"
[23] A four-point Likert scale (totally agree, agree, disagree, totally disagree).

tive output, i.e., more potentially patentable inventions, by holding R&D intensity constant, our independent variable logarithm of firm employees is a measure of economies of scale. We measure the importance of exports for each firm by exports per sales. Exporting firms need to be aware of national differences in IPR systems (Ginarte and Park 1997; Park 2008) in their target markets which could increase the relative importance of patents as all countries have patent systems, but a smaller share have UM systems (Kim et al. 2012). Group membership indicates whether a firm is a part of a larger group of firms. Firms that are part of a larger group, i.e., a conglomerate, may be able to leverage the knowledge and capabilities of their conglomerate to exploit IPR systems. The most robust finding in prior studies on the motives to patent is that the use differs across industries (Cohen et al. 2000; Arundel 2001; Hall et al. 2014). Furthermore, Johnson and Popp (2003) report varying grant lags across technologies. Therefore, to control for industry and technology heterogeneity, we include seven technology class dummies. We follow Eurostat's high-tech classification of manufacturing industries (high tech, medium high tech, medium low tech, low tech) and knowledge-intensive business services (knowledge-intensive businesses, low knowledge-intensive businesses).[24] The seventh technology class consists of NACE Rev. 1.1 industries 40 (electricity, gas, steam, and hot water), 41 (supply, collection, purification, and distribution of water), and 45 (construction).

5.3 Econometric models

Our data are cross-sectional. We model the use and importance of patents and UMs as follows. First, we examine which firm characteristics are associated with the use of patents and UMs by estimating a bivariate probit model (Greene 2012, pp. 778–781). The bivariate probit model is appropriate for modeling joint determination of patent and UM use, as they are presumably interrelated.

$$\mathrm{Use}_i^{*,j} = \alpha^j + \beta_1^j \log(\mathrm{Employees_i}) + \beta_2^j \mathrm{D(Short\ life\ cycle_i)} + \boldsymbol{\delta}'\mathbf{x}_i + \theta_k + \varepsilon_i^j,$$

$$\mathrm{Use}_i^j = 1 \text{ if } \mathrm{Use}_i^{*,j} > 1, 0 \text{ otherwise}$$

$$\left(\begin{matrix}\varepsilon_i^{P} \\ \varepsilon_i^{UM}\end{matrix}\middle| \log(\mathrm{Employees_i}), \mathrm{D(Short\ life\ cycle_i)}, \mathbf{x_i}\right) \sim N\left[\begin{pmatrix}0\\0\end{pmatrix}, \begin{pmatrix}1 & \rho\\ \rho & 1\end{pmatrix}\right]$$

where j ∈ {P, UM} and firm i belongs to technology class k, x is a vector of controls, ρ is the correlation between error terms, and, if ρ = 0, then the bivariate

[24] http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries Accessed on September 16, 2015.

probit becomes two independent univariate probit models (Greene 2012, p. 782). If $\rho \neq 0$, then there exists a disturbance correlation between the two equations, i.e., the unobservables affecting the concurrent choice of patent and UM use are correlated. In this case, bivariate probit gives more efficient parameter estimates than separate probit models, which assume disturbances to be independent.

Second, we study the interrelated importance of patents and UMs by estimating a bivariate ordered probit model which is a direct extension of a univariate ordered probit model (Greene and Hensher 2010). The model is the same as the above-presented bivariate probit model except that the dependent variable is now an ordinal variable indicating the importance of patents and UMs (see section 5.2.1).

We are not claiming any causal relationships, but we try to identify statistical associations between firm characteristics and the use and importance of IP protection methods. In particular, we are not investigating the decision to start using a specific IP protection method, but rather the prevailing status of a firm in utilizing IP protection methods (during the past three years, i.e., 2002–2004). The firms that have been innovative in the past may or may not have chosen to protect their inventions with patents or UMs or both.[25] Therefore, we did not want to narrow our baseline sample and estimations to only recently innovative firms (i.e., firms that introduced innovation from 2002 to 2004) or to R&D active firms (firms with R&D investments from 2002 to 2004).

We acknowledge that the firms may have protected their inventions and IP with several other protection methods than UMs and patents (cf. Thomä and Bizer 2013). In order to be concise, we leave them out of the current analysis and focus on the relationship between patents and UMs.

6 Empirical analysis

6.1 Descriptive analysis

Table 3 presents the descriptive statistics by the categories of patent and UM users. A total of 75% of our sample firms (2,265/3,016) used neither patents nor UMs to protect their IP. These firms are the smallest, invest the least in R&D, and are the least export-intensive, on average. A quarter of these firms report having short product and service life cycles. A minority, 4.2% (127/3,016), of the sample firms use UMs only. These firms are smaller on average, invest less in R&D per employee, and have a lower export share of turnover than patenting firms.

In line with the need for speed Hypothesis 2a, UM users (36.2%) frequently report short life cycles of products and services, although the differences be-

[25] It is possible that a firm had patented an invention in the 1980s and that this patent was still used to protect the firm's IP in the period from 2002–2004.

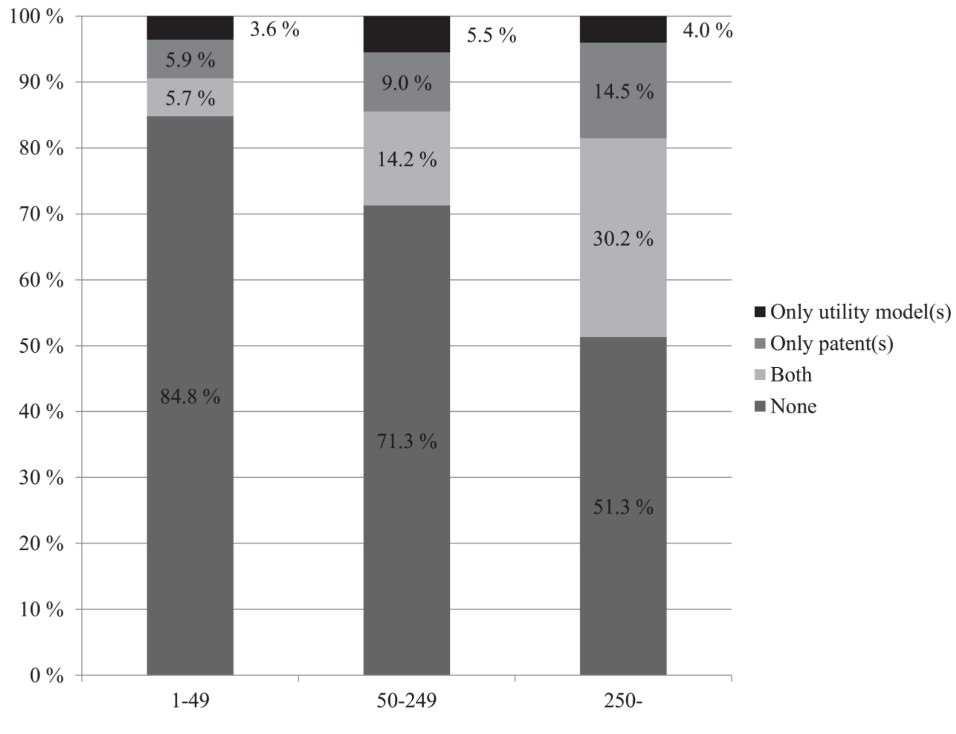
tween these users and both patent only users (32.1%) and patent and UM users (35.5%) are small. Consistent with the economies of scale and scope Hypothesis 1, the firms which use both protection methods to protect IP are large and, on average, have the most employees. Firms using patents only have, by far, the largest mean R&D expenditure.

TABLE 3 Descriptive statistics

	The use of patents and utility models														
	No patents or utility models			**Only utility models**			**Only patents**			**Patents and utility models**			**Total**		
	N	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.
Employees	2265	174.92	1322.21	127	214.34	943.63	249	309.07	597.74	375	1899.66	11724.51	3016	402.10	4330.27
R&D per employee (€)	2265	3539.75	26101.05	127	14642.54	72091.04	249	30338.13	61359.98	375	14642.45	28630.01	3016	7600.22	34691.19
Export share	2265	0.089	0.192	127	0.214	0.248	249	0.354	0.282	375	0.338	0.282	3016	0.147	0.240
Group member dummy	2265	0.544	0.498	127	0.598	0.492	249	0.711	0.454	375	0.731	0.444	3016	0.583	0.493
Short life cycle dummy	2265	0.250	0.433	127	0.362	0.483	249	0.321	0.468	375	0.355	0.479	3016	0.274	0.446

Figure 7 illustrates how the use of patents and UMs is associated with firm size categories measured by the number of employees. Firms are classified into three categories based on number of employees: 1–49 employees, 50–249 employees, and more than 250 employees. The majority of sample firms do not use any protection methods in all size categories. The share of firms utilizing both protection methods increases with firm size. This observation is in line with the economies of scale and scope Hypothesis 1, although it should be noted that the industry composition is likely to differ between size categories. Similarly, the share of firms using only patents increases with firm size, whereas the proportion of firms using only UMs is the largest among medium-sized (50–250 full-time equivalent employees) enterprises (5.5%). The small proportions of firms using only UMs in all size categories indicates that UM protection is a supplemental protection method for patenting firms rather than a main protection method on its own.

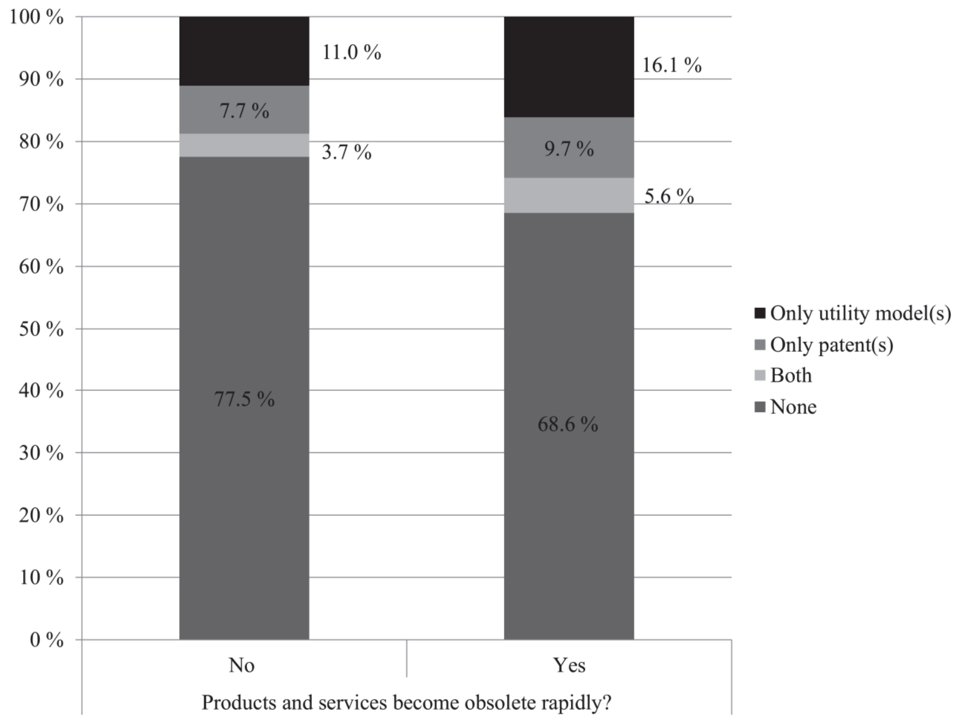
FIGURE 7 The use of protection methods by firm size (employees) categories



Note: Firms are classified into three size categories: 1–49 employees, 50–249 employees and more than 250 employees.

Figure 8 shows that those firms that have short life cycles of products or services are more active users of patents and UMs. Among firms which have short life cycles of products and services, 16.1% used UMs to protect intellectual capital, whereas, among firms which did not report short life cycles of products or services, 11% used UMs. This is consistent with Hypothesis 2a.

FIGURE 8 The use of protection methods by "need for speed"



6.2 Econometric results

6.2.1 The use and importance of patents and utility models

First, we estimate a biprobit model to analyze the determinants of concurrent patent and UM utilization. Table 4 reports the estimated coefficients (columns 1–2) and marginal effects (columns 3–6).

TABLE 4 The use of protection methods, bivariate probit model

Model	Bivariate probit					
			Patent=1,	Patent=1,	Patent=0,	Patent=0,
Dependent variable	Patent	UM	UM=1	UM=0	UM=1	UM=0
Estimate	Coeff.	Coeff.	M.E.	M.E.	M.E.	M.E.
	(1)	(2)	(3)	(4)	(5)	(6)
D(Short life cycle)	0.031	0.186***	0.015*	-0.008	0.023***	-0.030*
	(0.070)	(0.067)	(0.008)	(0.008)	(0.009)	(0.016)
log(Employees)	0.198***	0.164***	0.024***	0.016***	0.008***	-0.048***
	(0.021)	(0.020)	(0.002)	(0.003)	(0.002)	(0.005)
log(R&D per employee)	0.125***	0.078***	0.013***	0.012***	0.002**	-0.027***
	(0.008)	(0.008)	(0.001)	(0.001)	(0.001)	(0.002)
log(Export intensity)	1.482***	0.884***	0.155***	0.140***	0.018	-0.313***
	(0.172)	(0.176)	(0.022)	(0.022)	(0.021)	(0.040)
D(Group member)	-0.010	-0.078	-0.006	0.004	-0.009	0.012
	(0.072)	(0.067)	(0.008)	(0.008)	(0.008)	(0.016)
Constant	-2.199***	-2.120***				
	(0.136)	(0.136)				
Technology classes (7)	Yes					
ρ	0.767*** (0.024)					
Log-likelihood	-1869.07					
Observations	3016					

Notes: The dependent variables are indicator variables for the use of patents and utility models. First two columns report the estimated coefficients for bivariate probit model. Columns 3–6 present the marginal effects at means for patent and utility model combinations. Heteroscedasticity robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Regarding the combined use of patents and UMs, we find support for our economies of scale and scope Hypothesis 1: firm size is positively associated with the likelihood to use both protection methods (columns 1 and 2). The observation is consistent with prior literature, which suggests larger firms to be more capable users of formal protection methods (Cohen et al. 2000; Hussinger 2006; Byma and Leiponen 2009; Hall et al. 2013; Thomä and Bizer 2013). Firm size is also positively associated with the likelihood to use only patents (column 4) and only UMs (column 5), but the estimated marginal effect is the highest in the case of concurrent use of both protection methods. Moreover, in line with Hypothesis 2a, the estimates of Table 4 suggest that a short life cycle of products and services is associated with an increased likelihood to use only UMs or both patents and UMs. In line with our expectations, the association is more pronounced between short life cycles and the use of only UMs, an increase of 2.3 percentage points (column 5), than between short life cycles and the use of patents and UMs, an increase of 1.5 percentage points (column 3).

A statistically significant positive ρ, i.e., the correlation of error terms, indicates that the uses of patents and UMs are not independent of each other, conditional on the included covariates.[26] Furthermore, a positive ρ is in line with the view that patents and UMs are complements rather than substitutes.

The signs of control variables are in line with our expectations. We find R&D per employee to be positively associated with the likelihood to use patents and both protections methods. This is in line with the expectation that more important and costly inventions are protected with patents, whereas UMs are appropriate protection methods for incremental improvements (Johnson 2002; Beneito 2006; Kim et al. 2012). The analysis of marginal effects indicates that the positive association between R&D and the likelihood to use utility UMs is, in particular, driven by firms that use both patents and UMs, rather than by firms that use only UMs, since the estimated marginal effect for the former is more than six times larger than that of the latter.

The observed positive association between export intensity and the likelihood to use patents or both protection methods is consistent with the fact that exporting firms need to protect their inventions in target markets which more often have regular patent systems than two-tiered patent systems (e.g., the US and the UK) (Kim et al. 2012). The non-significant association between export intensity and likelihood to use only UMs highlights the importance of the UM system for firms mainly operating in Germany. It is likely that German firms which export within the EU protect their inventions with European patents granted by the EPO.

Next, we explore the factors associated with the stated importance of patents and UMs. Table 5 shows the results of the bivariate ordered probit estimation. Generally, the estimates corroborate our findings about the use of patents and UMs presented in Table 4. The need for speed Hypothesis 2b is supported as we find short life cycles of products and services to be associated with the importance of UMs, but not with the importance of patents. Again, the statistically significant positive ρ suggests that there exists a disturbance correlation between the equations, i.e., the reported importance of patents and UMs are related. Again positive ρ indicates that patents and UMs are complements rather than substitutes. The signs of the estimated coefficients of the control variables are similar between the bivariate probit model in Table 4 and the ordered probit model in Table 5: firm size, R&D intensity, and export intensity are all positively and significantly associated with the importance of both patents and UMs. Thus, the use and importance of protection methods are closely linked, as expected.

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[26] Separate probit models would not take into account this correlation of unobserved determinants of patents and UMs and would therefore be a less efficient alternative. However, we also estimated separate probit models and obtained similar results.

TABLE 5 The stated importance of UMs and patents, bivariate ordered probit model

Model	Bivariate ordered probit	
Dependent variable	Patent	UM
Estimate	Coeff.	Coeff.
	(1)	(2)
D(Short life cycle)	0.009	0.150**
	(0.067)	(0.065)
log(Employees)	0.184***	0.147***
	(0.019)	(0.018)
log(R&D per employee)	0.130***	0.081***
	(0.008)	(0.008)
log(Export intensity)	1.508***	0.928***
	(0.167)	(0.172)
D(Group member)	0.009	-0.053
	(0.068)	(0.065)
Technology classes (7)	Yes	
Constant cut1	2.228	2.066
	(0.129)	(0.125)
Constant cut2	2.376	2.212
	(0.127)	(0.124)
Constant cut2	2.686	2.599
	(0.131)	(0.130)
ρ	0.721*** (0.024)	
Log pseudolikelihood	-2818.01	
Observations	3004	

Notes: The dependent variables are ordinal variables indicating the importance of patents and utility models as IP protection methods. 12 firms, which reported to use patents and/or utility models but did not answer the importance question, are omitted. Heteroscedasticity robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

6.2.2 Robustness checks[27]

First, various prior studies which have utilized CIS data have focused on subsamples of "recent innovators" (e.g., Hussinger 2006; Thomä and Bizer 2013; Hall et al. 2013). Hence, we re-estimated the use of protection method models (Table 4) for the subsample of innovating firms (ones that introduced a product or process innovation during 2002–2004). The results are reported in Table A.1 in the Appendix. As in Table 4, we find firm size to be positively associated with the use of patents and UMs, and the estimated marginal effects are of similar magnitude. Also, short life cycles of products and services are found to be positively associated with the use of only UMs. The estimated marginal effects provide weak support that having a short life cycle of products and services is

[27] The results of robustness checks are presented in the Appendix.

negatively associated with the use of patents only. In the case of the importance of patents and UMs, when we restrict the sample to innovators (Table A.2 in the Appendix), we still find firm size to be positively associated with the use of patents and UMs. The positive association between UMs and short life cycles of products and services is also found, but the effect is somewhat weaker statistically.

Second, since UMs are arguably somewhat cheaper to acquire than patents (Königer 2009), we control for reported financial constraints, i.e., if the firm reported lack of financing (internal or external) to be an obstacle for innovation. Another reason to control for financial constraints is that patents may be more important than UMs in convincing investors (especially international investors who may not be equally familiar with UM protection) and acquiring financial resources (Mann and Sager 2007; Hoenen et al. 2014; Hoenig and Henkel 2015). We also control for the level of competition in the firm's main market.[28] The association between competition and the use of patents and UMs is unclear. On the one hand, stronger competition may induce firms to "escape competition" by innovating (Aghion et al. 2005) and by protecting their IP more intensively. On the other hand, more intense competition in fast-moving markets may induce firms to forgo IP protection altogether and focus on lead time advantages. Nevertheless, the results are robust for these controls on financial constraint and competition; firm size remains significantly positively associated with the use of and importance of patents and UMs. Short life cycle of products and services is also found to be positively associated with the use and importance of UMs, but not with the use and importance of patents. Hypothesis 2a, concerning the positive significant association between short product life cycle and the likelihood to use (only) UMs, gets further support.

Interestingly, we find a statistically significant positive association between the reported financial constraints and the use and importance of patents and no association with the financial constraints and the use and importance of UMs (Columns 1 and 2 in Table A.3). In particular, having financial constraints is positively associated with the likelihood to use only patents and not UMs (Column 4 in Table A.3). It is estimated that firms reporting financial constraints are 1.9 percentage points more likely to use only patents than firms which do not report financial constraints. This could be in line with the view that patents are more important than UMs in acquiring external financing, as firms signal the quality of their invention with patents (Mann and Sager 2007; Hoenen et al. 2014; Atal and Bar 2014; Hoenig and Henkel 2015). On the other hand, it could also indicate that patents protect more significant inventions which require additional financing for further development and commercialization. Nevertheless, our results do not support the view that financial constraints push firms to protect their inventions with "cheap" UMs instead of "expensive" patents.

[28] In the MIP2005 questionnaire, the firms were asked, "How many competitors has your firm in its main market?": 0, 1–5, 6–15, 15–. We constructed dummy variables to control for the level of competition.

Although none of the estimated coefficients for competition categories is statistically significant in Tables A.3 and A.4, the signs suggest a pattern that having zero competitors is associated with a lower likelihood to use patents and UMs than having more than 15 competitors (the reference group in estimations), whereas having 1–15 competitors is associated with a higher likelihood to use patents and UMs. This is consistent with the "escape competition effect" and in line with the inverted U-shaped association between competition and innovation (Aghion et al. 2005).

6.2.3 Limitations

An important limitation of the study is the focus on firm-level instead of invention-level utilization of patents and UMs (Hussinger 2006; Hall et al. 2013; Heger and Zaby 2013). In reality, patent and UM protection are utilized at the invention level (i.e., project-level) and different inventions require different protection as they might be of a different inventive step and have life cycles of a different length. Thus, when a firm has several product lines and services, the stated use and importance of IP protection methods probably reflect the overall importance of separate protection methods, i.e., "aggregated preferences." In other words, firms with multiple product lines and services may have short life cycles in their main market, but use patents and UMs to protect complementary products. Thus, although we control for R&D intensity per employee and firm size, the patterns that we observe might be driven by omitted variable bias: the number of product lines and services.

One source of bias is that our measure for short life cycle of products is a coarse proxy and is subjectively assessed by survey respondents. It is likely that this leads to attenuation bias, i.e., the estimated coefficient for short life cycle indicator is biased towards zero. Another possible source of bias is reverse causality: firms that are innovative protect their inventions with patents and UM, which gives them competitive advantage and helps them grow. Thus, the association between firm size and the use of patents and UMs is an endogenous process. Consequently, our estimates of this association are likely to be biased upwards. With the current data, we are not able to account for this endogeneity problem.

Our study focuses on a period before the German Supreme Court 2006 decision to abolish the inventive step difference between UMs and patents. Therefore, the external validity of our results might be diminished since the current German system is different from the system prior to the decision. As shown in Figure 2, the legal change did not lead to a sudden drop in UM filings, indicating that the lower inventive step requirement has not been the dominant motive to file UMs. Moreover, Figure A.1 in the Appendix shows that the registration lags of German UMs have been consistently shorter than grant lags of German patents even after the 2006 amendment. These observations are in line with Radauer et al.'s (2015) finding that the speed of protection was mentioned as the most important motive to file UMs, instead of protection for minor inventions. However, an important topic for further research is to analyze how the use of German UMs has evolved over time and how legal changes have affected filing activity.

7 Discussion and conclusion

We study the use and the relative importance of patents and UMs among German firms. The results suggest that larger firms tend to take advantage of both patent and UM systems. These observations indicate economies of scale and scope and are consistent with the view that larger firms have more resources and capabilities to exploit IPR systems. Furthermore, in line with the publicly expressed justification of the German UM system as "fast IP right", we find short life cycles of products and services to be associated with the use and stated importance of UMs.

Our study is related to the ongoing process of harmonization of IPR systems within the European Single Market (see European Commission 2011). Obviously, differences in national IPR systems increase transaction costs. Thus, it is likely that, for many inventors and SMEs, the patent system remains too complex and expensive and, therefore, hardly accessible. In this type of environment, larger and more experienced firms have the upper hand. In addition to a deepening harmonization of IPR systems in Europe and across the world, policy could focus on increasing the awareness of UMs as alternative protection methods and concurrently avoid an IPR environment that is excessively complex for SMEs and individual inventors. Especially firms and inventors from those EU member states which do not provide UM protection might be unaware of the UM option in other EU member states. In contrast, firms and inventors from the EU member states with UM systems are likely to gain a better understanding of the (dis)advantages of UMs relative to patents as legal protection mechanism. Hence, increasing the awareness of national IPR protection methods remains of the utmost importance in leveling the playing field between firms in the European Single Market.

Two-tiered patent systems provide a variety of interesting theoretical and empirical questions which have yet to be answered. A natural way to deepen the analysis of the relative importance of patents and UMs is to study patenting behavior with patent and UM data (e.g., PATSTAT) which are linked to data on applicant characteristics. As large firms seem to be active users of the UM system, an important topic for future research is how the UM system affects industry dynamics and competition between large incumbents and smaller entrants. Future studies could also investigate the underlying strategic motives to use UMs and how these motives vary across countries and industries.

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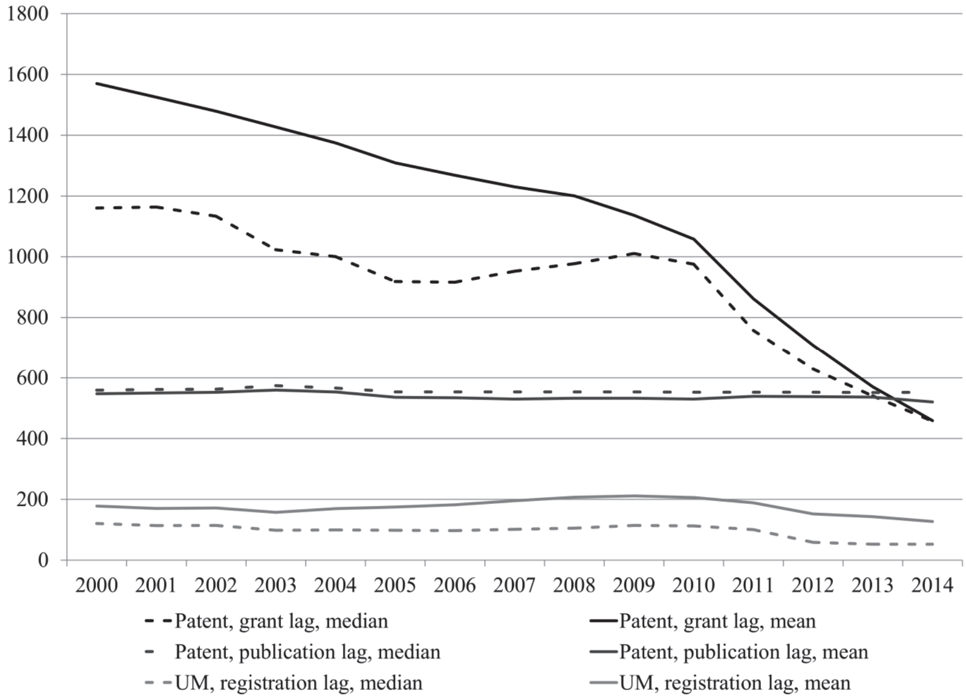
Appendix

FIGURE A.1 Grant, registration, and publication lags



Notes: Data source is the PATSTAT 2016 April edition. Priority patents and UMs filed at the German patent office 2000–2014 are reported. PCT applications are excluded. For UMs, the registration lag is the same as publication lag. Y-axis measures days from the filing date. Decreasing grant lag of patents is caused by truncation as pending patents are not taken into account when calculating medians and means.

TABLE A.1 The use of protection methods for the subsample of innovators, bivariate probit model

Model	Bivariate probit					
Dependent variable	Patent	UM	Patent=1, UM=1	Patent=1, UM=0	Patent=0, UM=1	Patent=0, UM=0
Estimate	Coeff.	Coeff.	M.E.	M.E.	M.E.	M.E.
	(1)	(2)	(3)	(4)	(5)	(6)
D(Short life cycle)	-0.019	0.186**	0.021	-0.027*	0.033**	-0.027
	(0.081)	(0.078)	(0.016)	(0.015)	(0.013)	(0.025)
log(Employees)	0.223***	0.188***	0.045***	0.024***	0.008**	-0.077***
	(0.026)	(0.024)	(0.005)	(0.005)	(0.004)	(0.008)
log(R&D per employee)	0.111***	0.053***	0.018***	0.017***	0.003*	-0.032***
	(0.012)	(0.010)	(0.002)	(0.002)	(0.002)	(0.003)
log(Export intensity)	1.545***	0.748***	0.246***	0.237***	-0.035	-0.449***
	(0.207)	(0.211)	(0.040)	(0.045)	(0.033)	(0.066)
D(Group member)	-0.041	-0.107	-0.018	0.005	-0.013	0.026
	(0.088)	(0.083)	(0.017)	(0.017)	(0.013)	(0.028)
Technology classes (7)	Yes					
Constant	-2.603***	-2.341***				
	(0.165)	(0.149)				
ρ	0.710*** (0.031)					
Log-likelihood	-1374.71					
Observations	1675					

Notes: The dependent variables are indicator variables for the use of patents and utility models. First two columns report the estimated coefficients for bivariate probit model. Columns 3–6 present the marginal effects for patent and utility model combinations. Heteroscedasticity robust standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

TABLE A.2 The importance of UMs and patents for the subsample of innovators, bivariate ordered probit model

Model	Bivariate ordered probit	
Dependent variable	Importance of patents	Importance of UMs
Estimate	Coeff.	Coeff.
	(1)	(2)
D(Short life cycle)	-0.030	0.140*
	(0.076)	(0.075)
log(Employees)	0.201***	0.157***
	(0.023)	(0.021)
log(R&D per employee)	0.113***	0.055***
	(0.012)	(0.010)
log(Export intensity)	1.547***	0.785***
	(0.197)	(0.201)
D(Group member)	-0.022	-0.061
	(0.083)	(0.079)
Technology classes (7)	Yes	
Constant cut1	2.094	1.788
	(0.170)	(0.156)
Constant cut2	2.207	1.894
	(0.170)	(0.155)
Constant cut2	2.532	2.306
	(0.174)	(0.161)
ρ	0.681*** (0.030)	
Log pseudolikelihood	-2129.30	
Observations	1664	

Notes: The dependent variables are ordinal variables indicating the importance of patents and utility models as IP protection methods. 12 firms, which reported to use patents and/or utility models but did not answer the importance question, are omitted. Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

TABLE A.3 The use of protection methods and additional controls, bivariate probit model

Model	Bivariate probit		Marginal effects after bivariate probit model			
			Patent=1,	Patent=1,	Patent=0,	Patent=0,
Dependent variable	Patent	UM	UM=1	UM=0	UM=1	UM=0
Estimate	Coeff.	Coeff.	M.E.	M.E.	M.E.	M.E.
	(1)	(2)	(3)	(4)	(5)	(6)
D(Short life cycle)	0.039	0.193**	0.017*	-0.009	0.025***	-0.034
	(0.073)	(0.070)	(0.009)	(0.009)	(0.010)	(0.018)
log(Employees)	0.215***	0.177***	0.028***	0.018***	0.009***	-0.055***
	(0.023)	(0.021)	(0.003)	(0.003)	(0.003)	(0.005)
log(R&D per employee)	0.120***	0.072***	0.014***	0.012***	0.001	-0.027***
	(0.009)	(0.008)	(0.001)	(0.001)	(0.001)	(0.002)
log(Export intensity)	1.429***	0.841***	0.161***	0.144***	0.014	-0.320***
	(0.180)	(0.183)	(0.024)	(0.025)	(0.024)	(0.044)
D(Group member)	-0.010	-0.100	-0.008	0.006	-0.013	0.015
	(0.074)	(0.070)	(0.009)	(0.009)	(0.009)	(0.017)
D(Financial constraint)	0.139**	0.022	0.011	0.019**	-0.007	-0.023
	(0.067)	(0.066)	(0.008)	(0.009)	(0.008)	(0.016)
Competition categories						
0 competitors	-0.119	-0.187				
	(0.209)	(0.217)				
1-5 competitors	0.167	0.062				
	(0.097)	(0.090)				
6-15 competitors	0.040	0.041				
	(0.112)	(0.105)				
15- competitors	ref.	ref.				
Technology classes (7)	Yes					
Constant	-2.863***	-2.341***				
	(0.156)	(0.149)				
ρ	0.760*** (0.025)					
Log-likelihood	-1741.85					
Observations	2704					

Notes: The dependent variables are indicator variables for the use of patents and utility models. First two columns report the estimated coefficients for bivariate probit model. Columns 3–6 present the marginal effects for patent and utility model combinations. Financial constraint is a dummy variable, 1 if firm reported a financial constraint as an obstacle for innovation in 2004 and 0 otherwise. Competition categories are dummies for the number of competitors: 0, 1–5, 6–15, 15–. The reference group is more than 15 competitors. Heteroscedasticity robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

TABLE A.4 The importance of UMs and patents and additional controls, bivariate ordered probit model

Model	Bivariate ordered probit	
Dependent variable	Importance of patents	Importance of UMs
Estimate	Coeff.	Coeff.
	(1)	(2)
D(Short life cycle)	0.011	0.151**
	(0.069)	(0.067)
log(Employees)	0.199***	0.157***
	(0.020)	(0.019)
log(R&D per employee)	0.126***	0.076***
	(0.008)	(0.008)
log(Export intensity)	1.472***	0.882***
	(0.173)	(0.177)
D(Group member)	0.012	-0.069
	(0.071)	(0.067)
D(Financial constraint)	0.125**	0.017
	(0.063)	(0.063)
Competition categories		
0 competitors	-0.019	-0.177
	(0.221)	(0.229)
1-5 competitors	0.118	0.049
	(0.094)	(0.087)
6-15 competitors	0.017	0.047
	(0.109)	(0.103)
15- competitors	ref.	ref.
Technology classes (7)	Yes	
Constant cut1	2.439	2.266
	(0.239)	(0.243)
Constant cut2	2.589	2.411
	(0.239)	(0.244)
Constant cut2	2.910	2.813
	(0.241)	(0.246)
ρ	0.714*** (0.025)	
Log pseudolikelihood	-2664.54	
Observations	2692	

Notes: The dependent variables are ordinal variables indicating the importance of patents and utility models as IP protection methods. 12 firms, which reported to use patents and/or utility models but did not answer the importance question, are omitted. Financial constraint is a dummy variable, 1 if firm reported a financial constraint as an obstacle for innovation in 2004 and 0 otherwise. Competition categories are dummies for the number of competitors: 0, 1–5, 6–15, 15–. Heteroscedasticity robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

CHAPTER 3: THE ROLE OF UTILITY MODELS IN PATENT FILING STRATEGIES: EVIDENCE FROM EUROPEAN COUNTRIES[29]

Abstract

We examine the role of utility models (UM) in patent filing strategies. With an extensive patent family data from European countries, we explore the structures and characteristics of patent families, which include UMs. A simple typology of patent families with UM members is introduced. We document that the geographical scope of most patent families with UM members is purely national. However, some UMs are members of international and transnational patent families, indicating that they may play some strategic roles in international patenting. Analysis of European Patent Office (EPO) patent families suggests that EPO filings with UM priorities are, on average, of lower quality than EPO filings with patent priorities. This implies that the choice between a patent and a UM priority conveys information about the quality of the protected invention. We also find weak evidence that EPO filings with UM priorities generally have shorter filing and grant lags than EPO filings with patent priorities. However, there is heterogeneity between priority filing countries. The findings highlight that UMs (and other equivalent second tier patents) should be taken into account when structures of patent families and patent filing strategies are analyzed.

[29] This paper is joint work with Michael Verba. We thank Ari Hyytinen, Mika Maliranta, Heli Koski and Aija Leiponen for comments. Earlier versions of this paper have been presented in the student seminar of Jyväskylä University School of Business and Economics, in TSG seminar at Tilburg University and in the JSBE Breakfast Seminar. Financial support from OP Group Research Foundation and Yrjö Jahnsson foundation is gratefully acknowledged.

1 Introduction

A patent is a territorial legal right to exclude others from the commercial use of the protected technical invention. When filing a patent application, the applicant must make a number of important and strategic choices (Guellec & van Pottelsberghe, 2002; Frietsch et al., 2013). First, she must choose, at which patent office to file the first patent application (the so-called "priority filing" or "priority" for short; see World Intellectual Property Organization (WIPO), 2008, pp. 243–245; de Rassenfosse et al., 2013; Frietsch et al., 2013).[30] Second, after filing the priority, the applicant must choose within twelve months, at which other patent offices she files subsequent patent applications (hereafter "subsequent filings") for the same technical invention. The priorities and subsequent filing(s) can be linked in many ways (e.g., directly or indirectly). Each priority and the sequence of subsequent filings representing the same technical invention constitute a patent family (Martínez, 2011; Dechezleprêtre et al., 2017).[31]

Since Putnam's (1996) seminal work, the size of a patent family has been frequently used as a proxy for the value of a patented invention (Lanjouw et al., 1998; Harhoff et al., 2003; Lanjouw & Schankerman, 2004; Reitzig, 2004; van Pottelsberghe & van Zeebroeck, 2008; Harhoff & Wagner, 2009; Frietsch et al., 2010; van Zeebroeck & van Pottelsberghe, 2011; Squicciarini et al., 2013). The underlying logic is that the more valuable the invention, the greater the expected returns net of filing costs. Since filing costs increase with the number of jurisdictions where patent protection is sought, expected returns for multi-jurisdictional inventions should also be higher on average.

While the size of a patent family is a standard indicator of an invention's value and quality, the internal structures of patent families have received little attention until recently (Stevnsborg & van Pottelsberghe, 2007; Martínez, 2011; Dechezleprêtre et al., 2017; Cao, 2015; Cao et al., 2016). In principle, patent families can contain a variety of patent documents (i.e., territorial exclusive rights) with heterogeneous scopes of protection and economic value. Due to differences in national patent laws, stringency of patent examination processes and incentives of patent examiners, it is possible that some of the national patent applications filed to protect the same invention are granted by national patent offices whereas some are rejected (Webster et al., 2007; Picard & van Pottelsberghe, 2013; Webster et al., 2014). The structure of patent families and the chosen filing routes are of interest because they convey information on the (expected) technological and economic value of the underlying invention and its derivative intellectual property rights (cf. Reitzig, 2004; Dernis & Khan, 2004;

[30] Formally, a priority filing is derived from Paris Convention (1883) priority right application (de Rassenfosse et al., 2013). In this paper, we use "filing" and "application" interchangeably.
[31] More complex patent family structures may contain divisionals and continuations. See Dechezleprêtre et al. (2017) for a review.

Frietsch & Schmoch, 2010; van Zeebroeck & van Pottelsberghe, 2011; Frietsch et al., 2013; Cao, 2015; Dechezleprêtre et al., 2017).

A further reason why patent families can contain different types of patents is that some countries have two-tiered patent protection systems. When a priority or subsequent filing is made in such a system, the patent family can also contain utility models (UM) or other types of second tier patent protection. Compared to patents, UMs are a weaker form of IP right, characterized by a shorter term of protection but a simpler and faster application procedure (WIPO, 2008, p. 40). Not all countries have the UM option, but when it exists, technical inventions can be protected with either patents or by UMs or, in some countries, even by both (e.g., Germany). UM systems have been widely used among European countries (European Commission, 1995; Janis, 1999; Suthersanen, 2006; Prud'homme, 2014; Radauer et al., 2015; Heikkilä, 2017; Heikkilä & Lorenz, 2018).

This paper builds on the observation that the role of UMs and the difference between patents and UMs are dimensions of the internal structure of patent families that have received relatively little attention. It is unclear to what extent UM systems boost local innovative and entrepreneurial activity and to what extent they extend the set of international patent filing strategies. For instance, a UM filed in one country can be used as a priority for subsequent patent filings in other countries (Cao, 2015; Cao et al., 2016) or as a priority for an international Patent Cooperation Treaty (PCT) filing (Radauer et al., 2015). In March 2000, the European Commission suspended the proposal of a "community utility model" (European Commission, 1995) due to difficulty in reaching agreement on its form and implementation and also because European Union (EU) member states wanted to focus on developing Community patent (European Commission, 2002). Thus, questions of the harmonization of UM systems across EU member states and of the desirability of multi-tier patent protection remain relevant.

This study contributes to the scarce literature on patent family structures (Martínez, 2011; Cao, 2015; Cao et al., 2016; Dechezleprêtre et al., 2017) by shedding light on the role of European UMs in patent filing strategies. We explore whether there are systematic patterns in the use of UMs within patent families and in international patenting. We also analyze whether there are quality, filing lag and grant lag differences between European Patent Office (EPO) patent filings with UM and patent priorities.[32] It is particularly important to study these questions in the European context since efficient harmonization of intellectual property right systems within the European Single Market requires that we understand the functioning and interaction of current patent and UM institutions.

The paper is structured as follows. In section 2, we briefly review the literature on patent families. In that section, we also introduce a simple typology of

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[32] For the sake of consistency, we refer to patents filed at the EPO as "EPO patents" or "EPO filings" throughout the paper. In other studies, they have been referred to as "European patents" (see e.g., Guellec & van Pottelsberghe, 2007; van Zeebroeck, 2008), but in this context, this terminology might create unnecessary confusion.

patent families with UM members and present a descriptive analysis of filing patterns in EU member countries. In section 3, we propose a set of hypotheses on the implications of using UMs as priority filings of subsequent EPO filings and analyze whether UM priorities convey information about the quality of the underlying inventions. Section 4 concludes.

2 Patent families with utility model members

In this section, a simple typology for classification of patent families with UM members is introduced. We analyze the filing patterns at national patent offices of EU countries using this typology.

2.1 Patent family structures and patent filing routes

Generally, a patent family consists of one or multiple priorities (de Rassenfosse et al., 2013)[33] and no or multiple subsequent filings (Martínez, 2011). According to Organisation for Economic Cooperation and Development's (OECD) Patent Statistics Manual, a patent family consists of a "set of patents (or applications) filed in several countries which are related to each other by one or several common priority filings" (OECD, 2009, p. 71, as cited in Martínez, 2011). However, there exist several different specifications of patent families and the measured sizes of patent families differ accordingly (Martínez, 2011).

Seminal studies using patent family information utilized the patent information database of Derwent Ltd. (e.g., Putnam, 1996; Harhoff et al., 2003; Lanjouw & Schankerman, 2004). The EPO has produced the Worldwide Patent Statistical Database (PATSTAT) since 2006. It contains information on priority linkages, and since 2008, it has included ready-made tables on patent families (Martínez, 2011). Current versions of PATSTAT provide data on two types of patent families: extended patent families (INPADOC), which include both published patent documents and unpublished priorities claimed in them as family members, and patent families (DOCDB)[34], which include published patent documents as members (Martínez, 2011).

The number of triadic patent families — that is, patents that are granted in the U.S. (USPTO) and for which patent applications are filed in both the EPO and the Japanese Patent Office (JPO) to protect the same invention (Dernis & Khan, 2004; Sternitzke, 2009a; Sternitzke, 2009b) — have been used as indicators of inventive activity between countries (Frietsch et al., 2010; de Rassenfosse et al., 2013). By definition, triadic patent families have three or more patent family

[33] Multiple priorities arise when a subsequent patent application claims more than one priority filings.
[34] According to the EPO (2016), when patent or utility model documents share a common DOCDB family identifier, this indicates that "most probably the applications share exactly the same priorities (Paris Convention or technical relation or others)".

members. Also other kinds of patent family definitions have been suggested to compare patenting at the country level, for instance, "transnational patents", which are patent families that include EPO or PCT applications (Frietsch & Schmoch, 2010). De Rassenfosse et al. (2013) introduced the count of priority patent applications filed by a country's inventors as an alternative indicator of inventive activity.

Generally, the filing date of a priority filing is the point in time from which the maximum duration of patent protection is counted. It is common practice among patent applicants to file the first patent application at the domestic[35] patent office and then continue to international protection routes, such as the EPO and the PCT (Dernis & Khan, 2004; Frietsch et al., 2013; de Rassenfosse et al., 2013; Dechezleprêtre et al., 2017). The patent application processes of national offices differ from each other (Webster et al., 2007; de Saint-Georges & van Pottelsberghe, 2013; Webster et al., 2014; Dechezleprêtre et al., 2017) and some patent offices provide a menu of different types of patents for applicants (Heikkilä & Verba, 2017; Heikkilä, 2017; Heikkilä & Lorenz, 2018). Thus, several strategic choices related to priority filings are available that, among other things, affect the timing of patent protection and the timing of invention disclosure (Johnson & Popp, 2003). The choice between patent and UM applications is one of these (Cao, 2015; Cao et al., 2016). Cao (2015) and Cao et al. (2016) showed that Chinese applicants wishing to obtain fast patent protection in the U.S. are likely to choose Chinese UMs instead of patents as priority filings.

Radauer et al. (2015) was among the first to shed light on the role of European UMs in patent families. They report that, in the period 2009–2011, 29% of DOCDB patent families in the PATSTAT database had at least one UM member. However, when the sample was limited to patent families with multiple members, only 3.4% contained UM members. This indicates that UMs are mainly used to protect inventions only in one market. In other words, when UMs are used, the scope of the sought protection is national rather than international.

2.2 Typology of patent families with utility model members

At the country (or patent office) level, all patent families that include at least one national UM filing at that country's patent office can be assigned to three mutually exclusive categories. The categories are as follows:

- **Category 1, National patent family**: This category refers to patent families in which all patent and UM filings are filed at the same national patent office.[36]

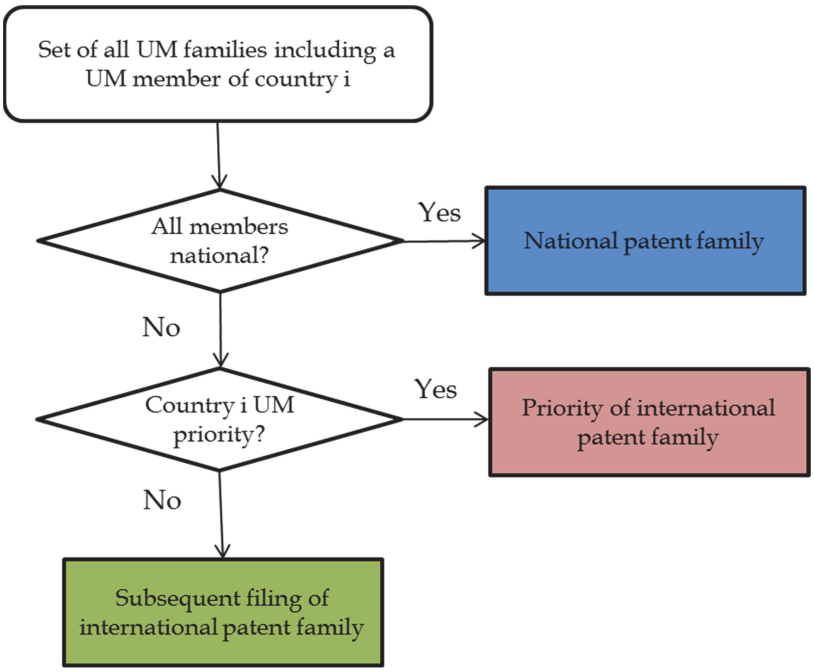
[35] Following the common terminology of patent literature, "domestic patent office", in this context, refers to the national patent office in the applicant's country of residence (see e.g., Webster et al., 2014).

[36] All singleton UMs are classified as national patent families. Generally, "a singleton" refers to a patent family with exactly one member (i.e., one filing; see Martínez, 2011; de Rassenfosse et al., 2013).

- **Category 2, Priority of international patent family**: This category refers to those patent families in which a national priority UM filing is followed by any subsequent filing at any other patent office.
- **Category 3, Subsequent filing of international patent family:** This category consists of those patent families in which a national UM filing is a subsequent filing of any priority filing at any other patent office.

Figure 1 illustrates the classification procedure that generates the three categories. In this simple typology, no difference is made between national patent families in which a UM is a priority filing and national patent families in which a UM is a subsequent filing. If an international patent family has both a national priority UM filing and a subsequent national UM filing then it is classified as "priority of international patent family" instead of "subsequent filing of international patent family".

FIGURE 1 Classification of patent families with UM members



Notes: Complex patent family structures (i.e., patent families with several priority filings; see Martínez, 2011) are excluded.

Clearly, not all patent families with UM members are similar. The core idea of this simple typology is to facilitate more rigorous analysis and "apples to apples" comparisons between patents, UMs and patent families. The premise that UMs are mainly a protection method for incremental inventions (Janis, 1999; Johnson, 2002; Beneito, 2006; Kim et al., 2012) can be questioned if it is observed that UMs are frequently used as part of international patent filing strategies.

A natural way to enrich the typology would be to add legal status (e.g., whether the patent and/or UM members of a patent family are granted or not, whether renewal fees are paid, whether they are withdrawn or objected, etc.) to the categorization. Such additional dimensions would arguably provide a more detailed picture of the internal workings of patent families and of patent applicants' choices. However, in this paper, we explicitly focus on simple patent family structures and filing routes and leave the analysis of legal status evolution for future research.

2.3 Data

The data are extracted from the EPO's PATSTAT database (2016 April edition). We use the readily available DOCDB simple patent family definition in the analysis of patent family structures. For the sake of consistency and clarity, the time window of our data in sections 2.4 and 3 is 2000–2010.[37] In section 2.4, we focus on EU member countries with UM systems and limit the data to patent families with UM members from these countries. In section 3, we focus on a subset of these and use data on EPO patent families with priority filings from the sample countries.[38] Table 1 lists the sample countries, their accession years to the EU and European Patent Convention and the years when each of the sample countries launched their UM systems.

[37] In PATSTAT, patent filings for more recent years are available, but the patent family structures of several priority filings filed after 2010 are still subject to changes due to secrecy periods, patent pendency times, etc.

[38] We exclude from the analysis countries with short-term patent systems (Belgium, Croatia, Ireland, the Netherlands and Slovenia). Although short-term patents are *de facto* second tier patent systems (likewise UMs) in relation to standard patents, in PATSTAT data, they are not distinguished from normal patents (see de Rassenfosse et al., 2013; Heikkilä, 2017; Heikkilä & Verba, 2017).

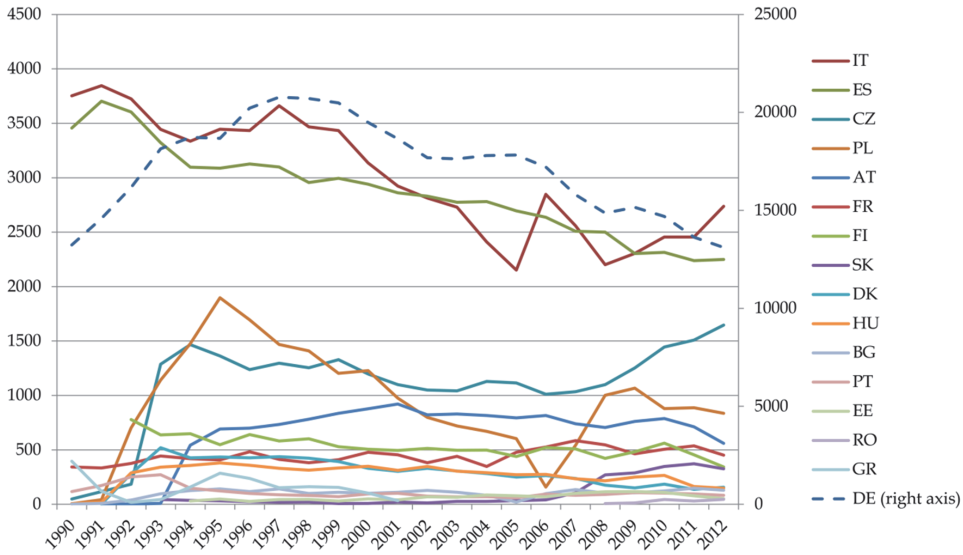
TABLE 1 EU member countries with UM systems

	EU	EPO	UM system
Austria	1995	1979	1994
Bulgaria	2007	2002	1993
Czech Republic	2004	2002	1992
Denmark	1973	1990	1993
Estonia	2004	2002	1994
Finland	1995	1996	1992
France	1952	1977	1968
Germany	1952	1977	1891
Greece	1981	1986	1988
Hungary	2004	2003	1992
Italy	1952	1978	1934
Poland	2004	2004	1924
Portugal	1986	1992	1940
Romania	2007	2003	2008
Slovakia	2004	2002	1992
Spain	1986	1986	1929

A patent family consisting of several filings typically contains members with different filing dates. Therefore, when analyzing the filing trends of patent families with UM members, a choice must be made whether the patent family is classified according to 1) the filing date of the first priority or 2) the filing date of the UM member or some other family member. In the next section (2.4), we classify patent families by the filing date of the UM member. In section 3, we compare EPO patent families with patent and UM priority filings and classify them according to the filing date of the EPO application.

Figure 2 displays the trends in the aggregate number of UM filings between 1990 and 2012. When measured by the number of filings, the German patent office receives by far the most UM filings and its filing numbers are reported on a different scale (right axis in Figure 2). Figure 2 shows a somewhat mixed pattern of trends. In some countries, such as Germany, Italy and Spain, UM filing activity has recently slightly decreased, while in most countries, the filings have remained at constant but modest levels.

FIGURE 2 UM filings at national patent offices, 1990–2012



Notes: Authors' calculations using PATSTAT 2016 April edition.

2.4 Descriptive findings

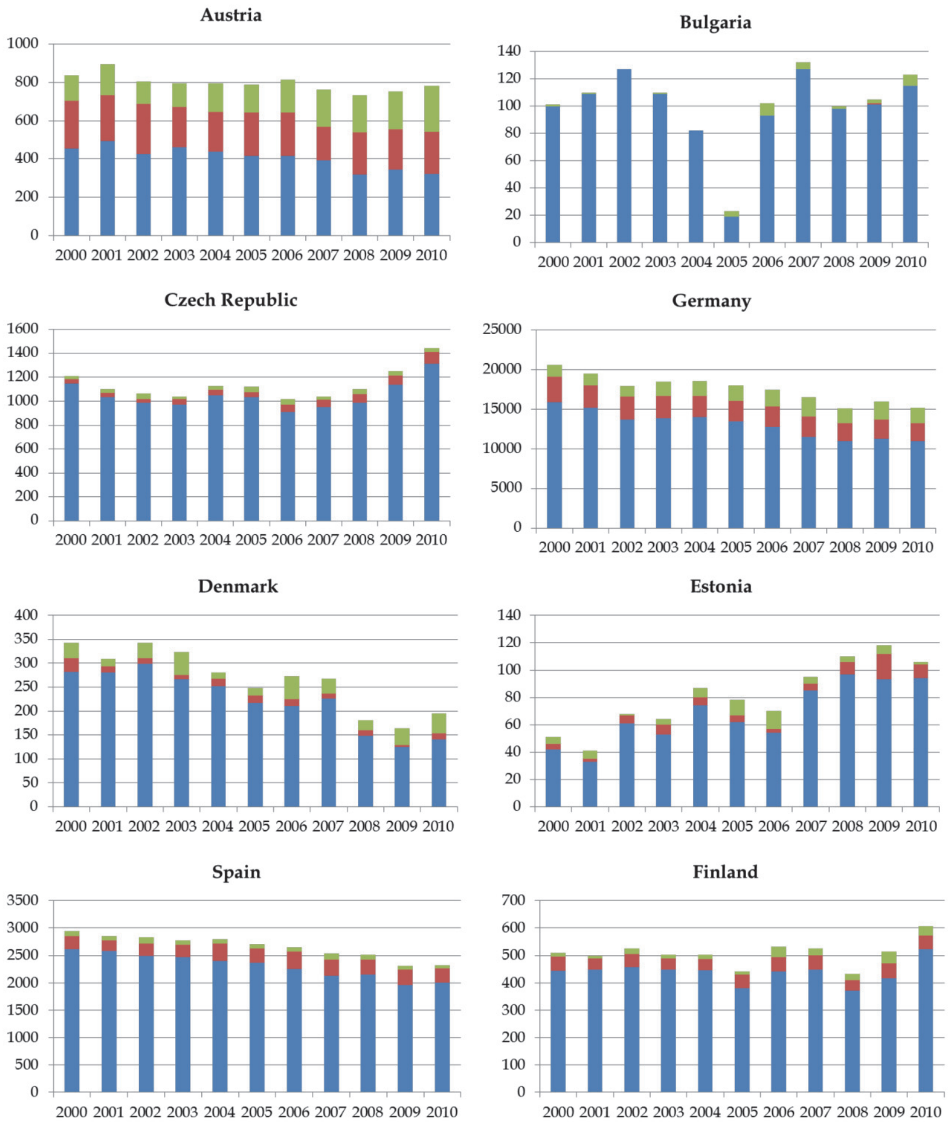
In this sub-section, we first look at general trends in patent families with UM members. Second, we briefly explore singleton patent and UM filing activity. Third, we investigate the role and frequency of UM filings in international and transnational patent filing strategies.

2.4.1 Filing trends in European countries

Figure 3 presents, at the country level, the shares of patent family categories for the period 2000–2010[39], using the typology that we introduced in section 2.2. In this figure, blue bars refer to national patent families, red bars to priorities of international patent families, and green bars to subsequent filings of international patent families. The predominance of blue bars indicates that UMs are, to a large extent, used to protect inventions for which no protection is sought abroad. This observation is in line with earlier empirical and anecdotal evidence (Radauer et al., 2015). An in-depth analysis of the underlying reasons and motives behind national patterns would be interesting but would require detailed information on the evolution of national institutional environments and is out of the scope of this study.

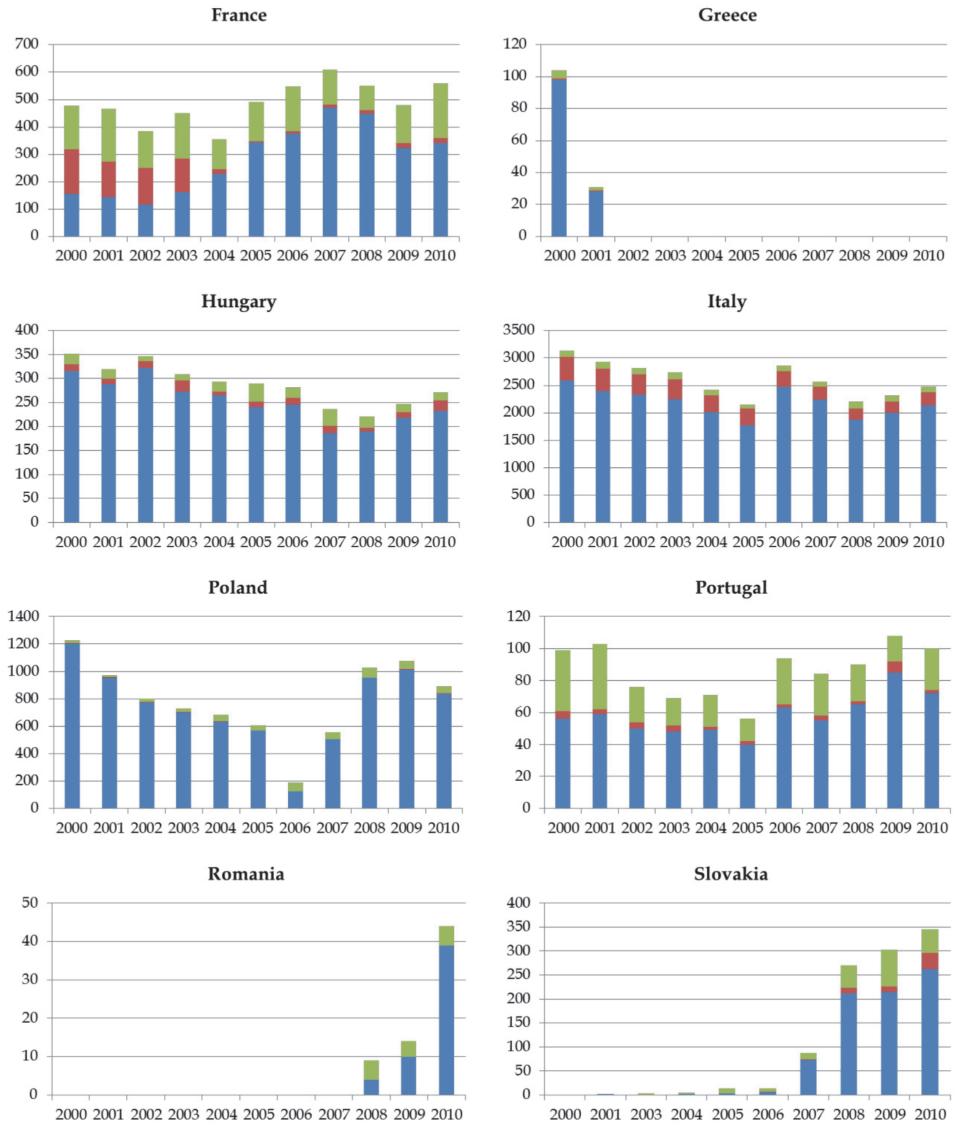
[39] Figure A.1 in the Appendix presents the corresponding figures for 1990-2012.

FIGURE 3 UM filings at national patent offices according to typology, 2000–2010



Notes: Blue: national patent family; Red: priority of international patent family; Green: subsequent filing of international patent family.

FIGURE 3 continued



Notes: Blue: national patent family; Red: priority of international patent family; Green: subsequent filing of international patent family.

2.4.2 National and singleton patent families

If most European UMs are used solely for national protection (see Figure 3; Radauer et al., 2015), it is of interest to ask how common their use is relative to patent singleton filings, which are an alternative way of protecting technical inventions nationally (Heikkilä & Verba, 2017).[40] Table 2 compares the average annual levels of UM and patent singleton filings across sample countries between 2000 and 2010. On average, 40% of all singleton filings during the period were UM singletons. However, there is a lot of heterogeneity between countries; the share of UMs of all national singleton filings ranges from a few percentages (Romania, France) to more than 60% (the Czech Republic, Denmark, Estonia, Spain and Slovakia). The high shares of UM singletons in several countries indicate that, when protection is sought only in one country, UMs can play an important role. Prominent heterogeneity suggests that country-specific institutional differences affect the relative importance of, and substitution between, patents and UMs.

TABLE 2 Patent and UM singletons

Country	Filing years	Average number of singleton filings per year		Share of UM singletons of all singletons
		Patent	UM	
Austria	2000-2010	397	394	49.8 %
Belgium	2000-2010	111	98	47.0 %
Czech Republic	2000-2010	502	1042	67.5 %
Denmark	2000-2010	135	214	61.4 %
Estonia	2000-2010	20	67	77.4 %
Finland	2000-2010	970	419	30.2 %
France	2000-2010	5320	273	4.9 %
Germany	2000-2010	20725	11935	36.5 %
Greece	2000-2001	299	63	21.1 %
Hungary	2000-2010	667	241	26.5 %
Italy	2000-2010	5629	2180	27.9 %
Poland	2000-2010	2151	750	25.9 %
Portugal	2000-2010	120	57	32.0 %
Romania	2008-2010	712	18	2.4 %
Slovakia	2008-2010	123	230	65.2 %
Spain	2000-2010	1257	2305	64.7 %

Notes: For Greece, there is no data on national UM filings after 2001 in the PATSTAT database (April 2016 edition). Romania introduced its UM system in 2008. For Slovakia, the numbers are reported for only 2008–2010 due to missing data.

The literature on pre-emptive patenting suggests that incumbents apply for patents in order to pre-empt or block others from protecting the invention (Gilbert & Newbery, 1982; Guellec et al., 2012). Another related strand of literature dis-

[40] In a complementary paper by Heikkilä and Verba (2017), we find suggestive evidence consistent with the view that, at the national level, lower-quality inventions are protected with utility models whereas patent protection is chosen for higher-quality inventions (see also Beneito, 2006; Hamdan-Livramento & Raffo, 2016).

cusses defensive publishing — that is, agents intentionally publish the results of their R&D projects in order to destroy the novelty and, thus, prevent competitors from patenting (e.g., Henkel & Lernbecher, 2008; Hall et al., 2014). Filing patents and later withdrawing them may be preferred to other forms of defensive publishing since a published patent application "leaves a paper trail" with a verifiable date of publication and could be easily found by patent examiners who examine the novelty of inventions (Guellec et al., 2012). Therefore, an interesting question for future research is how large a share of singleton UM filings aim to pre-empt competitors from patenting?

2.4.3 International filing strategies

The communicated *raison d'être* for several European UM systems is that they provide fast, simple and cheap protection, and that they are especially designed for small and medium-sized enterprises and individual inventors (see European Commission, 1995; Suthersanen, 2006; Prud'homme, 2014; Radauer et al., 2015; Heikkilä, 2017; Heikkilä & Lorenz, 2018). However, the use of UMs as part of international patent filing strategies would signal that they may also play a strategic role in protecting innovations. Next, we analyze this possibility by exploring how frequently UMs are used as a part of international patent filing strategies. First, we consider the filing activity and links between patent offices for every EU member state with a UM system separately. Second, we analyze transnational patent filings with UM members.

Filing activity and links between filing offices: Tables A.1–A.13 in the appendix report the ranking of the most frequent links (i.e., dyads) separately for every EU member state with a UM system over the period 2000–2010. The sample consists of patent families for which priority filings were filed between 2000 and 2010.[41] Moreover, only those subsequent filings, which were filed during the same period are counted. For every patent office, the dyads are reported separately for national patent and UM priorities and patent and UM subsequent filings to enable comparisons between patents and UMs.

A few interesting observations emerge: First, in several countries, the role of UMs is quite limited in international filings, and there are only a few dozen links between priority or subsequent UM filings and foreign patent offices (as Figure 3 already demonstrated). Second, the rankings of priority and subsequent filing countries are similar between patents and UMs. Third, for the largest EU member states with UM systems (Germany, Italy and Spain), the most frequent subsequent filing office for national UM filings is the EPO. Fourth and finally, national UM filings are relatively often used as priority filings for subsequent PCT filings at WIPO. The last two observations are in line with observations made by Radauer et al. (2015) and indicate that UMs provide some strategic advantages as priority filings of international patent families.

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[41] Greece, Bulgaria and Romania had few observations (less than 10 international patent families with national UM members) and these are not reported. Moreover, Tables A.1-A.13 report only links or dyads for which there are 10 or more observations.

Transnational patent filings with UM members: WIPO's PCT and the European Patent Convention are "supranational procedures" that have facilitated multinational patent filing strategies (Martínez, 2011). The PCT system is, in particular, designed to assist applicants in seeking international patent protection.[42] A PCT filing is not an actual patent application but a way to maintain the option to file patent applications abroad in the future (Guellec & van Pottelsberghe, 2007; WIPO, 2008; Dechezleprêtre et al., 2017). At the EPO, it is possible to file a patent application and, upon grant, validate the patent in desired EPO member states by paying national renewal fees (van Pottelsberghe & van Zeebroeck, 2008). Thus, an EPO patent is, in practice, a bundle of national patents. "Euro-PCT" is a patent application with a specific filing route; it is a PCT patent application for which the EPO is designated as the International Search Authority (ISA) (Guellec & van Pottelsberghe, 2002; Guellec & van Pottelsberghe, 2007; Frietsch et al., 2013). Euro-PCT filings are indicated in Tables A.1–A.13 as EPO (PCT). Frietsch and Schmoch (2010) suggested the number of "transnational patents" — that is, patent families with at least one EPO filing or PCT filing — as an innovation indicator that is comparable across countries. Interestingly, Tables A.1–A.13 in the appendix show that UM filings are relatively often used as priority filing for subsequent PCT filings and EPO filings. In other words, UMs are claimed as priority filings for transnational patents.

According to Sternitzke (2009a), applicants wishing to achieve fast patent protection in Europe should file a PCT application and choose the EPO as the international examination author. Frietsch et al. (2013) have documented that this Euro-PCT route is the most popular route for filing for patent protection at the EPO: it is more popular than direct EPO filing or the use of national filing as priorities for subsequent EPO filings. Radauer et al. (2015) pointed, out on the basis of qualitative feedback from IP professionals, that UMs can be used as priority filings for subsequent PCT applications to provide national protection during the application phase. Moreover, IP professionals noted that UMs are feasible solutions when an invention is initially considered to be of low importance but is later found to be significant; in this case, they can be used as priorities for PCT filings (Radauer et al., 2015).

Table 3 documents how frequently UMs from sample countries are members of transnational patent families (as either priority or subsequent filings). "EPO" indicates a patent family that contains an EPO filing, and "PCT" indicates that the patent family contains a PCT filing. These categories are overlap-

[42] According to WIPO (2008, p. 277): "The principal objective of the PCT is, by simplification leading to more effectiveness and economy, to improve on—in the interests of the users of the patent system and the Offices which have responsibility for administering it—the previously established means of applying in several countries for patent protection for inventions." The PCT process provides applicants with a longer period in which to decide whether to apply for national patents. Instead of the standard 12 months (Paris Convention priority year), with a PCT filing the "international phase" — that is, the time limit to enter the national or regional phase — is 30-31 months depending on the subsequent filing office (Sternitzke, 2009a). Due to this additional time, inventions with unclear market potential are likely candidates for using the PCT route (Guellec & van Pottelsberghe, 2000; Guellec & van Pottelsberghe, 2002; Sternitzke, 2009a; Dechezleprêtre et al., 2017).

ping as the patent family can simultaneously have a PCT filing and a filing at the EPO. “Euro-PCT” is a patent family in which the EPO is the receiving office of the PCT filing. Table 3 shows that, over the period 2000–2010, UM priorities in transnational patent families from 16 sample countries were most often used as priorities for subsequent EPO filings. German, Austrian and Italian UMs were most often members of Euro-PCT filings while, in other countries, the use of UMs as members of Euro-PCT families was negligible. A more detailed analysis of the use of UMs in EPO and PCT patent families is out the scope of this study and is left for future research.

TABLE 3 Transnational patent families with UM members, 2000–2010

	EPO	**PCT**	**Euro-PCT**	**Transnational patents**
Germany	21474	10185	6847	22777
Italy	2283	878	313	2582
Austria	1385	854	630	1609
Spain	413	196	22	461
Finland	193	211	13	290
Czech Republic	142	216	13	271
Denmark	133	130	14	173
Hungary	60	136	8	152
France	84	72	10	109
Poland	48	58	15	77
Estonia	29	47	8	57
Portugal	22	28	4	40
Slovakia	18	28	5	36
Bulgaria	3	5	0	6
Greece	2	0	0	2
Romania	1	1	0	1
Total	26290	13045	7902	28643

Notes: Patent families in which the priority filing and a UM member were filed from 2000 to 2010. Countries refer to the national patent offices at which UM members were filed. The categories are not mutually exclusive; EPO and PCT filings may overlap, and Euro-PCT filings are concurrently members of EPO and PCT families by definition.

3 Comparison of EPO filings with patent and UM priorities

Our descriptive analyses in previous sections showed that it is relatively common to claim UMs filed at certain European patent offices as priority filings in subsequent EPO filings. However, to our knowledge, the only study that has analyzed the choice between patents and UMs in national patent offices as priority filings for subsequent EPO filing is Cao et al. (2016).[43] While Cao et al. (2016) focused on Chinese priority patents and UMs, we examine whether there are quality differences between EPO filings with patent and UM priority filings in European patent offices. In this context, "quality" refers to the technological quality or value of the invention subject to patent or UM protection (see Frietsch et al., 2010; Squicciarini et al., 2013). According to this definition, incremental inventions (low inventive step) are often considered to be of low quality, whereas radical inventions (high inventive step) are considered to be of high quality. This quality definition is distinct from the "legal quality" of the patent (Burke & Reitzig, 2007; van Pottelsberghe, 2011; de Saint-Georges & van Pottelsberghe, 2013; Picard & van Pottelsberghe, 2013) — that, is how well it is drafted and what is the probability of its validity if challenged or enforced in court.

In an international context, when the same invention is protected in several countries, it goes through several screening processes — that is, its quality and patentability is examined at multiple national patent offices by multiple patent examiners. Webster et al. (2014) provide empirical evidence that the national treatment principle is not strictly practiced as domestic applicants are more often granted patents in comparison to foreign applicants.[44] Also, the stringency of examination between national patent offices has been observed to differ (van Pottelsberghe, 2011; de Saint-Georges & van Pottelsberghe, 2013). Hence, when comparing the quality of inventions that are protected in several countries, the differences in grant rates and other patent quality measures should be interpreted with caution. In order to enable quality comparison, we focus on patent families, which contain an EPO filing claiming a priority filing in some of our sample countries, and examine the differences between EPO filings with patent priority and UM priority filings. The focus on EPO filings guarantees a certain level of comparability between the quality of inventions as they are examined according to similar principles and stringency and are subject to the same patentability requirements (cf. Sapsalis et al., 2006; van Pottelsberghe, 2011; Cao, 2015; Cao et al., 2016).

3.1 Testable hypotheses

UM systems differ across countries and have evolved over time (European Commission, 1995; Janis, 1999; Suthersanen, 2006; Prud'homme, 2014; Radauer et al., 2015; Heikkilä, 2017; Heikkilä & Lorenz, 2018) but common to all of them is that they are considered to be an especially suitable method of protection for

[43] The settings of Cao (2015) and Cao et al. (2016) are very similar as they analyze the choice between a Chinese patent and a UM as a priority filing for a subsequent USPTO or EPO filing.

[44] According to WIPO (2008, pp. 242–243), "national treatment means that, as regards the protection of industrial property, each country party to the Paris Convention must grant the same protection to nationals of the other member countries as it grants to its own nationals" and "national treatment rule guarantees not only that foreigners will be protected, but also that they will not be discriminated against in any way".

incremental technical inventions (Johnson, 2002; Beneito, 2006; Kim et al., 2012). Hence, we expect that a larger share of technical inventions for which a national UM and a subsequent EPO application are filed are incremental inventions than of technical inventions, for which the priority for subsequent EPO application is a national patent.

Hypothesis 1a:
EPO filings with UM priorities are, on average, of lower quality than EPO filings with patent priorities.

In a recent study, Dechezleprêtre et al. (2017) provided evidence that the timespan between the first priority filing and the last filing within a patent family is associated with common patent quality measures. They found a statistically significant positive correlation between the timespan of a patent family and the value of the priority patent. Therefore, we complement Hypothesis 1a with an additional hypothesis on the quality of EPO filings:

Hypothesis 1b:
EPO filings with UM priorities have, on average, a shorter timespan (lag between first filing and last filing of the patent family) than EPO filings with patent priorities at the same patent filing office.

Patent pendency times and grant lags have been analyzed in previous studies (Johnson & Popp, 2003; Palangkaraya et al., 2008; Harhoff & Wagner, 2009; Régibeau & Rockett, 2011; Liegsalz & Wagner, 2013; Cao, 2015; Cao et al., 2016). UMs are quicker to obtain than patents and are, therefore, an especially attractive form of IP protection for applicants in need of fast protection (Cao, 2015; Radauer et al., 2015; Cao et al., 2016; Heikkilä & Lorenz, 2018). Cao (2015) and Cao et al. (2016) analyzed filing lags between Chinese patent and UM priorities and subsequent U.S. filings ("SIPO-USPTO dyads"[45]) and found evidence that applicants who favor fast protection in the U.S. choose Chinese UM priority instead of Chinese patent priority. Heikkilä & Lorenz (2018) using German firm-level data, found that having short product and process life cycles is associated with the use of UMs. Therefore, we expect the choice of a UM priority to be associated with shorter filing lags of subsequent EPO applications in comparison to patent priorities.

Hypothesis 2:
The average filing lag between priority UMs and subsequent EPO filings is shorter than the average filing lag between priority patents and subsequent EPO filings.

On the other hand, it is possible that the major underlying reason for the choice of priority UM over priority patent is simply cost minimization and, thus, we do not observe a significant difference in EPO filing lags.

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[45] SIPO refers to State Intellectual Property Office of China.

Following the same reasoning as for filing lags, we expect the applicants in need of fast protection to prefer fast granting and, therefore, to choose UMs. Hence, we expect the average grant lag of granted EPO patents with UM priorities to be shorter than the average grant lag of granted EPO patents with patent priorities.

Hypothesis 3:
The average grant lag of granted EPO patents with UM priorities is shorter than the average grant lag of granted EPO patents with patent priorities.

However, some applicants may choose a UM priority filing due to higher uncertainty about the value of the underlying invention (Radauer et al., 2015). This would have an opposite effect on the grant lag difference. Granted EPO filings are a set of inventions that have passed the examination process at the EPO and, thus, satisfy patentability requirements. As the examination process is, in practice, partly a process of negotiation between an applicant and an examiner (Harhoff & Wagner, 2009), a high level of uncertainty about the value of the invention might induce the applicant to lengthen negotiations strategically in order to learn more about the market potential of the invention.

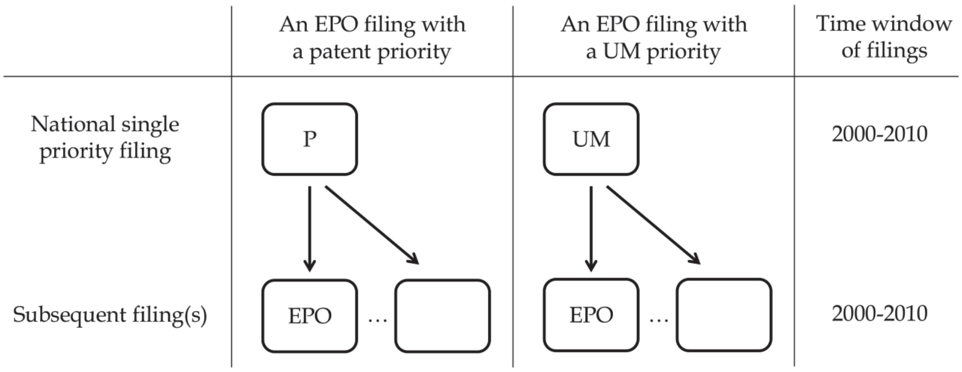
3.2 Results

3.2.1 Descriptive and graphical analysis

Our sample consists of EPO patent applications, filed between 2000 and 2010, that are subsequent filings of single national patent or UM priorities in any of the sample countries filed during the same period.[46] The patent families can have no or many subsequent filings in other patent offices in addition to at least one EPO filing claiming the priority. Figure 4 illustrates the particular types of patent family structures on which we focus in our analysis. It should be noted that a large share of EPO filings are direct filings (i.e., they are themselves priority filings at EPO and do not claim priority patents or UMs; see Frietsch et al., 2013), but they are not part of this analysis.[47]

[46] We have limited our attention to this period since several patent quality indicators (grant, citations) and grant lag information are available only several years after the priority filing date.
[47] Patent families with complex structures (multiple priorities) are excluded (see Martínez, 2011).

FIGURE 4 Patent family structures of interest



Notes: Only patent families in which both the priority filing and a subsequent EPO filing were filed between 2000 and 2010 are included in the sample.

UMs from some European countries are used only in rare occasions as priority filings of subsequent EPO filings. Therefore, we exclude from the sample national patent offices with less than 30 UM priorities followed by EPO filings during the period (Bulgaria, Estonia, France, Greece, Poland, Portugal, Romania and Slovakia). The final set of countries consist of EPO filings with priorities at the national patent offices of Austria, the Czech Republic, Germany, Denmark, Spain, Finland, Hungary and Italy. During the preliminary analysis of the data, it became clear that, by far, the largest share of patent families in our sample have German UM or patent priority filings (132823/172722 ≈ 77%). Hence, we report all descriptive statistics and results separately for two samples: Germany and other countries.

We measure the quality of patent families with common quality measures: whether the European patent is granted, whether the European patent is cited in future filings, the number of forward citations received, the patent family (DOCDB) size and the number of inventors (Frietsch et al., 2010; Squicciarini et al., 2013). Tables 4a and 4b compare the characteristics of EPO filings with patent and UM priorities.[48] In addition to common quality measures, we also report the share of individual first applicants, the share of EPO patent families containing PCT filings, the average filing lag between national priorities and subsequent EPO filings, the average grant lags of EPO patents and the average timespan (Dechezleprêtre et al., 2017) between the priority filing and the last subsequent filing.

[48] The descriptive statistics for the aggregate data are reported in Table A.14 in the Appendix.

TABLE 4a. Characteristics of EPO patent applications with single patent or UM priorities in countries other than Germany, 2000–2010

	Priority filing type		
	Utility model	Patent	Total
Applications	4153	35746	39899
Grants/Registrations	1746	17714	19460

	Utility model		Patent		Difference of	
Characteristic	Mean	Std. Dev.	Mean	Std. Dev.	means	Std. Err.
Granted	0.420	0.494	0.496	0.500	0.075***	0.008
Cited	0.687	0.464	0.770	0.420	0.083***	0.007
Number of citations	2.556	4.335	4.028	6.822	1.472***	0.108
Patent family size	4.416	3.029	5.770	4.117	1.353***	0.066
Timespan	411.712	266.099	518.290	442.083	106.578***	7.003
Number of inventors	1.431	0.924	1.946	1.464	0.515***	0.023
Individual applicant	0.242	0.428	0.150	0.357	-0.092***	0.006
PCT filing	0.297	0.457	0.520	0.450	0.223***	0.008
Domestic applicant	0.928	0.258	0.900	0.301	-0.029***	0.005
Filing lag	327.77	76.987	343.34	53.606	15.570***	0.926
Grant lag	1498.82	669.750	1578.36	713.740	79.540***	17.807

Notes: Other countries include Austria, the Czech Republic, Denmark, Spain, Finland, Hungary and Italy. All variables show the statistics for the applications sample (39899 obs.) except grant lag, which is reported for the granted subsample (19460 obs.). *** indicates statistical significance at a 1% significance level.

TABLE 4b. Characteristics of EPO patent applications with single patent or UM priorities in Germany, 2000–2010

	Priority filing type		
	Utility model	Patent	Total
Applications	12646	120177	132823
Grants/Registrations	7010	69072	76082

	Utility model		Patent		Difference of	
Characteristic	Mean	Std. Dev.	Mean	Std. Dev.	means	Std. Err.
Granted	0.554	0.497	0.575	0.494	0.020***	0.005
Cited	0.775	0.417	0.840	0.366	0.065***	0.003
Number of citations	3.644	5.56	5.304	7.983	1.660***	0.073
Patent family size	4.322	2.758	5.391	3.319	1.068***	0.031
Timespan	399.92	277.91	509.13	432.71	109.203***	3.930
Number of inventors	1.685	1.164	2.442	1.653	0.757***	0.015
Individual applicant	0.158	0.365	0.051	0.221	-0.106***	0.002
PCT filing	0.278	0.448	0.532	0.499	0.254***	0.005
Domestic applicant	0.863	0.344	0.893	0.309	0.031***	0.003
Filing lag	322.26	77.485	330.61	64.916	8.350***	0.619
Grant lag	1478.04	675.256	1579.58	712.491	101.536***	8.889

Notes: All variables show the statistics for the applications sample (132823 obs.) except grant lag, which is reported for the granted subsample (76082 obs.). *** indicates statistical significance at a 1% significance level.

In line with Hypothesis 1a, comparisons between patent and UM priorities in both Tables 4a and 4b reveal that the average quality of inventions (share of granted, share of cited, number of citations, patent family size and number of inventors) with patent priorities is systematically higher than that of UM priorities. The unconditional average quality differences (difference of means column) are, in most cases, more pronounced for the sample consisting of other countries (Table 4a) than for Germany (Table 4b). In both samples, a larger share of EPO filings with patent priorities belongs to patent families containing PCT filings. This is consistent with earlier studies that have found PCT filings to be positively associated with invention value (e.g., Reitzig, 2004; van Zeebroeck & van Pottelsberghe, 2011). The share of individual first applicants is statistically significantly higher for UM priorities than for patent priorities. The share of domestic[49] applicants is over 90% for both UM and patent priority groups but slightly higher for UM priorities in other countries' sample. Unexpectedly, the share of domestic applicants is statistically significantly higher for the patent priority group in Germany's sample. Consistent with Hypothesis 1b, the timespan is found to be longer for patent priorities than for UM priorities in both Table 4a and Table 4b. The differences of means are almost equal between samples (ca. 109 days for Germany and ca. 107 days for other countries).

Tables 4a and 4b show that both the average filing lag between the priority and the subsequent EPO filing and the average grant lag of subsequent EPO patents are shorter for patent families with UM priorities than for patent families with patent priorities. This is consistent with the fact that, in most countries, UMs provide faster protection than patents (Cao, 2015; Cao et al., 2016; Heikkilä & Lorenz, 2018). Thus, comparisons of unconditional means indicate that Hypotheses 2 and 3 are supported.

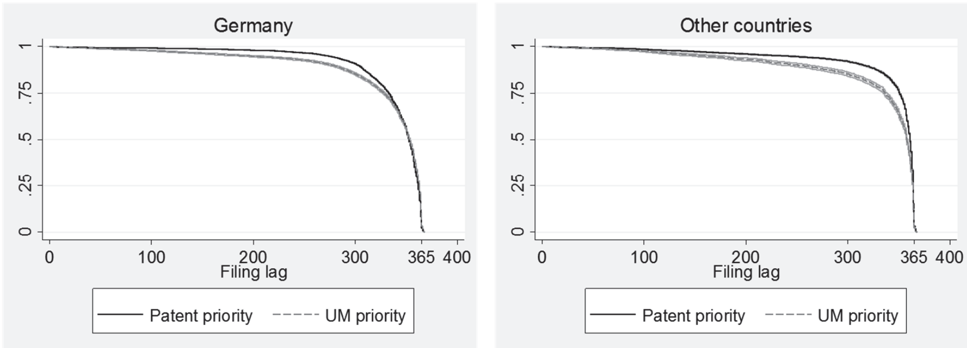
The distributions of filing lags, grant lags and time spans are reported in Figures A.2–A.4 in the appendix. No clear differences in lag patterns are evident except in the timespan distributions; both EPO filings with patent and UM priorities show a small peak at approximately 30 months, but the peak is relatively larger for patent priorities. The PCT system's time limit of 30 months to enter the national or regional phase (Sternitzke, 2009a; Frietsch et al., 2013) is the most likely reason for these peaks. Tables 4a and 4b reported that a significantly smaller share of EPO patent families with UM priorities include PCT filings (ca. 28–30%) in comparison to EPO patent families with patent priorities (52–53%). This is one potential explanation for the difference between timespan distributions in Figure A.4 in the Appendix.

Figures 5, 6 and 7 report the Kaplan-Meier survivor functions for filings lags, grant lags and timespans, respectively. The survival functions show similar patterns indicating that there are no radical differences in the filing and granting processes between EPO filings with patent and UM priorities. For both Germany and other countries, UMs have systematically smaller survival rates in every period, suggesting that filing lag, grant lags and timespans are consistently shorter for UMs. We test the equality of survival functions with standard log-rank tests (Kalbfleisch & Prentice, 2002, pp. 20–22). In all cases, log-rank

[49] These are applicants residing in the same country as the national patent office at which the priority is filed.

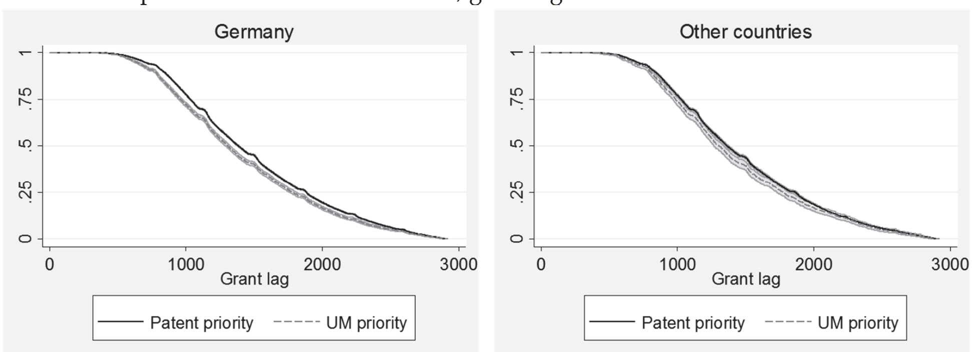
tests reject, at a 1% significance level, the null hypothesis that survivor functions between EPO filings with patent and UM priorities are equal.

FIGURE 5 Kaplan-Meier survivor function, filing lags



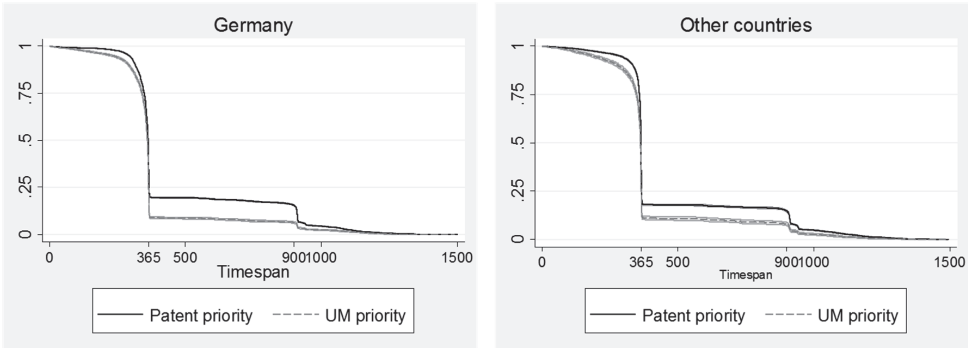
Notes: Filing lag refers to elapsed days from the priority filing date until filing of a subsequent EPO application. EPO patent applications with filing lags longer than 368 days are excluded. Other countries include Austria, the Czech Republic, Denmark, Spain, Finland, Hungary and Italy. 90% confidence intervals displayed.

FIGURE 6 Kaplan-Meier survivor functions, grant lags



Notes: Grant lag refers to the number of days elapsed from the filing of an EPO application until its grant. EPO patents with grant lags longer than eight years are excluded. 90% confidence intervals displayed.

FIGURE 7 Kaplan-Meier survivor functions, timespans



Notes: Timespan is the elapsed days between the priority filing date and the filing date of the last patent filing within the patent family. Patent families with timespans longer than 1500 days are excluded. 90% confidence intervals displayed.

3.2.2 Regression analyses

We analyze the association between the choice of priority filing (patent or UM) and subsequent EPO filings' quality and control for patent filing and family level characteristics. We estimate the following equation to test Hypothesis 1a:

$$Quality_{ijct} = \alpha + \beta_1 UM\_priority_i + \mathbf{x}_i'\boldsymbol{\gamma} + \theta_j + \mu_c + \eta_t + \varepsilon_{ijct}$$

where $Quality_{ijct}$ is an invention quality indicator of patent family i in technological field j, which priority office is c and filing year of the EPO filing is t. α is constant. $UM\_priority_{ijct}$ is a dummy variable: 1 if the priority of patent family i is a UM and 0 if a the priority of patent family i is a patent (see Figure 4). $\mathbf{x}_i$ is a vector of patent family level controls; θ_j is a technological field indicator; μ_c is a priority patent office indicator; and η_t is a filing year indicator. ε_{ijct} is a patent family specific error term. The results support Hypotheses 1a if the estimate of β_1 is statistically significant and negative.

Table 5 reports the estimation results. Different model specifications are used for different quality indicators. Since, in columns 1–4, the dependent variable is binary (1 if the EPO patent is granted, 0 otherwise; 1 if the patent family has received forward citations, 0 otherwise), we estimate probit models and report average marginal effects. In columns 5–8, the dependent variable is a count variable, and we estimate negative binomial models. Since patent family size is always 1 or larger, we estimate zero-truncated negative binomial models in columns 7 and 8.

In columns 9 and 10, the dependent variable is timespan — that is, duration between the first filing and the last filing within patent family i, and we estimate a Cox proportional hazard (PH) model. The Cox PH model is a standard method used to analyze survival data and, as a semiparametric model, it requires less than complete distributional specification and makes no assumptions about the baseline hazard's shape (Cox, 1972; Cameron & Trivedi, 2005). The Cox PH model can be written as follows: $h_i(t, \mathbf{x}) = h_0(t)\exp(\beta_1 x_{1i} + \ldots + \beta_k x_{ki})$, where h_i is the hazard rate for the last filing of patent family i to be filed at time t. h_0 is the baseline hazard, **x** is a vector of explanatory variables and βs are parameters to be estimated. Hazard ratio estimates smaller than one indicate that a one-unit change in the variable (status change from 0 to 1 for binary variables) is associated with a smaller hazard for the event to occur at time t (filing of the last patent application within the patent family) when other characteristics are held constant. Vice versa, hazard ratio estimates larger than one indicate a larger hazard rate for the event to occur.

TABLE 5 Patent family quality

Dependent variable	**Pr(Grant=1)**		**Pr(Cited=1)**		**Number of citations**		**Patent family size**		**Timespan**	
Model	Probit		Probit		Neg. bin.		Zero-inf. neg. bin.		Cox PH	
Estimate	M.E.		M.E.		Coeff.		Coeff.		Hazard Ratio	
Sample	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
D(UM Priority)	-0.065***	-0.020***	-0.059***	-0.024***	-0.322***	-0.165***	-0.099***	-0.028***	1.153***	1.111***
	(0.008)	(0.005)	(0.007)	(0.003)	(0.026)	(0.013)	(0.011)	(0.006)	(0.020)	(0.010)
D(Individual applicant)	-0.139***	-0.103***	-0.050***	-0.051***	-0.296***	-0.274***	-0.205***	-0.146***	1.088***	-0.951***
	(0.007)	(0.006)	(0.006)	(0.004)	(0.020)	(0.017)	(0.009)	(0.007)	(0.015)	(0.010)
Number of inventors	0.007***	-0.001	0.016***	0.012***	0.081***	0.074***	0.023***	0.018***	0.957***	0.979***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.006)	(0.002)	(0.002)	(0.001)	(0.004)	(0.002)
D(PCT family)	0.102***	0.069***	0.091***	0.080***	0.350***	0.319***	0.686***	0.606***	0.557***	0.588***
	(0.005)	(0.003)	(0.004)	(0.002)	(0.015)	(0.007)	(0.007)	(0.003)	(0.007)	(0.004)
Constant					1.701***	1.750***	1.514***	1.298***		
					(0.103)	(0.043)	(0.043)	(0.021)		
Observations	39891	132787	39891	132787	39891	132787	39891	132787	39864	131457
Log likelihood	-26009.69	-86767.21	-20782.16	-56250.92	-93870.78	-350394.55	-92334.91	-290072.42	-381937.55	-1413561.4
Pseudo R2	0.06	0.04	0.05	0.06						

Notes: The sample consists of EPO filings filed 2000-2010, which claim a single patent or single utility model priority filed between 2000-2010 in Austria, Czech Republic, Denmark, Finland, Germany, Hungary, Italy or Spain. All models include technology field dummies, filing year dummies and priority author dummies as controls. Robust standard errors in parentheses. In columns 9 and 10 Cox PH models use Breslow method for ties. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

The results show a robust negative association between the national UM priority indicator and common invention quality measures. It is estimated that EPO filings with a UM priority are approximately 2–7 percentage points less likely to be granted and 2–6 percentage points less likely to receive forward citations. Moreover, EPO filings with UM priorities receive, on average, 0.2–0.3 less forward citations in comparison to EPO filings with patent priorities and have, on average, 0.03–0.1 smaller patent family size. The estimates are consistently smaller for Germany than for other countries. This may indicate that German UM priorities are more often chosen for other reasons than the lower quality of the invention. Thus, Hypothesis 1a, which states that the average quality of EPO filings is lower for UM priority filings, is supported. The finding is consistent with UMs being the appropriate protection method for minor inventions (Johnson, 2002; Beneito, 2006; Kim et al., 2012).[50]

The signs of control variables are as expected and in line with the findings of prior studies: individual applicants file patents for inventions that are, on average, of lower quality (Bessen, 2008) and the number of inventors reported in a patent is negatively associated with invention quality and the number of forward citations (Sapsalis et al., 2006; Breitzman & Thomas, 2015; Dechezleprêtre et al., 2017). Moreover, if a patent family contains PCT filings, it is of higher quality.

Columns 9 and 10 indicate that, for EPO filings with UM priorities, the timespan between priority and the last filings is shorter than for EPO filings with patent priorities. This result corroborates the results of Dechezleprêtre et al. (2017), who found that timespan correlates positively with other patent quality measures. It is estimated that a UM priority is associated with a 11–15% increase in the expected hazard relative to patent priority, holding other variables constant. Hypothesis 1b is supported.

We test Hypothesis 2 on filing lags and Hypothesis 3 on grant lags by following the approach of earlier studies, which have modelled patent pendency durations by estimating Cox PH models (e.g., Johnson & Popp, 2003; van Zeebroeck, 2008; Régibeau & Rockett, 2011; Liegsalz & Wagner, 2013). The model is, thus, the same as that in columns 9 and 10 in Table 5, when the dependent variable was timespan, except that, now, hazard rate h_i is either 1) the hazard rate for EPO filing i to be filed at time t (columns 1 and 2 in Table 6) or 2) the hazard rate for a pending EPO filing i to be granted at time t (columns 7 and 8 in Table 6).

In addition to survival models, we analyze, following the approach of Cao (2015) and Cao et al. (2016), whether there exist differences between patent families with UM and patent priorities in the likelihood of subsequent EPO applications being filed "last minute" (i.e., during the last 10 days of the priority year). In columns 3 and 4, we estimate probit models in which the dependent variable is 1 if the subsequent EPO filing is filed within the last 10 days of the priority

[50] A more comprehensive analysis would also look at the reasons for non-grant (i.e., whether the application is withdrawn or refused; see e.g., van Zeebroeck, 2008). Moreover, patent quality could also be measured with renewal fee payments.

year and 0 otherwise. We also explore the other filing time extreme by testing whether UM priorities are more likely associated with a subsequent EPO filing within the first 10 days after priority filing. In columns 5 and 6, we estimate probit models in which the dependent variable is 1 if the subsequent EPO filing is filed within the first 10 days of the priority year.

TABLE 6 Filing behavior and grant lags

Dependent variable	Filing lag		Pr(Lastminute filing=1)		Pr(Filing within first 10 days=1)		Grant lag	
Model	Cox PH		Probit		Probit		Cox PH	
Estimate	Hazard Ratio		M.E.		M.E.		Hazard Ratio	
Sample	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D(UM Priority)	1.078***	0.920***	-0.048***	0.019***	-0.0014*	0.00002	1.010	1.055***
	(0.018)	(0.009)	(0.007)	(0.005)	(0.0009)	(0.001)	(0.030)	(0.015)
D(Individual applicant)	0.908***	0.667***	0.042***	0.186***	0.001*	0.015***	1.062***	1.096***
	(0.011)	(0.006)	(0.006)	(0.006)	(0.0006)	(0.001)	(0.024)	(0.019)
Number of inventors	0.969***	1.017***	0.017***	-0.008***	-0.001***	0.002***	0.985***	0.983***
	(0.003)	(0.002)	(0.002)	(0.001)	(0.0003)	(0.0002)	(0.006)	(0.002)
PCT family	0.839***	0.798***	0.058***	0.101***	0.0004	0.011***	0.760***	0.841***
	(0.008)	(0.004)	(0.005)	(0.003)	(0.0005)	(0.0008)	(0.012)	(0.007)
Observations	39826	130582	39834	132489	35012	132489	18385	72068
Log likelihood	-387480.29	-1416618.20	-23569.07	-88587.52	-465.80	-10766.90	-161298.14	-732241.14
Pseudo R2			0.04	0.03	0.10	0.08		

Note: The sample consists of European patents filed 2000-2010, which claim a single patent or single utility model priority filed between 2000-2010 in Austria, Czech Republic, Denmark, Finland, Germany, Hungary, Italy or Spain. *Last minute filing* indicates that the EPO filing is filed within 10 last days of the priority year. All models include technology field dummies, filing year dummies and priority author dummies as controls. Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

The patterns concerning filing lags (models 1–6) show that the patterns between Germany and other countries differ and have opposite signs. The estimated larger-than-one hazard ratio of the UM priority indicator in column 1 means that EPO filings with UM priorities have, on average, shorter filings lags in other countries. Also, column 3 suggests that EPO filings with UM priorities are 5 percentage points less likely to be filed "last minute" in comparison to patent priorities. These findings are in line with Hypothesis 2. On the contrary, the smaller-than-one hazard ratio in the case of Germany indicates longer filings lags for EPO filings with UM priorities, contradicting Hypothesis 2. Moreover, column 4 shows that EPO filings with German UM filings are approximately 2 percentage points more likely to be filed "last minute". Columns 5 and 6 do not show significant differences between UM and patent priorities with respect to very short filing lags. This might be due to the very small number of fast filings as demonstrated in Figure 5 and Figure A.2 in the Appendix. We may conclude that there exists country-specific heterogeneity in filing lag patterns, and Hypothesis 2 is supported only by the "other countries" sample.

Model 8 shows that German UM priorities have a statistically significantly higher hazard rate than German patent priorities, indicating that EPO filings with German UM priorities have shorter grant lags. It is estimated that EPO filings with German UM priorities are associated with approximately 6% higher expected hazard in comparison to EPO filings with German patent priorities, holding other variables constant. Model 7 shows that there is no similar significant difference for the "other countries" sample. Hypothesis 3 is thus supported but only by the German sample.

Interestingly, PCT filings are associated with longer filings (columns 1–2) and grant lags (columns 7–8) and higher likelihood of "last minute" filings (columns 3–4). This is consistent with the reasoning that PCT filings are used when the applicant is not sure about the commercial potential of the invention and "buys time" to further evaluate it by choosing the PCT route (Guellec & van Pottelsberghe, 2002; Radauer et al., 2015).

3.3 Robustness checks

We tested the robustness of the results using restricted samples and alternative model specifications. All robustness check estimations are reported in the appendix (Tables A.15–A.17).

3.3.1 Quality

First, the average quality of inventions for which EPO patents have been granted is likely quite different from the average quality of inventions for which EPO patent applications were made but no EPO patent was granted. Since the sample in our main analysis contains both granted and non-granted European patent filings, it means that all filings have not been subject to a similar examination process at the EPO. Moreover, non-granted EPO filings include those that were withdrawn by applicants during the examination process. It should be noted that such withdrawals comprise most "not granted" EPO applications. Lazaridis and van Pottelsberghe (2007) report that 30–35% of EPO patent applications are withdrawn by applicants during the examination process while only approximately 5% are rejected by examiners. The rest (60%) are granted. The pendency lags of European patents from filing to grant are approximately four years (Harhoff & Wagner, 2009). Thus, we estimate all the models in Table 3 by using a subsample of granted EPO filings with patent or UM priorities.

Table A.15 in the appendix reports the results. The observed patterns are similar to those in Table 5. Again, we find a robust negative association between the UM priority indicator and the quality of EPO filing for both granted and non-granted subsamples. Hypothesis 1a and 1b get further support. Unlike in Table 5, here, we do not observe a difference in the average patent family size between granted EPO patent families with patent and UM priorities for the Germany sample (Table A.15 (B), column 5). Thus, it seems that the quality difference between EPO filings with German UM and German patent priorities is higher for non-granted EPO applications than for granted EPO patents.

Second, in most countries, UMs cannot be used to protect process inventions. Thus, some share of EPO filings with patent priorities is presumably filed to protect process inventions whereas UMs are primarily used to protect product inventions. To partly account for this, we try to identify EPO filings with process inventions. This is done by searching the titles of EPO filings and excluding from the sample filings with the words "process", "method", "procedure", "technique" or "system" in their titles. Table A.16 reports the results for this restricted sample and demonstrates that the results of Table 5 are robust. Hypotheses 1a and 1b get further support.

3.3.2 Filing and grant lags

The Cox PH model is only one alternative among several models that are suitable for the analysis of survival data (see Kalbfleisch & Prentice, 2002). Alternatively, we estimate accelerated failure time models and ordinary least squares (OLS) models (cf. Harhoff & Wagner, 2009; Berger et al., 2012). The results are reported in Table A.17 in the appendix. In columns 1, 2, 5 and 6, the dependent variable is the logarithm of filing lag and grant lag. In columns 3, 4, 7 and 8, the accelerated failure time model assumes log-logistic distribution of survival time following prior studies (Wagner & Harhoff, 2009; Berger et al., 2012).

The signs of estimates in Table A.17 indicate that UM priorities are associated with shorter filings lags in both Germany and other countries and with shorter grant lags in Germany. The estimates are statistically significant at 1% a significance level. For other countries, no difference is found in grant lags between EPO filings with patent and UM priorities which is consistent with Table 6. Thus, the robustness checks partly corroborate the findings in the main analysis but partly contradict them. On one hand, further evidence is found in support of Hypothesis 2 for the sample consisting of other countries. On the other hand, in the case of Germany, Table 6 and Table A.17 display opposite results concerning the filing lag difference between UM and patent priorities. In case of grant lags, the results are similar between these two tables.

When the Cox PH model is used and time is assumed to be continuous, the tied survival times in the data must be treated one way or another in estimations. The models in Tables 5 and 6 used the Breslow method for ties. It is computationally the least demanding and is the default option in several statistical packages, but leads to inconsistent estimates when there are many ties in the data (Kalbfleisch & Prentice, 2002). In our data set there are many ties since several patent families have equal filing lags and timespans and several EPO filings have equal grant lags. We use the method suggested by Borucka (2014) to test whether the ties affect the estimates: We subtract from our duration variables (filing and grant lags and timespan) random numbers from a uniform distribution [0, 0.001]. Doing this, we artificially reduce the number of ties to close to zero. The estimations with this amended data produce similar results. These alternative estimations are not reported here but are available from the authors upon request.

4 Concluding remarks

This study sheds light on the role of UMs in patent filing strategies. We introduced a simple typology of patent families with UM members. When the classification is applied to patent families with European UM members, it is documented that 1) most UMs are filed to protect inventions nationally; 2) the use of UMs as part of international patent filing strategies is heterogeneous across Europe (in certain patent offices, it is frequent, whereas in others, it is only a marginal or negligible activity); and 3) UMs are used as priorities for subsequent transnational patents (EPO and PCT patent families). The third observation implies that UMs are not only a proxy for incremental inventions (Johnson, 2002; Beneito, 2006; Kim et al., 2012; Hamdan-Livramento & Raffo, 2016) but that they also provide a strategic option in international patent filing strategies.

Our empirical analysis provides suggestive evidence that priority UM filings are associated with lower quality of EPO filings in comparison to EPO filings with patent priorities. Analyses of filing and grant lags provide more mixed evidence. EPO filings with UM members have shorter filing and grant lags, but there is heterogeneity among countries. To conclude, UM systems provide flexibility to increasingly harmonized European national patent systems.

The findings of this study have two main implications for future research on the economics of patents. First and foremost, they highlight that UMs (and other equivalent second tier patents) should be taken into account when structures of patent families are analyzed. At minimum, future studies should explicitly report whether they include UM filings when reporting and analyzing, for instance, propensities to patent or patent filing strategies. Second, UM priorities may signal lower quality of the underlying invention. Therefore, they can be used as patent value indicators, and they complement existing patent family size indicators.

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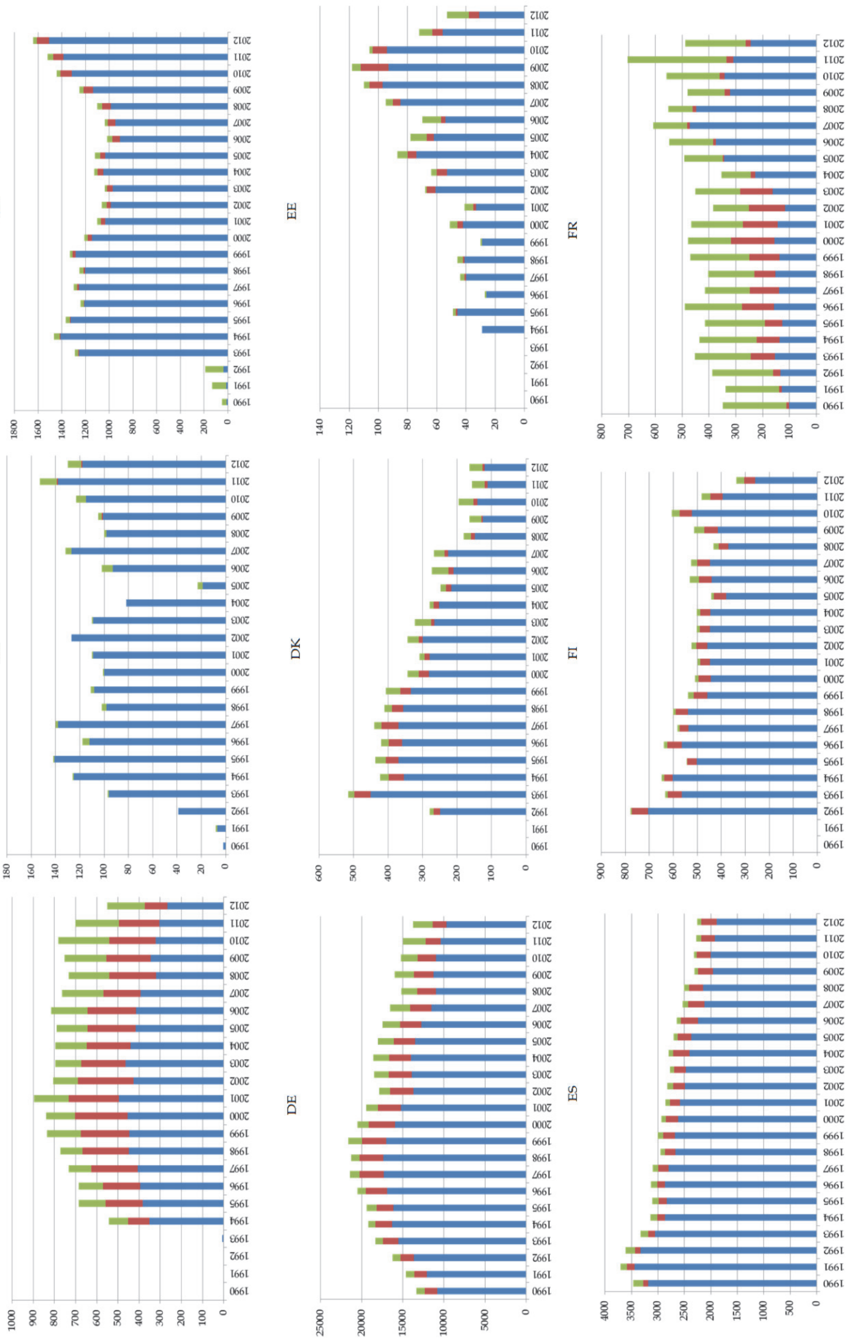
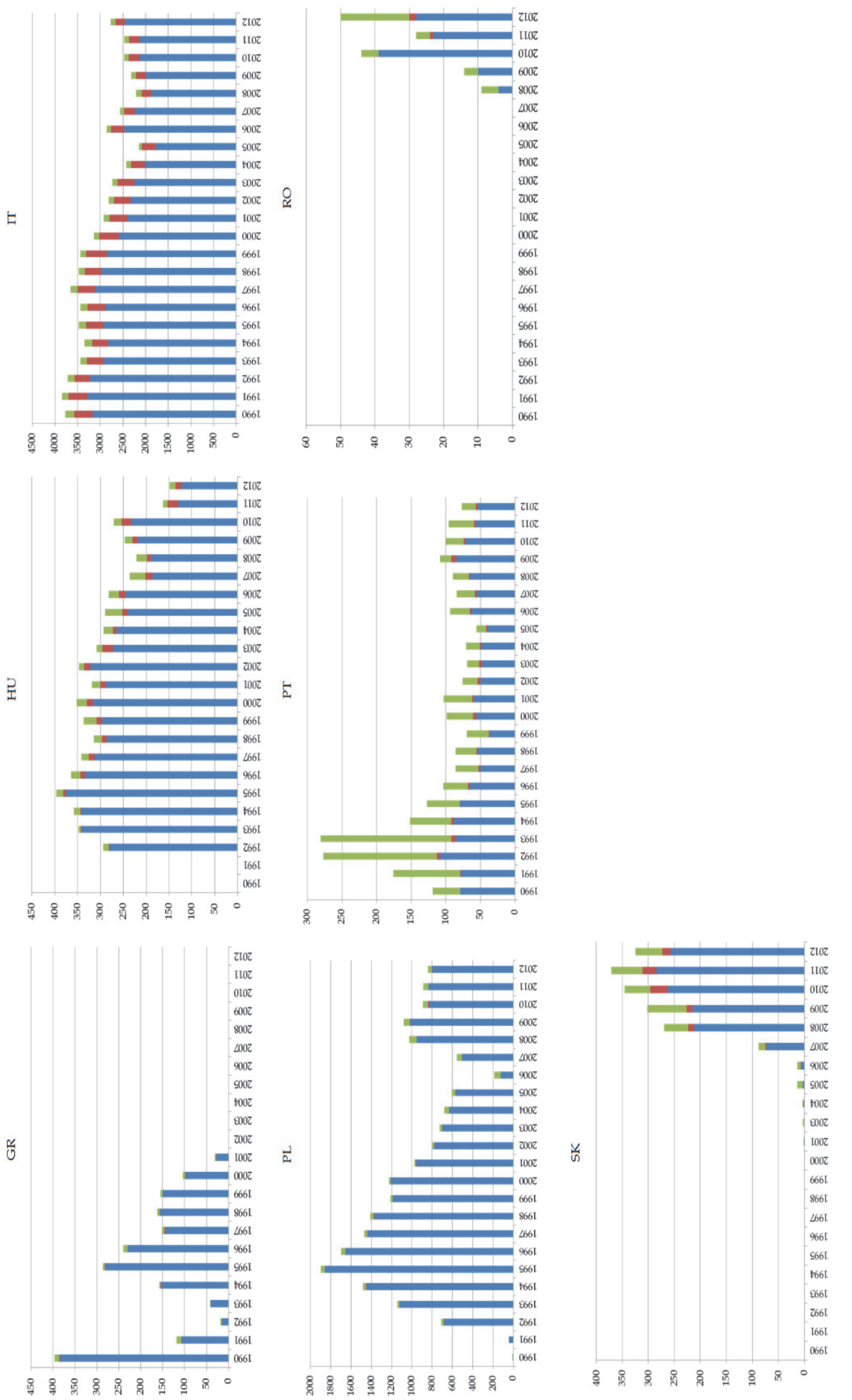
Appendix

FIGURE A.1 UM filings at national patent offices according to typology 1990–2012



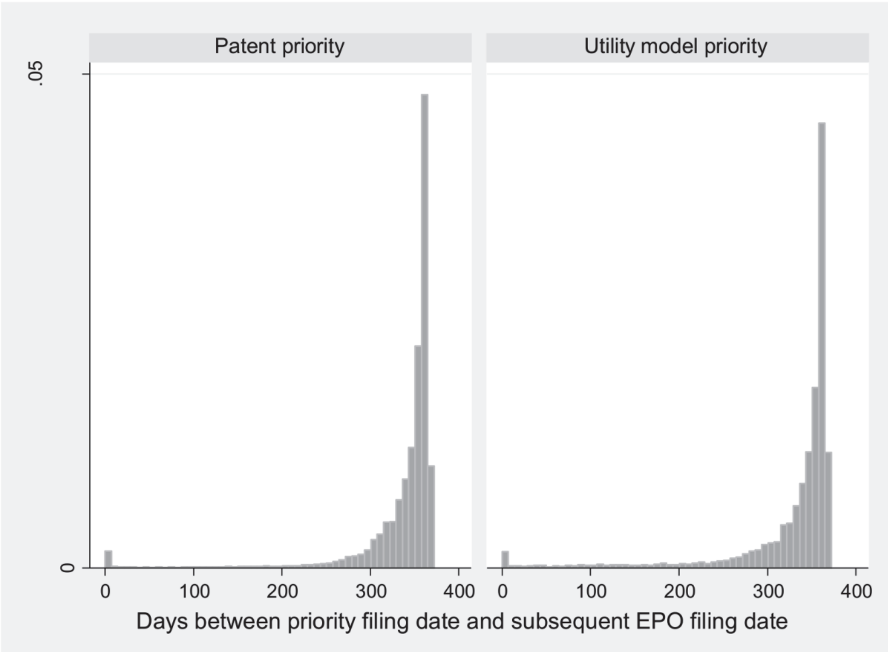
Notes: Blue: national patent family, red: priority of international patent family, green: subsequent filing of international patent family.

FIGURE A.1 (continued)



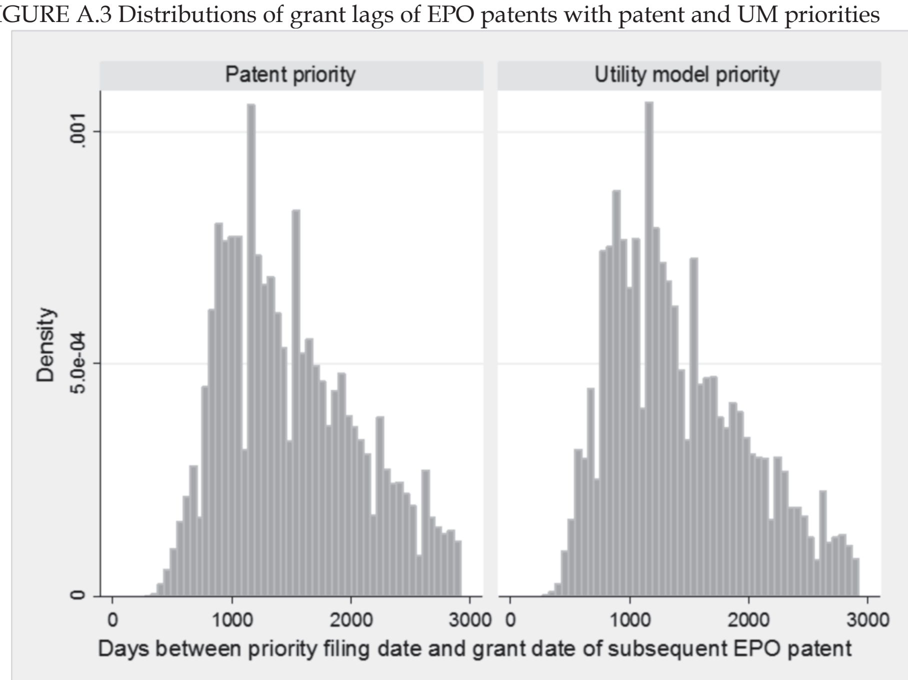
Notes: Blue: national patent family, red: priority of international patent family, green: subsequent filing of international patent family.

FIGURE A.2 Distributions of filing lags between priorities and subsequent EPO filings



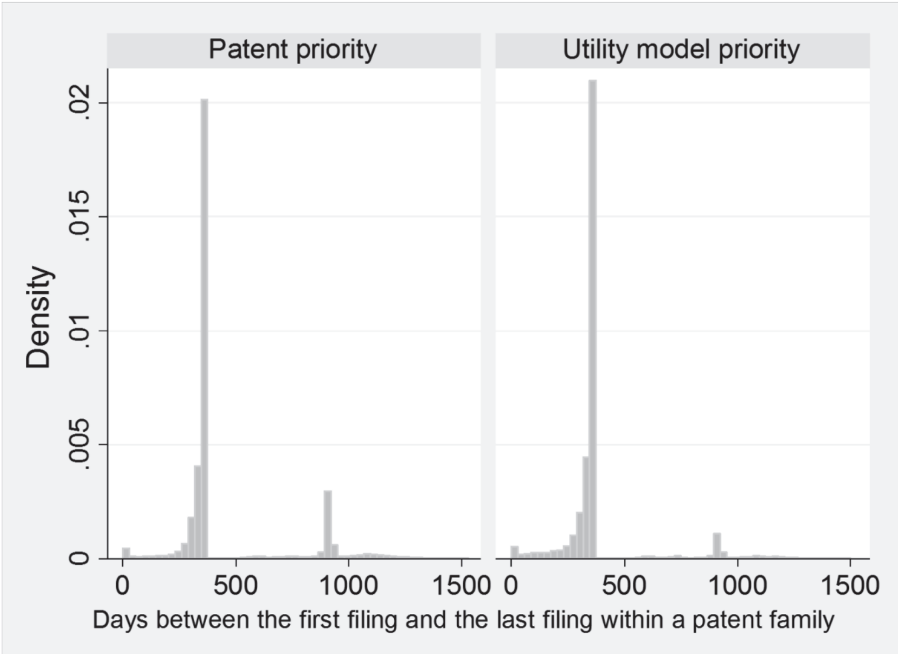
Notes: Patent families, which have longer than 12 months filing lag between the priority and subsequent EPO filing are excluded.

FIGURE A.3 Distributions of grant lags of EPO patents with patent and UM priorities



Notes: EPO patents with longer grant lags than 8 years are not reported.

FIGURE A.4 Distributions of timespans of EPO patent families with patent or UM priorities



Notes: Patent families, which have longer than 1500 days timespans between the priority and the last filing within the family are not reported.

TABLE A.1 International patent family dyads, Austria

Rank	Filing office at which an Austrian UM is claimed as priority	N	Rank	Filing office at which an Austrian patent is claimed as priority	N
1	EPO	1121	1	EPO	5240
2	DE	1109	2	US	2930
3	US	604	3	AT (PCT)	2862
4	AT (PCT)	517	4	DE	2264
5	CN	335	5	CN	1789
6	JP	289	6	JP	1314
7	CA	160	7	CA	1022
8	EPO (PCT)	139	8	AU	942
9	AU	137	9	EPO (PCT)	869
10	RU	116	10	RU	697

Rank	Filing office of the priority filing claimed in a subsequent Austrian UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent Austrian patent filing	N
1	DE	821	1	DE	1022
2	*AT*	107	2	FI	199
3	IT	54	3	*AT*	132
4	FI	47	4	US	73
5	CH	43	5	CH	58
6	CZ	34	6	JP	30
7	FR	20	7	IT	21
8	US	20	8	FR	20
9	EPO	18	9	GB	13
10	GB	10	10	CZ	11

TABLE A.2 International patent family dyads, Czech Republic

Rank	Filing office at which a Czech utility model is claimed as priority	N	Rank	Filing office at which a Czech patent is claimed as priority	N
1	DE	171	1	CZ (PCT)	727
2	CZ (PCT)	156	2	EPO	605
3	SK	143	3	US	350
4	PL	101	4	DE	175
5	EPO	93	5	SK	171
6	CN	54	6	CN	169
7	US	47	7	AU	108
8	RU	43	8	CA	106
9	AT	33	9	JP	101
10	HU	33	10	EA	97

Rank	Filing office of the priority filing claimed in a subsequent Czech utility model	N	Rank	Filing office of the priority filing claimed in a subsequent Czech patent filing	N
1	DE	87	1	DE	1752
2	CZ	44	2	US	818
3	SK	37	3	GB	336
4	AT	22	4	FR	326
5	TW	10	5	EPO	255
6			6	IT	189
7			7	JP	137
8			8	SE	113
9			9	US (PCT)	113
10			10	AT	98

TABLE A.3 International patent family dyads, Germany

Rank	Filing office at which a German UM is claimed as priority	N	Rank	Filing office at which a German patent is claimed as priority	N
1	EPO	18540	1	EPO	163256
2	US	8282	2	US	129187
3	EPO (PCT)	6534	3	EPO (PCT)	95896
4	CN	3890	4	JP	62106
5	JP	2887	5	CN	60661
6	*DE*	2623	6	*DE*	25813
7	DE (PCT)	1836	7	DE (PCT)	24633
8	AU	1518	8	KR	24118
9	CA	1398	9	CA	19714
10	RU	1240	10	AU	17586

Rank	Filing office of the priority filing claimed in a subsequent German UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent German patent filing	N
1	*DE*	3022	1	US	41151
2	TW	2075	2	JP	34733
3	AT	1068	3	*DE*	24974
4	CN	728	4	EPO	11539
5	US	669	5	FR	10429
6	EPO	578	6	GB	7384
7	IT	558	7	KR	6406
8	FR	389	8	IT	5084
9	GB	301	9	SE	2987
10	FI	271	10	AT	2289

TABLE A.4 International patent family dyads, Denmark

Rank	Filing office at which a Danish utility model is claimed as priority	N	Rank	Filing office at which a Danish patent is claimed as priority	N
1	EPO	77	1	EPO	981
2	DK (PCT)	66	2	DK (PCT)	929
3	US	30	3	US	690
4	DE	28	4	CN	381
5	AU	19	5	AU	271
6	*DK*	17	6	CA	245
7	NO	10	7	DE	241
8			8	JP	216
9			9	NO	134
10			10	KR	100

Rank	Filing office of the priority filing claimed in a subsequent Danish utility model filing	N	Rank	Filing office of the priority filing claimed in a subsequent Danish patent filing	N
1	DE	43	1	US	161
2	FI	32	2	DE	111
3	*DK*	15	3	NO	61
4	US	12	4	FR	28
5			5	FI	27
6			6	SE	25
7			7	*DK*	16
8			8	GB	13
9			9	JP	12
10			10	EPO	10

TABLE A.5 International patent family dyads, Estonia

Rank	Filing office at which an Estonian UM is claimed as priority	N	Rank	Filing office at which an Estonian patent is claimed as priority	N
1	EE (PCT)	28	1	EE (PCT)	66
2	EPO	18	2	US	46
3	US	10	3	EPO	42
4			4	RU	17
5			5	CA	13
6			6	EPO (PCT)	12
7			7	CN	11
8			8	EA	11
9			9	AU	10
10			10		

Rank	Filing office of the priority filing claimed in a subsequent Estonian UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent Estonian patent filing	N
1	FI	19	1	DE	151
2			2	SE	91
3			3	GB	74
4			4	US	64
5			5	FI	57
6			6	FR	52
7			7	EPO	31
8			8	US (PCT)	23
9			9	IT	23
10			10	AT	12

TABLE A.6 International patent family dyads, Spain

Rank	Filing office at which a Spanish UM is claimed as priority	N	Rank	Filing office at which a Spanish patent is claimed as priority	N
1	EPO	341	1	EPO	1447
2	DE	262	2	US	960
3	FR	237	3	DE	707
4	IT	180	4	ES (PCT)	624
5	PT	159	5	CN	430
6	US	153	6	JP	425
7	ES (PCT)	106	7	CA	360
8	CN	93	8	AU	354
9	BR	49	9	BR	312
10	CA	49	10	MX	294

Rank	Filing office of the priority filing claimed in a subsequent Spanish UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent Spanish patent filing	N
1	IT	236	1	DE	334
2	DE	185	2	FR	263
3	FR	40	3	JP	229
4	CN	39	4	IT	189
5	TW	30	5	US	126
6	AT	16	6	KR	103
7	US	15	7	ES	75
8	PT	14	8	GB	30
9	TR	14	9	TW	30
10	GB	11	10	FI	22

TABLE A.7 International patent family dyads, Finland

Rank	Filing office at which a Finnish UM is claimed as priority	N	Rank	Filing office at which a Finnish patent is claimed as priority	N
1	DE	188	1	FI (PCT)	7446
2	FI (PCT)	168	2	EPO	6974
3	EPO	143	3	US	6114
4	US	73	4	CN	3385
5	SE	56	5	JP	2266
6	CN	54	6	CA	1902
7	*FI*	38	7	DE	1800
8	AU	35	8	AU	1758
9	RU	33	9	KR	1177
10	NO	26	10	RU	1007

Rank	Filing office of the priority filing claimed in a subsequent Finnish UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent Finnish patent filing	N
1	*FI*	99	1	DE	204
2	DE	43	2	US	199
3			3	*FI*	183
4			4	SE	91
5			5	JP	69
6			6	KR	62
7			7	FR	28
8			8	GB	20
9			9	NO	18
10			10	TW	15

TABLE A.8 International patent family dyads, France

Rank	Filing office at which a French utility certificate is claimed as priority	N	Rank	Filing office at which a French patent is claimed as priority	N
1	EPO	28	1	EPO	60462
2	US	27	2	US	45384
3	*FR*	23	3	FR (PCT)	33868
4	FR (PCT)	22	4	JP	24348
5	CN	11	5	CN	21362
6	JP	10	6	CA	13629
7			7	DE	10810
8			8	KR	8853
9			9	EPO (PCT)	8697
10			10	AU	8571

Rank	Filing office of the priority filing claimed in a subsequent French utility certificate filing	N	Rank	Filing office of the priority filing claimed in a subsequent French patent filing	N
1	DE	311	1	DE	6418
2	TW	248	2	JP	3039
3	IT	222	3	US	2118
4	CN	134	4	FR	974
5	ES	126	5	KR	785
6	US	35	6	TW	431
7	AT	31	7	IT	339
8	FR	31	8	GB	310
9	BE	26	9	ES	256
10	FI	18	10	CN	192

TABLE A.9 International patent family dyads, Hungary

Rank	Filing office at which a Hungarian UM is claimed as priority	N	Rank	Filing office at which a Hungarian patent is claimed as priority	N
1	HU (PCT)	101	1	HU (PCT)	942
2	EPO	35	2	EPO	607
3	DE	22	3	US	472
4	US	21	4	CN	301
5	AU	18	5	AU	267
6	*HU*	12	6	JP	236
7			7	CA	208
8			8	EA	154
9			9	UA	115
10			10	*HU*	113

Rank	Filing office of the priority filing claimed in a subsequent Hungarian UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent Hungarian patent filing	N
1	*HU*	109	1	DE	1341
2	DE	36	2	US	621
3	CZ	34	3	FR	439
4			4	GB	401
5			5	EPO	242
6			6	IT	188
7			7	US (PCT)	153
8			8	SE	115
9			9	AT	92
10			10	JP	74

TABLE A.10 International patent family dyads, Italy

Rank	Filing office at which an Italian utility model is claimed as priority	N	Rank	Filing office at which an Italian patent is claimed as priority	N
1	EPO	2121	1	EPO	25389
2	US	806	2	US	15064
3	DE	739	3	CN	7119
4	CN	374	4	EPO (PCT)	6261
5	EPO (PCT)	302	5	WIPO (PCT)	5826
6	IT (PCT)	297	6	JP	4980
7	FR	259	7	DE	4908
8	WIPO (PCT)	227	8	CA	3786
9	JP	198	9	IT (PCT)	3786
10	ES	182	10	AU	3353

Rank	Filing office of the priority filing claimed in a subsequent Italian utility model filing	N	Rank	Filing office of the priority filing claimed in a subsequent Italian patent filing	N
1	DE	315	1	DE	3153
2	ES	144	2	JP	979
3	TW	82	3	US	546
4	CN	81	4	FR	408
5	AT	64	5	KR	390
6	FR	40	6	ES	143
7	*IT*	37	7	*IT*	117
8	US	34	8	TW	92
9	FI	17	9	AT	85
10	TR	17	10	GB	71

TABLE A.11 International patent family dyads, Poland

Rank	Filing office at which a Polish UM is claimed as priority	N	Rank	Filing office at which a Polish patent is claimed as priority	N
1			1	PL (PCT)	868
2			2	EPO	792
3			3	US	418
4			4	AU	178
5			5	CN	158
6			6	RU	120
7			7	JP	114
8			8	DE	99
9			9	CA	92
10			10	UA	67

Rank	Filing office of the priority filing claimed in a subsequent Polish UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent Polish patent filing	N
1	DE	82	1	DE	3701
2	CZ	79	2	US	1805
3	IT	19	3	FR	1035
4	ES	18	4	GB	877
5	SK	11	5	EPO	695
6	US	11	6	IT	458
7	FI	10	7	SE	447
8			8	AT	203
9			9	JP	202
10			10	FI	198

TABLE A.12 International patent family dyads, Portugal

Rank	Filing office at which a Portuguese UM is claimed as priority	N	Rank	Filing office at which a Portuguese patent is claimed as priority	N
1	ES	15	1	EPO	279
2	EPO	11	2	PT (PCT)	209
3	PT (PCT)	10	3	US	193
4			4	WIPO (PCT)	172
5			5	JP	74
6			6	CA	71
7			7	BR	70
8			8	AU	65
9			9	CN	59
10			10	KR	27

Rank	Filing office of the priority filing claimed in a subsequent Portuguese UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent Portuguese patent filing	N
1	ES	149	1	ES	139
2	IT	21	2	FR	29
3	PT	17	3	IT	21
4	DE	10	4	JP	18
5			5	US	15
6			6	GB	14
7			7	BR	13
8			8	DE	12
9			9		
10			10		

TABLE A.13 International patent family dyads, Slovakia

Rank	Filing office at which a Slovak UM is claimed as priority	N	Rank	Filing office at which a Slovak patent is claimed as priority	N
1	CZ	26	1	SK (PCT)	167
2	PL	12	2	EPO	88
3			3	CZ	72
4			4	US	49
5			5	RU	34
6			6	AU	23
7			7	CN	22
8			8	DE	20
9			9	JP	18
10			10	WIPO (PCT)	17

Rank	Filing office of the priority filing claimed in a subsequent Slovak UM filing	N	Rank	Filing office of the priority filing claimed in a subsequent Slovak patent filing	N
1	CZ	143	1	DE	506
2			2	CZ	171
3			3	FR	166
4			4	US	144
5			5	GB	138
6			6	EPO	102
7			7	IT	97
8			8	SE	66
9			9	US (PCT)	51
10			10	AT	47

TABLE A.14 Characteristics of EPO patent applications with (single) patent or UM priorities, 2000–2010, all countries

	Priority filing type		
	Utility model	Patent	Total
Applications	16799	155923	172722
Grants/Registrations	8756	86786	95542

	Utility model		Patent		Difference of	
Characteristic	Mean	Std. Dev.	Mean	Std. Dev.	means	Std. Err.
Granted	0.521	0.500	0.557	0.497	0.035***	0.004
Cited	0.753	0.431	0.824	0.381	0.071***	0.003
Number of citations	3.375	5.283	5.012	7.751	1.637***	0.061
Patent family size	4.346	2.828	5.478	3.522	1.132***	0.028
Timespan	402.838	275.076	511.228	434.891	108.390***	3.427
Number of inventors	1.622	1.115	2.328	1.625	0.706***	0.013
Individual applicant	0.179	0.383	0.074	0.262	-0.105***	0.002
PCT filing	0.282	0.450	0.529	0.499	0.247***	0.004
Domestic applicant	0.879	0.326	0.895	0.307	0.016***	0.003
Filing lag	323.622	77.396	333.528	62.733	9.906***	0.522
Grant lag	1482.187	674.175	1579.33	712.744	97.144***	7.953

Notes: All other variables show the statistics for applications sample (172722 obs.) except grant lag is reported for subsample of granted EPO patents (95542 obs.). *** indicate statistical significance at a 1% significance level.

TABLE A.15 Results for granted and not-granted subsamples

(A) Germany excluded

Dependent variable	**Cited**		**Number of citations**		**Patent family size**		**Timespan**	
Model	Probit		Neg. bin.		Neg. bin.		Cox PH	
Estimate	M.E.	M.E.	Coeff.	Coeff.	Coeff.	Coeff.	Hazard Ratio	
Sample	Germany excluded		Germany excluded		Germany excluded		Germany excluded	
Subsample	Granted	Not granted	Granted	Not granted	Granted	Not granted	Granted	Not granted
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D(UM Priority)	-0.058***	-0.051***	-0.269***	-0.313***	-0.035***	-0.107***	1.142***	1.152***
	(0.009)	(0.010)	(0.037)	(0.035)	(0.012)	(0.014)	(0.030)	(0.026)
D(Individual applicant)	-0.043***	-0.039***	-0.295***	-0.206***	-0.111***	-0.143***	1.122***	1.023
	(0.008)	(0.008)	(0.028)	(0.028)	(0.011)	(0.012)	(0.025)	(0.018)
Number of inventors	0.013***	0.018***	0.075***	0.083***	0.014***	0.027***	0.965***	0.951***
	(0.002)	(0.003)	(0.008)	(0.008)	(0.003)	(0.004)	(0.005)	(0.005)
D(PCT family)	0.063***	0.102***	0.247***	0.402***	0.504***	0.837***	0.533***	0.600***
	(0.006)	(0.007)	(0.019)	(0.022)	(0.007)	(0.010)	(0.009)	(0.010)
Constant			1.785***	1.449***	1.775***	0.851***		
			(0.130)	(0.154)	(0.039)	(0.070)		
Observations	19422	20469	19422	20469	19422	20469	19409	20455
Log likelihood	8795.34	-11777.22	-49265.34	-44121.39	-47634.15	-39232.74	-171468.68	-182976.17
Pseudo R2	0.05	0.04						

Notes: The sample consists of EPO filings filed 2000–2010, which claim a single patent or single utility model priority filed between 2000–2010 in Austria, Czech Republic, Denmark, Finland, Hungary, Italy or Spain. All models include technological field dummies, filing year dummies and priority author dummies as controls. Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

TABLE A.15 (continued)

(B) Germany

Dependent variable	Cited		Number of citations		Patent family size		Timespan	
Model	Probit		Neg. bin.		Neg. bin.		Cox PH	
Estimate	M.E.	M.E.	Coeff.	Coeff.	Coeff.	Coeff.	Hazard Ratio	
Sample	Germany		Germany		Germany		Germany	
Subsample	Granted	Not granted	Granted	Not granted	Granted	Not granted	Granted	Not granted
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D(UM Priority)	-0.024***	-0.022***	-0.151***	-0.178***	-0.009	-0.095***	1.094***	1.134***
	(0.004)	(0.006)	(0.016)	(0.021)	(0.006)	(0.009)	(0.014)	(0.016)
D(Individual applicant)	-0.043***	-0.049***	-0.249***	-0.239***	-0.066***	-0.156***	0.968**	0.914***
	(0.005)	(0.006)	(0.023)	(0.025)	(0.009)	(0.012)	(0.015)	(0.013)
Number of inventors	0.010***	0.016***	0.070***	0.083***	0.014***	0.026***	0.980***	0.976***
	(0.002)	(0.001)	(0.003)	(0.004)	(0.001)	(0.002)	(0.002)	(0.003)
D(PCT family)	0.063***	0.094***	0.273***	0.352***	0.503***	0.742***	0.559***	0.639***
	(0.002)	(0.003)	(0.009)	(0.012)	(0.003)	(0.005)	(0.005)	(0.006)
Constant			1.924***	1.433***	1.499***	0.949***		
			(0.050)	(0.079)	(0.023)	(0.036)		
Observations	76055	56732	76055	56732	76055	56732	75392	56065
Log likelihood	-28426.32	-27495.16	-210202.46	-139265.14	-171677.42	-108203.31	-767622.29	-556405.98
Pseudo R2	0.06	0.05						

Notes: The sample consists of EPO filings filed 2000–2010, which claim a single patent or single utility model priority filed between 2000–2010 in Germany. All models include technological field dummies, filing year dummies and priority author dummies as controls. Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

TABLE A.16 Excluding process inventions

Dependent variable	**Pr(Grant=1)**		**Pr(Cited=1)**		**Number of citations**		**Patent family size**		**Timespan**	
Model	Probit		Probit		Neg. bin.		Zero-trunc. neg. bin.		Cox PH	
Estimate	M.E.		M.E.		Coeff.		Coeff.		Hazard Ratio	
Sample	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
D(UM Priority)	-0.075***	-0.024***	-0.065***	-0.022***	-0.346***	-0.151***	-0.100***	-0.027***	1.146***	1.097***
	(0.009)	(0.005)	(0.007)	(0.004)	(0.028)	(0.014)	(0.012)	(0.006)	(0.021)	(0.011)
D(Individual applicant)	-0.145***	-0.108***	-0.050***	-0.051***	-0.304***	-0.280***	-0.215***	-0.147***	1.099***	0.938***
	(0.008)	(0.007)	(0.007)	(0.005)	(0.024)	(0.020)	(0.011)	(0.009)	(0.017)	(0.012)
Number of inventors	0.007***	-0.001	0.016***	0.012***	0.077***	0.074***	0.022***	0.019***	0.959***	0.976***
	(0.002)	(0.001)	(0.003)	(0.001)	(0.007)	(0.003)	(0.003)	(0.001)	(0.005)	(0.002)
D(PCT family)	0.110***	0.066***	0.096***	0.083***	0.353***	0.327***	0.695***	0.610***	0.548***	0.569***
	(0.006)	(0.003)	(0.006)	(0.003)	(0.018)	(0.009)	(0.008)	(0.004)	(0.008)	(0.005)
Constant					1.761***	1.750***	1.565***	1.290***		
					(0.117)	(0.049)	(0.049)	(0.026)		
Observations	26132	84842	26132	84842	26132	84842	26132	84842	26114	84054
Log likelihood	-17070.43	-55137.03	-13781.23	-36595.89	-60587.92	-221697.74	-59979.115	-184303.07	-239170.13	-866143.68
Pseudo R2	0.06	0.04	0.05	0.06						

Notes: The sample consists of EPO filings filed 2000-2010, which claim a single patent or single utility model priority filed between 2000-2010 in Austria, Czech Republic, Denmark, Finland, Germany, Hungary, Italy or Spain. EPO filings with "process", "method", "procedure", "technique" or "system" in their title are excluded. All models include technology field dummies, filing year dummies and priority author dummies as controls. Robust standard errors in parentheses. In columns 9 and 10 Cox PH models use Breslow method for ties. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

TABLE A.17 Filing and grant lags, alternative model specifications

Dependent variable	**Log(Filing lag)**		**Filing lag**		**Log(Grant lag)**		**Grant lag**	
Model	OLS		Accelerated failure time		OLS		Accelerated failure time	
Estimate	Coeff.		Coeff.		Coeff.		Coeff.	
Sample	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany	Germany excluded	Germany
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D(UM Priority)	-0.020***	-0.037***	-0.011***	-0.005***	-0.006	-0.025***	-0.009	-0.029***
	(0.006)	(0.008)	(0.001)	(0.001)	(0.010)	(0.005)	(0.011)	(0.006)
D(Individual applicant)	0.001	-0.118***	0.004***	0.020***	-0.007	-0.028***	-0.007	-0.027***
	(0.005)	(0.012)	(0.010)	(0.001)	(0.008)	(0.006)	(0.009)	(0.007)
Number of inventors	0.013***	-0.014***	0.003***	-0.001***	0.007***	0.007***	0.008***	0.007***
	(0.001)	(0.002)	(0.0002)	(0.0001)	(0.002)	(0.001)	(0.002)	(0.001)
PCT family	-0.001	-0.052***	0.005***	0.012***	0.167***	0.127***	0.161***	0.110***
	(0.004)	(0.004)	(0.001)	(0.0005)	(0.006)	(0.003)	(0.007)	(0.003)
Constant	5.113	4.140***	5.316***	5.675***	7.358***	7.322***	7.371***	7.348***
	(0.059)	(0.082)	(0.060)	(0.009)	(0.033)	(0.016)	(0.035)	(0.017)
Observations	39749	132281	39826	130582	18409	72093	18409	72093
Log pseudolikelihood			13420.8	42760.06			-8086.06	-34911.78
R2	0.04	0.04			0.12	0.07		

Notes: The sample consists of European patents filed 2000-2010, which claim a single patent or single utility model priority filed between 2000-2010 in Austria, Czech Republic, Denmark, Finland, Germany, Hungary, Italy or Spain. Last minute filing indicates that the EPO filing is filed within 10 last days of the priority year. Accelerated failure time models in columns 3, 4, 7 and 8 assume the distribution of survival time (filing and grant lags) to have a log-logistic distribution. All models include technology field dummies, filing year dummies and priority author dummies as controls. Robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

CHAPTER 4: UNCERTAIN DESIGN RIGHTS AND DESIGN SPILLOVERS: THE CASE OF THE FINNISH SAUNA HEATER MARKET[51]

Abstract

We present a case study of a surge in design right filings in an industry transforming from technology-based to design-based competition. The motives for and outcomes of filing, and how these have changed over time, are discussed. We go on to explore the events that offered agents opportunities to update their beliefs about the scope of design right protection. We find that uncertain design rights may have fostered entrepreneurial optimism. We also find that the scope of design right protection has been dynamically evolving in this context: The more designs were introduced into the market, the smaller the improvements that qualified for design right protection and the narrower the scope of existing design rights became. Policy makers could level the playing field and decrease information asymmetries between experienced and inexperienced players by mandating digital open access to design right databases and existing court cases. However, the expected welfare effects from this libertarian paternalistic policy are contradictory.

[51] This study is joint work with Mirva Peltoniemi. We thank PRH for providing IPR documents, Helsinki District Court and Helsinki Court of Appeals for providing court case material, the Finnish Sauna Society for providing access to Sauna magazine archives and the Central Archives for Finnish Business Records (Elka) for providing sauna heater photos. We thank Ari Hyytinen, Mika Maliranta, Tuomas Takalo, Hannu Piekkola, Kaisa Kotakorpi, Heli Koski and Aija Leiponen for helpful comments. We received valuable comments from an anonymous IPR expert who reviewed our paper. Earlier versions of this paper have been presented in JSBE breakfast seminar, the XXXIII Summer Seminar of Finnish Economists in Jyväskylä, Allecon seminar in Tampere and in the 11th European Policy for Intellectual Property (EPIP) conference in Oxford. The financial support from Yrjö Jahnsson Foundation, OP Group Research Foundation, IPR University Center Association, Jyväskylä University School of Business and Economics and the Finnish Sauna Society is gratefully acknowledged.

1 Introduction

Most economics of innovation studies have focused on patents as the proxy for innovation activity, and other types of intellectual property rights (IPRs) have received far less attention (see Beneito, 2006 and Kim et al., 2012 for utility models, Filitz et al., 2015 for design rights, Schautschick & Greenhalgh, 2016 for trademarks). Good availability of patent data[52], the possibility to proxy potential knowledge flows with patent citations (Jaffe et al., 1993; Criscuolo & Verspagen, 2008), and perhaps also established conventions in operationalizing innovation variables with patent data have directed researchers' attention to industries that are active users of patents (see e.g., Hall & Ziedonis, 2001 for semiconductors, Thumm, 2004 for biotechnology, Cockburn & MacGarvie, 2011 for software). Patent filing surges have been analyzed at the global level and national level (Kortum & Lerner, 1999; Kim & Marschke, 2006; Fink et al., 2016), but far fewer studies theorize on or provide empirical evidence of firm-level actions, motives, and learning mechanisms relating to the adoption of a specific IP protection method and how that changes competition within an industry.

The use and importance of IPRs are industry-specific and depend on the strategic interaction between competing firms (Levin et al., 1987; Grindley & Teece, 1997; Cohen et al., 2000; Hall & Ziedonis, 2001; Blind et al., 2009; Guellec & van Pottelsberghe, 2007). Hence, to understand how the IPR institutions shape innovation, competition, and industry dynamics, we need in-depth industry case studies (Schautschick & Greenhalgh, 2016). By focusing on specific markets, in which firms truly compete with each other for the same customers and share a knowledge base, researchers can shed light on underlying strategic interaction, knowledge and innovation dynamics, and learning processes (e.g., Malerba, 2002, 2006; Engler, 2015; Klepper, 2015).

Our case study focuses on the design right institution[53] and examines the underlying explanations for the surge in design right filings in Finnish sauna[54] heater markets in 2008. Figure 1 displays the filings of design rights at the Finnish patent office in aggregate and the dramatic increase in filings in the product category "sauna heaters".

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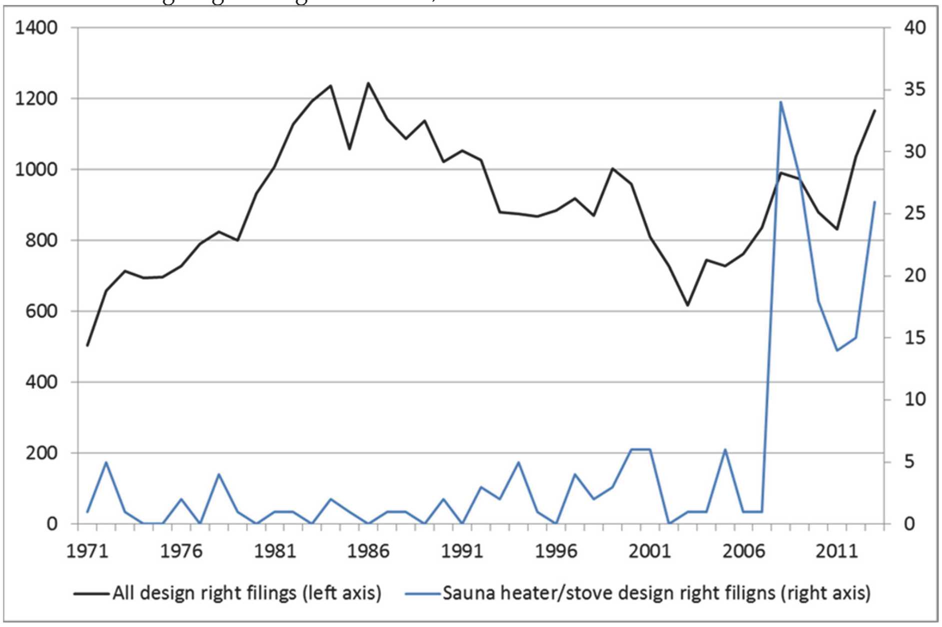
[52] For instance, NBER's patent data and European Patent Office's PATSTAT data.
[53] Following Filitz et al. (2015) we focus explicitly on design right institution and do not consider design more generally (cf. Eisenman, 2013).
[54] The Oxford Dictionary defines *sauna* as "a small room used as a hot-air or steam bath for cleaning and refreshing the body". Source: http://www.oxforddictionaries.com/definition/english/sauna

FIGURE 1 Design right filings in Finland, 1971–2013



Note: Since 2003, design right filings also include filings at the OHIM/EUIPO.

The Finnish sauna heater market is particularly suitable for the proposed case analysis since all competing firms are easily identifiable as they operate mainly in the Finnish market and are therefore subject to the same institutional environment. Finland is also one of the largest and oldest sauna heater markets in the world, and Finnish firms are at the forefront of innovation. Moreover, Finland has advanced IPR institutions[55] (patent, trademark, and design right systems combined with a trusted legal system), which are actively used by sauna heater producers. Hence, the setting enables us to explore IPR-related strategic interaction between competing firms and to shed light on their evolving beliefs about the effectiveness of design rights.

The paper is structured as follows. In section 2, we review the related literature and present the research questions. Section 3 presents the empirical context, and section 4 describes the methods and data collection. Section 5 narrates the sequence of events relating to the case, and in section 6, we analyze our observations and discuss policy implications. Section 7 concludes.

[55] See e.g., World Economic Forum's Global Competitiveness Index dataset for 2006–2015: http://www3.weforum.org/docs/GCR2014-15/GCI_Dataset_2006-07-2014-15.xlsx

2 Design rights, uncertainty, and strategic use of IPRs

2.1 Design rights

The criteria for design right protection[56] may vary across national jurisdictions since they are not currently harmonized by the WTO, and the international TRIPS agreement[57] does not provide a precise definition of industrial design or limitations for the eligibility of different types of objects for design protection (Galindo-Rueda & Millot, 2015). In practice, the scope of design right protection is defined solely by the drawings or photos in registered design right documents, which are stored in design right databases.

Several surveys have found that industrial designs play a minor role in appropriating returns from innovations (Arundel, 2001; Moultrie & Livesey, 2014; Lim et al., 2014; Galindo-Rueda & Millot, 2015). In Arundel's (2001) sample of innovative firms, only 3% reported registered designs to be the most important method to appropriate returns from innovation. Galindo-Rueda and Millot (2015) report that design rights were the least-used type of IP protection among the 20 largest IP applicants at the European level. They also point out that the reason for relatively rare use of design rights in many countries may be that the costs of design rights are perceived to be too high compared with the benefits, or that the protections provided by design rights are perceived to be too narrow (Galindo-Rueda & Millot, 2015). Moultrie and Livesey (2014) report that in their UK pilot study, most firms perceived registered designs to be difficult to defend and believed that design rights held little value as tradable assets. Lim et al. (2014) conducted in-depth interviews with seven Australian design companies and concluded that design rights are of limited relevance in the market for designs. The interviewees were aware of the design right system, but had made informed decisions not to use design rights actively. These findings on the limited usefulness and relative weakness of design rights raise the question of why their usage would surge in an industry with a history of minimal design right filings.

The recent study by Filitz et al. (2015) offers some indication that design rights are becoming more important. They point out that the active filing of European registered community designs and recent court cases — e.g., Apple vs.

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[56] In the EU, the definition of *a design* is as follows: "The appearance of the whole or a part of a product resulting from the features of, in particular, the lines, contours, colors, shape, texture and/or materials of the product itself and/or its ornamentation". Source: https://oami.europa.eu/tunnel-web/secure/webdav/guest/document_library/contentPdfs/designs/design_definition/62002_cv_en.pdf Accessed 11.2.2016.

[57] The Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement is Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization, signed in Marrakesh, Morocco, on the 15th April 1994. See: https://www.wto.org/english/docs_e/legal_e/27-trips_01_e.htm. Section 4 considers industrial designs (articles 25 and 26).

Samsung — suggest that firms regard design rights to be important for competition. Also, Orozco (2009) presents Apple as an example of successfully utilizing design rights in combination with other IPRs. Filitz et al. (2015), moreover, document different design right strategies within and between industries. Some firms register design rights much more selectively (automotive and tools), while others apply an "all-you-can-file" strategy, e.g., the footwear industry. In addition to industry specificity, experience in design right filings has been found to be associated with future filing activity in a recent study by Fjaellegaard et al. (2015). They use linked employer-employee data, which indicated that hiring a designer is associated with the firm's likelihood of producing aesthetic innovations measured in design right filings. Even though the evidence on the effectiveness of design rights is mixed and inconclusive, recent filing activity and the emergence of specific filing strategies suggest that design rights are important in many industries and product categories.

2.2 Uncertainty and strategic use of IPRs

In most industries, patent protection is imperfect and probabilistic (Ayres & Klemperer, 1999; Lemley & Shapiro, 2005; Farrell & Shapiro, 2008), which means that potential sellers of inventions are vulnerable to expropriation (Teece, 1986; Gans & Stern, 2003). Weak IPRs may therefore reduce the incentives to innovate and hinder the formation of markets for patent-protected inventions and licensing (Arora & Ceccagnoli, 2006; Gans et al., 2008; Spulber, 2013). Generally, our understanding of the behavioral effects of probabilistic property rights is limited. For instance, how do decision makers who use IPR systems for the first time form beliefs and learn (i.e., "update their beliefs") about the scope of protection provided by a particular protection method?

Game theoretical literature on patent litigation often focuses on analyzing competing firms' equilibrium strategies with a given probability of whether the court rules a patent to be valid and infringed (Choi, 1998; Farrell & Shapiro, 2008; Shapiro, 2010). In other words, game theorists implicitly or explicitly assume that patent strength is common knowledge (Shapiro, 2010). Thus, decision makers are implicitly considered to be fully aware of recent court rulings and case law in addition to other legislative changes, and that they interpret them in a similar manner. In practice, it is possible that decision makers have differing beliefs about the scope of IPR protection, either due to different prior experiences, asymmetric information, or cognitive biases (Bebchuck, 1984; Gans et al., 2008). Lab experiments suggest that decision makers are likely to be subject to self-serving biases, meaning they interpret new information favorably for themselves (Babcock & Loewenstein, 1997; Benabou & Tirole, 2002; Van den Steen, 2004; Miettinen et al., 2012).

In an operating environment in which the boundaries of IPRs are blurred and uncertain, an attack strategy might be the best form of defense or as Guellec & van Pottelsberghe (2007) put it, "If your competitors take out many patents, a condition for your survival is to do the same". Indeed, it has been documented that strategic patenting may lead to self-reinforcing "patent wars" within industries (Guellec & van Pottelsberghe, 2007). Hall and Ziedonis' (2001) description of the semi-conductor industry is a classic example. They found that the strengthening of U.S. patent rights in the 1980s led to "patent portfolio races" among semi-conductor firms. When patent-filing activity increases within an industry, the firms must ensure that they are not infringing on others' patents, i.e., to ensure that they have the freedom to operate (Grindley & Teece, 1997). This may lead to a new industry equilibrium in which competing firms file more patents to pre-empt or block competitors from patenting (Blind et al., 2009; Guellec et al., 2012), or to be able to negotiate better terms in cross-licensing agreements (Grindley & Teece, 1997; Ziedonis, 2004).

Filitz et al. (2015) confirm that strategic use of design rights is also prevalent in certain industries. Their interviews revealed that in the footwear industry, "some firms wittingly file invalid design rights to prevent infringement suits from third parties and/or to improve bargaining power over retailers". Orozco (2009) argues that relatively low cost and ease of prosecution induce experienced firms to seek multiple design patents to block rivals from entering their design space and cites Apple's strategy to protect iPod with various design patents as an example of this behavior. Thus, design rights seem to induce strategic behavior that is similar to strategic patenting, e.g., pre-emptive filing of design rights (cf. Gilbert & Newbery, 1982; Guellec et al., 2012).

2.3 Research questions

Our case study focuses on a specific local industry, Finnish sauna heaters, in which design right filings suddenly increased in 2008. Thus, our initial research question is why did the design right filings surge among Finnish sauna heater producers.

During the data-collection process (explained in detail in section 4.1), it became clear that within the industry, competing firms had different beliefs about the scope of design right protection, and they employed different filing strategies. Therefore, we pose two additional research questions: 1) How did the motives to use design rights evolve over time? 2) Which events offered the decision makers learning opportunities concerning the scope of design right protection?

3 Empirical context

3.1 Finnish IPR environment and design right system

The history of the Finnish Patent and Registration Office (PRH) began in 1835 when the Manufacture Board was established in the Finnish Senate, and the first Finnish patent was granted in 1842.[58] Throughout the 2000s, the Finnish IPR system has been ranked several times among the most advanced national systems in various international evaluations.[59]

Finland introduced its national design right system in 1971. This new institution was a result of a Nordic collaboration in which Sweden, Norway, and Denmark updated their design right legislation, and Finland introduced it (Government proposal 113/1970, Laisi, 2009). The new law made it possible to protect novel designs with individual character for a maximum of 15 years. In 1992, the Finnish IPR system was complemented with a utility model system (Laisi, 2009), which is a protection method for technical inventions that do not satisfy patentability requirements.

Finland became a member of the European Union in 1995 and has since implemented IPR law directives, including a design right directive (Government proposal 6/2002, implemented since 1st Aug 2002). The directive extended the maximum term of protection from 15 years to 25 years and extended the scope of protection by eliminating the product-class-specific protection. Previously, a design right was limited to Locarno product classes[60] specified in the application, whereas after the implementation of the directive, a design right was protected automatically in all classes. Moreover, amended design right law introduced a grace period, i.e., the option to file for design right protection within 12 months after the design has been publicly disclosed. On the 1st April 2003, the EU's Office for Harmonization in the Internal Market (OHIM, currently EUIPO) began to register EU-wide community designs (Filitz et al., 2015), which have led to a shift from national Finnish design right applications to registered community design right applications.

According to the Finnish Design Protection Act (12.3.1971/221), a design right provides an exclusive right to a design that is new and has individual character. The Finnish patent office examines the requirement before registering designs. The boundaries — i.e., novelty and individual character of design rights — are defined as follows (2 §):

"A design shall be considered new if no identical design has been made available to the public before the date of filing of the application for registration or, if priority is claimed, the date of priority.

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[58] Source: https://www.prh.fi/en/presentation_and_duties/historia.html Accessed 28th April 2016
[59] See World Economic Forum's Global Competitiveness Index.
[60] See http://www.wipo.int/classifications/locarno/en/ Accessed 19th August 2016

A design shall be deemed to be identical if their features differ only in immaterial details.

A design shall be considered to have individual character if the overall impression it produces on the informed user differs from the overall impression produced on such a user by any design which has been made available before the date of filing of the application for registration or, if priority is claimed, the date of priority. In assessing individual character, the degree of freedom of the designer in developing the design shall be taken into consideration."

Haarmann (2012) points out that when an applicant is granted a design right, she can be relatively sure that the granted design right does not infringe on other designs. The Finnish design right system has been criticized for providing only narrow legal protection. Thus, users of the system consider enforcement of design rights to be challenging, and some forgo it (Puustinen, 2001; Oesch et al., 2005). Generally, design right is considered to be protection only against direct copying (Finnish IPR strategy 2008; Puustinen, 2001).

3.2 Finnish sauna and design

The sauna is an integral part of both the traditional and modern Finnish culture (Tommila, 1996; Särkikoski, 2012). There are more than 2 million saunas in Finland.[61] The heart of a sauna is the heater ("kiuas" in Finnish, see Tommila, 1996 p.40; Helamaa, 1999). Thus, sauna statistics provide quite an exact proxy for the number of working sauna heaters. The interviewed sauna heater producers (see Table 2) estimate that roughly 200000 heaters are sold annually in the Finnish market.

Sauna heaters are durable goods with lifetimes of approximately 5–20 years. There are several different types of heaters, and their technical features and energy efficiency have been subject to continuous development for more than 100 years (Tommila, 1996; Helamaa, 1999; Särkikoski, 2012).[62] Generally, wood-burning sauna heaters (stoves) are popular in summer cottages, whereas urban apartments and houses often have convenient electric sauna heaters. In this paper, we refer to both electric sauna heaters and wood-burning sauna heaters as "sauna heaters" for simplicity and consistency.[63] Urbanization has led to a shift from wood-burning sauna stoves to electric heaters. The demand

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[61] http://www.stat.fi/tup/suoluk/suoluk_asuminen_en.html (Statistics of Finland) Accessed 30.6.2016.

[62] In 1904, The Finnish Economic Association was concerned that inefficient ovens wasted firewood. A committee was established to acquire blueprints for more energy-efficient ovens and later also for more efficient wood-burning sauna heaters. (Anonymous, 1999 p. 444)

[63] The oldest type of sauna is the smoke sauna, in which the heater is traditionally "a pile of stones" above a furnace (Vuolle-Apiala, 2011). Infrared sauna heaters and smoke sauna heaters are marginal products and are therefore left out of this analysis.

for electric sauna heaters increased in the 1970s and 1980s, when it became more common to include sauna rooms in urban apartments.[64] Harvia, which currently is the largest Finnish sauna heater producer, started to produce electric heaters in 1988.[65]

International patent classification (IPC) has used an eight-digit technology class for sauna heaters — A61H 33/06, "Artificial hot-air or cold-air baths; Steam or gas baths or douches, e.g. sauna or Finnish baths" — since the IPC system was established in 1971.[66] According to patent databases, the first Finnish sauna heater related patent dates back to 1906.[67] Moreover, when the design right system was introduced in Finland in 1971, the first design registration was a sauna heater designed by Finnish architect Matti Suuronen.[68] Figure 2 demonstrates how the IPR activity among sauna heater producers has evolved since the 1970s. There has been a shift from patent and utility model applications (technical inventions) toward design right applications after 2008.[69]

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[64] Statistics Finland reports that there were 548,000 saunas in flats in 1980, 932,000 in 1990, 1,202,000 in 2000 and 1,502,000 in 2010.
http://www.stat.fi/tup/suoluk/suoluk_asuminen_en.html Accessed 4th May 2016.

[65] http://www.harvia.fi/content/en/1/19/History.html Accessed 2nd May 2016.

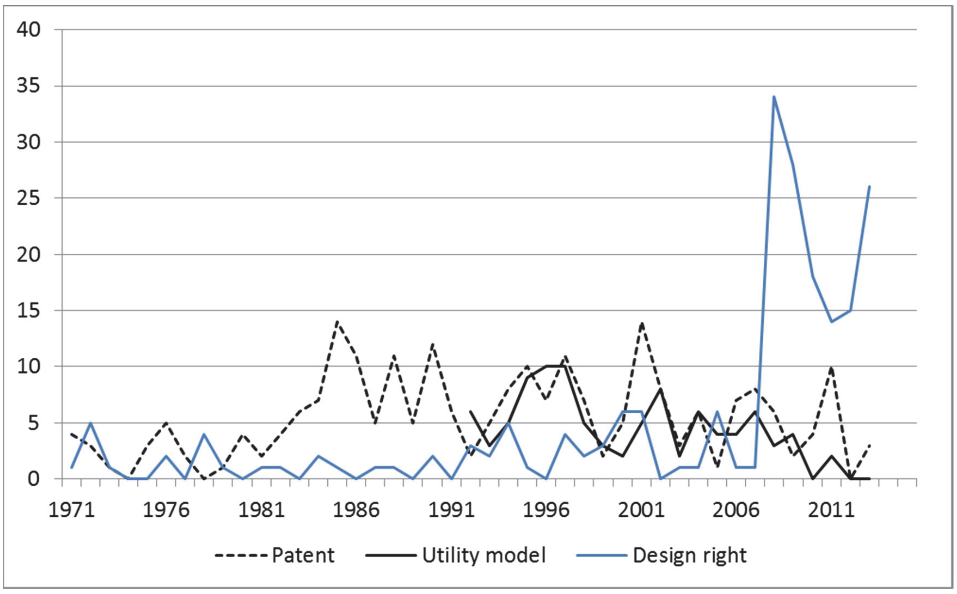
[66] See version 1 of IPC at http://web2.wipo.int/classifications/ipc/ipcpub Accessed 11th February 2016

[67] Finnish patent 2556 "Saunan uuni nimeltä säästäjä" granted on the 15th February 1906, inventor Kaarlo Juho Massinen. Source: PRH's PATE database, https://patent.prh.fi/pate/haku.asp

[68] Registered Finnish design right number 1 "Saunankiuas (kiuas)", applied on the 7th April 1971 by Matti Suuronen and Ingmar Westerling and registered on the 30th November 1971. Source: PRH, Design database. Sauna heater designs are classified into Locarno class 23-03 "heating equipment" (International classification for industrial designs). Suuronen's futuristic sauna heater "Sauna-Spirit" was never commercially produced (Särkikoski, 2012 p. 203).

[69] Trademark filings are not reported here. However, the Finnish trademark database shows that the industry started to actively protect brands already in 1950s and 1960s: e.g., Muko (1955), Misa (1964), Kastor (1965), Narvi (1967) and Tylö (1968). See: http://tavaramerkki.prh.fi/en/web/tietopalvelu/haku

FIGURE 2 Finnish sauna heater related IPR filings at PRH, 1971–2013



4 Methods

The approach of our in-depth case study is both explanatory and exploratory (Yin, 2003). We analyze underlying explanations for the increase in design right filings in a specific industry and explore the process of how decision makers learn the boundaries of design rights. We use several information sources, both secondary and primary, to triangulate our findings (Starr, 2014; Helper, 2000; Jick, 1979) and to create a detailed and cross-validated picture of the sequence of events. Our main information sources are IPR databases, especially the design right database of the Finnish Patent and Registration Office (hereafter PRH), EUIPO's DesignView, and public legal documents of the Helsinki district court from six sauna heater related design right litigation cases. We complement these with interviews of key informants, financial statement data, and other archival data. Table 1 lists the information sources.

TABLE 1 Data sources and use

Type of Data	Data Sources	Use in the Analysis
Archival data		
	Finnish design rights (PRH's Design database)	Track filing activity
	Related physical documents of design rights at PRH	Identify obstacle designs ("estemallit")
	Registered Community Designs (EUIPO's DesignView)	Track filing activity
	Appeal documents at the board of appeals of PRH	Identify who appealed and why
	Rulings and documents at the Helsinki District Court and Court of Appeals	Identify allegedly infringed and infringing designs. Crosscheck events.
	Finnish patents, utility models and trademarks relating to sauna heaters (PRH's PatInfo and Trademark databases)	Track filing activity
	Financial statement data of sauna heater producers (Virre digital database of PRH)	Track performance and identify M&As
	Sauna magazine of Finnish Sauna Association	Crosscheck events
Interviews		
	Confidential semi-structured interviews of key informants	Identify motives and beliefs and crosscheck events
Other		
	Websites of sauna heater producers	Crosscheck events

4.1 Data collection

Our data collection proceeded as follows: During autumn 2015, we collected IPR information (design right, patent, utility model, and trademark data) from PRH and EUIPO, analyzed the filing patterns, and identified key players in the sauna heater market. This filing information was updated during the research process as we learned more about the relationships between sauna heater firms, e.g., mergers and acquisitions, supplier relations and employees. For instance, some IPRs listed the inventor, instead of the firm, as the applicant. One of the study's authors visited the PRH and reviewed the physical design right documents. At this point, we learned about the court cases between sauna heater producers. We contacted Helsinki District Court and bought digital versions of court rulings. It was possible to order all the court-case material, including court evidence documents, from physical court archives and review it by visiting the Helsinki District Court. One of the authors also visited Helsinki District Court and the Court of Appeals, and digitized the documents.

Concurrently with the analysis of IPR documents, we were planning the semi-structured interview questions and gathered information about the Finnish sauna heater producer population. We identified producers from IPR databases, books focusing on saunas and sauna heaters (Helamaa, 1999; Tommila, 1996; Särkikoski, 2012), webpages of Finnish hardware stores and advertisements on the Sauna magazine. As the firm population is small, we decided to interview all identified sauna heater producers to take into account all perspectives and avoid confirmation bias. Since the beliefs, motives, and decision-making processes of decision makers are typically not directly observable to the researcher from the usual data sources, the only way to learn more about these is to ask decision makers directly by conducting interviews (Bewley, 2002; Huber & Power, 1985).

We identified and contacted 18 firms, of which 14 key informants were interviewed between November 2015 and May 2016. Most of the interviewed persons were company founders, CEOs, or ex-CEOs. Two firms refused to participate, and CEOs at three firms could not be reached. The firms that our interviewees represented accounted for more than 80% of Finnish sauna heater related design right applications filed between 1990 and 2013, and also accounted for a large share of sauna heater related patent and utility model applications filed between 1990 and 2013 in IPC class A61H 33/06.[70] Table 2 lists the interviewed persons.

[70] A large share of other sauna heater related IPR applicants, which our interviews did not cover, consists of individual inventors.

TABLE 2 List of interviewees

Firm	Position	Inventor/Designer	Date	Reason for non-response
IKI-Kiuas	Founder, ex-CEO	X	9 Nov 2015	
IKI-Kiuas	Ex-CEO	X	16 Nov 2015	
IKI-Kiuas	CEO		16 Nov 2015	
Tähtisaunat	Founder, CEO	X	4 Dec 2015	
Sydänkiuas	Founder	X	4 Dec 2015	
Harvia	CEO	X	25 Jan 2016	
Helo (former Saunatec)	Ex-CEO		1 Feb 2016	
Mondex	Founder, ex-CEO	X	15 Feb 2016	
Narvi	Ex-CEO		25 Feb 2016	
Kauhavan Rauta	Founder, ex-CEO	X	1 Mar 2016	
Designpolis	CEO	X	8 Mar 2016	
Vuolux	CEO	X	10 Mar 2016	
Muko	CEO		15 Apr 2016	
Muko	Ex-CEO		15 Apr 2016	
Misa	CEO		26 Apr 2016	
Misa	Production manager		26 Apr 2016	
Tulikivi	CEO		6 May 2016	
Teuvan keitintehdas	CEO		13 May 2016	
Jadeca	CEO			No contact
Sawo	CEO			No contact
Sauna-Eurox	CEO			Refusal
Farmtools				Refusal
Aurinkokiuas	Founder, CEO	X		Deceased
University of Helsinki	IP scholar	X	11 Jan 2016	
IP service firm	IP lawyer		11 Mar 2016	
International Sauna Association	President		14 Mar 2016	
Jussi Ahola Design	CEO	X	2 May 2016	
VTT	Standardization expert (retired)		4 May 2016	
PRH	Director		13 May 2016	
University of Helsinki	IP scholar		23 May 2016	

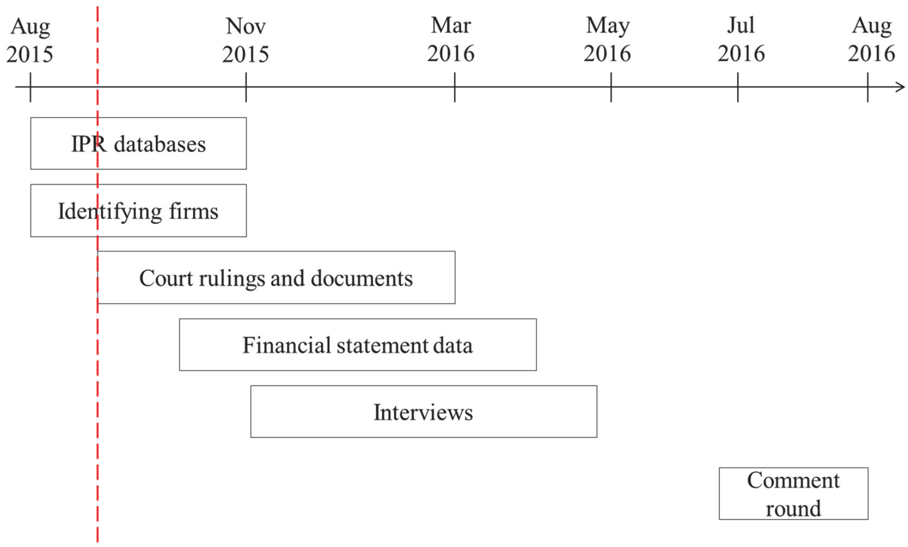
Key informants, i.e., the decision makers working for sauna heater producers, were interviewed either face-to-face (13 persons) or by phone (five persons) using the semi-structured interview method.[71] All interviews were recorded and transcribed. The interviews provided information about the underlying motives of decision makers, which the archives could not provide, and helped us understand the timing of events better. We also conducted four unstructured interviews with IPR experts who specialize in design rights. They shared with us their experiences on how the Finnish design right system functions in practice.

Figure 3 illustrates the whole data collection and analysis process, and indicates the point in time when we received detailed information about the court

[71] The semi-structured interview questions are available from the corresponding author upon request.

cases between sauna heater producers (see Table A.1 in appendix). At this point, we posed two additional research questions (see section 2.3).

FIGURE 3 Data collection process



Notes: The dashed red line indicates the point in time when we learned about the court cases in which design rights were involved. At this point, we supplemented the original research question with two additional ones.

4.2 Data analysis

Step 1. Construction of event history database

We began our case study by identifying focal events and constructing an event history database (see table A.2 in the appendix). The database was updated and refined as we discovered more about the Finnish sauna heater markets. We limit our analysis to the post-1990 period since design rights were not actively used among sauna heater producers before the 1990s. Also, most of the identified key informants have worked at sauna heater producing firms only after 1990.

Step 2. Identification of phases and description of events

We analyzed the event history database and divided the events into three phases. Phase I describes the emerging design trend among sauna heater producers and the market entry of IKI-Kiuas, a firm that introduced a novel sauna heater design to markets and whose IPR strategy relied solely on design rights. Phase II narrates the competitive entry of other sauna heater producers and court cases, in which IKI-Kiuas, the pioneer, sued competing sauna heater producers for design right infringements. Phase III focuses on the period after the court cases were resolved and the uncertainty considering the scopes of design rights was unravelled. All three phases are divided into a brief description of IPR filing activity and a review of focal events, motives to use design rights, and related learning events.

Step 3. Systematic analysis of data

In section 6, we present our interpretation of the collected evidence and answer the research questions. The challenge with case study research traditionally has been the lack of methodological rigor (Gibbert et al., 2008; Ketokivi & Choi, 2014). A key issue in explanatory case study research is to distinguish between the actual evidence and the investigators' interpretation of the evidence (Harder, 2010 pp. 370–371). To make this distinction as clear as possible, section 5 presents the evidence as objectively as possible, and in section 6, we provide our interpretation. Finally, to increase reliability, we followed the suggestion of Yin (2003) and sent the draft of the case study to the interviewed persons so that they had an opportunity to comment on it.

5 The use of design rights among sauna heater producers, 1990–2013

5.1 Phase I: A novel design and market entry (1990–2007)

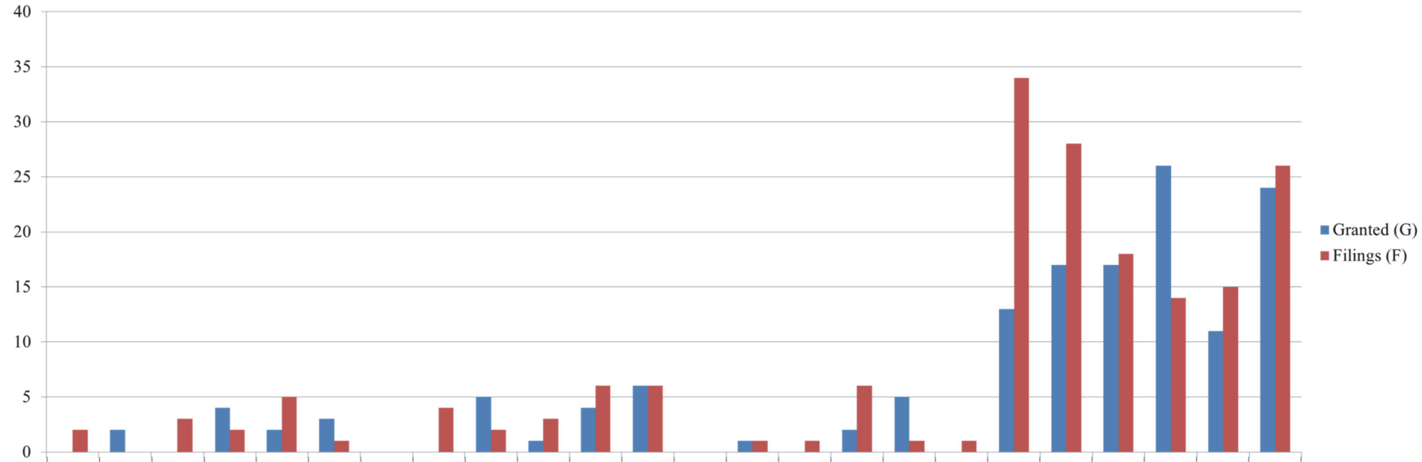
This first phase illustrates how design gradually became an important part of sauna heaters. In the early 1990s, design thinking started to emerge, and some sauna heater producers began to hire famous industrial designers. According to our interviews, the emerging sauna heater design trend was initiated by the more general interior design trend.[72] Central to our case, the first phase saw the entry of a new sauna heater producer with a novel product design.

5.1.1 IPR activity

Figure 2 in section 3.2 demonstrates how patents and utility models were more actively used than design rights as protection methods for sauna heaters between 1990 and 2007. Tables 3–5 present IPR filing activity by sauna heater producers. They show that sauna heater related design right filing activity was at a very low level between 1990 and 2007 and that utility models were applied for mostly by firms that also applied for patents.

[72] According to an interviewee, at the beginning of the 1990s, Helo (then Saunatec) organized a sauna heater design competition, and industrial designer Arto Kukkasniemi designed a new sauna heater model for Helo.

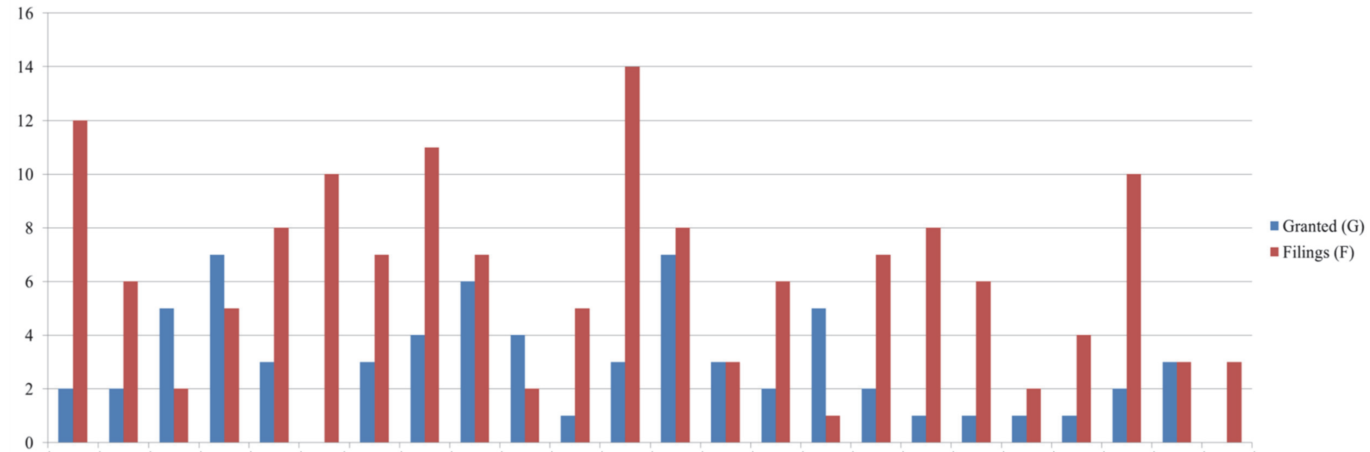
TABLE 3 Composition of sauna heater related design right filings and registrations 1990–2013



Applicant	1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001	
	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F
Aurinkokiuas																								
Pekka Pirinen																								
Designpolis							0	1	1	0														
Harvia																								
Helo					0	1	1	0	1	2	1	0							0	1	2	4		
Kastor															0	3	3	0			0	1	1	0
Tylö																	1	1						
IKI-Kiuas															0	1	1	1	1	0	0	1	1	2
Jouni Kerrman																								
J K Roster																							4	4
Kajosauna																								
Kauhavan Rauta																								
Mondex																								
Narvi																								
Puulämpö					0	2	2	0																
Starsauna Oy																								
Tulikivi																								
Others	0	2	2	0			1	1	0	3	2	1							0	2	2	0		
Total	0	2	2	0	0	3	4	2	2	5	3	1			0	4	5	2	1	3	4	6	6	6

Applicant	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Total	
	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F
Aurinkokiuas																	1	1	1	1	2	3	1	2	5	7
Pekka Pirinen																							2	2	2	2
Designpolis																									1	1
Harvia									1	1			1	5	2	1			4	1			1	1	9	9
Helo							1	1					0	1	2	2	3	3	4	3	2	2	1	1	18	21
Kastor											0	1	2	1											6	6
Tylö																	1	1			1	1			3	3
IKI-Kiuas			1	0	0	1	1	0					7	11	5	2	1	2	1	3	4	4	1	0	24	28
Jouni Kerrman															0	1					0	1			0	2
J K Roster													1	3	7	9	6	2	3	3					21	21
Kajosauna																							2	2	2	2
Kauhavan Rauta													0	1											0	1
Mondex							0	4	4	0			0	8	0	13	4	6	8	0	2	0	10	13	28	44
Narvi													0	1			1	0					1	1	2	2
Puulämpö																									2	2
Starsauna Oy																	0	2	3	1					3	3
Tulikivi																			1	1					1	1
Others			0	1			0	1					2	3	1	0	0	1	1	1	0	4	5	4	16	24
Total			1	1	0	1	2	6	5	1	0	1	13	34	17	28	17	18	26	14	11	15	24	26	143	179

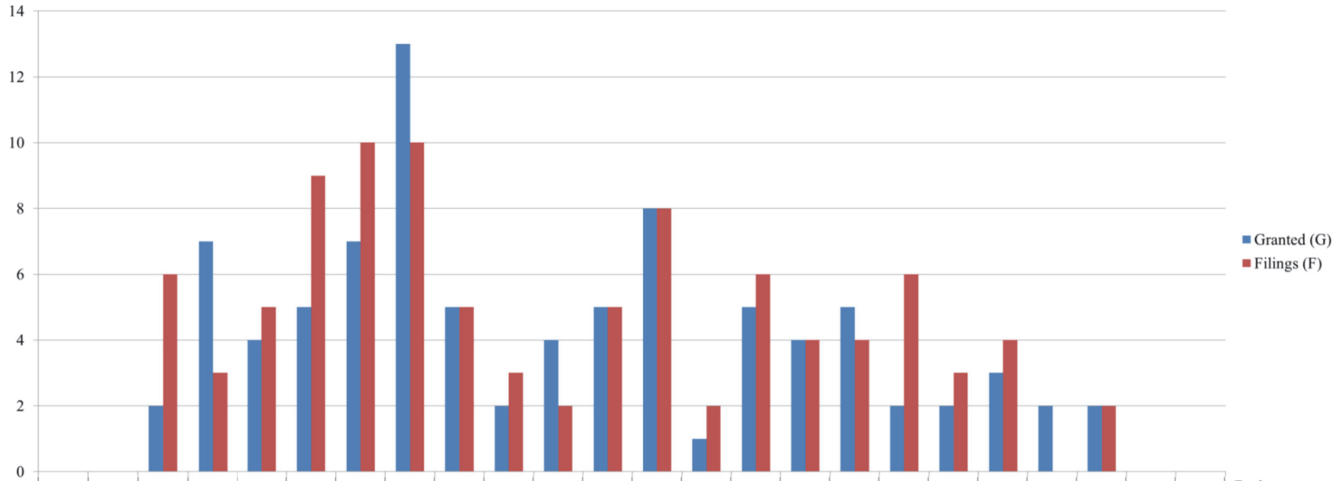
TABLE 4 Composition of sauna heater related patent filings and grants, 1990–2013



	1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001	
Applicant	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F
Aurinkokiuas																								
Pekka Pirinen																								
Harvia																	0	2	1	0				
Pertti Harvia	0	1			0	2	1	0	1	0			0	2			2	0			0	1	0	1
Helo	0	3	1	0	2	0	1	0	1	0			0	1	1	1	1	0						
Kastor																								
Mondex																							0	1
Narvi									0	1			1	0										
Sauna-Eurox											0	1			1	0	0	1						
Tähtisaunat																								
Vuolux																							0	3
Warmheart																								
Reijo Vierimaa																							0	1
Others	2	8	1	6	3	0	5	5	1	7	0	9	2	4	2	10	3	4	3	2	1	4	3	8
Total	2	12	2	6	5	2	7	5	3	8	0	10	3	7	4	11	6	7	4	2	1	5	3	14

	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Total	
Applicant	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F
Aurinkokiuas																									0	0
Pekka Pirinen																							0	1	0	1
Harvia									0	1			1	0			0	1	1	0					3	4
Pertti Harvia			0	1	0	1	1	0		1	1	0													6	10
Helo					0	1			1	0															8	6
Kastor													0	2	1	0									1	2
Mondex			0	2			1	1	0	2			0	1	0	1					1	0			2	8
Narvi																									1	1
Sauna-Eurox	1	0																							2	2
Tähtisaunat																	0	1			1	0			1	1
Vuolux			1	0																					1	3
Warmheart	0	1					1	0																	2	1
Reijo Vierimaa	1	0																							1	1
Others	5	7	2	0	2	4	2	0	1	3	0	8	0	3	0	1	1	2	1	10	1	3	0	2	41	110
Total	7	8	3	3	2	6	5	1	2	7	1	8	1	6	1	2	1	4	2	10	3	3	0	3	68	150

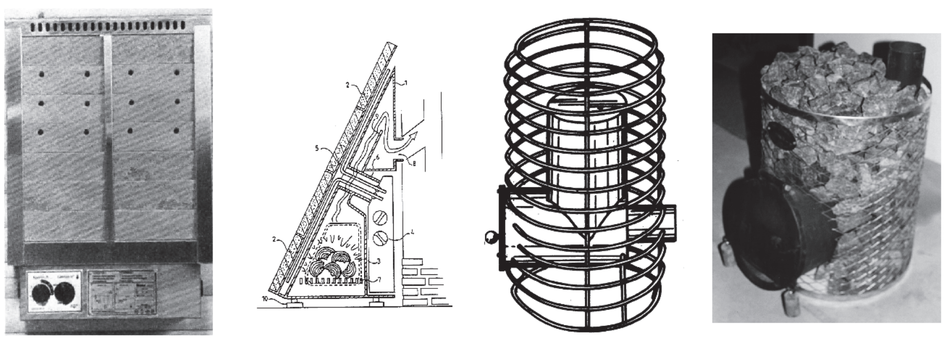
TABLE 5 Composition of sauna heater related utility model filings and grants, 1990–2013



Applicant	1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Total	
	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F	G	F
Harvia																	0	1	1	0																													1	1
Pertti Harvia							1	1							2	2			0	2	2	0	1	1																									6	6
Helo					2	6	4	0	1	2	2	1	0	5	5	0															1	1																	15	15
Kastor																																			0	1													0	1
Mondex																							1	1	4	4	0	2	4	2	0	1	1	1				1	1	1	1	0							12	13
Seppo Nikkanen																																	0	1															0	1
Narvi									1	1																			0	2	2	0																	3	3
Sauna-Eurox							2	2	1	1	1	1	1	2	2	2	1	0	0	1	1	0																											9	9
Vuolux																																											1	1					1	1
Reijo Vierimaa																					0	1	1	0																									1	1
Others					0	0	0	0	1	1	2	7	6	3	4	6	4	4	1	0	1	1	2	3	4	4	1	0	1	2	1	2	4	2	2	5	2	2	2	3	1	0	1	1					40	46
Total					2	6	7	3	4	5	5	9	7	10	13	10	5	5	2	3	4	2	5	5	8	8	1	2	5	6	4	4	5	4	2	6	2	3	3	4	2	0	2	2					88	97

During the first phase, several product innovations were introduced. Soapstone sauna heaters and generally "plane sauna heaters" (sauna heaters with a large stone surface) were a new phenomenon in the 1990s, and several firms began to sell them. The first Finnish design right for a soapstone sauna heater was applied for and registered to Nunnanlahden Uuni in 1993 (Finnish design right No. 16454, see Figure 4), but the design right was not renewed after the first five years. In the mid-1990s, stone radiator producer Mondex introduced and successfully commercialized soapstone sauna heaters, which it protected with a utility model (Finnish utility model No. 3114). Also, Sauna-Eurox introduced a plane sauna heater that was patent and utility model protected (Finnish patent No. 98788 and utility model Nos. 2322, 2981, 3015). Later, Vuolux entered the product segment with patent and utility model protected soapstone sauna heaters. Also, Laavukiuas sold utility model protected soapstone sauna heaters, which at that time were the only "combination heaters" with both alternative heating methods (wood-burning and electricity). Laavukiuas was not successful, and Misa bought the business from Laavukiuas. Helo (RCD 000406194) and Harvia (RCD 000463195) were the first to apply for sauna heater related registered community designs in 2005 and 2006, respectively, and these designs were soapstone sauna heaters.

FIGURE 4 Examples of sauna heater inventions and novel designs in the 1990s



A B C D

Notes: A: a soapstone heater (Nunnanlahden Uuni, Finnish design right No. 16454), B: a plane heater (Laavukiuas, Finnish utility model No. 2307), C: an open frame heater (Designpolis, Finnish design right No. 17063), D: a mesh sauna heater (IKI-Kiuas, Finnish design right No. 20399). Source: PRH's design database and patent database.

In 1993, Designpolis, a firm launched by Finnish entrepreneur and inventor Osmo Rantapelkonen, filed a design right application for a pillar-shaped, wood-burning sauna heater with an open-structure exterior. PRH granted the design right (No. 17063, see Figure 4). Since Designpolis did not have any production facilities, it tried to license the design to a large sauna heater producer in 1995.[73] At that time, Designpolis had a couple of heater prototypes, but had no sales and the incumbent was not interested in licensing. Designpolis decided not to continue commercialization and let the design right lapse after the first five years. The interviewees systematically stated that licensing is not common in the sauna heater industry and that IPRs are more often transferred via mergers and acquisitions than through licensing.

> *"It has been discussed whether somebody would buy a license or whether we could produce something on a license, but I consider it as a precluded option."* (Interviewee R)

> *"Once in a while, somebody offers something, but we have never bought anything. And usually, these people are not from the sauna heater industry."* (Interviewee F)

> *"Quite frequently, someone with an idea calls and suggests collaboration."* (Interviewee J)

Jouni Kerrman developed a wood-burning sauna heater with a novel mesh-frame design in the late 1990s (Tommila, 2009). He got the idea in the mid-1990s and started to develop prototypes as a hobby. Commercialization of the design was his goal from the start, and in 1997, IKI-Kiuas was established. The firm filed its first design right application at PRH briefly after the firm was established, but this design did not have an open structure. In 1999, IKI-Kiuas applied for the first design right (Finnish design No. 20399, see Figure 4) for a distinctive mesh-frame sauna heater. PRH registered the design after examination of its novelty, indicating that the design satisfied requirements of registration (novelty and individual character; see section 3.1). Later, in 2004, IKI-Kiuas filed the first design right application (Finnish design right No. 23810) for an electric version of the mesh sauna heater and it was granted in 2005. The difference between these sauna heaters and traditional models (see Figure A.1 in the Appendix) is 1) they have a pillar shape, 2) their exterior is made of mesh, 3) they require many more heater stones, and as a result, the sauna bath has lower temperatures and is more humid. For simplicity and consistency, we refer to this type of sauna heater, which has either a mesh exterior or a pillar structure, as a mesh sauna heater.

All interviewed sauna heater producers confirmed that IKI-Kiuas was the first to commercialize mesh sauna heaters, although several interviewees also said the company just re-applied the old design for a smoke sauna stove in a new way and that the design, hence, was not novel[74]:

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[73] Evidence from IKI-Kiuas vs. Harvia litigations (see Appendix).

[74] The first Estonian design right for a mesh sauna heater (00919) was registered already on the 27th February 2004 suggesting that Estonian sauna heater producers adopted the novel design before other Finnish producers.

> *"The litigation considered a product, which had existed for ages. It made no sense suddenly to file for an exclusive right for it, as if you could have an exclusive right to produce a product, which others have already produced."* (Interviewee Q)

> *"They were not novel to market. They were already sold in the 1950s, but they just disappeared temporarily from the market."* (Interviewee F)

> *"These mesh sauna heaters, they were already produced in the 1960s."* (Interviewee C)

However, we did not find any documents about earlier versions of mesh frame heaters.

Between 1999 and 2005, the Finnish sauna heater industry witnessed a court case in which Harvia sued Narvi for utility model infringement, concerning Finnish utility model No. 2972. Although the infringement case considered technical features of electric heaters, the court case documents revealed that Harvia and Narvi were concurrently in the middle of an aggressive sauna heater price war. Helsinki District Court ruled in favor of the defendant in 2001. Harvia appealed to the Court of Appeals, which upheld the decision on the 22nd November 2005, and denied a request to appeal to the Supreme Court.

5.1.2 Motives to use design rights

In addition to the fundamental motive to protect a design from imitation, we identified two additional motives to use design rights during the first phase: 1) licensing for external manufacturing and 2) protection for contract-designed sauna heaters.

The first designers of mesh sauna heaters reported that their main goal was to licence the design for manufacturing by another firm. These design right owners did not have the manufacturing capacity, retail networks, or marketing resources necessary for commercialization and therefore attempted to make deals with established firms within the industry. The interviewees reported that at this point, they had the genuine belief that a design right offers sufficiently strong protection to enable such licencing transactions. In the late 1990s, Helo hired famous Finnish designer Ristomatti Ratia to design a new sauna heater. Ratia's name was actively used in the marketing of this new sauna heater design. Helo filed a design right application (Finnish design right No. 21091) for this design.

5.1.3 Learning events

During the first phase, three distinct courses of events took place that created opportunities for learning about the scope of design right protection. First, the pioneer, IKI-Kiuas, filed for and was granted several design rights: Between 1990 and 2007, the company was granted nine sauna heater related design rights. As the granting of design rights depends on PRH determining whether the requirements of novelty and individual character have been met, these decisions communicated to the designer that the filings were valid. Therefore, granting the design rights may have had a positive effect on the beliefs of some decision makers about the strength of design right protection.

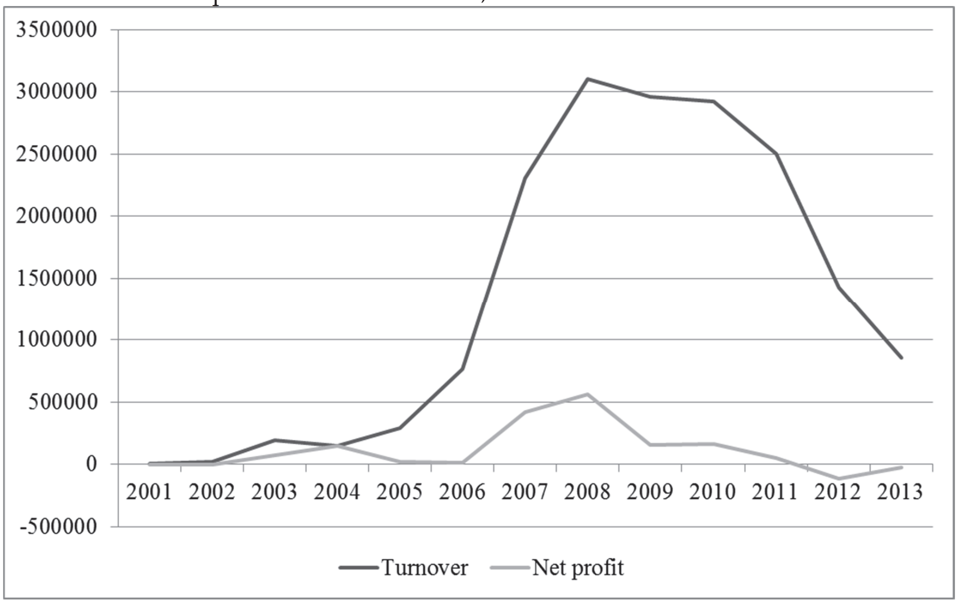
The second important turn of events was the tendency of incumbents to decline licencing and sale offers by designers with granted design rights. Both IKI-Kiuas and Designpolis attempted licencing. We found evidence that in 2000, IKI-Kiuas tried to sell its sauna heater business to existing sauna heater producers: A document that was used as a piece of evidence in forthcoming court cases (see section 5.2) suggests that IKI-Kiuas tried to sell its business to Helo, Harvia, Misa, Narvi, Suomen Puulämpö, Kastor, Mondex, and Tylö in the early 2000s.[75] However, at that time, the producers were not interested, as they were not convinced of the market potential of design heaters.[76] Some interviewees denied that there were any negotiations. In any case, the failed licencing and sale attempts signalled to the design right owner that the design right, in itself, without manufacturing facilities, has limited value.

This led the pioneer to put effort into marketing and selling mesh sauna heaters on its own, but with little success. According to our interviews, only a couple of dozen sauna heaters were sold until 2005. Over time, IKI-Kiuas, however, gathered important references and publicity by selling sauna heaters to the president of the Philippines, the then prime minister of Russia (Vladimir Putin), the CEO of Nokia (Jorma Ollila) and several famous Finnish sportsmen. According to our interviews, the Habitare 2005 design fair, the largest annual event for furniture and interior decoration and design in Finland, was the crucial event, after which the demand for mesh sauna heaters increased remarkably. Figure 5 presents the financial performance of IKI-Kiuas and shows how the business grew around this time. Ultimately, IKI-Kiuas was successful in commercializing its novel design, and this profitable product segment was also noticed by incumbent sauna heater producers. Several interviewees said the market signalled increasing demand for mesh heaters and that they had to respond to this trend.

[75] Defendant's (Harvia) written evidence H2, "History of IKI-Kiuas". Written by Jouni Kerrman on 4th June 2008.

[76] Of course, the details of negotiations are known only to the negotiating parties, so outside observers lack an objective information source. Thus, these claims should be interpreted with caution.

FIGURE 5 Financial performance of IKI-Kiuas, 2007–2013

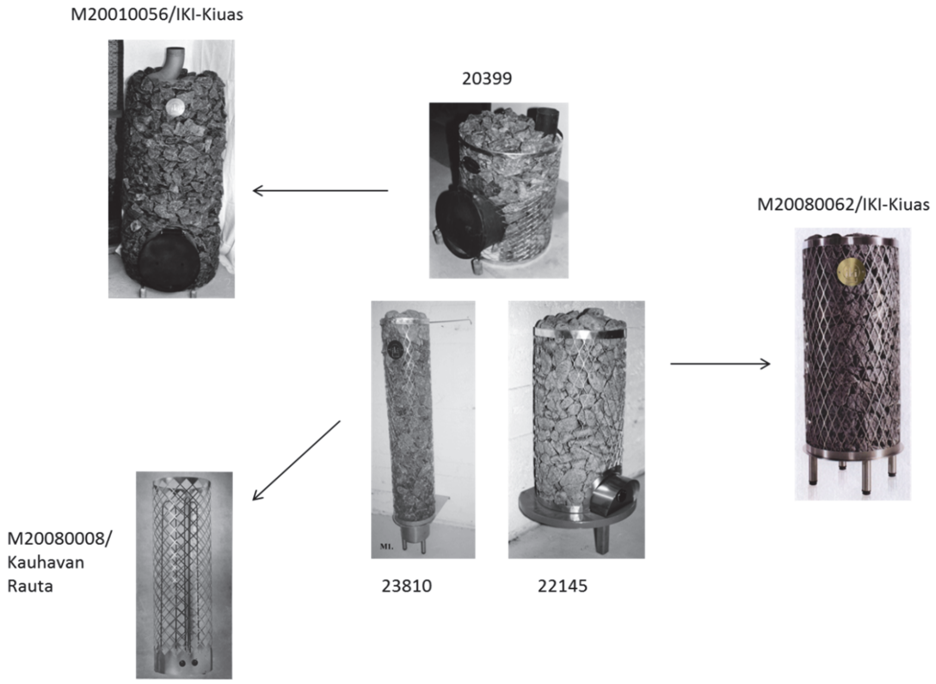


Source: PRH's financial statement database Virre.

The third focal learning opportunity during this time resulted from one of IKI-Kiuas' filings being rejected due to one of its own granted design rights being an obstacle to it. Design right application No. M20010056 was rejected by PRH in 2001. According to PRH, the design was not sufficiently different from IKI-Kiuas' own design, Finnish design right No. 20399 (see Figure 6). The stated grounds for rejection were:

> *"The applied design differs from the obstacle design so that the mesh in applied design has a lighter structure than the mesh in obstacle design, and also the applied design is taller than the obstacle design. The bureau considers that the mentioned differences are not sufficient to bring about essential difference between the applied design and the obstacle design."* (PRH's decision not to grant design right application No. M20010056 on the 20th Jun 2001)

FIGURE 6 Obstacle designs for granting design rights



Source: PRH’s design database

This turn of events signalled that a design right protects also against designs that have some minor differences and not just against exact copies. Therefore, this may have strengthened the beliefs regarding the scope of protection achieved with a design right.

5.2 Phase II: Competitive entry and alleged infringements (2008–2010)

Between 2008 and 2010, several sauna heater producers started to produce mesh sauna heaters, which led to litigations initiated by IKI-Kiuas. The uncertainty about the scopes of design rights lasted until November 2010, when PRH’s board of appeals issued its rulings on the validity of several design rights. The global financial crisis hit the Finnish economy harshly during this period. In 2009 alone, Finnish gross domestic product (GDP) decreased by 8.3%.[77] This had a negative effect on the construction sector and the demand for all kinds of sauna heaters decreased dramatically.

[77] Source: Statistics Finland, Annual national accounts.

5.2.1 IPR activity

Sauna heater related design right filings hit a record level in 2008, and in 2009 and 2010, filings remained at high levels (see Figure 2). A two-sample t-test for the difference in means corroborates the fact that the average annual filings were statistically and significantly (t-statistic -6.041, $p<0.05$) higher between 2008 and 2013 (mean 22.5) than between 1990 and 2007 (mean 2.4), whereas for sauna heater related patent and utility model filings, no similar pattern can be observed: Sauna heater related patent filings temporarily decreased, and utility model filings almost totally ceased between 2008 and 2010.

The design sauna heater market witnessed both *de novo* and *de alio* entries during the period. In 2008, several firms diversified into the mesh sauna heater product segment and filed design right applications concurrently: Kauhavan Rauta, Harvia, Mondex, Helo, and Narvi. Misa also entered the market, but filed no design right applications. Moreover, in 2010, *de novo* firm Aurinkokiuas entered and protected its sauna heaters with design rights (e.g., Finnish design right No. 24883). Vuolux, which previously had focused on soap-stone sauna heaters, diversified into the mesh sauna heater segment in 2010, but did not file design right applications. Similarly, Star Sauna, a sauna-building firm, diversified into the design sauna heater product segment and filed a patent application for a sauna heater with a module structure (Finnish patent No. 122490).

5.2.2 Motives to use design rights

During the second phase, we can discern two distinct motives to use design rights in addition to the fundamental protection from imitation motive: 1) freedom to operate and 2) defense in court (which is related to freedom to operate). As described in the section above, other sauna heater producers introduced new sauna heater designs that had the same basic idea as the pioneer's (IKI-Kiuas) models. They filed design right applications around the time that they launched the products.

The freedom-to-operate motive means that by being granted a design right, a firm can ensure that it is not infringing on other firms' design rights. Therefore, filing for design rights became concurrently a risk management issue in addition to a basis for competitive advantage. During the aforementioned litigations, some defendants used design right filings to strengthen their cases. The court cases also increased awareness of the design right system among sauna heater producers since the litigation received news media attention. As the firms became aware of the design right institution, they also learned, based on the court rulings, that a design right only protects from exact copying. Therefore, the firms began to see value in design rights as a vehicle to deter other firms from making direct copies.

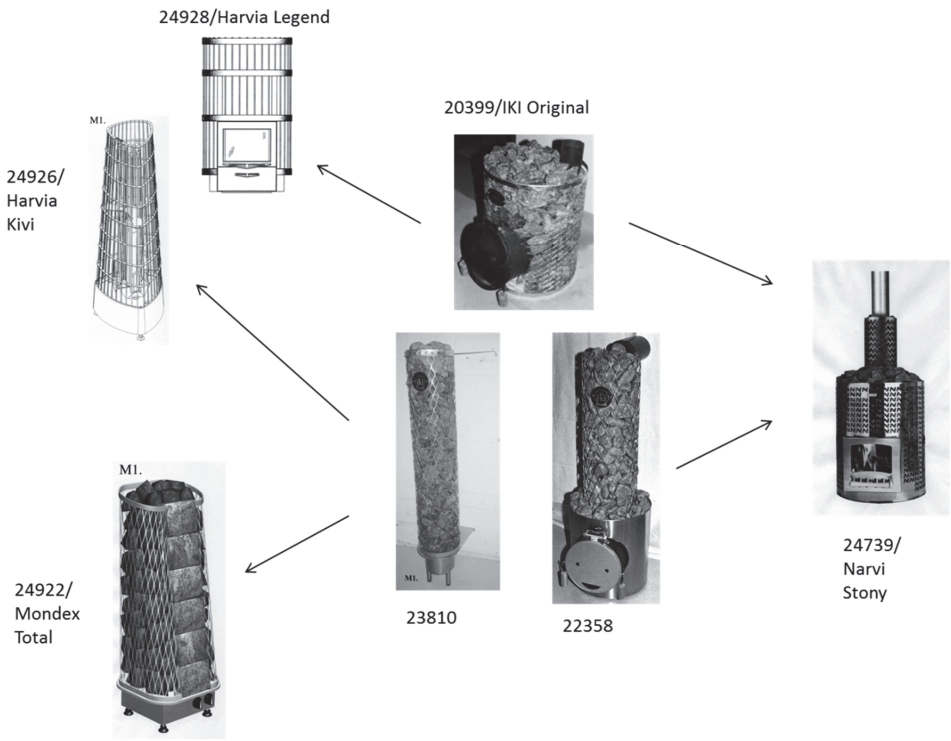
5.2.3 Learning events

During the second phase, there were three events that gave the participants opportunities to shape their beliefs concerning design right protection: 1) A competitor was not granted a design right due to the pioneer's design being an obstacle to it, 2) several other competitors were granted design rights despite the pioneer's appeals, and 3) the pioneer sued these competitors for infringements and lost.

The first event concerned a firm called Kauhavan Rauta. According to PRH's design database, it was the second Finnish firm that applied for a design right for a mesh sauna heater, when it filed its application in January 2008 (Finnish design right application No. M20080008). However, PRH rejected the design right application in June 2008, as it did not differ substantially from IKI-Kiuas's design No. 23810 (see Figure 6). Kauhavan Rauta appealed this decision to PRH's board of appeals, which ultimately upheld the decision not to grant the design right in 2010. As a result, Kauhavan Rauta ceased to produce and sell mesh sauna heaters. This event likely reinforced sauna heater producers' beliefs concerning the strength of design right protection.

However, the events relating to other competitors were completely different. In 2008, Harvia, Mondex, and Narvi introduced novel sauna heater designs on the Finnish market. According to PRH's design right documents, Harvia and Mondex applied for design rights in spring 2008. Their applications were made public in May and June 2008. IKI-Kiuas responded by filing claims at PRH that the designs by Mondex and Harvia did not satisfy novelty requirements. In September 2008, IKI-Kiuas decided to enforce its exclusive design rights, alleging that Harvia's heater designs infringed on them (see Figure 7). In November 2008, IKI-Kiuas also sued Mondex and Narvi, alleging design right infringements.

FIGURE 7 Alleged design right infringements



Source: PRH's design database

At this point, Narvi did not have any design rights, but it filed a design right application for the design of its allegedly infringing sauna heater (see Figure 7) in December 2008. Due to the grace period, introduced to the Finnish system when the nation implemented the EU's design right directive in 2002, it was possible to be granted a design right for a design that had become public if no more than 12 months had passed since the publication date. The fact that PRH eventually granted the design right to Narvi was an indication that the scope of IKI's design rights did not cover Narvi's design.

The infringement cases concerned the boundaries of IPRs, i.e., the scope of the pioneer's design rights relative to defendants' sauna heater designs. PRH granted design rights to competitors' design heaters despite the claims made by IKI-Kiuas. This was an indication that according to design right examiners at PRH, these new designs were not infringing on existing design rights, i.e., the designs were novel and had individual character. Kerrman, the designer of IKI-Kiuas' sauna heater designs, appealed, but PRH's board of appeals kept the design rights in force in its decision dated November 2nd, 2010. The documented correspondence between the board of appeals and IKI-Kiuas illustrates how Kerrman reacted when PRH granted design rights to competitors' mesh sauna heaters. Here is a quote from the letter (15th Jan 2009) to the board of appeals:

> *"During the past years, I have applied for and been granted several design rights in the belief that they will protect me as the first producer from copying and unhealthy competition. Now it seems that it is the opposite case. PRH seeks to protect the imitators from me."*

Legal documents of the court cases reveal that sauna heater experts evaluated the sauna heater designs for the Helsinki District Court (see Table A.2 in the Appendix) and concluded that an informed person would not confuse the pioneer's designs with other products, but that an ordinary consumer might. The court ruled that the imitators' heater designs were based on the same idea, but that they were not direct design copies. According to the court rulings, they differed in several relevant details and that the overall impressions made on an informed user were substantially different compared with IKI-Kiuas' designs. Thus, the competitors' designs were not infringing on the design rights of IKI-Kiuas.[78] Our interviewees consistently pointed out that IKI-Kiuas held a false belief about the scope of design right protection: they thought that design rights protected the entire idea of mesh sauna heaters.

> *"At that point, it little by little became clear to IKI, as litigation proceeded, what the design right protects and what it does not."*(Interviewee F)

> *"It was totally clear; they did not understand what they were doing. They did not understand that they are not going to win. - - just sued due to stubbornness. - - but after all, the end result was that they burned a huge amount of money."* (Interviewee L)

> *"It wasn't a patent for a mesh sauna heater, which would prevent everybody from producing. There was no technical invention. The design was protected, and nobody infringed that design right, and it was a fact."* (Interviewee J).

> *"It [the court case] was a walkover."* (Interviewee C)

> *" - - it was quite a unique solution, and if they had filed the design right application in time — and nevertheless lost — then that probably indicates that these solutions are easy to imitate, unless one doesn't copy one-to-one."* (Interviewee D)

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[78] After the first set of court cases in summer 2009, there was "a new wave" of design right court cases when former IKI-Kiuas CEO Jouni Kerrman, who was also the designer and owner of the company's mesh sauna heater design, sued Helo, Misa, and Kauhavan Rauta for design right infringements. However, these suits were cancelled before hearings were held in district court. IKI-Kiuas (the firm) was not involved in these cases.

5.3 Phase III: Post litigations (2011–2013)

After the district court's decision to dismiss the infringement cases in 2009 and the decisions of PRH's board of appeals to grant design rights to other sauna heater producers in 2010 despite IKI-Kiuas' appeals, several uncertainties regarding the scopes of design rights were settled. Design has become an integral part of Finnish sauna heaters, but sauna heater related design right filings have decreased slightly relative to the preceding period.

5.3.1 IPR activity

Between 2011 and 2013, design right filing activity decreased relative to 2008–2010 (see Figure 2). An analysis of the firm-level IPR statistics (see Table 3) reveals that the increase in design right filings in 2013 was driven by one firm: Mondex was the applicant in 10 design right filings in 2013. The leading Finnish fireplace producer Tulikivi entered the sauna heater market in 2011 and protected its sauna heater designs with registered community designs via EUIPO (then OHIM). A general trend has been that sauna heater producers have shifted to file at the EUIPO instead of PRH.

Moreover, a few Estonian sauna heater producers have entered the Finnish sauna heater market with their own mesh sauna heater models. However, none of the Estonian sauna heater models were design-protected between 1990 and 2013 in Finland, although a search of the Estonian patent office design database retrieves three sauna heater designs (Estonian design rights Nos. 00919, 01262, 01562).

5.3.2 Motives to use design rights

After the litigations, protection from imitation and freedom to operate remained important motives to use design rights, according to our interviewees. The third identified motive relates to building the reputation and credibility of the firm. Some interviewees mentioned that retailers required design rights to prove that the firm's sauna heaters did not infringe on others' products. In other words, this was retailers' risk management issue.

> *"And then what is the image that you give to collaborators, retailers? If a retailer begins to advertise sauna heater X, then it doesn't have to worry whether there will be a similar sauna heater X, which a competing retailer is selling at half price after a few weeks. Hence, it [design right] provides protection so that the retailer has an incentive to advertise. Therefore it provides a good basis for collaboration and brand building."* (Interviewee J)

Design rights were filed to make the firm look like a proper business in the eyes of collaborators and retailers. Some interviewees also stated that being granted design rights increases the firm's status within the industry because it sends the message of having your own vision and making an effort of further develop the product category. Finally, design rights were seen as a component of the firm that increases its value in the case of acquisition.

5.3.3 Stated beliefs about the strength and importance of design rights

The design space of sauna heaters became increasingly crowded between 1990 and 2013. Between 1971 and 1989, there were 20 sauna heater related design right filings at PRH, whereas between 1990 and 2013, there were 161 sauna heater related design right filings. The motives to use design right applications have also evolved during the latter period. Table 6 summarizes the identified motives for filing and learning events in the three phases. The signs indicate the potential effects on beliefs about the scope of sauna heater design rights.

TABLE 6 Summary of motives and learning events

	Phase 1	Phase 2	Phase 3
Motives for filing	**Protection from imitation** **Licencing for external manufacturing** **Protection for "contract designed" sauna heaters**	**Protection from imitation** **Freedom to operate** **Defence in court**	**Protection from imitation** **Freedom to operate** **Reputation**
Learning events	**Incumbents decline licencing offers (-)** **Pioneer firm was granted several design rights (+)** **Pioneers own design as obstacle design (+)**	**Pioneer's design obstacle to a competitor's design (+)** **Design rights granted to competitors despite appeals by the pioneer (-)** **Pioneer lost the court cases against competitors (-)**	

In our interviews, we asked sauna heater producers about their beliefs considering the scope and strength of design rights after the litigations and appeal processes were resolved. The post-litigation converged common belief among sauna heater producers is that design rights provide only narrow protection, i.e., protection against direct copying. The following quotations illustrate these updated beliefs of the interviewees:

TABLE 7 Posterior beliefs about design right protection

Cheap but low importance	Easy to design around	Weak compared to patents
"I can draw a figure in five minutes and send it to [PRH] as a design right application. But it won't be valid, it's pointless work." (Interviewee Q)	*"[design rights] are not of high importance after all. They can always be invented around if you want to make something similar." (Interviewee F)*	*"A patent provides effective protection but I don't believe in design right at all because you need to change so little in order to design around it. - - And it is not examined. It is granted to everyone. But a patent application is examined always and it must differ enough." (Interviewee E)*
"The design right has been tested, it kind of doesn't help much. On the other hand the threshold to file [a design right application] is low, thus it doesn't cost much to apply." (Interviewee P)	*"You can make almost one-to-one the same [design] so that from a consumer's view it is the same product." (Interviewee H)*	*"some patents have been quite important as they have disturbed competitors a lot. But these design rights and others, they don't have high significance at all." (Interviewee F)*
"- - their [design rights] usefulness is very limited." (Interviewee H)	*"We have the feeling from the past that they [design rights] are totally useless, they don't have any significance. One can design them around by any means. They can't prevent anything." (Interviewee Q)*	*Design rights are of low importance because the scope of protection is "a line drawn in water" and in the sauna heater industry "everything has been invented already". (Interviewee K)*
"They are total nonsense. If somebody today asked, whether I would apply for design rights, I wouldn't. They're not useful." (Interviewee M)	*" - - this design right is so stupid that in principle it cannot prevent anything. If [competitor] wants to copy it, they just put a little different things on it." (Interviewee L)*	
	"And of course they [design rights] provide some protection but if the producer analyses them beforehand - before producing, which of course is essential – it will not stumble on them. Hence, if one headlong begins to produce one could infringe but if an IPR service firm studies the case a little, then… One can always make them that much different." (Interviewee C)	

6 Discussion

6.1 Why did we observe a surge in design right filings?

The design right databases reveal that the surge in design right filings in the 2000s was mainly driven by two firms: IKI-Kiuas and Mondex. Concurrently, the number of sauna heater producers using design rights also increased (see Table 3). Based on our analysis, the surge in design right filings was triggered by 1) the emergence of a new design product segment 2) the decision of a pioneer firm to protect its designs with design rights, and 3) the response by competitors and preparation for court cases.

In the first phase, design right filings were motivated by the plan to licence the new designs for external production. This is in line with the policy objectives of IPR legislation creating incentives for innovators by protecting their rights, thus enabling markets for technology (Arora et al., 2001; Guellec & van Pottelsberghe, 2007; Gans et al., 2008). However, licensing did not materialize, and the motives shifted considerably in the second phase. The pioneer's IPR strategy was to protect its product innovation with several design rights. As a result, the new dominant strategy for firms producing mesh sauna heaters was to file design right applications and to engage in design-based competition. When competitors introduced their sauna heater designs, which competed more directly than their old products with IKI-Kiuas products, IKI-Kiuas sued them for design right infringement.

As the court cases proceeded, some firms filed for design rights with the purpose of using them as part of their defense in court. Also, the publicity relating to court proceedings increased the awareness of the design right institution within the industry and may have triggered additional filings. The awareness argument has been documented in recent studies on the surge of patent filings (Intarakumnerd & Charoenporn, 2015). It also seems that the uncertainty about design right scope during pending court cases (2008–2009) and pending appeals at the PRH's court of appeals (2008–2010) played a role in inducing sauna heater producers to engage in a design right arms race. The pioneer did its best to pre-empt competitors from protecting their designs with design rights and entering its niche market (cf. Gilbert & Newbery, 1982; Orozco, 2009; Blind et al., 2009; Guellec et al., 2012).

As industry participants became increasingly aware of design rights due to court cases, which received considerable media attention, and learned about their narrow scope of protection, they began to use them in the narrow sense of deterring exact imitation. Interviewed IPR experts pointed out that the scope of design right protection is product-specific and contingent on the product life cycle: When a product design is truly novel, the scope of protection can be broader, but as the product segment matures and more variations of differentiated products are introduced, the scope narrows, and design rights are granted to increasingly smaller product attributes. In other words, the scope of design right protection in a specific product category is dynamic and depends essentially on the evolving interpretations of "individual character" and "informed user" (see section 3.1 for the judicial definition of design right scope). Individual character is evaluated from the point of view of an informed user and as more product variations enter the market and time goes by, the hypothetical informed user learns to distinguish increasingly smaller product differences. Thus, when a design right is granted, it creates a negative externality by narrowing the scope of protection enjoyed by neighboring design rights in the design space.

In the final phase, the motives were reduced to freedom to operate and reputation motives. The freedom-to-operate motive entails testing the boundaries of existing design rights and making sure of not infringing them in the increasingly crowded design space (Filitz et al., 2015). The reputation motive is most important for new firms entering the market and establishing retail channels. This also relates to the freedom-to-operate motive and risk management: By requiring design rights from their suppliers, the retailers are minimizing infringement risks and avoiding being sued. The reputation or status-building motive can be viewed as more psychological than business-based. It also has been documented among artists, including composers, authors, and performers, who find copyright an important institution as a vehicle of status and prestige, even though most artists do not benefit financially from it (Towse, 2001).

6.2 Learning the boundaries of design rights

As outside observers, we are unable to retrospectively reveal the true subjective beliefs of decision makers about the scope of design right protection at each point in time. However, we can identify events that offered opportunities for learning and belief updating. Some events, including being granted design rights and competitors being denied them due to obstacle designs, signalled strong protection. However, later on, competitors were granted design rights despite appeals, with the court ruling that no infringement had taken place. These events sent very different signals on industry-level belief formation concerning the scope of design right protection.

6.2.1 First-movers and second-movers

Our evidence indicates that IKI-Kiuas had the belief that its design right portfolio would protect its design sauna heater business from imitators.[79] Some of the interviewees wondered why IKI-Kiuas did not apply for a patent or a utility model as the novel mesh sauna heater also had technical character. We found no evidence on whether other protection methods were considered by IKI-Kiuas. As the sauna heater business requires production capabilities, i.e., complementary assets (Teece, 1986), which IKI-Kiuas initially lacked, it tried to license the invention to established sauna heater producers. This behavior is consistent with Arora & Ceccagnoli (2006), who pointed out that licensing probability in the context of effective patent protection increases when the firm lacks specialized complementary assets.

Experienced incumbent sauna heater producers were reluctant to license the invention, and some claimed it would be too easy to design around due to narrow design right protection.[80] The observation that no licensing occurred is consistent with the findings of prior studies, which suggest that the effectiveness of IPR protection is positively associated with the licensing propensity (Arora et al., 2001; Gans et al., 2002; Arora & Ceccagnoli, 2006; Gans et al., 2008). On the other hand, the reluctance to license might also derive from other things. It might have been the case that the new design would have cannibalized the markets for existing heater designs or that the potential licensees were simply not yet convinced of the market potential and wanted to see the concept be proven first. Finally, we cannot rule out the possibility that licensing parties simply could not reach an agreement on licensing conditions — profit sharing, in particular.

Eventually, it turned out that design rights did not protect IKI-Kiuas' business from competitive market entry, although we cannot rule out the possibility that design rights actually delayed the entry of competitors (cf. Ayres & Klemperer, 1999). The design rights may have postponed the entry, but on the other hand, imitators also may have strategically waited for IKI-Kiuas to make marketing investments to build the new market segment (Ethiraj & Zhu, 2008). Another reason for postponed entry of competing sauna heater producers into the mesh sauna heater product segment could, of course, be that it took time to design around IKI-Kiuas' design. When PRH granted the design rights to competing firms despite appeals by IKI-Kiuas, it was a clear signal that competing designs were sufficiently different and outside the scope of IKI-Kiuas' design

[79] The first sauna stove related design right filing is dated on the 15th December 1997, for a round-shaped sauna stove, filed after the firm IKI-Kiuas was established to commercialize sauna heaters. The sequence of events, including the establishment of the firm before IPR protection, suggests that design protection may not have been pivotal for the commercialization decision. IKI-Kiuas Oy was registered on the 23th October 1997. Source: PRH's Virre database of the Finnish Trade Register.

[80] The information about licensing negotiations was contradictory across informants. Some claimed that there were negotiations, whereas others claimed that there were no negotiations.

right protection. In other words, competitors were successful in designing around.

At this point, all the marketing investments made by IKI-Kiuas were already sunk costs. Hence, the lack of interest by competing firms for licensing could also be explained by anticipated second-mover advantages. Other sauna heater producers were able to closely monitor the success of IKI-Kiuas in the small Finnish market. As Lieberman & Montgomery (1988) point out, important sources of second-mover advantages are the resolution of market and technological uncertainty, and the ability to free-ride on first-mover's investments. Moreover, it is likely that consumers' perception of the IKI-Kiuas brand (novel sauna heater design) spilled over to competitors' brands, i.e., competitors benefitted from the learning, which had already taken place (Janakimaran et al., 2009). The fact that some witnesses in court pointed out that a consumer might confuse IKI-Kiuas' models with competitors models suggests that there, indeed, were design spillovers. Competition seems to have promoted product differentation, widened the range of products available to consumers, and decreased prices,[81] leading to an increased consumer surplus (cf. Teece, 1986). This is in line with Eisenman (2013), who suggested that firms' pursuit of aesthetic innovation increases the overall attention to design in their industries because they are easily imitated by competitors. As shown in Figure 5, IKI-Kiuas had a monopoly, was profitable and on a strong growth path until the competitors entered the mesh sauna heater market segment in 2008. The competitive entries happened at the same time as the financial crisis hit the Finnish economy, including the domestic construction sector, so it is impossible to disentangle the effect of these separate negative shocks on IKI-Kiuas' performance.

6.2.2 Litigations and beliefs

When modelling strategic interaction in patent litigation game-theoretically, the modellers often make the convenient simplifying assumption that the probability of validity is common knowledge (e.g. Shapiro, 2010). Our case study demonstrates that heterogeneous or subjective beliefs[82] about the scope of IPR protection (which a judge should objectively define on the basis of IPR legislation and accumulated case law) could be a more realistic starting point in the context of complex IPR environment, in which decision makers have unequal accumulated experience and capabilities. At a specific point in time, it is logically impossible for decision makers to have common knowledge about the scope of existing IP rights relative to yet non-existing future designs. Technological uncertainty can be modelled by assigning a probability distribution over a finite

[81] Unfortunately, we were unable to collect systematic price information.

[82] Harsanyi (1968) argues that all discrepancies in the beliefs of players must be caused by the differences in the information they have received. This common prior assumption is also referred to as the "Harsanyi doctrine" and its role is central in many game theoretical models (Morris, 1995; Halpern & Kets, 2015). In this context, priors and posteriors could be interpreted as the subjective probabilities of decision makers about the scope of IPR protection before and after they have actual experience about how the system works.

set of anticipated states of the world, but not for an infinite set of unanticipated states of the world. Thus, the assumption of unboundedly rational agents with rational technological expectations is not on par with reality (Dosi, 1997; Lovallo & Dosi, 1997).

It is plausible to assume that information asymmetries and subjective probabilities arise at least partly from differences in accumulated experiences and know-how. More experienced market participants are likely to have learned more about the practical interpretation of IPR legislation. When IKI-Kiuas sued Harvia, Narvi, and Mondex in 2008, the firm's management did not have previous experience with IPR litigation, whereas, e.g., Harvia and Narvi went through litigation a few years earlier over alleged utility model infringement between 2001 and 2005. When interviewees were asked which sauna heater related court cases they remember, some remembered this Harvia vs. Narvi court case in addition to court cases between IKI-Kiuas and other producers. However, several interviewees did not remember the ruling in the Harvia vs. Narvi court case and what the case exactly concerned.

> *" - - it was a long dispute, and it ended in a court ruling. I can't remember which won the case, Narvi or Harvia, but the other had to pay compensation to the other."* (Interviewee D)

> *"Probably Narvi and Harvia had a dispute at some point but - - I can't remember who won - - I don't know if there have been any other [disputes]."* (Interviewee L)

Some interviewees even reported that they do not pay much attention to others' disputes.

> *"I haven't followed what others have done."* (Interviewee P)

> *"I've heard of some [court cases], but I don't have enough time; I haven't followed them at all. I know that there have been court cases, but I haven't concentrated on them."* (Interviewee E)

Information about previous Finnish IPR court cases is, in principle, accessible to everyone, but at a cost of time and effort.[83] Already Bebchuk (1984) stated that "legal rules and institutions that magnify the extent to which an informational asymmetry is present might well increase the likelihood of litigation" and the mentioned access costs are exactly this kind of magnifying factor. Hence, it is possible that sauna heater producers made decisions under a specific form of

[83] One can visit archives to access court cases in Helsinki, or one can buy rulings of previous court cases at a fixed per-page fee.

bounded rationality, i.e., without all the relevant historical information and legal knowledge.[84] Some interviewees were skeptical about the legal system:

> *"They [litigations] are annoying; you never know what will happen."* (Interviewee F)

> *"- - litigations are so extremely expensive in Finland and rulings are more or less erratic."* (Interviewee H)

A rational reason for litigations may have been IKI-Kiuas' seek for "reputation for toughness" (Kreps & Wilson, 1982). The incumbent sues early entrants to create a reputation for toughness and signals to other potential entrants that they would also be sued if they decided to enter (Choi, 1998). Not suing is therefore not an option, since it would signal to competitors that imitation and future entry would be accepted. Our interviews supported this "reputation of toughness" view. Most of the informants thought IKI-Kiuas had a very low chance of success in the court cases, but many pointed out that suing was the only rational option because not suing would have signalled surrender. Some interviewees pointed out that IKI-Kiuas received a lot of free media coverage during these court cases:

> *"It might have been marketing, but expensive marketing."* (Interviewee G)

> *"I think it was, to a large extent, a publicity stunt. They got a lot of publicity - -"* (Interviewee F)

> *"Maybe it was also about marketing in a sense, as they got a lot of attention - -"* (Interviewee L)

Research on behavioral economics has indicated that in addition to rational reasons, there might also be behavioral explanations for litigations. The uncertain design right protection may have biased the expectations of IKI-Kiuas. IKI-Kiuas did make profits by commercializing mesh sauna heaters and stoves as illustrated in Figure 5, but it was probably more due to first-mover and lead-time advantages than due to strong IPRs. However, since it took so long for competitors to enter the market, it could have strengthened IKI-Kiuas' beliefs on the exclusive power of its design rights. This observation is consistent with Babcock et al. (1995), who conjecture that predictions on judicial decisions will be systematically biased in a self-serving manner. Finally, robust empirical evidence exists that entrepreneurs are prone to unrealistic optimism and overconfidence (Camerer & Lovallo, 1999; Åstebro, 2003; Åstebro et al., 2007; Åstebro et al., 2014; Hyytinen et al., 2014). Empirical evidence indicates also that uncertain-

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[84] Even for researchers, it is not easy to access legal documents, which are physically stored in the court's archives. To learn what exactly has happened in past court cases, one needs to visit the archives.

ty increases self-serving bias (Babcock & Loewenstein, 1997; Miettinen et al., 2012). Thus, uncertain (probabilistic) IPRs may further diverge the beliefs between competing entrepreneurs and increase the probability of litigation. In other words, probabilistic property rights may foster unrealistic entrepreneurial optimism.[85]

6.3 Policy implications

Although implementation of the EU's design right directive in 2002 somewhat broadened the scope of design right protection[86], at the time of the interviews, most of the interviewed sauna heater producers considered design rights to be of low importance, as demonstrated in section 5.3.3. This observation is in line with earlier anecdotal Finnish evidence (Puustinen, 2001; Oesch et al., 2005; Finnish IPR strategy, 2008). Low design right filing activity until 2008 further reflects the perceived low importance of design right protection among sauna heater producers.

Natural language is often ambiguous, which means the same information can be interpreted differently by different decision makers (Halpern & Kets, 2015). IPR-related legislation, like any other legislation, is also ambiguous, and there is a chance that some decision makers have different beliefs about how particular litigations will be judged, especially when there is little accumulated case law. Patent offices and courts can affect the level of information asymmetry between experienced and inexperienced decision makers as they decide how accessible to make information on past litigations. In other words, they choose the information access costs. These decisions affect belief formation and the updating processes of decision makers. When information access costs are high, there is a chance that learning by doing becomes more important, and information asymmetry between experienced and inexperienced users of IPR institutions broadens. By decreasing information access costs, patent offices and courts could help agents make more informed (i.e., less boundedly rational) decisions.

Paradoxically, it may not be socially beneficial to try to diminish asymmetric information and entrepreneurial biases. From the perspective of social welfare, it might even be beneficial that innovators are irrationally overconfident and optimistic (Lovallo & Dosi, 1997; Crouch, 2008; Åstebro et al., 2014). Åstebro et al. (2014) point out that some entrepreneurs generate substantial pos-

[85] Giuri et al. (2007) found suggestive evidence that inventors over-estimate the value of their patents relative to managers. Thus, inventor-entrepreneurs are probably even more prone to unrealistic optimism.
[86] An anonymous expert pointed out that since the amended Finnish design law made it possible to protect parts of products, this could be one explanation for the increased filings. However, a review of the design database reveals that most sauna heater design rights are applied to cover the whole appearance of sauna heaters, not just parts of sauna heaters (although in many cases, a single design right may contain several designs, both sauna heaters and their parts).

itive externalities and that excessive entry may be central to the process of creative destruction, even "a blessing for society". Pioneering entrepreneurs may shake up industries by introducing higher-quality products and services. Often, successful entry into markets leads to imitation, and second-mover competitors equipped with better complementary assets reap major shares of profits (Teece, 1986; Lieberman & Montgomery, 1988). Therefore, IPR institutions may serve as extractive institutions (Acemoglu & Robinson, 2012) when optimism of innovators is based on unrealistic beliefs about the scope of IPR protection and society benefits from their innovation and commercialization efforts in the form of knowledge spillovers and faster technological progress.

If policy makers would like to decrease information asymmetries between experienced and inexperienced agents and reduce unrealistic optimism caused by uncertain IPRs, they could consider asymmetric or libertarian paternalism approaches (Camerer et al., 2003; Coelho, 2010; Thaler & Sunstein, 2003). The patent office and IPR courts could provide more information on expected validity of design rights and other IPRs, as suggested above. This should have no effect on rational and experienced decision makers, but could help boundedly rational and inexperienced decision makers assess their expected returns, taking into account the probabilistic nature of IPRs, and evaluate entry and commercialization decisions more carefully. In other words, patent offices could make it more explicit to IPR applicants that "*the patent system gives the patent holder a right to try to exclude others by asserting its patent against them in court*" (Lemley & Shapiro, 2005). Thus, if access costs to past IPR case rulings were decreased or removed, the excessive entry of optimistic entrepreneurs could also decrease. The cost of this policy (digitizing court rulings and offering open access to databases) is negligible, but its effect on behavior could make a substantial difference. The effect on social welfare is unclear, as on the one hand, this policy may promote more efficient allocation of innovative labor (decrease excessive entry) but on the other hand, it could reduce positive externalities and knowledge spillovers if entrepreneurs forgo commercialization of their inventions and also reduce the competitive pressure caused by optimistic entrepreneurs on incumbents.

7 Conclusions

Our case study documents that the surge in design right filings among Finnish sauna heater producers in 2008 was associated with the birth of a new product segment. It was particularly driven by one design-intensive firm — the first to commercialize mesh sauna heaters and whose IPR strategy relied solely on design right protection. Its design-based IPR strategy induced later competitors to file design right applications to protect their designs from imitation and to test the boundaries of existing design registrations.

We also explored the process of how agents learn the boundaries of design rights and identified several events that potentially affected the beliefs of sauna heater producers in this particular case. Building on previous studies, we propose that uncertain design rights may induce self-serving biases and foster unrealistic optimism. Regulators may decrease asymmetric information and heterogeneous beliefs between experienced and inexperienced decision makers and biases caused by uncertainty by providing digital open access to earlier court cases. However, the expected welfare effects of this policy are mixed. On one hand, it may make the division of innovative labor more efficient by decreasing excessive entry, but on the other hand, it may hinder innovation and the accumulation of knowledge.

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Appendix

FINNISH SAUNA AND DESIGN

Interestingly, although sauna is such a central part of Finnish culture, the history of Finnish industrial design does not pay much attention to sauna heater designs or designers. A recent history of Finnish design by Korvenmaa (2009, p. 238) explicitly mentions only one sauna heater designer: Jussi Ahola who designed an electric sauna heater for Upo Osakeyhtiö in 1967.[87] In the late 1960s Finnish industrial designers Eero Aarnio[88], Pekka Wikström[89] and Pentti Leskinen[90] also designed sauna heaters. However, at that time Finland did not yet have a design right system in place and these sauna heaters were not design right protected. Recently the use of famous Finnish designers has become more common. Figure A.1 displays examples of traditional Finnish sauna heater designs.

FIGURE A.1 Finnish sauna heater designs

Note: On the left an electric sauna heater designed by Pekka Wikström for Metos. (Source: Design archive of Finland, year unknown), in the middle an electronic sauna heater designed by Jussi Ahola for UPO in 1967 (Source: Ahola's collection), on the right a wood-burning sauna heater by Mikael Samppa (Misa) (Source: PRH's design right database, Finnish design 405 granted in 1973).

[87] Upo Osakeyhtiö protected a slightly modified version of Jussi Ahola's sauna heater design in 1971 (Finnish design right 268) but Jussi Ahola was not marked as the designer in that application.
[88] No documents of this sauna heater are available but an interviewed industrial designer confirmed this fact, which is also mentioned at the Eero Aarnio exhibition of the Finnish design museum 8.4.2016–25.9.2016.
[89]Source: Finnish Industrial Design Archives http://www.elka.fi/fida/index.php?id=187&page=Pekka%20Wikstr%F6m
[90] Source: Finnish Industrial Design Archives http://www.elka.fi/fida/index.php?id=74

The founder of the sauna heater producer Misa, Mikael Samppa, was one of the first to protect sauna heaters with design rights. On the 15th March 1972 he filed nine sauna related design right applications of which five were sauna heaters (Finnish design rights 404, 405, 406, 407 and 411). All of them were granted but none was renewed after five years and the design rights lapsed in 1977. Another active filer of sauna heater related design right applications in 1970s and 1980s was Niilo Teeri, the CEO of Kastor (see Finnish designs 2586, 2793, 4682, 7289). In total less than 20 sauna heater and stove related design rights were filed during 1971–1990. Generally, the analysis of Finnish sauna heater related designs reveals that often the CEOs of firms (e.g. Samppa and Teeri) have doubled as designers and continue to do so.

The Finnish sauna heater industry is a mature industry. In 1938 Metos Oy produced the first factory-made electric sauna heater.[91] Some of the sauna heater producers are multiproduct firms and in addition to sauna heaters sell e.g. fireplaces, radiators and vaporizers. Several firms operate also in the industry for sauna construction materials and offer complete "sauna solutions" (in addition to sauna heater also the whole sauna interior including i.a. panels, benches, lights, doors and windows) to customers. During the past few decades the industry has concentrated through mergers and acquisitions.[92] Harvia, Helo and Narvi are the three largest companies followed by a dozen of smaller firms. Most firms concentrate on the Finnish market but Sweden, Germany and Russia are also important export destinations.[93]

According to our interviews of sauna heater producers the larger a firm is the more of its processes are vertically integrated: The smallest sauna heater producers rely on suppliers whereas larger ones produce most of the parts in their own factories. The image of sauna heaters as domestic products is still an important sales argument to Finnish customers, but in fact a large share of sauna heaters sold in Finland are produced abroad. Despite the fact that the Internet has made it much easier to sell products directly to customers, hardware stores remain the main sales channel according to our interviews. Annual fairs (e.g. summer cottage, interior design and renovation and construction fairs) have traditionally been important forums to launch new sauna heaters.[94]

European standards have become increasingly important push factor for innovating more environmentally friendly sauna heaters. In the European Single Market sauna stoves are required to have CE (Conformité Européenne) marking since 2013. With the CE marking "a manufacturer declares that the

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91 Metos discontinued sauna heater production in 1983. Source: http://www.metos.com/page.asp?pageid=2,1,4&languageid=EN&title=History Accessed 2nd May 2016.

92 For instance, Kastor has been acquired by Swedish Tylö and Tylö has been merged with Helo and Aitolämpö has been acquired by Narvi.

93 In addition Sawo is a large Philippines based sauna heater producer, which was established by a Finn.

94 Interviewed sauna heater producers had contradictory opinions on fairs' current role: some stated that they are still very important forum whereas others did not participate to any fairs anymore. For exporting companies international fairs are important forums to meet trade partners and import agents.

product meets all the legal requirements for CE marking and can be sold throughout the EEA". The European standard (CEN/TC 295/WG 7 Heat storage stoves) covers "appliance construction, performance, (e.g. efficiency and emissions), safety and commissioning requirements, together with their associated test methods and installation and operating instructions". The interviewees had contradictory views on how much the standards affect sauna heater design. One interviewee, who was involved in developing the standard stated that in practice the standards do not constraint design possibilities but focus mainly on fire safety, efficiency and carbon monoxide emissions, while another interviewee claimed that actually standard inhibits design. A few interviewees pointed out that stricter requirements for efficiency and emissions would stimulate innovation.

SEARCH ALGORITHMS FOR FINDING SAUNA HEATER OR SAUNA STOVE RELATED IPRS

All design rights in PRH's design right database in Locarno class 23-03, which product class includes Finnish word "kiuas" in its different inflected forms.

All patents and utility models in PRH's PatInfo database, which were classified into A61H IPC class and the title includes Finnish word "kiuas" in its different inflected forms.

Registered design rights in Designview, which contain "sauna heater" in indication of the product and which territory of protection is "FI" or "EM".

COURT CASES

Helsinki District Court
Helsingin käräjäoikeus, 3. osasto. TUOMIO Nro 17735. 18.6.2009 08/27922,
Helsingin käräjäoikeus, 3. osasto. TUOMIO Nro 17736. 18.6.2009 08/34254,
Helsingin käräjäoikeus, 3. osasto. TUOMIO Nro 17737. 18.6.2009 08/34255,

Helsinki Court of Appeals
L08/27922 IKI-Kiuas vs. Harvia
L08/34254 IKI-Kiuas vs. Narvi
L08/34255 IKI-Kiuas vs. Mondex

TABLE A.1 Design rights involved in court cases

Firm	Design registration	Filing date	Publishing date	In force	Opposition	Role
Designpolis	17063	22.12.1993	22.6.1994	31.10.1994-22.12.1998		Evidence of prior art in court.
IKI-Kiuas	20399	13.10.1998	30.10.1998	31.5.1999-		Allegedly infringed by 24926, 24928 and 24739
IKI-Kiuas	22145	29.12.2000	29.12.2000	31.8.2001-29.12.2005		Evidence in court. Obstacle for grant of M20080062
IKI-Kiuas	M20010056	25.1.2001	25.1.2001	not granted		Evidence in court. 20399 obstacle for granting
IKI-Kiuas	22358	27.4.2001	27.4.2001	30.11.2001-27.4.2011		Allegedly infringed by 24739
IKI-Kiuas	23810	8.3.2004	30.3.2004	31.5.2005-		Allegedly infringed by applications of M20080008, 24922, 24926, 24637 and Misa.
Kauhavan Rauta	M20080008	18.1.2008	18.3.2008	not granted		Allegedly infringing 23810, 22511 and 24538
Mondex	24922	6.2.2008	5.6.2008	28.2.2011-	Yes	Allegedly infringing 23810
IKI-Kiuas	M20080062	4.4.2008	30.4.2008	not granted		Evidence in court. 22145 obstacle for granting
Harvia	24926	25.4.2008	16.5.2008	28.2.2011-	Yes	Allegedly infringing 23810
IKI-Kiuas	24511	8.5.2008	15.5.2008	28.11.2008-		Allegedly infringed by M20080008
Harvia	24928	21.5.2008	21.5.2008	28.2.2011-	Yes	Allegedly infringed by 20399
IKI-Kiuas	24538	27.8.2008	31.8.2008	31.12.2008-		Allegedly infringed by M20080008, 24637.
Helo	24637	27.11.2008	27.5.2009	31.8.2009-		Allegedly infringing 23810, 22511 and 24538
Narvi	24739	2.12.2008	31.3.2009	29.1.2010-2.12.2013	Yes	Allegedly infringing 20399 and 22358
IKI-Kiuas	M20090024	12.2.2009	12.2.2009	not granted		Evidence in court. Not granted due to copyright infringement.
Misa						Allegedly infringing 23810, 22511 and 24538

TABLE A.2 Event history database

Date	Event
1993	
22th Dec	Designpolis applies for a design right for a sauna stove (17063)
1995	
3rd Mar	Designpolis tries to license its sauna stove design right (17063) to Harvia
1997	
23th Oct	IKI-Kiuas Oy is founded by Jouni Kerrman
15ht Dec	IKI-Kiuas applies its first design right (19914)
1998	
13th Oct	IKI-Kiuas applies for the first design right for a mesh sauna stove (20399)
22th Dec	Designpolis's design right 17063 lapses
2000	
29th Dec	IKI-Kiuas applies a design right for a mesh sauna heater (22145)
2001	
25th Jan	IKI-Kiuas applies a design right for a sauna stove (M20010056)
27th Apr	IKI-Kiuas applies a design right for a sauna stove (22358)
20th June	PRH rejects IKI-Kiuas design right application M20010056, since it does not differ substantially from IKI-Kiuas's design right 22145
	IKI-Kiuas tries to sell its sauna heater business to incumbents
2002	
	IKI-Kiuas starts to sell sauna heaters at its own store (Saunakauppa) in Helsinki
2004	
	IKI-Kiuas applies a design right for a sauna heater (23810)
2005	
	IKI-Kiuas participates to design fair Habitare 2005
2008	
	Harvia, Mondex, Narvi, Helo, Misa and Kauhavan Rauta enter the mesh sauna heater market
18th Jan	Kauhavan Rauta applies for a design right for a mesh sauna heater (M20080008)
6th Feb	Mondex applies for its first design rigths for mesh sauna heaters (24922, 24923, 24924, 24925)
4th Apr	IKI-Kiuas applies a design right for an advanced mesh sauna heater design (M20080062)
25th Apr	Harvia applies for a design right for a mesh sauna heater (24926)
16th May	Harvia's design right application 24926 is disclosed
21st May	Harvia applies for a design right for a mesh sauna stove (24928)

	Harvia's design right application 24928 is disclosed
5th Jun	Mondex design right application 24922 is disclosed
6th Jun	PRH rejects Kauhavan Rauta's design right application M20080008, since it does not substantially differ from IKI-Kiuas's design right 23810
31st Jul	Kauhavan Rauta appeals to PRH's board of appeals about the rejection of design right application M20080008
8th Aug	IKI-Kiuas makes a claim to PRH that Mondex's design 24922 does not substantially differ from IKI-Kiuas's design rights 22145 and 23810
25th Aug	PRH rejects IKI-Kiuas's design right application M20080062, since it does not substantially differ from IKI-Kiuas's design right 22145
29th Aug	IKI-Kiuas makes a claim to PRH that Harvia's design 24926 does not substantially differ from IKI-Kiuas's design right M20080061
15th Sep	IKI-Kiuas appeals to PRH's board of appeals about the rejection of design right application M20080062
26th Sep	IKI-Kiuas sues Harvia for design right infringement claiming that Harvia is infringing design rights 20399 and 23810
15th Oct	Harvia applies for a design right for a mesh sauna stove (24613)
	IKI-Kiuas makes a claim to PRH that Harvia's design 24927 does not substantially differ from IKI-Kiuas's design right 22145
	IKI-Kiuas makes a claim to PRH that Harvia's design 24928 does not substantially differ from IKI-Kiuas's design right 20399 and application M20010056
17th Nov	IKI-Kiuas sues Mondex for design right infringement claiming that Mondex is infringing design right 23810
	IKI-Kiuas sues Narvi for design right infringement claiming that Narvi is infringing design rights 20399 and 22358
18th Nov	Mondex's design right 24922 is registered despite IKI-Kiuas claim
	Harvia's design right 24927 is registered despite IKI-Kiuas claim
27th Nov	Helo applies for a design right for a mesh sauna heater (24637)
2nd Dec	Narvi applies for a design right for a mesh sauna stove (24739)
2009	
15th Jan	IKI-Kiuas appeals to PRH's board of appeals about the decision to grant Mondex design right 24922
23rd Jan	IKI-Kiuas appeals to PRH's board of appeals about the decisions to grant Harvia's design rights 24926 and 24927
1st Apr	Narvi's design right application 24739 is disclosed
28th May	Helo's design right application 24637 is disclosed
15th Jun	IKI-Kiuas made a claim to PRH that Narvi's design right 24739 is non-novel and should be rejected.
18th June	Helsinki district court rules in favor of defendants Harvia, Mondex and Narvi in design right infringement cases.
31st Aug	Helo's design right 24637 is granted
2010	
29th Jan	Narvi's design right 24739 is granted

28th June	Aurinkokiuas is founded
18th May	Aurinkokiuas applies for its first sauna stove design right (24883)
29th Oct	Aurinkokiuas' design right 24883 is granted
2nd Nov	PRH's board of appels upholds the decision to reject Kauhavan Rauta's design right application M20080008
	PRH's board of appels upholds the decision to reject IKI-Kiuas's design right application M20080062
	PRH's board of appels upholds the decision to grant Harvia's desing rights 24926 and 24927
	PRH's board of appels upholds the decision to grant Mondex desing right 24922
2011	
	Tulikivi enters the design sauna heater market
26th Jun	Tulikivi files its first design right application for sauna heaters at OHIM (001884263)
2013	
2nd Dec	Narvi's design right 24739 lapses

CHAPTER 5: THE RELATIONSHIP BETWEEN PATENT AND SECOND TIER PATENT PROTECTION: THE CASE OF THE DUTCH SHORT-TERM PATENT SYSTEM ABOLITION[95]

Abstract

Empirical evidence on the interaction between regular patent and second tier patent systems in advanced economies is almost non-existent. This paper studies how the abolition of the Dutch short-term patent system in June 2008 was related to the patent filing activity at the Dutch patent office. The abolition was motivated by the uncertainty that the unexamined short-term patents were claimed to create. The analysis, using a synthetic control method, indicates that the abolition of the short-term patent institution was associated with a temporary decrease in the level of patent applications. This might indicate that potential short-term patent applicants eventually shifted to apply for regular patents. No effect on the quality of inventions protected with Dutch patents is found.

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1 Introduction

Utility models (UM) and short-term patents are intellectual property rights, which are specially designed to protect minor and incremental inventions (European Commission, 1995; Maskus & McDaniel, 1999; Janis, 1999; Beneito, 2006; Suthersanen, 2006; Boztosun, 2010; Kim et al., 2012). In this paper, they are referred to as second tier patents (cf. Janis, 1999; Kingston, 2001; Suthersanen, 2006; Moritz & Christie, 2006; Cummings, 2010).[96] They supplement the patent system as innovation policy instruments, and they may be used as alternative protection methods for technical inventions. Second tier patent protection has been considered especially beneficial for developing countries, since it can be used as a learning device in the technological catching up process (Kim et al., 2012; Suthersanen, 2006; Prud'homme, 2017).

Yet there exists no empirical evidence on the benefits of second tier patent systems in advanced economies.[97] In fact, an increasing number of authors have questioned the need for such systems in advanced economies especially due to the potential legal uncertainty that these systems may create (e.g., Janis, 1999; Moritz & Christie, 2006; Björkwall, 2009; Königer, 2009; Bielig, 2012; Prud'homme, 2014; Radauer et al., 2015; Johnson et al., 2015).[98] This legal uncertainty was also the reason why the Netherlands abolished its second tier patent protection system in June 2008 (ROW, 1995b, 2007; Prud'homme, 2014; Radauer et al., 2015). The Netherlands is an interesting case, as unlike most other countries, it has a history of patent system abolitions: its first patent act of 1817 was abolished in 1869 because patent rights were at odds with the ideology of free trade (Moser, 2005 citing Penrose, 1951; see also Janis, 2002 and Guellec & van Pottelsberghe, 2007, p. 24).

The institutional details of second tier patent protection systems vary across jurisdictions[99], but common differences in comparison to regular patent protection are shorter periods of protection (generally 6–10 years), lower application costs, and less stringent patentability requirements (see Kim et al., 2012 section 3; Prud'homme, 2014 section 3; Boztosun, 2010; Beneito, 2006; Radauer

[96] Utility models and its equivalents are sometimes referred to as "petty patents" (Australia, Thailand), "short-term patents" (e.g. Belgium, Ireland, the Netherlands), "certificate of utility" (France) or "innovation patents" (Australia).

[97] Boztosun (2010) argues that second tier patent protection is necessary for both developed and developing economies but does not provide empirical evidence to back this argument. Beneito (2006) uses utility models as a proxy for incremental innovations among Spanish firms but does not study their benefits. Bielig (2012) report a statistically significant negative association between the stock of German utility models and GDP 1999-2009. Johnson et al. (2015) find that in Australia there is no statistically significant relationship between innovation patent (local equivalent to utility models) filings and sales growth at the firm level.

[98] In contrast, Ayres & Klemperer (1999) highlight the benefits of uncertain patent rights and of the delays that they create. Lemley & Shapiro (2005) also emphasize that the uncertainty of patents is not a mistake but an inherent part of patent systems.

[99] According to WIPO (2013) around 75 countries provide protection for utility models. See Suthersanen (2006), Radauer et al. (2015) and Prud'homme (2014) for reviews of utility model systems in selected countries. Moritz & Christie (2006) and Johnson et al. (2015) provide overviews of Australian petty patent and innovation patent experiences.

et al., 2015).[100] Furthermore, the pendency time from application to grant is usually much shorter than in case of regular patents, because in most jurisdictions there is no examination of novelty and inventive steps—that is, substantive examination. Radauer et al. (2015) document the speed of protection as the prime motive behind firms registering UMs in selected European countries. Presumably due to the lack of international harmonization, the share of resident applicants of total UM applications worldwide was as high as 98.1% in 2012 (see WIPO, 2013, pp. 92–95).[101] Also Maskus and McDaniel (1999) report that 98% of the UM applications filed at Japanese patent offices were domestic during 1960–1993, and Moritz and Christie (2006) report that 87% of Australian petty patents were domestic during 1979–2001. Thus, second tier patent protection is mainly a protection method for resident firms and individuals (see also Radauer et al., 2015).

The first second tier patent protection system, which is still in place, was introduced in Germany in 1891 to fill the gap between design and patent protection (European Commission, 1995; Janis, 1999; Suthersanen et al., 2006).[102] Since then, many countries have adopted some sort of second tier patent protection system to create incentives to invest in the R&D of minor and sub-patentable technical inventions. However, still after over 125 years of practice (Königer, 2017), empirical evidence on the effectiveness of second tier patent protection systems is scarce, and its relationship with regular patent protection remains obscure (Janis, 1999; Kim et al., 2012).

According to Janis (1999), the second tier patent protection has been considered the "backwater of intellectual property", since TRIPS (Agreement on Trade-Related Aspects of Intellectual Property Rights) does not explicitly mention it and leaves WTO members with the freedom to formulate their own second tier patent regimes as they see fit (see Königer, 2009; Boztosun, 2010; Kim et al., 2012; Grosse Ruse-Khan, 2012).[103] Some authors state that there exists almost unlimited policy space in designing UM systems according to domestic needs and in particular to promote incremental innovation (Grosse Ruse-Khan, 2012). A natural consequence is a lack of harmonization and very scarce empirical evidence on the functioning of second tier patent protection systems. Overall, it remains unclear whether advanced economies actually need second tier patent protection to supplement normal patent protection to boost innovation.

This paper aims to shed light on the interaction between national patent and second tier patent systems by investigating the abolition of the Dutch short-

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[100] For an overview see World Bank's and OECD's Innovation Policy Platform on utility models: https://innovationpolicyplatform.org/content/utility-models?topic-filters=12277.

[101] It should be noted that about 90% of all world's utility model applications are Chinese and in China the share of non-resident utility model applications in 2012 was only 0.8% whereas e.g. in Germany the share was 22.9% (see WIPO 2013).

[102] According to Janis (1999) the 1891 German utility model regime was originally conceived as a form of design protection.

[103] Grosse Ruse-Khan (2012) states: "- - the policy space available for countries with regard to exceptions applicable to utility models is extraordinary. Any country with a utility model system may therefore consider without any constraints what kind of uses should be exempted from the protection available for utility models."

term patent system in June 2008. As the trend in the harmonization of patent protection has been the strengthening of intellectual property rights (IPRs) (see, e.g., Ginarte & Park, 1997; Sakakibara & Branstetter, 2001; Gallini, 2002; Moser, 2005; Qian, 2007; Park, 2008; Lerner, 2009), the case of the Netherlands provides a rare opportunity to study the abolition of an IPR system. As we do not observe a counterfactual, i.e, the Netherlands with short-term patent protection after abolition, the synthetic control method approach (Abadie & Gardeazabal, 2003; Abadie, Diamond, & Hainmueller, 2010, 2015) is implemented to construct one. This synthetic counterfactual enables the investigation of the association between the abolition of second tier patents and national patenting: how did the abolition affect the level of patenting and the quality of inventions protected with Dutch patents?

The paper is organized as follows. Section 2 reviews the theoretical framework. Section 3 briefly discusses the institutional context. Section 4 describes the synthetic control method. Section 5 presents the data, and the results are reported in Section 6. Section 7 concludes.

2 Patent systems as sorting mechanisms

2.1 Prior literature

Patent systems are *de facto* sorting mechanisms[104] (Scotchmer, 1999; Cornelli & Schankerman, 1999; Hopenhayn & Mitchell, 2001; Encaoua et al., 2006; Picard & van Pottelsberghe, 2013; Kou et al., 2013; Atal & Bar, 2014; Schankerman & Schuett, 2016). In the simplest case, the patent office offers patent protection for inventions that satisfy patentability requirements, and applicants self-select to use or not to use patents. Scotchmer (1999) and Cornelli and Schankerman (1999) go one step further and show that a menu of patent lengths and associated fees (renewal system) can also be used as a screening mechanism: applicants self-select their preferred length of patent protection from a menu of patent lengths with associated fees: more valuable inventions are protected for a longer time. On the other hand, Hopenhayn and Mitchell (2001) argue that the patent office may use a menu of patent breadths and lengths as a more efficient sorting device than a menu of patent lengths and fees. Kou et al. (2013) show that the non-obviousness requirement is in itself a screening device, which discourages inefficient innovators from investing in research and development. Atal and Bar (2014) assume that patent applicants use patents for signaling purposes—that is, the perceived quality of patents is important to them. They prove that the patent office can reduce the incidence of "bad patents" by introducing a two-tiered patent system, i.e., by offering a menu of two patents with associated fees and examination intensities. Schankerman and Schuett (2016) contribute to pa-

[104] See Mas-Colell et al. (1995) and Salanié (2005) for sorting mechanisms.

tent screening theory by analyzing the interactions between the following screening instruments: examination intensity, application and renewal fees, and post-examination challenges in the courts.

Despite various theoretical predictions, very little empirical evidence exists about the screening function of patent systems. One of the few recent studies is that of de Rassenfosse and Jaffe (2014), who find that patent fees are an effective mechanism in weeding out low-quality patents. This finding is consistent with theoretical predictions (Schuett, 2013; Kou et al., 2013). To the best of our knowledge, this paper is among the first to study empirically how a change in the menu of patents offered by the patent office (from two types of patents to one type of patent) is associated with the level of patent applications and average patent quality.

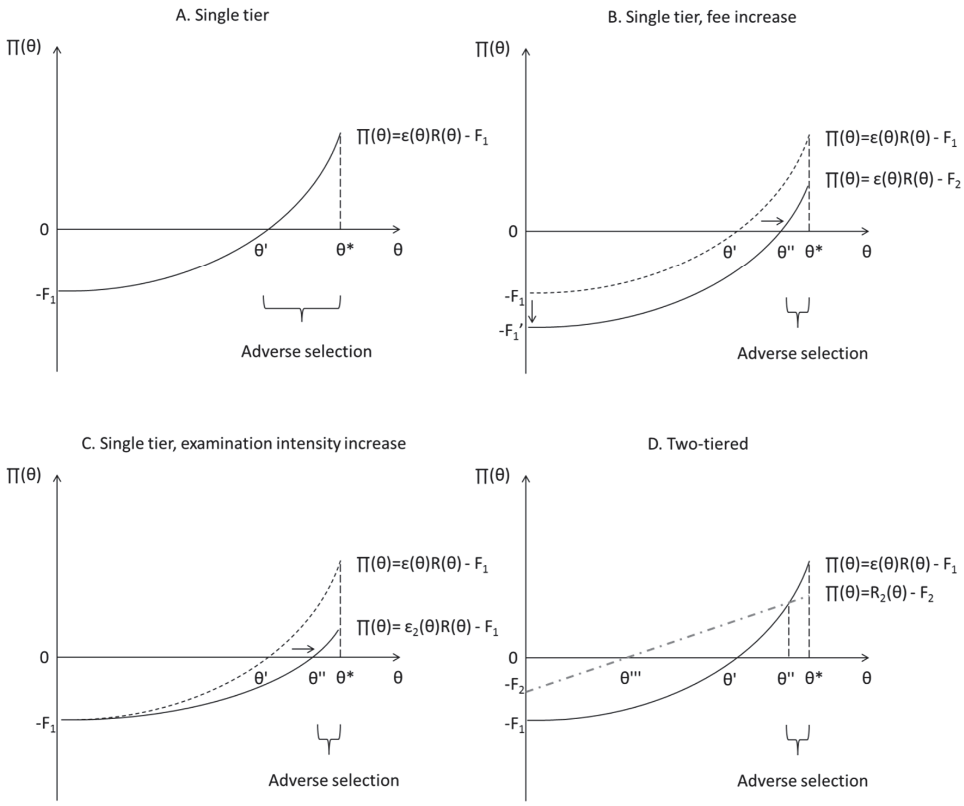
2.2 Graphical analysis

A two-tiered patent system is a screening device: the patent office offers applicants a menu of two types of patents with associated fees, and applicants select their profit-maximizing alternative (Hopenhayn & Mitchell, 2001; Kou et al., 2013; Atal & Bar, 2014; Heikkilä & Verba, 2017). Based on this theoretical background, we illustrate graphically how different patent policy instruments can be used to decrease adverse selection in patenting choices and, in particular, how a two-tiered patent system affects self-selection. In this context, adverse selection refers to the situation in which applicants file patent applications for inventions that do not satisfy the patentability requirements. These applications burden patent examiners and increase the backlog at the patent office. Moreover, patent examiners sometimes make mistakes—Type II errors—and grant patents to inventions that do not satisfy patentability requirements. The more patents are granted to inventions that do not satisfy patentability requirements, the weaker the signal is that patent owners can send to investors about the quality of their inventions. Both increased backlog and incidence of bad patents are negative externalities caused by adverse selection. Figure 1 offers a simple illustration of the choice made by applicants with sub-patentable inventions.

To see how Figure 1 has been drawn, let us consider the following scenario and assumptions: there exists a set of potential patent applicants with technical inventions that do not satisfy patentability requirements. By definition, adverse selection occurs if patents are filed for these inventions. Let θ measure the inventiveness of the invention, $\theta \in [0, \theta^*)$, where $\theta = 0$ refers to totally obvious inventions with no inventive step and θ^* is the inventive step requirement for patentability. Inventions with $\theta \geq \theta^*$ satisfy patentability requirement and are not considered here. An applicant's expected revenue from patent-protected invention θ is $R(\theta)$ and from second tier patent-protected invention $R_2(\theta)$, where $R(\theta) > R_2(\theta)$ for all θ. The revenue is assumed to be linearly increasing in the inventiveness of the invention, $R'(\theta) > 0$, and zero for an invention with no inventive step, $R(0) = 0$.[105] The patent office has three patent policy instruments: 1) It can have either a single-tiered or a two-tiered patent system, 2) it can choose patenting fees (F), and 3) it can choose its examination intensity. Examination intensity determines the probability of Type II errors, ε—in other words, the probability that an examiner grants a patent to an invention that does not satisfy patentability requirements. ε is increasing and convex in the inventiveness of the invention.[106] There is no examination for second tier patents, implying that all kinds of inventions (any type θ) can be protected. Type θ applicant's expected net profit from patenting is $\prod(\theta) = \varepsilon(\theta)R(\theta) - F_1$ and from second tier patenting $\prod(\theta) = R_2(\theta) - F_2$. Consistent with most European two-tiered patent systems, it is assumed that applying for a second tier patent is less expensive than patenting: $F_1 > F_2$.

Figure 1 illustrates how adjusting fees (Graph B) and examination intensities (Graph C) and introducing a second tier patent (Graph D) affect the incidence of adverse selection relative to benchmark patent system (Graph A).

FIGURE 1 Screening instruments and adverse selection



[105] For simplicity, it is assumed that the expected profit from an invention is 0 when it is not patent protected (free imitation).
[106] More formally, $Pr(\text{Type II error} \mid \theta<\theta^*)=\varepsilon(\theta)$, $\varepsilon(\theta) \in [0,1)$, $\varepsilon(0)=0$, $\varepsilon'(\theta)>0$ and $\varepsilon''(\theta)>0$.

Graph A illustrates the case of a single-tiered patent system. Suppose that given the default patent policy $\{\varepsilon, F_1\}$ there is adverse selection: Applicant types $\theta \in [\theta',\theta^*)$ with inventions that do not satisfy patentability requirements apply for patents, as their expected net profit from applying is positive (i.e., higher than the outside option, 0 profits from non-patented invention). Graphs B, C, and D show that the incidence of adverse selection can be reduced (partial screening) either by increasing the patenting fee, by increasing the examination intensity (decreasing the probability of Type II errors), or by introducing a two-tiered patent system.[107]

The essential difference between graphs B and C relative to Graph D is that in the case of a two-tiered patent system, a larger share of types ($\theta \in [\theta''',\theta^*)$) apply for some type of offered patent protection. It is rational for types $\theta \in [\theta''',\theta')$ to apply for second tier patents, since expected net profits are positive, $R_2(\theta) - F_2 \geq 0$; for types $\theta \in [\theta',\theta'')$ to apply for second tier patents, since expected net profits are positive and higher than expected profits from patenting, $R_2(\theta) - F_2 \geq 0$ and $R_2(\theta) - F_2 \geq R(\theta) - F_1$; and for types $\theta \in [\theta'',\theta^*)$ to apply for patents (*adverse selection*), since expected net profits are positive and higher than the expected profits from applying for second tier patents, $R(\theta) - F_1 \geq 0$ and $R(\theta) - F_1 \geq R_2(\theta) - F_2$.

This simple graphical analysis shows that, *ceteris paribus,* a two-tiered patent system can be equally effective in reducing the incidence of adverse selection as adjusting patent fees and examination intensity in a single-tier system. As Graph D in Figure 1 illustrates, a shift from a two-tiered to a single-tiered patent system, which happened in the Netherlands, is expected to be associated with 1) a decrease in the total number of patent filings (sum of patent and second tier patent filings), 2) an increase in the number of regular patent filings, and 3) a decline in the average quality of regular patents.

3 Institutional context

3.1 IPR policy in the European Single Market

The major project of the European Union has been the creation of an effective single market.[108] Over the past decades, the harmonization process has con-

[107] It should be noted that increasing patenting fee affects directly individual rationality constraint of applicants with patentable inventions whereas increasing examination intensity does not (assuming plausibly that increasing examination intensity does not increase the probability of rejecting patent applications of patentable inventions).

[108] The European integration process aims at creating "one single market", which goals are free movement of goods and undistorted competition (see European Commission, 1985). According to European Commission's single market strategic programme in 1993 "the overriding aim of Community action in the field of intellectual property is to achieve free circulation of goods which are covered by intellectual or industrial property rights" (European Commission, 1993 p. 32).

stantly progressed in many dimensions, but patent protection has been one of the most challenging issues. The European Commission (1985) has declared: "Differences in intellectual property laws have a direct and negative impact on intra-Community trade and on the ability of enterprises to treat the common market as a single environment for their economics activities." Also, the ultimate objective of the European Patent Convention (EPC), which was signed in 1973 and became effective in 1977, is to create a community patent that would cover the whole area of member states, as in the US (Harhoff et al., 2009). Since 1977, the number of EPC contracting states has increased from 7 to 38 in 2014. Simultaneously, the European patent has replaced direct applications to national patent offices in significant numbers (Hall & Helmers, 2012; Eaton et al., 2003).[109] Being an EU member requires eventually joining the EPC.

The introduction of second tier patent protection systems in EU member countries seems to have been closely linked to the European integration process at the turn of 1980s and 1990s. Since 1985, most old and new EU members have adopted second tier patent protection systems (see Appendix), the Netherlands among them in 1995. In 1992, the Maastricht treaty (Treaty on European Union) was signed, and the EU was created. A few years after the European Commission suggested a community utility model for the single market (European Commission, 1995; Kingston, 2001). However, this project ended when the member countries suspended the utility model directive in 2000 since they wanted to put the priority on the Community patent.[110] Thus, still in 2015, most member countries have their own national patent offices and own patent right territories, and there are no harmonized second tier patent protection systems in the European Single Market. Transaction costs to obtain an EU-wide patent protection remain high: having many IPR regimes results in the stacking of applications (including translation costs) and maintenance (renewal fees) as well as enforcement costs (Harhoff et al., 2009).[111]

Suthersanen (2006) classified European UM systems into three regimes: the three-dimensional regime (Italy, Denmark, Finland, Greece, Portugal, Spain), the German regime (Germany and Austria), and the patent regime (Belgium,

[109] Hall & Helmers (2012) report that the decrease is mainly explained by the change in foreign applicants' behaviour as they substitute domestic patents with EPO patents whereas the authors observe no discernible effect among domestic applicants in terms of domestic patent applications. The level of substitution between direct national patent applications and EPO patent applications depends presumably on various factors, major factors being relative prices, expected grant rate and pendency. Furthermore, the more EPO countries, in which an applicant wants her invention to be protected, the higher the likelihood that the chosen filing channel is EPO instead of national patent offices. In Prud'homme (2014, p. 53 chart 4) the drop in the number of Czech domestic patent applications is evident in 2004 after joining the EPO.

[110] "The work on this proposal was suspended in March 2000, because of the difficulty of reaching agreement on some basic problems raised by the proposal and the priority which the majority of Member States attached to a Community patent." (European Commission, 2002 p. 3) Janis (1999) also emphasized that efforts to harmonize utility model system may have taken attention from more important topics such as Community patent.

[111] European patents granted by European Patent Office (EPO) decreases stacking of applications but in general obtaining patent protection in the EU is a much more expensive operation than obtaining a patent in the US or in Japan (Harhoff et al., 2009).

Ireland, the Netherlands, France). Since the publication of Suthersanen's report, several countries have amended their second tier patent legislation, and the Netherlands and Belgium abolished their short-term patent systems completely in 2008 and 2009, respectively. The United Kingdom, Sweden, Luxemburg, Belgium, and the Netherlands are pre-2004 EU member countries without second tier patent protection as of 2015. Moreover, the inventive step requirement for the German and Austrian UMs has been the same as for patents since the "Demonstrationsschrank" decision by German Federal Court of Justice in 2006 (Björkwall, 2009, Radauer et al., 2015) and since the decision of "the Oberster Patent und Markensenat" in Austria in 2010 (Radauer et al., 2015).

In 2004 the EU grew with 10 new member countries, of which Czech Republic, Estonia, Hungary, Poland, Slovenia, and Slovakia have second tier patent protection systems in place in 2014, whereas Malta, Cyprus, Latvia, and Lithuania do not. Of the latest members, Bulgaria and Romania (EU members since 2007) provide UM protection, but Croatia (EU member since 2013) does not.[112] All these different national regimes reflect the complexity of the European IPR environment. Indeed, it requires much time and effort to learn all the national peculiarities, and it should be noted that 99% of European firms are small and medium sized enterprises (SMEs), which have a limited budget to consult experts in IPR issues.[113]

The Netherlands is an interesting case as it is a country that has abolished its second tier patent protection, contradicting the general trend of new countries adopting second tier patent protection systems. It is also the first EU member state to abolish its second tier patent system, and its decision may serve as a trigger for other countries to study the effectiveness of their own systems. Indeed, Belgium followed the Netherlands by abolishing its short-term patent system in January 2009 (Prud'homme, 2014; Radauer et al., 2015).[114]

3.2 Dutch short-term patent system

The Dutch short-term patent system ("zesjarige octrooi", a six-year patent) was in place between the 1st of April 1995 and the 5th of June 2008, a bit over 13 years. It was introduced to provide SMEs with a simple, cheap, and fast protection for their inventions when the Dutch patent system was reformed in 1995 (ROW, 1995a, 2006, p. viii and p. 11). The main difference between the Dutch short-

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112 Although Prud'homme (2014) points out that Croatia has a "consensual patent", which is equivalent to a utility model.

113 INNOVACCESS – A European Network of National Intellectual Property Offices provides information about European IPR regimes in a centralized manner. See http://www.innovaccess.eu/. Prud'homme (2014) and Radauer et al. (2015) document national peculiarities of European utility model systems.

114 Recently the Productivity Commission of Australia recommended abolition of the Australian second tier patent protection system, the innovation patent. See: http://www.pc.gov.au/inquiries/completed/intellectual-property/draft/intellectual-property-draft.pdf (Accessed September 5th 2016).

term patent system and other European second tier patent protection systems was that it required inventions to satisfy full patentability standards and had a maximum duration of six years.[115]

The Patent Act of 1995 shifted the traditionally extremely restrictive Dutch patent system closer to "the French regime" of no prior review system, as the substantive examination was abandoned.[116] Furthermore, a peculiarity of the Dutch system was that the applications of patent applicants who did not request a novelty search report within 13 months from the application date were automatically granted six-year short-term patents after 18 months from the filing date when the application was published (ROW, 1995a, 2007, p. 15 and p. 32). In other words, the applicant could postpone by 13 months the decision whether to have a short-term patent or to apply for a normal patent by requesting a novelty search. On average, there were about 600 short-term patent filings per year, which was roughly a fourth of the annual patents granted by the Dutch patent office (ROW, 1995a).

In March 2006, the abolition of the short-term patent system was suggested in an evaluation report of the Dutch Patents Act 1995 (hereafter "ROW, 1995") by the Ministry of the Economic Affairs (ROW, 1995a 2006), and the decision to abolish the system in 2008 was announced at the end of February 2007 (ROW, 1995b, 2007). The main argument for the abolition was the legal uncertainty that unexamined property rights created (ROW, 1995b, 2007, p. 10; Prud'homme, 2014). The two-tiered system also created confusion between normal patents and short-term patents.[117] The Dutch Ministry of Economic Affairs estimated that 75% of the annual 600 short-term patent applications would shift to apply for 20-year patents after the abolition (ROW, 1995b, 2007, p. 13).

Figure 2 shows that the level of patent applications at the Dutch patent office was relatively stable during 1990–2013. The shift to a two-tiered patent system with no substantive examination in 1995 was associated with an increase in patenting filings. However, the abolition of the short-term patent system did not lead to a permanent decrease in patenting activity, indicating that applicants might have shifted from short-term patents to normal patents, as was predicted by the Ministry of Economic Affairs (ROW, 1995b, 2007, p. 13).

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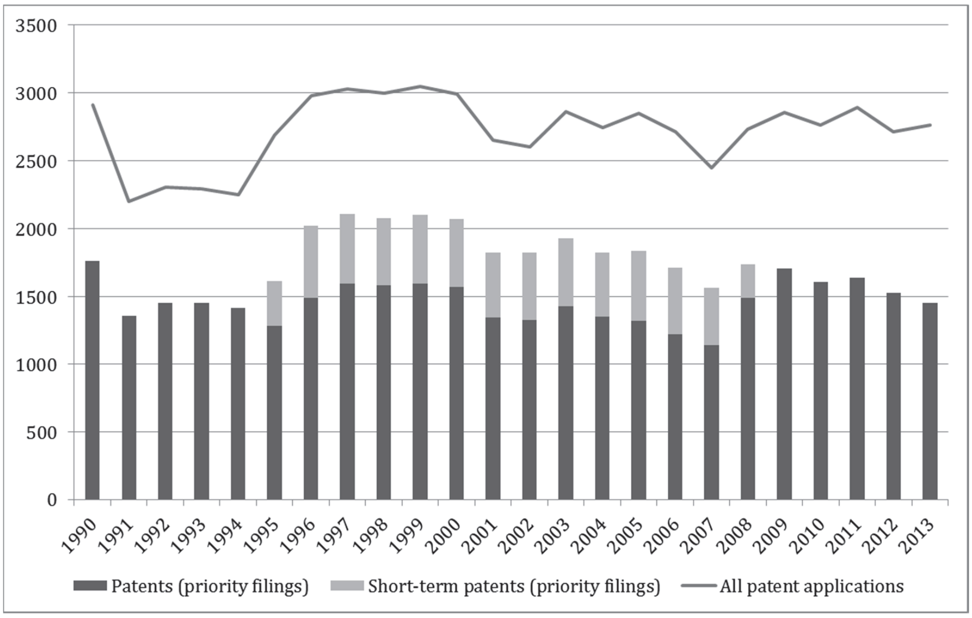
[115] Also Belgium and France share the same characteristics. Although Suthersanen (2006) classifies Ireland to the same "patent regime", actually Irish short-term patent protection does not require the same inventive step as patents and its maximum length is 10 years.
[116] According to Guellec et al. (2007, p. 24) the Dutch patent system has historically been one of the most restrictive having very low grant rates.
[117] In order to decrease this kind of confusion, the Irish review of the Patent Act 1992 suggested to change the name of Irish short-term patent to utility model. See: http://www.djei.ie/publications/ria/2012RIAReviewPatentsAct1992.pdf

FIGURE 2 Patent filings at the Dutch patent office



Notes: The data for all patent applications was retrieved from WIPO IP Statistics Data Center (http://ipstats.wipo.int/ipstatv2/index.htm) and also include non-priority filings and Patent Cooperation Treaty (PCT) filings. Priority patent and short-term patent filings are identified from PATSTAT data (April 2016 version).

4 Empirical framework: The synthetic control method

Different empirical methods have been applied to identify the effects of patent reforms on patenting activity. The fundamental challenge in these studies remains the same: the construction of an appropriate counterfactual for the treated country. Lerner (2009) constructs a weighted index of control countries, whereas Moser (2005) and Qian (2007) use matched sampling. The contribution of this paper is to apply the synthetic control method to identify the effect of the Dutch short-term patent system abolition.

In brief, the synthetic control method (SCM) facilitates comparative case studies with small samples and "when no single untreated unit provides a good comparison for the unit affected by the treatment or event of interest" (Abadie, Diamond & Hainmueller, 2015). It was introduced by Abadie and Gardeazabal (2003) and was further developed by Abadie, Diamond, and Heinmueller (2010). The method has been applied, for instance, to study the effect of terrorism on economic growth (Abadie & Gardeazabal, 2003), the effect of smoking law change on cigarette consumption (Abadie et al., 2010), the effect of Germany's reunification on economic growth (Abadie et al., 2015), and the effect of economic liberalization on economic growth (Billmeier & Nannicini, 2013). To my knowledge, this study is the first to apply SCM to investigate a change in patent policy.[118]

In studies that focus on estimating the country-level effects of policy changes, the number of potential control countries is always very limited. In the case of a national IPR system, the availability of appropriate control countries is even more limited due to several interacting institutions and confounding factors. In these cases, regression-based methods such as difference-in-differences design are infeasible, and researchers tend to prefer qualitative case study methods. SCM provides a way to fill in the gap between quantitative and qualitative research approaches (Abadie, Diamond & Hainmueller, 2015).

The implementation of SCM is straightforward. We observe a panel of J+1 countries, of which the first (the Netherlands) is exposed to the treatment (the abolition of second tier patent protection) and J are not, over T periods. Y_1 and Y_0 are the outcome variable values for the treated and non-treated countries, respectively. These J countries serve as potential controls[119], and any weighted average of non-exposed countries is considered as a potential synthetic control. Let W be a (J x 1) vector of positive weights given to non-treated countries that sum to one. Each choice of W represents a weighted average of the available control countries—that is, a synthetic control for the treated country. Let T_0 be the number of pre-treatment periods and $T_1 = T - T_0$ be the number of post-treatment periods.

Let $X_1 = (Z_1', Y_1^1, \dots, Y_1^{T_0})$ be a (k x 1) vector of pre-treatment characteristics' values (Z') and outcome variable values (Y in the chosen pre-treatment periods) of the treated unit and X_0 be a (k x J) matrix of the same values of potential control countries, respectively. Vector Z consists of predictor variables, which are meant to be predictors of post-treatment outcomes, and they should not be affected by the treatment (Abadie, Diamond & Hainmueller, 2015). In other words, there should not be an anticipation effect. The aim is to match the values of these characteristics as closely as possible between the treated and the synthetic control.

The discrepancy between the actual and the synthetic Netherlands is given by $X_1 - X_0W$. The vector of weights W* is chosen to minimize $(X_1 - X_0W)'V(X_1 - X_0W)$ subject to $w_j \geq 0$ (j = 1,2,…,J) and $w_1 + \dots + w_J = 1$, where V is a (k x k) symmetric and positive semidefinite diagonal matrix. Abadie and Gardeazabal (2003) and Abadie, Diamond and Hainmueller (2010) suggest choosing a V matrix, which minimizes the mean squared prediction error (MSPE) of the outcome variable in the pre-treatment period, and that approach is applied here. Vector W* (J x 1) defines the combination of control countries that best resembles the treated country in the pre-treatment period. Thus, when

$$\sum_{j=2}^{J+1} w_j^* Y_{j1} = Y_{11}, \ \sum_{j=2}^{J+1} w_j^* Y_{j2} = Y_{12}, \ \dots, \ \sum_{j=2}^{J+1} w_j^* Y_{jT_0} = Y_{1T_0}$$

[118] Moser (2005) studies the effect of patent laws on innovation. She cites Abadie & Gardeazabal (2003) but uses Mahalanobis matching estimator instead of synthetic control method to construct counterfactuals for countries, which did not have patent laws.
[119] Abadie et al. (2010) refer to the set of potential controls as "donor pool".

and $\sum_{j=2}^{J+1} w_j^* \boldsymbol{Z}_j = \boldsymbol{Z}_1$

hold, we have a reasonable counterfactual for the Netherlands. An estimate of the treatment effect is calculated by comparing the post-treatment values of the treated actual unit against the values of the synthetic control in a chosen point of time t after the treatment: $Y_1^t - \sum_{j=2}^{J+1} w_j^* Y_j^t$.

5 Data

We use annual country-level panel data for the period 2002–2012. The Dutch short-term patent system was abolished on the 5th June 2008, but to account for the possible anticipation effect, the pre-treatment period is defined to be the year 2007, since the decision of the abolition was published in February 2007.[120] The length of the pre-treatment period is therefore from 2002 to 2006 (5 years) and that of the post-treatment period from 2007 to 2012 (6 years).

5.1 Outcome variables

5.1.1 Quantity of patent applications

The outcome variable is the number of distinct patent families[121] with priority filing at the domestic patent office, "priority filings" (de Rassenfosse et al., 2013). The use of patent families instead of simple patent applications avoids the problem of double counting when there are several national application documents (e.g., amended applications) in the PATSTAT database for the same invention. Thus, the variable reflects the number of distinct technical inventions for which exclusive rights were sought at a national patent office.

In the main analyses, patent filings are used instead of grants due to varying grant lags (patent pendency times) and different examination processes between countries. PCT patent applications are intentionally excluded, as international protection is probably applied for more valuable inventions. The patent data are extracted from the EPO's PATSTAT database (April 2016 version).

[120] The decision was published on the 28th of February 2007 in an official document of the Ministry of Economic Affairs (ROW1995b, 2007). The evaluation of ROW1995 already suggested the abolition in March 2006 (ROW1995a, 2006).

[121] DOCDB patent families from PATSTAT database are used in the analyses. See Martínez (2011) for a review of different patent family definitions.

5.1.2 Quality of inventions in patent applications

We use three patent quality measures (Harhoff et al., 2003; Reitzig, 2004; Frietsch et al., 2010; Squicciarini et al., 2013) as the outcome variable: the number of citations, the number of inventors, and the number of patent family members. Here "quality" refers to the value of the invention subject to patent protection. This is distinct from the "legal quality" of patents (Burke & Reitzig, 2007), which measures how well patents are drafted and how likely they will be deemed valid if challenged in court. The assumptions considering the association between these indicators and quality of inventions are the following: higher quality inventions are technologically more important and therefore receive more citations from succeeding patents. More radical R&D projects require larger inventor teams, and the likelihood of inventing high quality inventions is higher with greater R&D input. Inventor team size is also a predictor of future citations (Breitzman & Thomas, 2015). A large patent family size indicates that the invention is worth protection in multiple jurisdictions.

As in the case of quantity (section 5.1.1), we focus on national priority filings, and the analysis is conducted using annual panel data. The patent quality data are extracted from the EPO's PATSTAT database (April 2016 edition).

5.2 Control countries

In the main analysis, the set of potential controls consists of European countries that were members of OECD, the EU, and EPO and that had some type of second tier patent protection system in place at the beginning of the pre-treatment period (January 2002). These criteria ensure a certain level of institutional similarity between potential controls and the Netherlands. The 10 countries include Finland, Denmark, Austria, France, Germany, Italy, Greece, Ireland, Portugal, and Spain.[122] See Table A.1 in the appendix, which presents the years of second tier patent protection system adoption in OECD countries. Although there exist certain national differences in two-tiered patent protection systems, these national systems are likely most comparable in their patenting activity. The evaluation of the Dutch 1995 patent reform (ROW, 1995a, p. 18) suggests that the short-term patent systems of France, Belgium, and the Netherlands should be considered as offering an equivalent protection to that of UM systems in other countries.[123] Belgium is excluded from the set of potential control countries,

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[122] Hungary, Poland, Czech Republic, Slovenia and Slovak Republic met the presented criteria after they joined EPO during the first years of the new Millennium and the EU on the 1st of May 2004. They are not considered in the analysis since joining the EPO affected strongly the substitution between direct national patent applications and EPO applications (see Hall & Helmers, 2012). Furthermore, as Aghion et al. (2015) have demonstrated, joining the EU also has an effect on patenting as it boosts product market competition.

[123] "Hierbij dient opgemerkt te worden dat de WIPO Nederland, België en Frankrijk ook schaart onder de landen waar een utility model bestaat." (ROW1995a, 2006)

since Belgium abolished its short-term patent system in January 2009, shortly after the abolition of the Dutch system.

5.3 Predictor variables

In SCM, predictor variables should predict post-treatment period outcomes as closely as possible. Following the prior literature (Porter & Stern, 2000; Furman et al., 2002; Qian, 2007; Kim et al., 2012), we use conventional predictors for the number of patent applications: R&D intensity, GDP per capita (constant 2005 PPP prices), share of industrial employees of the total population, average years of schooling (of populations older than 25 years; Barro & Lee, 2013), IPR index (Ginarte & Park, 1997; Park, 2008), trade openness, and economic freedom index (Gwartney et al., 2014). The predictor variables are summarized in Table A.2 in the appendix. The same predictor variables are also used in predicting the average quality of inventions.

Annual values within the pre-treatment period of 2002–2006 are available for R&D measures, GDP per capita, population, and share of industrial employment. For schooling, IPR index, trade openness, and economic freedom, the values of 2005 are used. Since these institutional characteristics change slowly over time, the 2005 observation is a reasonable proxy for the whole pre-treatment period. These factors are generally used as explanatory variables in knowledge or ideas production functions (e.g., Porter & Stern, 2000; Furman et al., 2002), in which number of patents is interpreted as a proxy for innovations.[124] Here the interpretation is a bit different: the interest simply lies in the number of applied exclusive rights instead of innovation capacity. Filing a patent application at a specific patent office is a strategic decision related to the appropriation of R&D investments, and here the aim is to understand how the abolition of a complementing institution affects the filing behavior of applicants. Moreover, we are interested in the effect of the abolition on patent quality.

R&D intensity and share of industrial employees are proxies for the effort to produce patentable inventions. GDP per capita (purchasing power), population (market size), and the economic freedom index reflect the expected returns from patenting. Similarly, the IPR index is a proxy for expected returns from patenting, as it measures the strength of patent protection.[125] The trade openness index measures the flow of ideas across borders, and schooling measures the level of human capital—that is, absorptive capacity—both of which are positively associated with the subsequent production of new patentable ideas.

[124] Furman et al. (2002) study the determinants of national innovation capacity.
[125] As noted already by Gould & Gruben (1996), this kind of IPR indexes may overestimate the level of protection, when there are strong anti-infringement laws on the books, which however are not implemented in practice.

6 Empirical analysis

6.1 Evolution of priority patent filings

The synthetic Netherlands is constructed as a convex combination of potential control countries that most closely resembles the Netherlands in terms of patenting activity predictors, minimizing the root mean squared prediction error (RMSPE, see section 4) within the specified pre-treatment period (2002–2007). RMSPE is the average of squared monthly discrepancies between the outcome variable in the Netherlands and its synthetic control in the pre-treatment period. SCM gives the following weights for potential control countries: Denmark 0.929, France 0.06, and Germany 0.011. Austria, Finland, Greece, Ireland, Italy, Portugal, and Spain are each assigned zero weight. Table 1 compares pre-treatment period patenting activity predictor means between the actual Netherlands and the synthetic. Most of the characteristics of the synthetic control more closely match the actual Netherlands than the average characteristics of the control countries, which are also reported in Table 1.

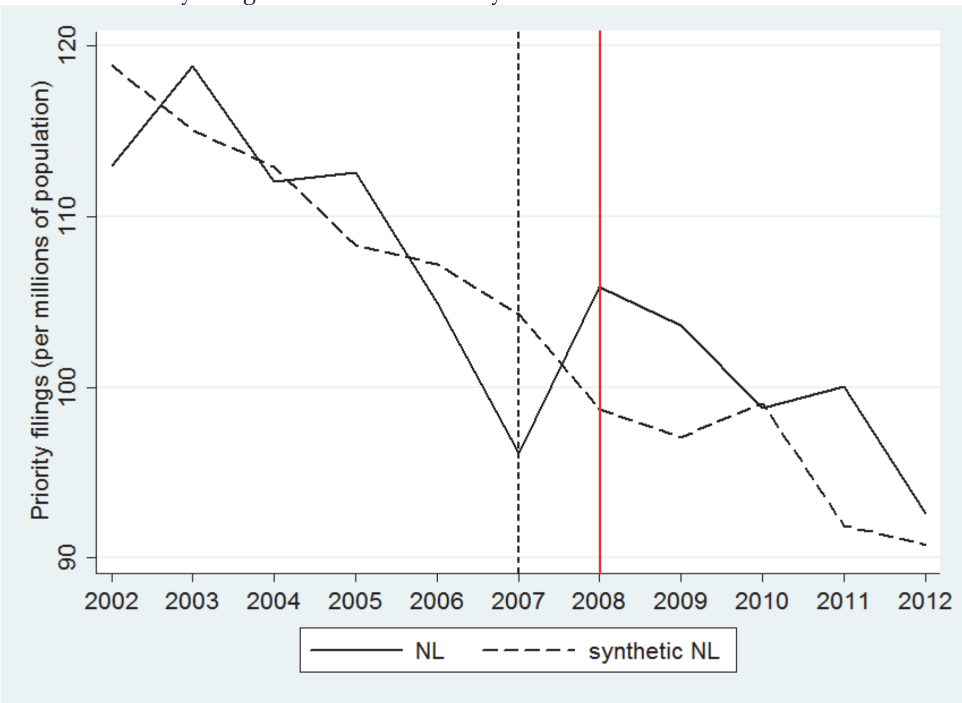
TABLE 1 Patenting activity predictor means 2002–2006

	The Netherlands	Synthetic control	Average of control countries
Priority filings*	112.28	112.47	170.92
R&D intensity	1.90 %	2.30 %	1.82 %
Population	16300000	5911078	31100000
Industrial employment share	0.36	0.35	0.35
GDP per capita	34016.66	33191.39	28474.07
Trade openness	8.69	8.55	8.30
Economic freedom	7.92	7.97	7.64
Schooling	10.98	10.84	10.58
IPR index	4.67	4.59	4.45
RMSPE		3.80	

Note: *Priority filings are distinct patent families with priority filing at the domestic patent office per year scaled by population (millions). All predictor variables are averaged over the pre-treatment period, 2002-2006.

Figure 3 displays annual patenting activity for the Netherlands (solid line) and its synthetic counterpart (scattered line) between 2002 and 2012. Both show a decreasing trend. The patenting of the synthetic control tracks the trajectory of the actual Netherlands during the pre-treatment period, and the predictor variables in Table 1 are relatively balanced. This suggests that the synthetic control provides an approximation of the number of patents that would have been applied for in the Netherlands if the short-term patent system had not been abolished. The treatment effect of the abolition of the Dutch short-term patent system is then the difference between the actual Netherlands and the synthetic one in the post-treatment period.

FIGURE 3 Priority filings in the Netherlands: synthetic vs. actual



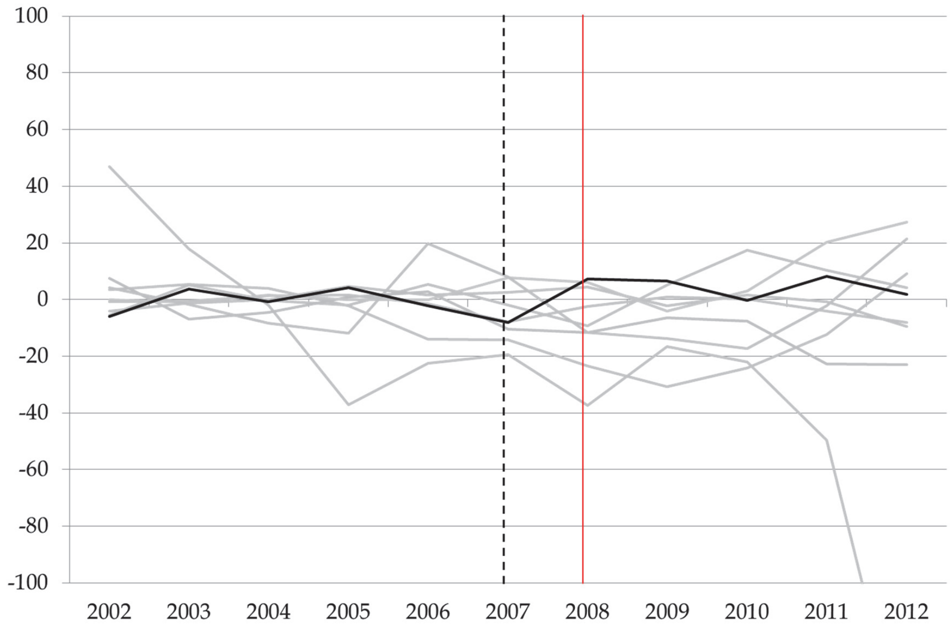
Notes: Priority filings at the DOCDB patent family level, scaled by the country's population (millions). The dashed line indicates 2007 when the abolition decision was published, and the red line indicates 2008 when the system was abolished.

Figure 3 shows that the announcement of patent policy amendments had a negative effect on the level of patent filings in 2007 (as depicted by the black dotted vertical line). However, the abolition of the short-term patent system in 2008 (as depicted by the red line) itself did not have a negative effect on national Dutch patenting activity. We do not observe a permanent level drop, which would be expected if potential short-term patent applicants ceased completely from applying for patents (no substitution). In contrast, the filing activity in the Netherlands seems to be actually slightly higher than in its counterfactual after the abolition. An underlying reason for this could be that a share of potential short-term patent applicants shifted to apply for regular patents as was expected in the official documents of the Dutch Ministry of the Economic Affairs (ROW, 1995b, 2007, p. 13). This indicates that short-term patents and normal patents were substitutes in the medium run.

To see, whether the difference between the Netherlands and its synthetic control is significant, placebo tests are conducted following Abadie et al. (2010). We assume that all control countries had their two-tiered patent systems abolished in 2007 and construct synthetic controls for them. If the gaps in post-treatment period between control countries and their synthetic controls are of the same magnitude as the one estimated for the Netherlands, the interpretation is that the abolition of the two-tiered patent system did not have an effect. In contrast, if the gaps between control countries and their synthetic controls are systematically smaller than the one estimated for the Netherlands, this would indicate that the abolition indeed had an effect on patent filing activity at the Dutch patent office.

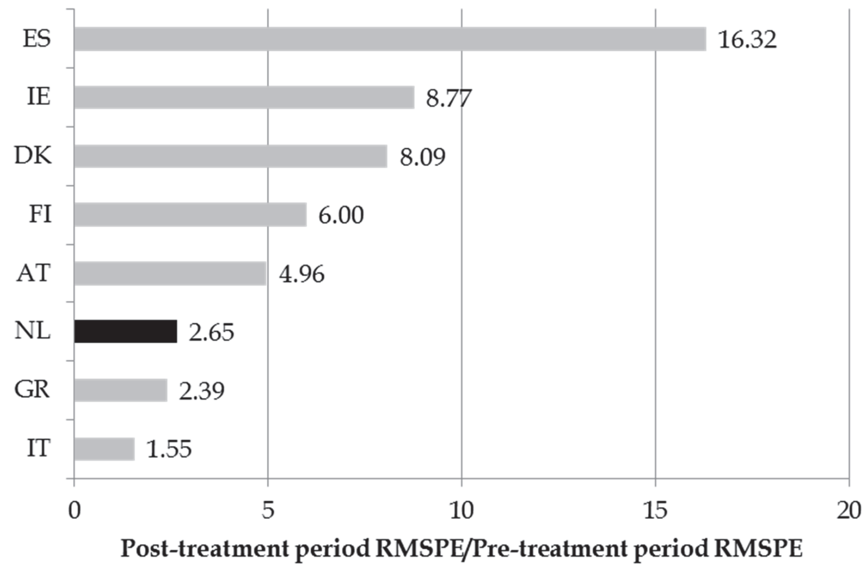
The estimated gaps between actual countries and their synthetic controls in annual priority filings per million of the population are presented in Figure 4. The black line represents the gap in the Netherlands, and the grey lines represent placebo gaps in the control countries. Figure 4 confirms that the effect of the abolition of the Dutch two-tiered patent system was not associated with a permanent decrease in the level of national priority filings. Rather, it seems that the abolition was associated with "an anticipation effect"—a slight decrease in the level of priority filings in 2007—followed by a rebound to the earlier trend in 2008. Note the scale of the graph: for the Netherlands 10 units (priority filings per million of the population) correspond to approximately 10*16=160 patent filings per year.

FIGURE 4 Patent filing gap in the Netherlands and placebo gaps in control countries



Notes: The Y-axis measures the gap between the actual country and its synthetic control. Synthetic controls could not be constructed for Germany and Portugal.

FIGURE 5 Ratios of post-treatment and pre-treatment period RMSPEs



Notes: France's ratio, 306.62, is out of scale and thus not reported in the figure.

We conducted the same synthetic control analyses using both quarterly and monthly patent filing data. The results are reported in the Appendix. Both quarterly and monthly analyses suggest, in line with the main analysis, that the shift from a two-tiered patent system to a single-tiered patent system had no long-term effects on the level of patent filing activity. Only in 2007 does there seem to have been a temporary decline in priority patent filings relative to the Netherland's synthetic control. This difference disappears after the actual abolition in 2008.

6.2. Quality of inventions protected with patents

We analyze whether the abolition of the Dutch two-tiered patent system was associated with any changes in the quality of the inventions for which Dutch patents were filed. As discussed in section 2.2, we would expect the quality of regular patents to decline if short-term patent applicants shift to apply for regular patents, the only available national protection method left for technical inventions. Figures 6, 7, and 8 show the evolution of these quality indicators over time.

FIGURE 6 Average number of forward citations to Dutch priority patents

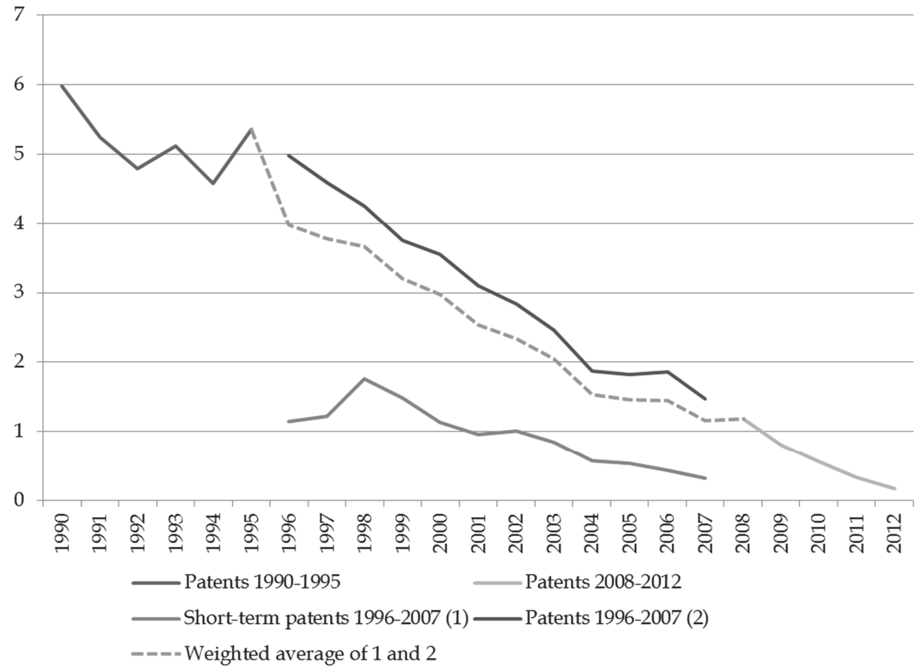
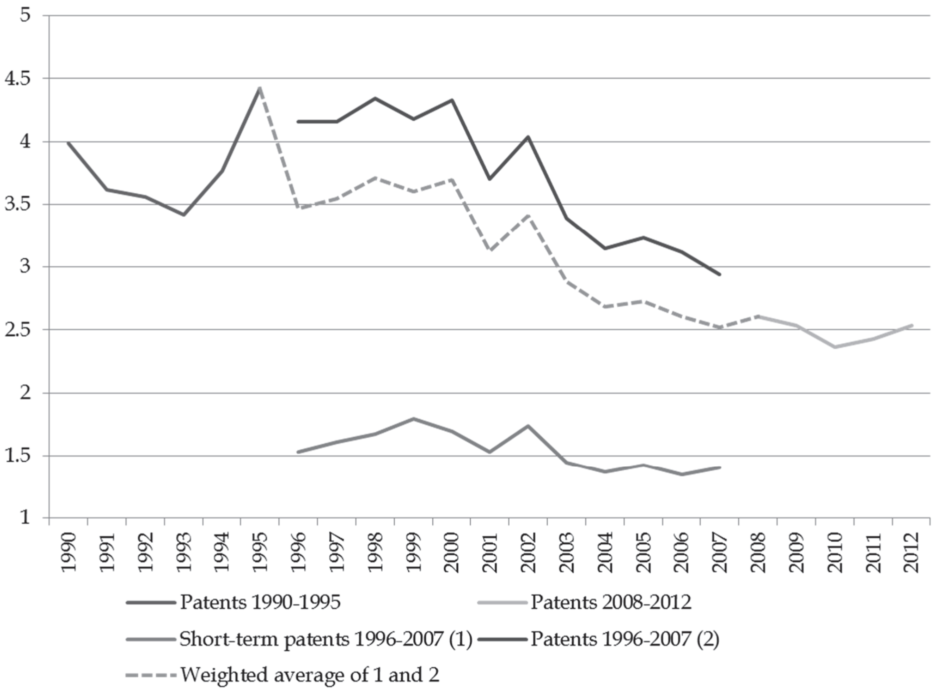


FIGURE 7 Average number of inventors in Dutch national priority patents

Notes: The number of inventors is not systematically available in patent applications before 1994.

FIGURE 8 Average patent family size of Dutch priority patents



Notes: The patent family definition used is the DOCDB patent family from the PATSTAT 2016 April edition.

Figures 6, 7, and 8 illustrate that the Dutch two-tiered patent system induced sorting among patent applicants: inventions protected with short-term patents are systematically of lower quality on average than normal 20-year patents. The self-selection of applicants by quality of inventions is consistent with the theoretical predictions of Atal and Bar (2014). Their findings indicate that a two-tiered patent system may increase the actual and perceived quality of normal patents, because applicants with low value inventions self-select second tier patent protection. However, it should be noted that financially constrained patent applicants may more often select short-term patents irrespective of the quality of their invention. The self-selection by financially constrained applicants could explain smaller average patent family size (Figure 7) and team size (Figure 8) but not the smaller number of citations received by short-term patents (Figure 6). Thus, we may conclude that short-term patents are indeed used to protect lower quality inventions. Interestingly, in figures 6, 7, and 8, the trends in the quality of inventions protected with regular patents when the two-tiered patent system was in place (black line, patents 1996–2007) seem to not differ from the trends of regular patents after the abolition (the lightest grey line, patents 2008–2012).

Next, we use SCM to analyze whether the quality of inventions protected with Dutch regular patents declined in comparison to its counterfactual. As in the previous section 6.1, the synthetic Netherlands is constructed as a convex combination of potential control countries that most closely resembles the Netherlands in terms of the patent quality predictors, minimizing the RMSPE within the specified pre-treatment period (2002–2006).

6.2.1 Number of citations

SCM gives the following weights for potential control countries: Austria 0.5, Greece 0.343, and France 0.158. Finland, Denmark, Ireland, Spain, Germany, Italy, and Portugal are each assigned zero weight. Table 2 compares pre-treatment period forward citation predictor means between the actual Netherlands and the synthetic. The characteristics match relatively well.

TABLE 2 Number of citation predictor means 2002–2006

	The Netherlands	**Synthetic control**	**Average of control countries**
Average number of citations*	1.77	1.77	2.00
R&D intensity	1.90 %	1.70 %	1.79 %
Population	16300000	17500000	28800000
Industrial employment share	0.36	0.34	0.34
GDP per capita	34016.66	29206.81	29025.27
Trade openness	8.69	7.96	8.53
Economic freedom	7.92	7.59	7.64
Schooling	10.98	9.68	9.98
IPR index	4.67	4.38	4.52
RMSPE		0.13	

Note: *Average number of forward citations to priority patent filings (patent application filed at national patent office). All predictor variables are averaged over the pre-treatment period, 2002 - 2006.

FIGURE 9 Number of citations in Dutch patents: synthetic vs. actual

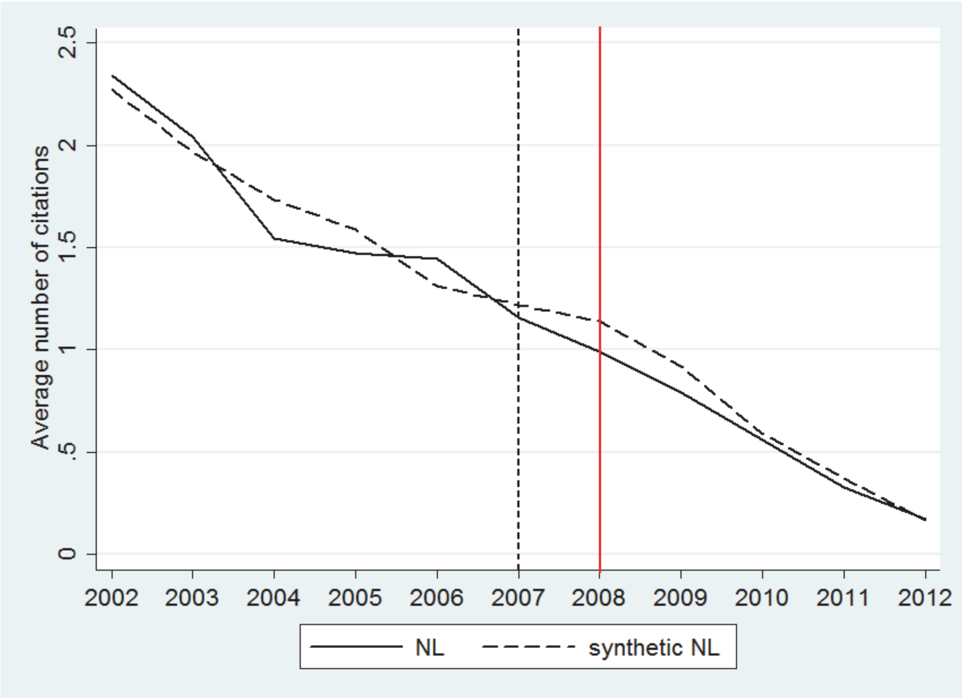
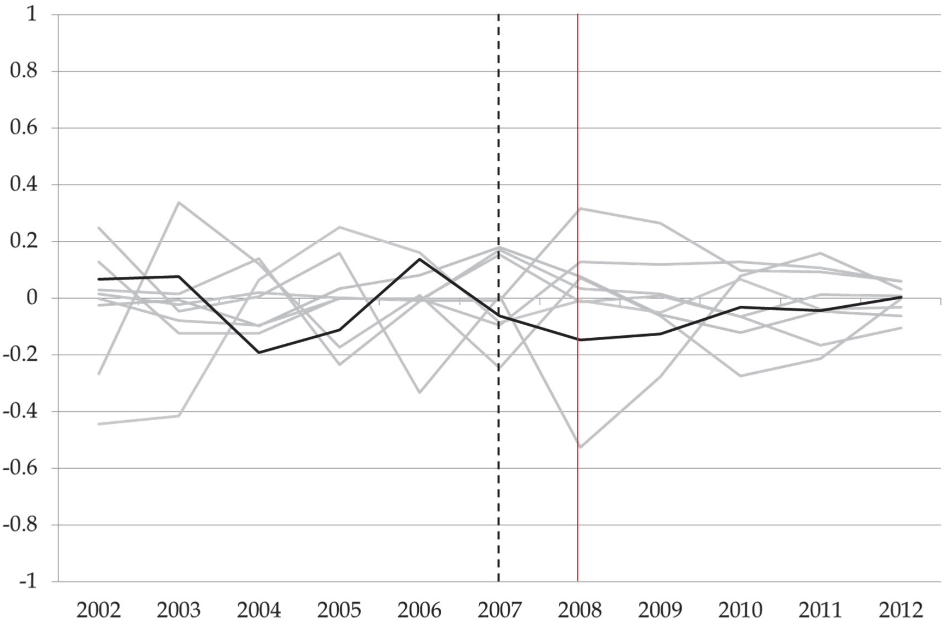


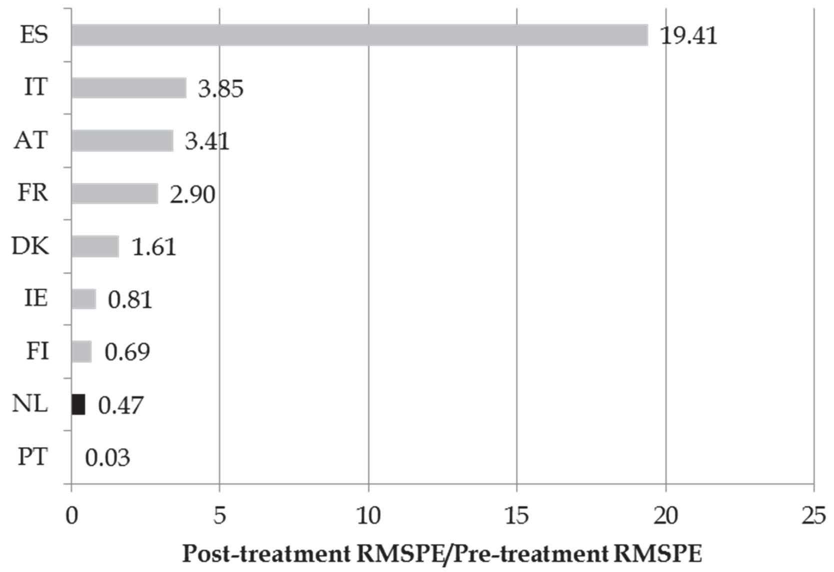
Figure 9 shows that Dutch regular patents received somewhat fewer citations than the patents of the synthetic control after the abolition. Again, it seems that the declined quality of Dutch patents was only temporary, and no long-term effects could be found in comparison to the counterfactual. Again, to see whether the difference between the Netherlands and its synthetic control is significant, we conduct "in-place" placebo tests, as in the previous section. Figure 10 shows how the difference between the Netherlands and its synthetic control (black line) compares to the differences between other control countries and their synthetic controls (grey lines). The gap between the Netherlands and its synthetic control was indeed larger in 2008 and 2009 than in most control countries but of equal magnitude since 2010. Figure 11 compares the ratios of post-treatment period and pre-treatment period RMSPEs. The low ratio of the Netherlands indicates that the abolition did not have a clear effect on the quality of Dutch patents.

FIGURE 10 Average number of citations gaps in the Netherlands and placebo gaps in control countries



Notes: Average citations gaps in the Netherlands (black line) and in 8 control countries (grey lines). Synthetic controls could not be constructed for Germany and Greece.

FIGURE 11 Ratios of post-treatment and pre-treatment period RMSPEs



6.2.2 Number of inventors

SCM gives the following weights for potential control countries: Denmark 0.509, Italy 0.367, and France 0.124. Finland, Austria, Greece, Ireland, Germany, Portugal, and Spain are each assigned zero weight. Table 3 compares pre-treatment period patenting activity predictor means between the actual Netherlands and the synthetic control. The characteristics match relatively well.

TABLE 3 Number of inventor predictor means 2002–2006

	The Netherlands	**Synthetic control**	**Average of control countries**
Average number of inventors*	1.51	1.51	1.80
R&D intensity	1.90 %	1.95 %	1.79 %
Population	16300000	31600000	28800000
Industrial employment share	0.36	0.33	0.34
GDP per capita	34016.66	30452.7	29025.27
Trade openness	8.92	8.39	8.53
Economic freedom	7.88	7.64	7.64
Schooling	10.98	10.24	9.98
IPR index	4.67	4.67	4.52
RMSPE		0.02	

Note: *Average number of inventors in priority patent filings (patent application filed at national patent office). All predictor variables are averaged over the pre-treatment period, 2002 - 2006.

FIGURE 12 Number of inventors in Dutch patents: synthetic vs. actual

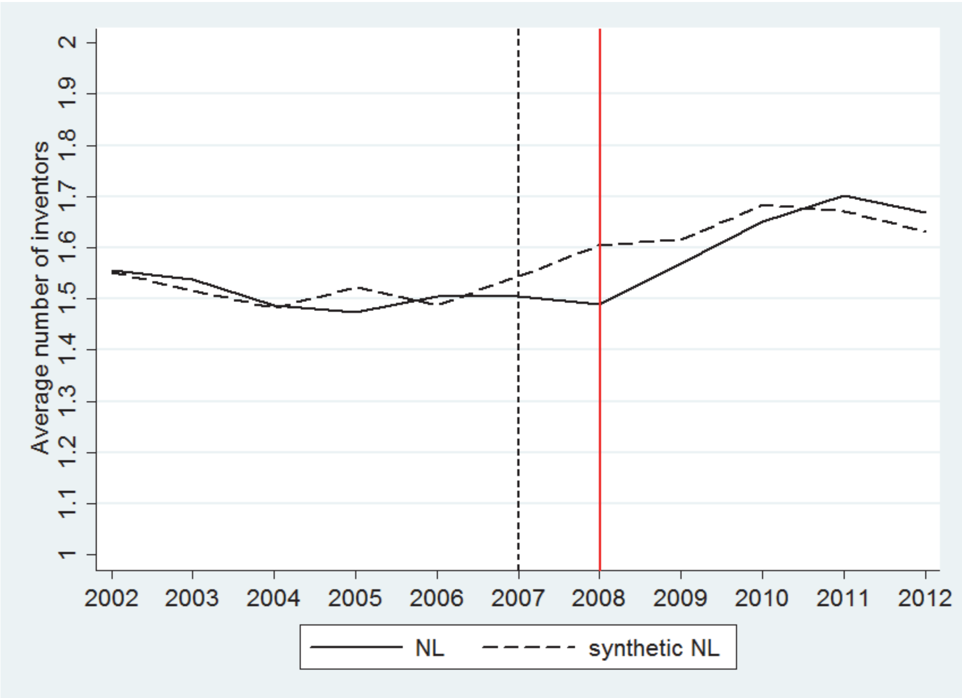
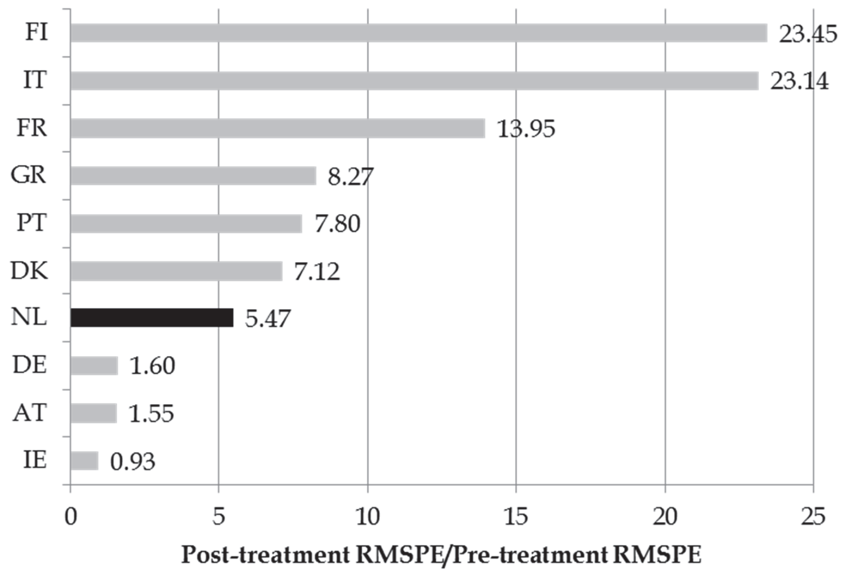


Figure 12 reveals that the average number of inventors in Dutch priority patent filings declined when the two-tiered patent system was abolished, but the decline was temporary. This is in line with the reasoning that patent applicants with low quality inventions shifted to apply for regular patents.

Again we conducted placebo experiments by constructing synthetic controls for countries that did not face the abolition of their two-tiered patent system. The black line in Figure 13 is the difference between the Netherlands and its synthetic control, while the grey lines depict the differences between control countries and their synthetic counterfactuals. It is clear that the difference between the Netherlands and its synthetic control is not more prominent than the differences between control countries and their synthetic controls. In several control countries, the average quality of inventions protected with patents has evolved over time much more relative to the synthetic control than in the case of the Netherlands. Figure 14 compares the ratios of post-treatment period and pre-treatment period MSPEs. Again the low ratio of the Netherlands indicates that the abolition did not have a clear effect on the quality of Dutch patents.

FIGURE 13 Average number of inventors gaps in the Netherlands and placebo gaps in control countries

FIGURE 14 Ratios of post-treatment and pre-treatment period RMSPEs



Notes: Spain's ratio, 5330.78, is out of scale and thus not reported in the figure.

6.2.3 Patent family size

SCM gives the following weights for potential control countries: Denmark 0.434, Ireland 0.224, Greece 0.204, and France 0.139. Austria, Finland, Germany, Italy, Portugal, and Spain are each assigned zero weight. Table 4 compares pre-treatment period patent family size predictor means between the actual Netherlands and the synthetic control. The characteristics match relatively well.

TABLE 4 Patent family size predictor means 2002–2006

	The Netherlands	**Synthetic control**	**Average of control countries**
Average patent family size*	2.87	2.87	2.82
R&D intensity	1.90 %	1.77 %	1.79 %
Population	16300000	14000000	28800000
Industrial employment share	0.36	0.34	0.34
GDP per capita	34016.66	31300.68	29025.27
Trade openness	8.69	8.46	8.53
Economic freedom	7.92	7.85	7.64
Schooling	10.98	10.87	9.98
IPR index	4.67	4.60	4.52
RMSPE		0.06	

Note: *Average patent family size of priority patent filings (patent application filed at national patent office). All predictor variables are averaged over the pre-treatment period, 2002 - 2006.

FIGURE 15 Patent family size in Dutch patents: synthetic vs. actual

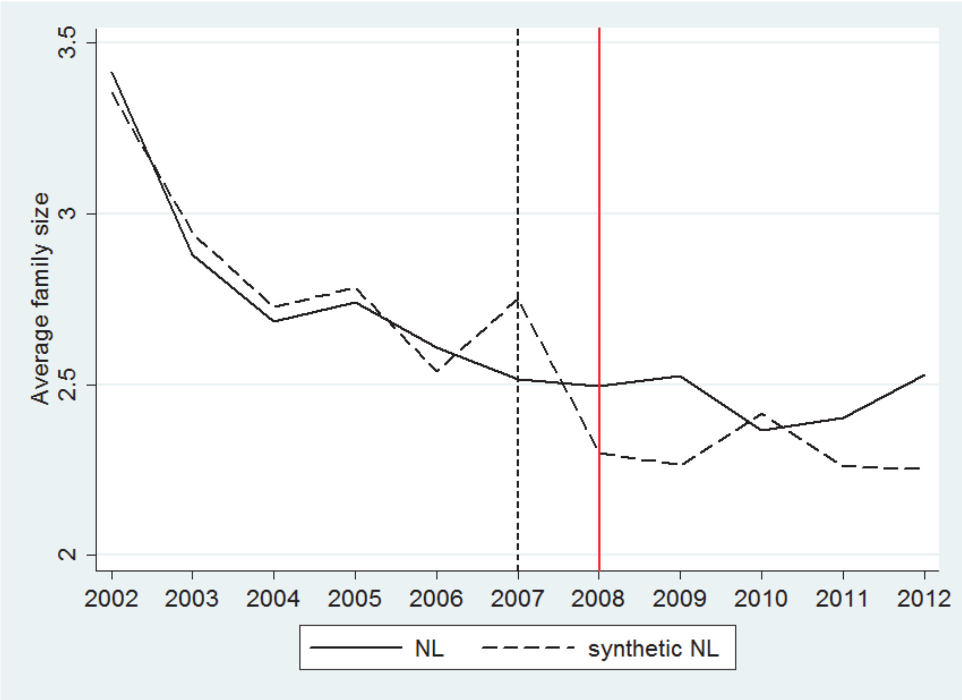


Figure 15 indicates that the abolition was not associated with a sudden change in the average size of Dutch patent families. The quality of patents protected with regular 20-year Dutch patents increased rather than decreased after the abolition of the two-tiered system. This is in contrast to our expectation of decreasing quality. Figure 16 indicates further that the average size of patent families between the Netherlands and its synthetic control did not differ significantly from the gaps between control countries and their synthetic counterfactuals. Also, the decline in 2007 and increase in 2008 and 2009 are not actual changes in the quality of Dutch patents but are caused by the changes in the synthetic counterfactual, as the scattered line in Figure 15 depicts. Figure 17 reports the RMSPE ratios for the Netherlands and control countries for which synthetic controls could be constructed. The RMSPE of the Netherlands is inflated by the post-treatment period variation in the synthetic control.

FIGURE 16 Average patent family size gap in the Netherlands and placebo gaps in control countries

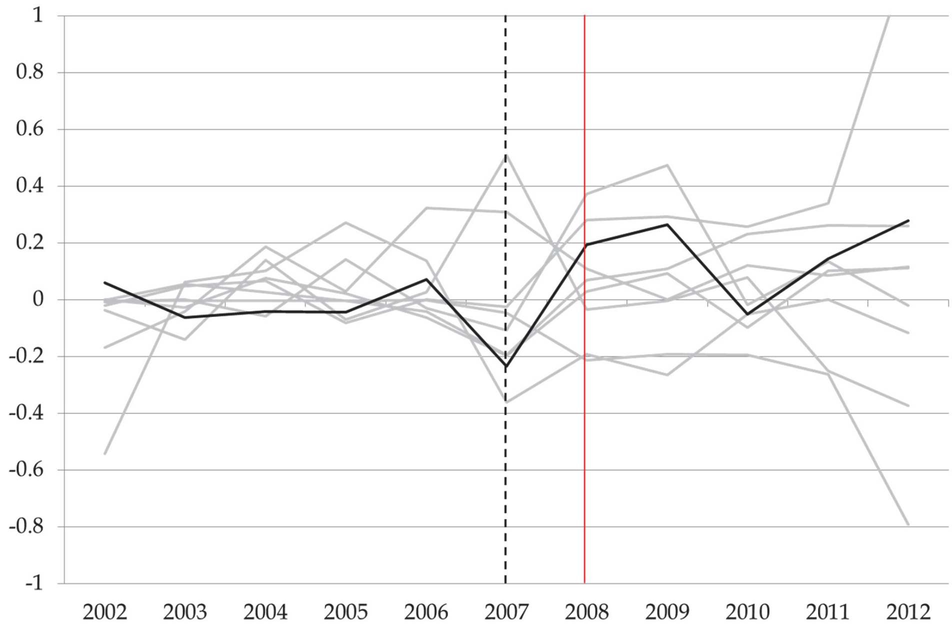
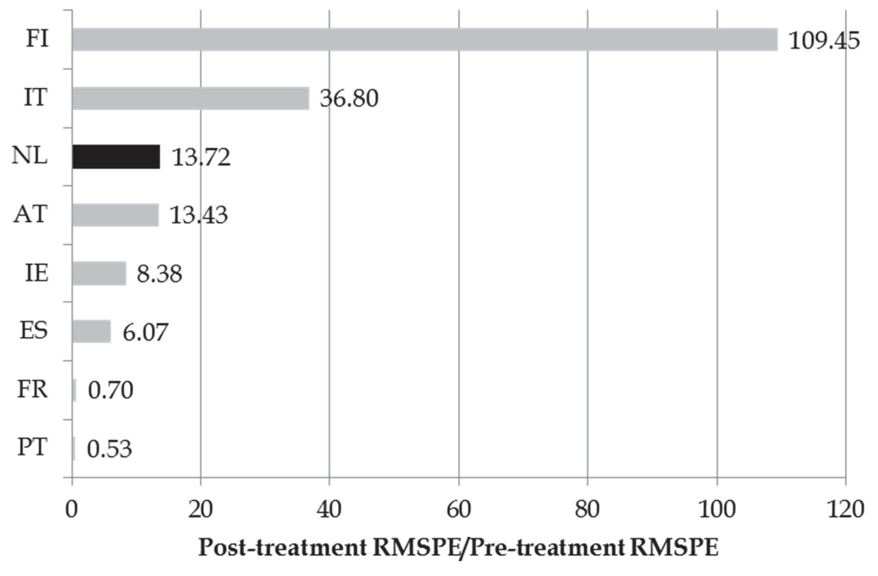


FIGURE 17 Ratios of post-treatment and pre-treatment period RMSPEs



Notes: Germany's ratio, 16359.02, is out of scale and thus not reported in the figure.

To conclude, none of the analyses conducted with three different patent quality measures suggests that the abolition had any permanent effects on the quality of Dutch patents at the aggregate level in the period 2007–2012.

6.3 Limitations

Several confounding macro factors make it difficult to distinguish the effect of short-term patent system abolition from other factors. In particular, the global financial crisis began almost exactly concurrently with the abolition of the Dutch short-term patent system in June 2008. The crisis hit sample economies hard and probably led to a decrease in domestic patent applications in most sample countries, as global markets and investments were frozen for a while. However, due to the global nature of the crisis, patentees in all sample countries faced the same global uncertainty, and therefore the negative effect of the financial crisis on national patenting activity was likely relatively symmetric in the sample economies.

Concurrently, other changes in national patent laws and the institutional environment further blur the effect of the short-term patent system's abolition. The Dutch patent office decreased patenting fees to boost domestic patenting activity. On the other hand, the London agreement entered into force on 1st May 2008—just a month before the abolition—and thereafter the Dutch patent office no longer required the translation of granted EPO patents' descriptions into the Dutch language. This probably affected negatively the demand of the Dutch patent office as a patent filing route. Furthermore, the introduction of the Dutch patent box in 2007 (see Mohnen et al., 2017) is another country-specific confounding factor, constituting a major policy change, which changed the patenting incentives of Dutch inventors.[126] It possibly mitigated the negative effect of the short-term patent system's abolition. Finally, changes in national patent and related laws in the control countries undermine the accuracy of the synthetic controls.

Additionally, the study lacks the price information of national patent and short-term patent protection. De Rassenfosse and van Pottelsberghe (2012) have shown by comparing USPTO, JPO, and EPO that patent fees can be used as an effective policy leverage to affect the propensity to patent. They estimate the price elasticity of demand for patents to be -0.3—that is, a 10% increase in price decreases patent applications by 3%. Nicholas (2011) studied the 1883 Patents Act in Britain and found that an 84% decrease in patenting fees led to a 2.5-fold increase in patent filings. Eaton et al. (2003) report that European patent publi-

[126] Mohnen et al., (2017, p.141) define "patent boxes" as tax incentive schemes, which aim is to stimulate R&D by providing favourable tax rates to profits that can be linked to a specific immaterial asset, e.g., a patent. However, Mohnen et al. (2017) point out that although the Dutch patent box initially applied to only projects that led to patents, this requirement was dropped already in 2008. This made the patent box *de facto* a patent box without the formal requirement of a patent.

cations increased by 70% during the period 1991–2000 and that the decrease in the cost of seeking protection via EPO could explain about 40% of this increase. Hence, patenting fees are an important predictor of the number of patent applications in a country and should be taken into account when comparing patenting activity at the national level.

Furthermore, the heterogeneity of second tier patent systems and national peculiarities weaken the external validity of the obtained results. Non-harmonized national systems have varying intensities of patent examination and country-specific patentability requirements, which among other things affect the level of substitution between national and EPO patents. Hence, the results cannot be directly generalized to other second tier patent protection systems due to these country-specific characteristics. Dutch short-term patents were probably closer substitutes to normal 20-year patents than second tier patents in most other advanced European economies since the inventive step requirement was the same for short-term and normal patents.

Finally, country-specific differences in industry structures were not taken into account when the aggregate level of patent filings and aggregate quality of inventions protected with patents were analyzed. A more in-detail analysis should be performed at the industry or technological field level.

7 Conclusions

This study sheds light on the interaction between regular patent and second tier patent protection systems in advanced economies. It documents that the transition from a two-tiered patent system to a single-tiered system may not always have a long-lasting negative effect on the level of national patenting activity. The analysis shows that the amendment of the Dutch Patent Act, which included the abolition of the Dutch short-term patent system in June 2008, was not associated with a permanent drop in the number of Dutch patent applications. In fact, patent statistics suggest that applicants were already adjusting their filing behavior when the decision of the policy reform was made at the end of February 2007 and even before that. No significant effect on the average quality of inventions protected with Dutch patents is found.

The current study analyzed aggregate patenting without taking into account technological field differences. Further research could address, in the spirit of Eswaran and Gallini (1996) and Moser (2005), whether second tier patent protection affects the direction of innovation—that is, the structure of R&D efforts by directing attention from more radical inventions toward imitative and incremental inventions (Boztosun, 2010). Also, more empirical micro evidence is needed on the role of second tier patents for SMEs and individual inventors in acquiring finance and in licensing activity. What remain invisible in patent statistics are the underlying motives of the applicants. With purely quantitative analysis, it is impossible to directly assess whether a patent applicant applied for a patent to commercialize the protected invention or to strategically increase the uncertainty of competitors' R&D projects. From the perspective of the patent office, it would be important to empirically study the screening function of two-tiered patent systems (see Hopenhayn & Mitchell, 2001; Atal & Bar, 2014): if a two-tiered patent system does not boost innovation, it might at least weed out bad patent applications, which burden patent examiners and increase backlog. The social costs and benefits of cost-effective "rational ignorance" at the patent office and uncertainty induced by unexamined patents are an important topic for future research (Ayres & Klemperer, 1999; Lemley, 2001). It remains an empirical question whether the net effect of a two-tiered patent system on welfare is positive or negative: on one hand, more disclosure reduces the duplication of R&D, while on the other hand, more patented inventions increase transaction costs and legal uncertainty when the innovation is cumulative. This analysis is out of the scope of this study and is left for future research.

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Appendix

TABLE A.1 OECD countries and second tier patent protection

	Member of				Second tier patent protection	
	OECD	PCT	EU	EPO		
AUSTRALIA	1971	1980	-	-	1979-	Innovation patent
AUSTRIA	1961	1979	1995	1979	1994-	Utility model
BELGIUM	1961	1981	1995	1977	1987-2009	Short-term patent
CANADA	1961	1990	-	-	-	-
CHILE	2010	2009	-	-	1991-	Utility model
CZECH REPUBLIC	1995	1993	2004	2002	1992-	Utility model
DENMARK	1961	1978	1973	1990	1992-	Utility model
ESTONIA	2010	1994	2004	2002	1994-	Utility model
FINLAND	1969	1980	1995	1996	1992-	Utility model
FRANCE	1961	1978	1952	1977	1968-	Utility certificate
GERMANY	1961	1978	1952	1977	1891-	Utility model
GREECE	1961	1990	1981	1986	1988-	Utility model
HUNGARY	1996	1980	2004	2003	1992-	Utility model
ICELAND	1961	1995	-	2004	-	-
IRELAND	1961	1992	1973	1992	1992-	Short-term patent
ISRAEL	2010	1996	-	-	-	-
ITALY	1962	1985	1952	1978	1934-	Utility model
JAPAN	1964	1978	-	-	1905-	Utility model
KOREA	1996	1984	-	-	1961-	Utility model
LUXEMBOURG	1961	1978	1952	1977	-	-
MEXICO	1994	1995	-	-	1991-	Utility model
THE NETHERLANDS	1961	1979	1952	1977	1995-2008	Short-term patent
NEW ZEALAND	1973	1992	-	-	-	-
NORWAY	1961	1980	-	2008	-	-
POLAND	1996	1990	2004	2004	1924-	Utility model
PORTUGAL	1961	1992	1986	1992	1940-	Utility model
SLOVAK REPUBLIC	2000	1993	2004	2002	1992-	Utility model
SLOVENIA	2010	1994	2004	2002	1992-	Short-term patent
SPAIN	1961	1989	1986	1986	1929-	Utility model
SWEDEN	1961	1978	1995	1978	-	-
SWITZERLAND	1961	1978	-	1977	-	-
TURKEY	1961	1996	-	2000	1995-	Utility model
UNITED KINGDOM	1961	1978	1973	1977	-	-
UNITED STATES	1961	1978	-	-	-	-

OECD members: http://www.oecd.org/about/membersandpartners/list-oecd-member-countries.htm
PCT members: http://www.wipo.int/treaties/en/summary.jsp
EU members: http://europa.eu/about-eu/countries/index_en.htm
EPO members: http://www.epo.org/about-us/organisation/member-states.html
Second tier patent protection information: http://www.wipo.int/directory/en/
See also : The INNOVACCESS network of National Intellectual Property Offices http://www.innovaccess.eu/

TABLE A.2 List of variables

Variable	Description	Source
Priority filings	DOCDB or INPADOC patent families with a domestic priority filing.	PATSTAT database (Spring 2016 version)
Patent applications	Number of patent and second tier patent (utility models, short-term patents) applications	PATSTAT database (Spring 2016 version)
IPR index	A composite index measuring strenght of IPR protection. Ginarte & Park (1997) provide 1980-1995 values and Park (2008) 1995-2005 values.	Ginarte & Park (1997) and Park (2008)
GDP per capita	Gross domestic product per capita in 2005 dollar prices and constant PPP	OECD
R&D expenditure	Total R&D expenditure in constant 2005 dollar prices	OECD
R&D employment	Number of full time equivalent R&D employees	OECD
R&D intensity	GERD per GDP	OECD
Population	Number of inhabitants in country	OECD
Industrial employment	Number of employees working in the industrial sector	OECD
Schooling	Average years of schooling for population older than 25 years	Barro & Lee (2013)
Economic Freedom index	A composite index measuring country's general economic freedom	Fraser Institute, Gwartney et al. (2014)
Trade Openness index	A measure of trade openness, part of Economic Freedom index	Fraser Institute, Gwartney et al. (2014)

RESULTS FOR QUARTERLY AND MONTHLY DATA

1. Quarterly data

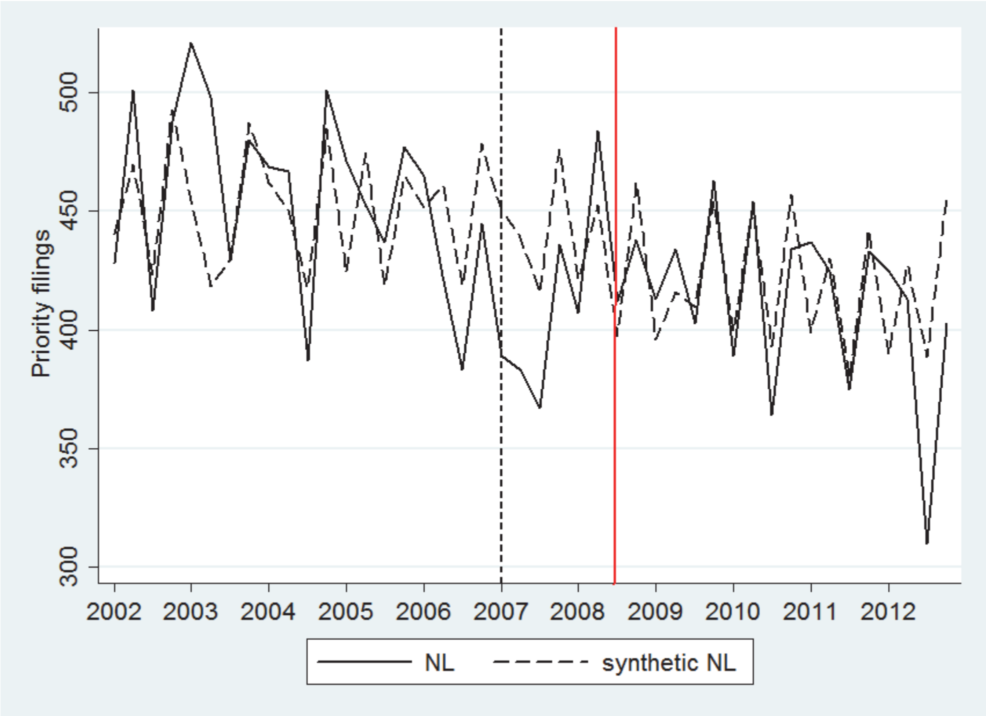
Pre-treatment period is Q1/2002 – Q4/2006. The treatment period is Q1/2007 and the post-treatment period Q1/2007 – Q4/2012. Country weights: Denmark 0.739, Ireland 0.151, France 0.045, Italy 0.02, Germany 0.011 and Portugal 0.034. Finland, Austria, France and Spain are assigned zero weight each.

TABLE A.3 Patenting activity predictor means before abolition of the Dutch short-term patent system, quarterly data

	The Netherlands	Synthetic control	Average of control countries
Priority filings*	456.50	451.16	2217.21
R&D intensity	1.89 %	2.19 %	1.77 %
Population	16200000	9741536	28847078
Industrial employment share	0.36	0.35	0.34
GDP per capita	33527.31	31907.87	29025.27
Trade openness	8.69	8.64	8.53
Economic freedom	7.92	7.95	7.64
Schooling	10.98	11.03	9.98
IPR index	4.67	4.66	4.52
RMSPE		31.95	

Note: *Priority filings are distinct patent families per quarter with priority filing at the domestic patent office. All predictor variables are averaged over the pre-treatment period, q1/2002 - q4/2006.

FIGURE A.1 Priority filings: the Netherlands vs. synthetic control, quarterly data



Note: Priority filings at DOCDB patent family level. Dashed line indicates Q1/2007 when the abolition decision was published and red line indicates Q2/2008 when the system was abolished.

2. Monthly data

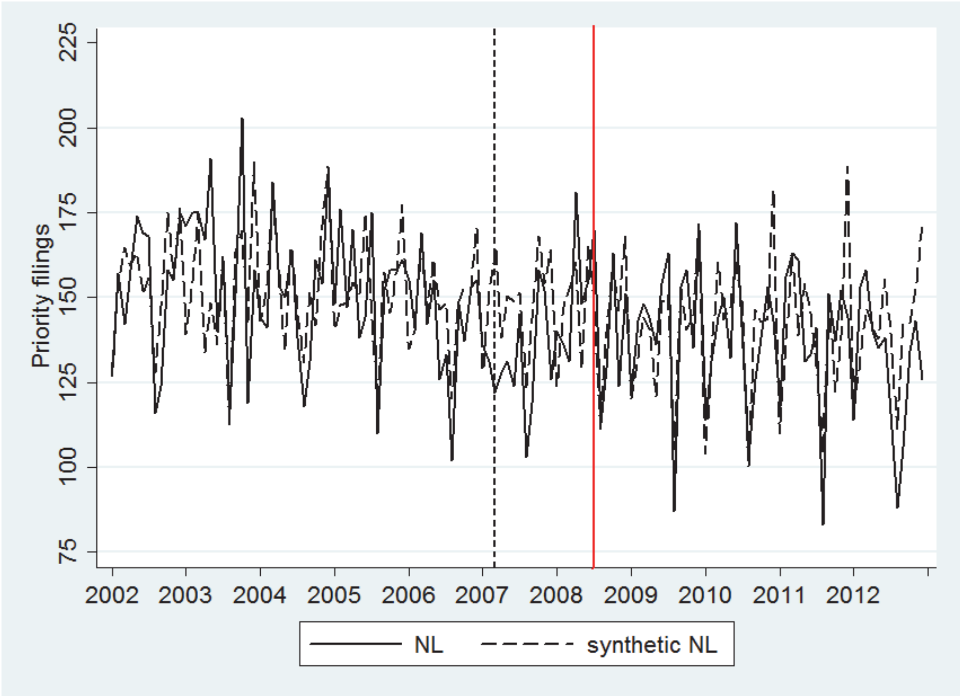
Pre-treatment period is January 2002 – February 2007. The treatment period is March 2007 and the post-treatment period March 2007 – December 2012. Country weights: Denmark 0.929, France 0.06 and Germany 0.011. Austria, Finland, Greece, Ireland, Italy, Portugal and Spain are assigned zero weight each.

TABLE A.4 Patenting activity predictor means before abolition of the Dutch short-term patent system, quarterly data, monthly data

	The Netherlands	Synthetic control	Average of control countries
Priority filings*	152.56	152.09	737.00
R&D intensity	1.90 %	2.48 %	1.77 %
Population	16300000	9573528	28800000
Industrial employment share	0.36	0.34	0.34
GDP per capita	34016.66	32300.27	29838.65
Trade openness	8.92	8.87	8.19
Economic freedom	7.88	7.91	7.70
Schooling	10.98	11.13	9.98
IPR index	4.67	4.67	4.52
RMSPE		16.62	

Note: All predictor variables are averaged over the pre-treatment period, January 2002 - February 2007. *Priority filings are distinct patent families per month with priority filing at the domestic patent office.

FIGURE A.2 Priority filings: the Netherlands vs. synthetic control, monthly data



Note: Priority filings at DOCDB patent family level. Dashed line indicates February 2007 when the abolition decision was published and red line indicates June 2008 when the system was abolished.

CHAPTER 6: DO TWO-TIERED PATENT SYSTEMS INDUCE SORTING? EVIDENCE FROM EUROPEAN COUNTRIES[127]

Abstract

We analyze sorting induced by two-tiered patent systems in European countries. The results suggest that two-tiered patent systems induce self-selection by both invention quality and applicant type. Second tier patents are chosen for more marginal inventions and more often by individual applicants in comparison to regular patents. The ratio of second tier patents to regular patents is the highest in technology fields in which the average quality of inventions protected with regular patents is the lowest. We find ambiguous evidence on the quality differences between regular patents in single-tiered and two-tiered patent systems. Significant heterogeneity across countries and technology fields indicates the need for further patent-system-specific case studies, which take into account national institutional differences.

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1 Introduction

Technological progress has been identified as the main channel for socioeconomic development (Solow, 1957; Jones, 2002). The *raison d'être* of intellectual property (IP) protection is the promotion of technological discovery. Although the necessity of legal mechanisms for the protection of IP was at times contested (e.g., Machlup & Penrose, 1950; Janis, 2002; Moser, 2016), developed economies settled the question of the necessity of a patent system a long time ago. The sentiment that the patent system is here to stay has been well summarized by Machlup (1958, p. 80):

"If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it."

However, questions about the specific design of the patent system, its institutional features and procedures, are still ongoing and occupy the attention of both theorists and policy practitioners (Scotchmer, 2004; Encaoua et al., 2006). These questions are important because the chosen designs can affect the rate and direction of innovation (Eswaran & Gallini, 1996; Moser, 2005). How should patent systems be designed? What should the length and breadth of patent protection be (Gilbert & Shapiro, 1990; Klemperer, 1990; Eswaran & Gallini, 1996)? What should the optimal fee structure be (Scotchmer, 1999; Cornelli & Schankerman, 1999)? When evaluating ideas for patent protection, how should patent authorities operationalize non-obviousness (Kou et al., 2013) and novelty thresholds (Scotchmer & Green, 1990; van Dijk, 1996)? Should patent systems offer differentiated IP products—in other words, a multi-tier "menu" of IP protection (Hopenhayn & Mitchell, 2001; Encaoua et al., 2006; Atal & Bar, 2014)? These are just some of the practical design questions confronting IP systems.

In this paper, we inquire into the role of one specific institutional design option for patent systems, namely, multiple tiers of IP protection. In practice, several national patent offices offer a menu of two types of patents: patents (or patents of invention, the standard form of protection for technical inventions; referred to as "regular patents" hereafter) and "utility models" or equivalents (a weaker form of IP right characterized by a shorter term of protection but a simpler and faster application procedure).[128] For the sake of consistency, we refer to

[128] The utility model is the most common type of second tier patent protection. However, similar systems have different names across countries. Second tier patent protection systems that are close to equivalent to utility model systems are called *inter alia* "short-term patents", "utility certificates", "innovation patents", "petty patents", and "consensual patents" (Janis, 1999; Prud'homme, 2014).

the latter as "second tier patents" throughout this paper.[129] Although much international harmonization has taken place over time, patent systems remain largely national institutions.[130] When second tier patent protection exists, technical inventions can be protected with patents, by second tier patents, or, in some countries, by both. In this context, sorting (alternatively, self-selection or screening) refers to the situation in which a patent office, the uninformed party, offers a menu of differentiated patent types (patents and second tier patents) and an applicant, the informed party, self-selects the profit-maximizing option.

Second tier patent protection systems have been widely used among European countries (European Commission, 1995; Janis, 1999; Beneito, 2006; Suthersanen, 2006; Prud'homme, 2014; Radauer et al., 2015; Heikkilä, 2017). However, it is unclear to what extent second tier patents boost innovative and entrepreneurial activity and to what extent they promote strategic patenting such as pre-emptive patenting and strategic non-use (Kingston, 2001; Blind et al., 2006; Guellec et al., 2012; Torrisi et al., 2016; Heikkilä & Lorenz, 2018). It is important to study the subject in the context of European countries because the efficient harmonization of intellectual property rights (IPR) systems within the European Single Market requires us to have a deeper understanding of the functioning and interaction of current patent and second tier patent institutions.

A number of justifications have been put forward for the second tier patent option alongside patent protection. First, the second tier patent protection might attract technologically less important inventions (European Commission, 1995; Beneito, 2006), providing an extra signal about the relative quality[131] or value of inventions to potential investors (Atal & Bar, 2014). The quality of patents is a cumbersome concept and may refer, for example, to the technological and economic value of the protected invention or to the "legal quality" (Burke & Reitzig, 2007), which measures the enforceability of the patent. We focus on the former. Second, second tier patent protection has been promoted as a way to aid small enterprises and individual inventors for whom regular patent protection is prohibitively expensive (European Commission, 1995; Janis 1999). Finally, granting some form of IPRs to technologically marginal inventions creates a more inclusive IP regime by bringing into the patent system innovations and innovators that would otherwise be left without IPR protection (Janis, 1999). Inventions protected by second tier patents are also registered in patent data-

[129] In Lemley et al. (2005) and Atal and Bar (2014), the additional tier refers to a superior form of patent protection, also called the "gold-plated" patent. In existing patent systems, and, therefore, in our discussion, the second tier of patent protection is inferior to the first tier "regular patents".

[130] These national mechanisms are linked through international IP treaties, including, for example, the Paris Convention for the Protection of Industrial Property of 1883, the World Trade Organization's (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), the European Patent Organization's (EPO) European Patent Convention (EPC), and the World Intellectual Property Organization's (WIPO) Patent Cooperation Treaty (PCT).

[131] Patent quality is a concept that has been given several different definitions. These are discussed, for example, by Frietsch et al. (2010) and Squicciarini et al. (2013).

bases, and they may, therefore, prevent the duplication of R&D on minor inventions or help inventors and start-ups to attract venture capital.

On the adverse side, arguments against two-tiered patent systems can also be listed. One argument is that multiple tiers of protection complicate the IP regime (Heikkilä, 2017). Another argument is that the low technological threshold coupled with no (or only *pro forma*) examination of second tier patents create an aura of property rights for inventions that do not represent a technological contribution and that would not stand up to scrutiny if contested in the courts (cf. Farrell & Shapiro, 2008). Issuing patent rights to simple and obvious inventions may lead to the tragedy of the anti-commons and severe blocking of future inventions (Heller & Eisenberg, 1998; Janis, 1999; Kingston, 2001). In other words, whether patent systems should be single-tiered or multi-tiered is an institutional design choice with potentially serious implications. Whether two-tiered patent protection with utility models is welfare improving depends on the relative balance of its costs and benefits.

Do second tier patents attract lower-quality inventions, or do they appeal to applicants with tighter financial constraints, or both? Whether second tier patents represent, on average, technologically marginal inventions or financially constrained inventors has rather different implications for the optimal design and future development of patent systems. If technologically less valuable inventions self-select into the lower tiers of patent protection, then systems with multiple tiers are providing additional information to economic agents about invention quality. Conversely, if selection is based on financial characteristics, it can be said that two-tier systems grant weaker and less valuable rights to financially constrained applicants. As a consequence, it is harder for financially constrained applicants to signal the quality of their invention. There may be more effective ways to bring inventors with financial constraints into the patent system, such as through lower filing fees for small entities (Bessen, 2008; Schuett, 2013).

The remainder of this paper is organized as follows: section 2 presents the theoretical framework and testable hypotheses. In section 3, the differences between patents and second tier patents are analyzed, and the sorting induced by two-tiered patent systems is empirically tested. Discussion and conclusions are presented in section 4.

2 Screening with patent menus

Scotchmer (1999) and Cornelli and Schankerman (1999) modeled patent renewal fees as a direct mechanism[132]: In their models, the renewal fee schedule is interpreted as a menu of patents with different lengths and fees that the patent

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[132] In mechanism design context, direct mechanisms or direct revelation mechanisms are special mechanisms in which the set of messages and the set of types are the same, agents report their types, and given their announcements, the principal assigns respective alternatives to agents (see Mas-Colell et al., 1995; Salanié, 2005).

office offers to profit-maximizing applicants who self-select to use their preferred option. Hopenhayn and Mitchell (2001) suggested a menu of patents with varying breadths and lengths as a direct mechanism. Interestingly, they suggested a menu in which patent breadth is traded for length—that is, more breadth is granted for inventions that are protected for shorter periods of time and vice versa. In contrast, established two-tiered patent systems are typically menus consisting of long and broad patents and short and narrow second tier patents.

Two-tiered patent systems are *de facto* sorting mechanisms. However, the sorting can occur along several dimensions. National patent systems establish differences between patents and second tier patents with respect to

1. novelty and inventive step (obviousness) requirements,
2. examination intensity of patentability requirements,
3. length of protection,
4. grant lags (speed of protection), and
5. patenting fees

as sorting instruments (see also Lerner, 2000). Patent applicants are a heterogeneous set: they differ multidimensionally in their characteristics, in their preferences for IP protection, and in the quality of their inventions. Applicants self-select to use either patents and/or second tier patents or to forgo filing given the menu offered by the patent office (Atal & Bar, 2014).[133] There is asymmetric information, as the patent office does not know applicants' motives, and applicants have more information about the invention than the patent office. The patent office faces an adverse selection problem. Patent applications for inventions that do not satisfy patentability requirements are socially wasteful in many ways. If the patent examination process is imperfect (Caillaud & Duchêne, 2011)—that is, the patent office grants patents for non-deserving patents with some probability (Type II error) leading to a "lemons problem" á la Akerlof (1970): low-quality inventions exert a negative externality on high-quality patents, and, as a consequence, a patent is an imperfect signal of invention quality to investors (Kou et al., 2013; Atal & Bar, 2014). Additionally, "bad patents" direct examination efforts away from patent applications for high-quality inventions that unambiguously deserve patent protection. This increases patent backlog and prolongs the average pendency times of both high- and low-value inventions. Conversely, if deserving inventions systematically fail to receive IP protection due to a high hurdle of application (Type I error), then technology creation might not be sufficiently well incentivized.

Figure 1 illustrates the screening mechanism and the interaction between an uninformed patent office and an informed applicant. In the figure, $E\pi(i)$, where $i \in \{P_1,P_2\}$, denotes the expected profit from choosing patenting (P_1) or second tier patent (P_2).

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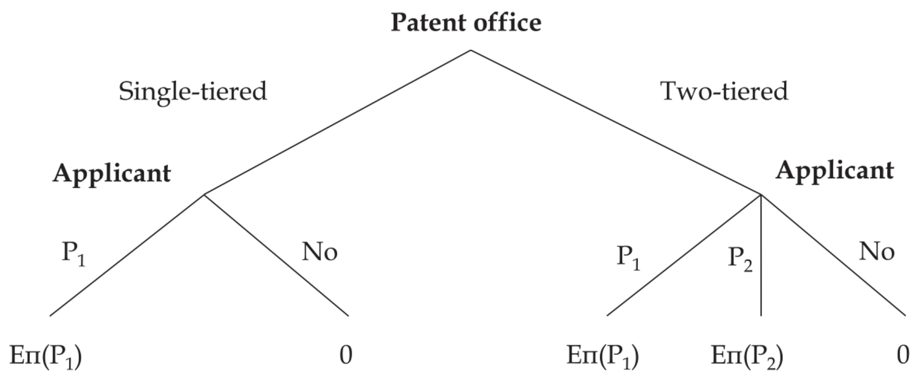
[133] Thus, current analysis focuses simply on applicants' self-selection of patent types and abstracts from the self-selection of applicants into R&D (cf. Schuett, 2013).

FIGURE 1 Screening with patent menus



The timing of events is as follows:

1. The patent office chooses the menu to offer: {P_1}, "single-tiered" or {P_1, P_2}, "two-tiered"
2. A profit-maximizing applicant chooses either regular patent protection, second tier patent protection, or to forgo filing altogether (No) given the expected payoffs.
3. Self-selection and examination intensity (probability of Type II error) define the average quality of patents and second tier patents.

Although the patent office could be assumed to be interested in inducing the truthful revelation of invention quality—that is, designing a direct mechanism, in which protection is assigned optimally contingent on the types reported by applicants (cf. Scotchmer, 1999; Cornelli & Schankerman, 1999; Hopenhayn & Mitchell, 2001)—the objective function of the patent office is actually unclear. In an ideal world, the patent office could act as a social planner and aim to maximize social welfare, for example, by weeding out "bad patents", which often refer to low-quality inventions that do not satisfy patentability requirements (Lemley et al., 2005; Caillaud & Duchêne, 2011; Schuett, 2013; Atal & Bar, 2014; de Rassenfosse & Jaffe, 2014). In practice, many national patent offices are organizations that self-finance their operations. Public choice theory (see Niskanen, 1968) suggests that the incentive systems faced by self-interested patent office bureaucrats may not lead to the maximization of aggregate social welfare but to the maximization of the patent office's budget (Gans et al., 2004; Frakes & Wasserman, 2013; Picard & van Pottelsberghe, 2013).

Generally, self-financed patent offices must scale their activities to meet the demand for their services. In Europe, harmonization and integration have led to a decrease in the demand for national patent offices' services, as patents are increasingly sought at the European Patent Organization (EPO) (see, e.g., Hall & Helmers, 2012)—that is, the EPO's services substitute for the national patent office's services. Because lower-tier patent systems are not harmonized in Europe, and there exists no "community utility model" (European Commission, 1995, 2002), national patent offices still have local monopolies on granting second tier patent protection. Thus, national patent offices may have incentives to increase their revenue stream by extending the menu of IPRs provided to applicants and by making national protection more lucrative relative to EU-level IPR protection options. Second tier patent systems also provide flexibility for national patent offices to serve the needs of patentees, which cannot be satisfied by standard patent systems (Kingston, 2001).[134]

2.1 Sorting by invention quality

The fundamental theoretical sorting mechanism of a two-tiered patent system is that applicants with high-quality inventions self-select into higher-quality tiers, and lower-quality inventions self-select into lower-quality tiers (Schuett, 2013; Kou et al., 2013; Atal & Bar, 2014).

The patent office decides the examination intensity of patents (Lemley, 2001; Caillaud & Duchêne, 2011, Picard & van Pottelsberghe, 2013; Schuett, 2013; Atal & Bar, 2014). We can say that the patent office decides the level of its "rational ignorance" (Lemley, 2001), and in a two-tiered patent system, it can actually differentiate in its level of rational ignorance between different types of patents. On a practical level, the patent office decides how much time and effort patent examiners should allocate to the examination of different types of patents, and that intensity defines the probability of Type II errors. Lemley (2001) reports that U.S. patent examiners spend on average 18 hours examining a single patent. The time used by patent examiners to examine second tier patents is much less, in several jurisdictions negligible, and rather a registration process than an examination. By offering a menu of differentiated patents, the patent office induces sorting—that is, self-selection by applicants according to the quality of their inventions. A recent study by Hamdan-Livramento and Raffo (2016) indicates that second tier patents (utility models) are chosen for inventions that are less valuable. Thus, we test the following hypothesis:

Hypothesis 1:
The likelihood of choosing second tier patent protection is negatively associated with invention quality.

We expect that in two-tiered patent systems a portion of applicants with patentable inventions apply for second tier patents instead of regular patents. We would expect that a large share of these consist of incremental inventions with the lowest expected profits. In addition, we expect that a portion of applicants

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[134] It should be noted that European patent systems are not only two-tiered, but the menu of protection methods for technical inventions is actually wider: European patent systems are actually at least "three-tiered" by the cost of filing: 1. EPO, 2. national patent, 3. Second tier patent (utility model or equivalent).

with inventions that do not satisfy patentability requirements but who would, nevertheless, apply a patent in single-tiered patent system in the hope of Type II error by patent examiners, apply for second tier patents in a two-tiered patent system. As a consequence of this hypothesized self-selection, the average quality of regular patents is expected to increase, and we test the following hypothesis:

Hypothesis 2:
In two-tiered patent systems, the quality of inventions, for which regular patent protection is applied for, is higher than in single-tiered patent systems.

2.2 Sorting by applicant type

In general, sorting by applicant (assignee) type is secondary to sorting by invention quality from the perspective of social welfare. The self-selection of applicants does not exert similar externalities on other applicants as self-selection by invention quality. Nevertheless, the financial constraints of small entities have been acknowledged in some countries, and patent offices have differentiated fees for small and large entities (Bessen, 2008; Frakes & Wasserman, 2013; Schuett, 2013; de Rassenfosse & Jaffe, 2014). Patent fees are an important screening instrument (Scotchmer, 1999; Cornelli & Schankerman, 1999; de Rassenfosse & van Pottelsberghe, 2013; de Rassenfosse & Jaffe, 2014), and financially constrained applicants are, presumably, more likely to rely on cheaper protection. Although we lack systematic information on the application and renewal fee structure across countries, time, and IPR type, the general practice is that second tier patent applications are somewhat cheaper than regular patent applications, and their renewal fees are lower (European Commission, 1995; Prud'homme, 2014; Radauer et al., 2015; Heikkilä, 2017; Heikkilä & Lorenz, 2018). Presumably, individual inventors invest less in R&D, have lower quality inventions and have fewer resources than corporate and other institutional assignees to invest in IPR protection. Indeed, Bessen (2008) reports that patents owned by small entities are significantly less valuable than patents owned by large entities. Therefore, we expect individual applicants to be more likely to choose second tier patents instead of regular patents. We test the following hypothesis:

Hypothesis 3:
The likelihood of choosing second tier patent protection is negatively associated with an applicant being a non-individual.

As a consequence of this hypothesized self-selection, the composition of applicants applying for regular patents is likely to be affected. We test the following hypothesis:

Hypothesis 4:
The share of regular patents filed by non-individual applicants is higher in two-tiered patent systems than in single-tiered systems.

If financially constrained applicants select cheaper second tier patent protection instead of more expensive regular patent protection irrespective of the quality of their invention, then the sorting by quality of invention (Hypotheses 1 and 2) is confounded. The more often high-quality inventions are protected with second tier patents, the higher the average quality of second tier patents. As a consequence, the difference in average quality between inventions protected with regular patents and second tier patents would be smaller.

3 Empirical analysis

3.1 Data and variables

The sample consists of EPO member states in 2012 and their patent filing activity over the period 2000–2012. Table 1 lists EPO member states. During the period, there have been several changes in national patent systems, but we focus on one simple dimension: whether the national patent office offers to applicants a single type of patent protection or a menu of patent protection consisting of regular patents and second tier patents.[135] Although several countries already had two-tiered patent systems in place before 2000, some institutional changes also occurred during 2000–2012. For instance, the Netherlands abolished its short-term patent system in June 2008 and Belgium in January 2009 (Prud'homme, 2014; Radauer et al., 2015; Heikkilä, 2017). Romania's utility model system entered into force in 2008. In aggregate, we have an unbalanced panel of 33 countries over the period 2000–2012.

We acknowledge the difference between different types of patent families and focus our attention on two types of patent filings: priority filings and singleton filings. Priority filings are the first filings at national patent offices (de Rassenfosse et al., 2013), and they reflect the initial choice between patent and second tier patent protection within a patent family. Hence, for each country, we exclude national filings, which are subsequent filings of priority filings in other patent offices (see Martínez, 2011). We exclude patent families, in which the priority filing at a national patent office is a Patent Cooperation Treaty (PCT)

[135] There exists an indicator for utility models in the PATSTAT database (ipr_type "UM") but not for short-term patents. Short-term patents are, therefore, harder to distinguish from normal patents. We provide the indicators of short-term patents in Table A.1 in the Appendix (see also de Rassenfosse et al., 2013).

filing.[136] Singleton patents or "singletons" refer to patents whose patent family consists of only one patent filing—that is, the priority filing is not followed by any subsequent filings in other countries (Martínez, 2011; de Rassenfosse et al., 2013). Singleton patents are a subset of priority filings: protection is applied only in one country and market. Hence, these singleton patents correspond best to the theoretically modeled role of patents as innovation incentives in models that abstract away the international dimension of patenting. International patent families are less comparable across countries because they can differ in various dimensions, and there are several strategic considerations. Moreover, singleton patents are also the closest substitute to second tier patents, which are often used only for national protection purposes.

Testing Hypotheses 1 and 3 requires patent filing–level analysis, whereas Hypotheses 2 and 4 are tested at the country and technology field level. In sections 3.1.1–3.1.3, we describe the dependent, independent, and control variables separately for these different levels of analysis.

[136] Most second tier patents are applied in order to obtain solely national protection, and their use in international patent filing is less common (Heikkilä & Verba, 2017). We discuss the strategic choices between priority patents and second tier patents in the context of international patenting in a complementary paper (Heikkilä & Verba, 2017).

TABLE 1 EPO member states

	EPO	EU	Two-tiered patent system
Belgium	1977	1952	1987-2008
France	1977	1952	1968
Germany	1977	1952	1891
Luxembourg	1977	1952	
Switzerland	1977		
The Netherlands	1977	1952	1995-2008
United Kingdom	1977	1973	
Italy	1978	1952	1934
Sweden	1978	1995	
Austria	1979	1995	1994
Liechtenstein	1980		
Greece	1986	1981	1988
Spain	1986	1986	1929
Denmark	1990	1973	1993
Monaco	1991		
Ireland	1992	1973	1992
Portugal	1992	1986	1940
Finland	1996	1995	1992
Cyprus	1998	2004	
Turkey	2000		1995
Bulgaria	2002	2007	1993
Czech Republic	2002	2004	1992
Estonia	2002	2004	1994
Slovakia	2002	2004	1992
Slovenia	2002	2004	1992
Hungary	2003	2004	1992
Romania	2003	2007	2008
Iceland	2004		
Lithuania	2004	2004	
Poland	2004	2004	1924
Latvia	2005	2004	
Malta	2007	2004	
Croatia	2008	2013	1992
Norway	2008		
Macedonia	2009		
San Marino	2009		
Albania	2010		2009
Serbia	2010		2004

Notes: Information gathered from official websites of the EPO, EU and WIPO.

3.1.1 Dependent variables

Filing-level analysis

When testing Hypotheses 1 and 3, the unit of observation is a priority filing at a patent office in a specific year. The dependent variable is an indicator variable, which equals 1 if the priority filing is a second tier patent application and 0 if the priority filing is a regular patent application.

Country- and technology field–level analysis

Testing Hypotheses 2 and 4 is more challenging. The unit of observation here is the quality of regular patents in a specific technology field in a specific country in a specific year. Due to incomplete data and institutional differences across national patent offices, the comparison of regular patent quality between countries is not straightforward. Several invention quality indicators (e.g., Harhoff et al., 2003; Reitzig, 2004; Lanjouw & Schankerman, 2004; Frietsch et al., 2010; Squicciarini et al., 2013; de Rassenfosse & Jaffe, 2014), which have been used in the prior literature for studying, for example, the quality of USPTO and EPO patents, require information that is not readily and reliably available at the level of European national patent offices. Forward citations are the most common measure of patent quality but the comparability of citation counts across countries is questionable, as citation practices differ across patent offices (Bakker et al., 2016; Boeing & Mueller, 2016), and presumably, language barriers affect citation counts at the national level (Boeing & Mueller, 2016). Similarly, procedural differences at national patent offices make it difficult to compare patent grant rates between countries (de Saint-Georges & van Pottelsberghe, 2013). The size of patent family is also an imprecise measure of invention value due to large differences in market sizes across countries.[137] The number of claims in patents is also not available for national patents and the analysis of national renewal fee payments (cf. Thompson, 2017) is left for future research.

Therefore, in addition to traditional patent quality indicators (forward citations and patent family sizes), we use the number of inventors in patent applications as an additional proxy for invention quality. The number of inventors is systematically available for regular patents in the cases of all national patent offices (EPO's PATSTAT database, April version 2016) and is suitable for testing the sorting induced by two-tiered patent systems. The more radical an invention is, the more likely it is that it has been invented within an R&D team (Sapsalis et al., 2006; Frietsch et al., 2010; Breitzman & Thomas, 2015). Sapsalis et al. (2006) point out that larger inventor teams may indicate that the project is a more strategic research project with a high expected profit. Breitzman and Thomas (2015) show that inventor team size is a good predictor of future citations and reason that team size may reflect the greater resources devoted to

[137] One way to make patent family measures more comparable is to weight members of patent families with GDP of protected markets (van Pottelsberghe & van Zeebroeck, 2008; Neuhäusler & Frietsch, 2013). What complicates matters with this type of an advanced measure is the heterogeneity between patent family members: some are granted some are rejected; some are patents some are second tier patents, etc.

more valuable inventions. The number of inventors is available in most patents but, unfortunately, is missing in the case of second tier patents for several countries (e.g., Germany). When we test Hypothesis 2, the dependent variable is 1) the logarithm of the average number of inventors, 2) the logarithm of the average number of forward citations or 3) the logarithm of average patent family size, in patent filings in a specific technology field in a specific country in a specific year.

Our indicator for applicant type is whether the applicants in a patent application are all individuals or not. This is a proxy for how resource constrained the applicant is. In PATSTAT, there is information available about the sector of applicants. An applicant can be assigned to one or more of the following sectors: individual, company, government, nonprofit organization, university, or hospital. If the sector cannot be assigned, then the applicant is "unknown". All of those patent filings in which the sector of any of the applicants is unknown are excluded. We construct an indicator variable to determine whether the applicant is a non-individual applicant. The indicator variable is 1 if any of the applicants is not an individual—that is, is classified as a company, government, nonprofit organization, university, or hospital—and 0 if all applicants are individuals. The indicator variable is a proxy for the resources and know-how of applicants: individual applicants presumably have fewer resources and IPR know-how than non-individual applicants. When we test Hypothesis 4, the dependent variable is the share of patent filings with non-individual applicants of all patent filings in a specific technology field in a specific country in a specific year.

3.1.2 Independent variables

Filing-level analysis

When testing Hypotheses 1 the variable of interest is the proxy for invention quality, the number of inventors in patent filing. Forward citations and patent family size are also measures for the quality of the invention but they are determined only after the choice between patent and second tier patent has been made by the applicant. Therefore, they are not considered in the filing-level analysis. When testing Hypothesis 3 the variable of interest is the indicator for applicant type, whether any applicant in a specific filing is a non-individual (company, university, government, nonprofit organization, or hospital) or not. Applicant type is assumed to measure how resource constrained the applicant is.

Country- and technology field-level analysis

When testing Hypotheses 2 and 4, the main variable of interest is the indicator of two-tier patent protection, which equals 1 if a country has a two-tiered patent system in place in a specific year and 0 otherwise. Information on two-tiered patent systems is collected from PATSTAT and WIPO Lex database.[138] Table 1 presents the information for sample countries.

[138] http://www.wipo.int/wipolex/en/

3.1.3 Control variables

Filing-level analysis

We control for country, year, and technology field fixed effects by including respective sets of dummy variables. Because a single invention can be classified into several technology fields with related weights in PATSTAT, we assign for each filing the technology field that has a weight higher than 50%. If all technology field weights given for a specific invention are equal to or less than 50%, we classify the filing into "other" technology field. Hence, in aggregate, we have 36 technology field categories. Table A.8 in the Appendix 2 lists the technology fields.

Country- and technology field-level analysis

Patenting practices and propensity to patent are heterogeneous across industries and technology fields (e.g., Scherer, 1983; Arundel & Kabla, 1998). Similarly, we expect the average number of inventors, the share of individual inventors, the share of non-individual applicants, and the substitution between patents and second tier patents to differ between technology fields. In order to account for this, we include technology field fixed effects (see Table A.8 in the Appendix 2). As explained above, a single invention can be classified in the PATSTAT database into several technology fields with respective weights. Here, we employ the same approach and assign for each filing the technology field that has a weight higher than 50%, and if all technology field weights given for a specific invention are equal to or less than 50%, we classify the filing into "other" technology field. We control for technology field fixed effects and also account for time-varying common patterns by including year fixed effects.

There exists evidence that when a country accedes to the EPO, foreign applicants shift to use the EPO route instead of the national route in patent filings (Hall & Helmers, 2012). Also, becoming an EU member and part of the European Single Market may affect national patenting activity, as the related product market reforms induce competition (Aghion et al., 2015). Thus, we control for countries' EPO and EU membership status over years with indicator variables. Territorial exclusive rights, such as patents, have higher expected revenues in larger markets, and larger markets may, therefore, attract proportionally more inventors and more applicants with incremental inventions. We control for this with a logarithm of GDP (current $). Finally, a country's innovation system and level of technological development may affect the composition of patent applications. We control for this with a logarithm of R&D share of GDP. The source of both R&D and GDP data is the World Bank's DataBank. Table A.6 in the Appendix reports relationships between these control variables and the likelihood of a country to have a two-tiered patent system. Figure A.12 in the Appendix shows the evolution of these variables separately for countries with single-tiered and two-tiered patent systems.

3.2 Sorting between patents and second tier patents

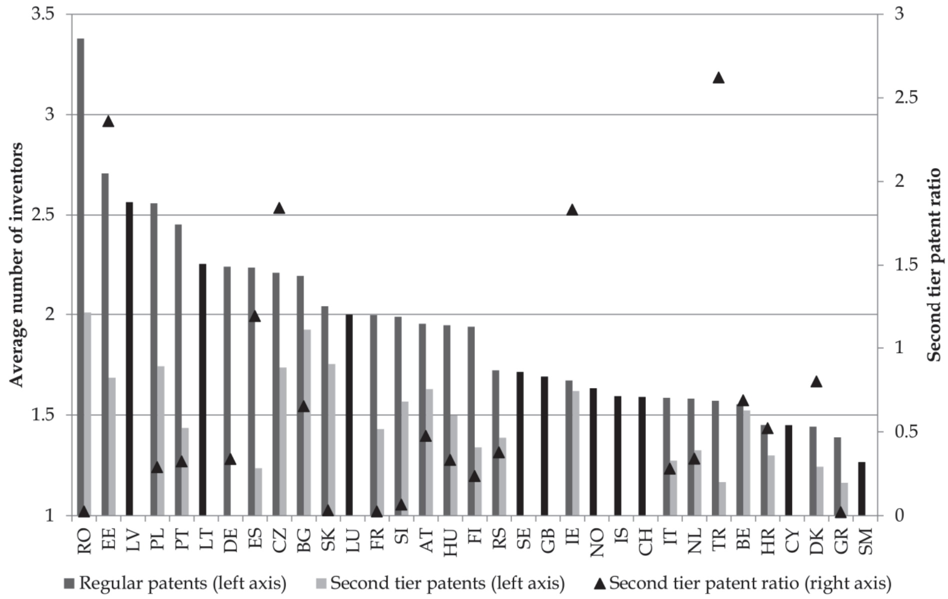
3.2.1 Sorting and invention quality

The simplest way to analyze sorting induced by patent menus is to investigate quality difference between all regular patent and second tier patent filings. Figures A.1, A.3 and A.5 in the Appendix present the distributions of our invention quality measure separately for all regular patents and second tier patents in our dataset (1606549 observations). They show that second tier patents are of lower quality regardless of the invention quality measure. Second tier patents have the smallest inventor team sizes, receive the least citations and have the smallest patent family sizes, on average. Figures A.2, A.4 and A.6 in the Appendix indicate that these quality differences between patens and second tier patents are systematic over time and the ranking between patent categories does not change. Regular patents in two-tiered countries have the highest average quality, regular patents in single-tiered countries slightly lower average quality and second tier patents have clearly the lowest average quality. Only exception is the average patent family size, for which there is little difference between regular patents in two-tiered and single-tiered systems over time (Figure A.6). These simple comparisons do not take into account country and technology field differences and are driven by countries with the largest number of filings. Hence, next we analyze each of these quality measures across countries and technology fields.

Figure 2 reports the average number of inventors in priority patent filings by country. Countries are ranked by the average number of their inventors in descending order from left to right. Clearly, the average number of inventors is lower in second tier patents (light grey; mean: 1.5) than in regular patents (dark grey for countries with two-tiered patent systems; mean: 1.99) and in countries with single-tiered patent systems (black; mean: 1.78). Black triangles indicate "second tier patent ratio", the number of second tier patents priorities relative to the number of regular patent priorities between 2000–2012 (see Table A.7 in the Appendix 2). If the intensity of second tier patent use reflects substitution from patents, we should observe that the difference in the average number of inventors between regular patents and second tier patents is the largest in two-tiered patent systems with the highest second tier patent ratios. Figure 2 does not show this type of systematic pattern.

According to Figure 2, several Eastern European countries, such as Romania, Estonia, Latvia, Poland and Lithuania, are among the countries with the highest average number of inventors whereas advanced countries such as Germany, the Netherlands, Finland and Sweden have much lower average number of inventors. This observation casts doubt on the validity of the number of inventors as a measure of quality of patent protected inventions. However, estimates in Table A.3 in the Appendix show, consistent with findings by Breitzman & Thomas (2015), that the number of inventors in regular patent filings is positively associated with the more common patent quality measures, the number of forward citations and the patent family size in regular patents. Figure A.1 in the Appendix shows the number of inventors distributions for regular patents and second tier patents and Figure A.2 presents the time trends in the average number of inventors in single-tiered and two-tiered patent systems. They indicate that inventions protected with regular patents in two-tiered patent systems are of higher quality in comparison to single-tiered countries. Second tier patents are of lowest quality as expected.

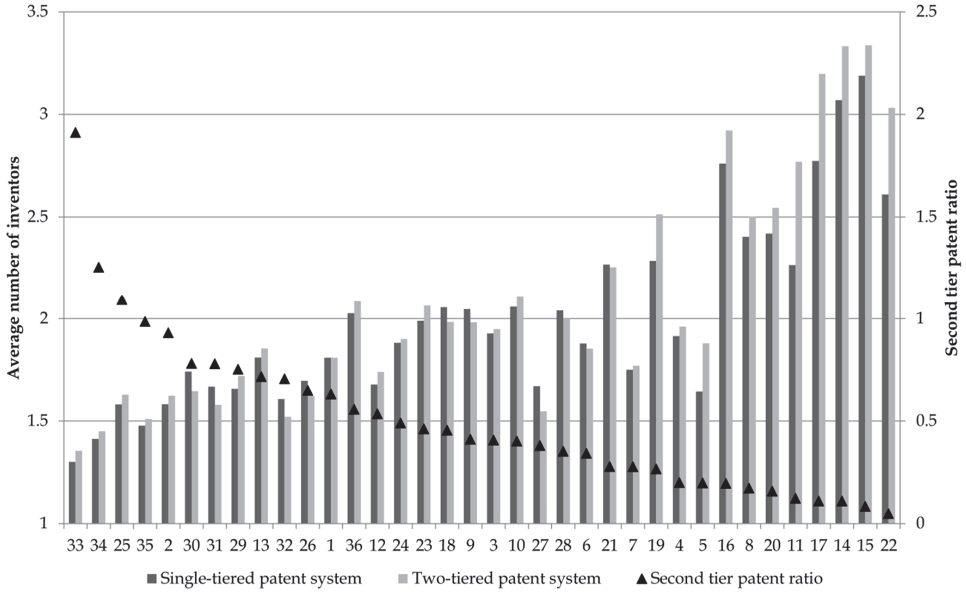
FIGURE 2 Average number of inventors 2000–2012



Notes: Left axis indicates the average number of inventors in national priority filings in sample countries between 2000 and 2012. Right axis indicates second tier patent ratio. Information on the number of inventors in German utility models is not directly available in PATSTAT. For countries that shifted between single and two-tiered paten system during the period, the averages are calculated for two-tiered patent system period: RO, 2008–2012; NL, 2000–2008; BE, 2000–2008; RS, 2004–2012). For GR the averages are calculated for 2000–2001 due to missing data.

Figure 3 presents the average number of inventors in each technology field, which are ranked in descending order from left to right according to technology field specific second tier patent ratios (see Table A.8 in the Appendix 2). It reveals interesting patterns. First, it shows that the higher the second tier patent ratio in a technology field, the lower is the average number of inventors in two-tiered patent systems (correlation: -0.72). This suggests that in industries, in which inventions are, on average, of low quality, applicants tend to file second tier patents relatively more often. Second, Figure 3 shows that the average number of inventors in regular patents is higher in most technology fields in two-tiered patent systems in comparison to single-tiered patent systems.

FIGURE 3 Number of inventors by technology fields 2000–2012

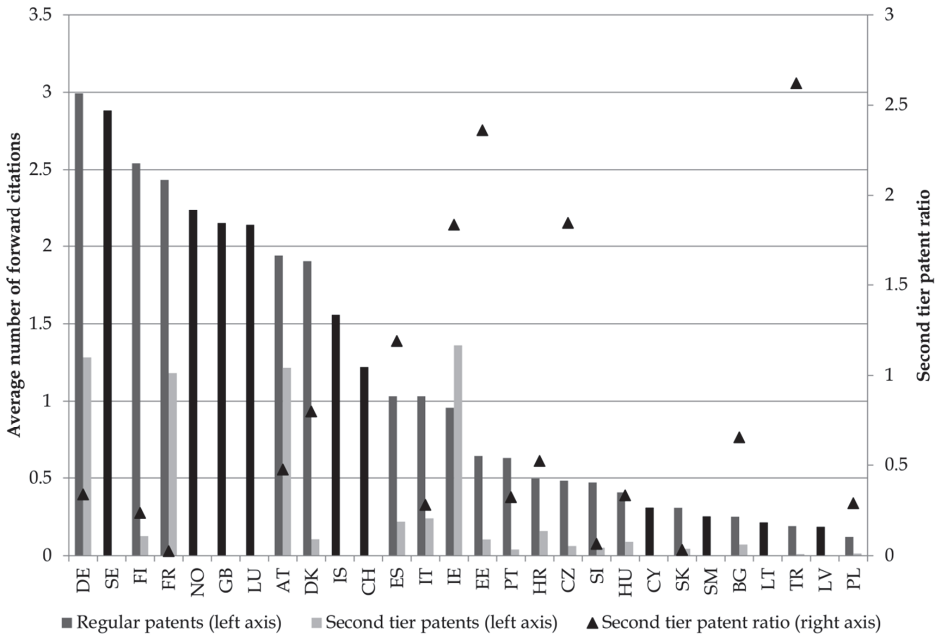


Notes: Left axis indicates the average number of inventors in national priority filings in sample countries between 2000 and 2012. Right axis indicates second tier patent ratios and numbers on x-axis refer to technology fields in Table A.8 in the Appendix 2.

Figure 4 reports the average number of forward citations to patent families and second tier patent ratios by country. Generally, second tier patents receive much fewer citations (mean: 0.36) than regular patents in single- (mean: 1.32) and two-tiered patent systems (mean: 1.05). Ireland is the only exception as there patent families containing Irish short-term patent priority filings have received, on average, more forward citations than patent families with regular patent priorities. The ranking of countries in Figure 4 shows that regular patents in the most advanced economies (Germany, Sweden, Finland, France) receive, on average, the most forward citations whereas the regular patents in new EU member states and the Eastern parts of Europe (Poland, Latvia, Turkey, Lithuania) receive the least citations.

Figure A.3 in the Appendix shows the distributions of forward citations for regular patents and second tier patents and Figure A.4 presents the time trends in the average number of forward citations in single-tiered and two-tiered patent systems. The distributions corroborate that inventions protected with second tier patents are of lower quality when the citations are used as quality measure. Less than 30% of second tier patents were cited during the period. Naturally, more recent patents have received less citations than older ones as they have been searchable in patent databases for longer time as demonstrated by Figure A.4.

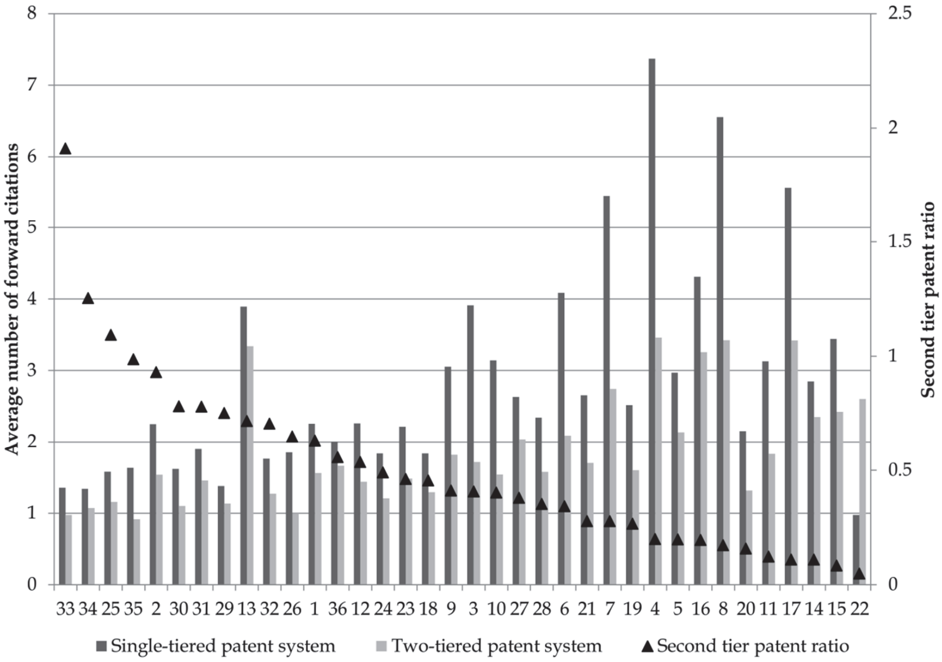
FIGURE 4 Average number of forward citations 2000–2012



Notes: Left axis indicates forward citations to priority patents and second tier patents at DOCDB family level. Black bars indicate the average number of citations in countries that have single-tiered patent systems. Countries that shifted from single-tiered system to two-tiered patent system (RO, RS) or vice versa (NL, BE) during 2000–2012 are not reported. Greece is excluded due to missing data after year 2001. Second tier patent ratios are presented

Figure 5 shows that regular patents in single-tiered patent systems receive systematically more forward citations in almost all technology fields in comparison to regular patents in two-tiered patent systems. The observation contradicts Hypothesis 2. We also find similar correlation as Figure 3 between second tier patent intensity and quality of regular patents in two-tiered patent systems. Second tier patent ratio and the average number of received forward citations are negatively associated in two-tiered patent systems (correlation: -0.58). The systematically higher observed quality of regular patents in single-tiered countries may reflect the differences in technological development of single- and two-tiered countries. Indeed, Table A.6 in the Appendix shows that countries with two-tiered patent systems have been associated with significantly lower R&D shares of GDP over the period 2000–2012.

FIGURE 5 Average number of forward citations by technology field, 2000–2012

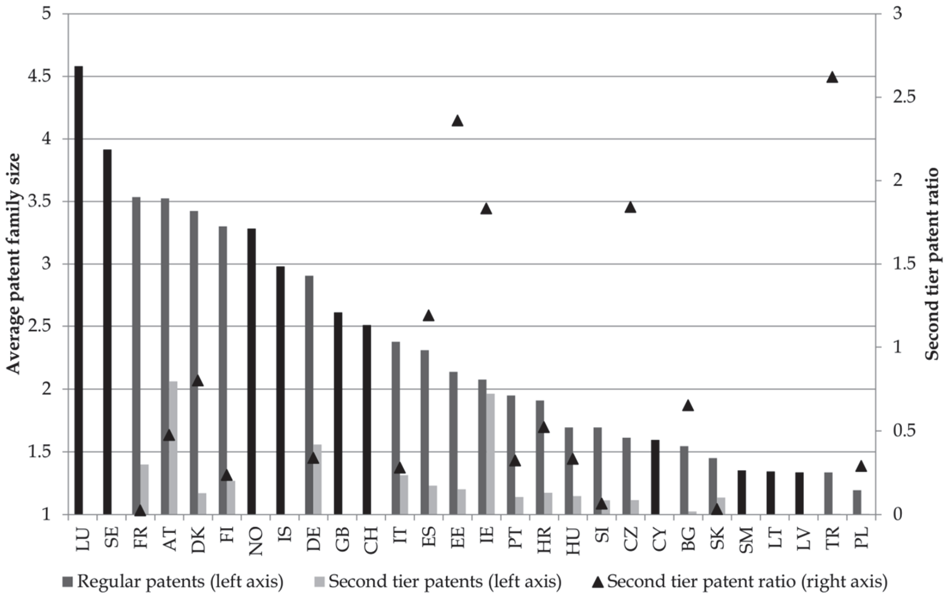


Notes: Left axis indicates the average number of forward citations in national priority filings in sample countries between 2000 and 2012. Right axis indicates second tier patent ratios and numbers on x-axis refer to technology fields in Table A.8 in the Appendix 2.

Figure 6 reports the average patent family sizes by country. Again, second tier patent priorities have much smaller average patent family size (mean: 1.28) compared to patent priorities in two-tiered (mean: 2.22) and in single-tired patent systems (mean: 2.55). The pattern in country ranking is similar to that for citations in Figure 4: the patents in most advanced economies (Luxemburg, Sweden, France, Austria) have, on average, the largest patent families whereas patent families in new EU member states and the Eastern parts of Europe (Poland, Turkey, Latvia, Lithuania) are the smallest.

Figure A.5 in the Appendix reports the distributions of patent family sizes for regular patents and second tier patents and Figure A.6 shows the time trends in the average patent family sizes in single-tiered and two-tiered patent systems. As in the case of citations, more recently filed priority patents have smaller patent family sizes than older ones since the patenting process might still be on-going (e.g., divisionals; see Dechezleprêtre et al., 2017). The small average patent family size of second tier patents suggests that they are mainly used to protect inventions nationally (cf. Heikkilä & Verba, 2017).

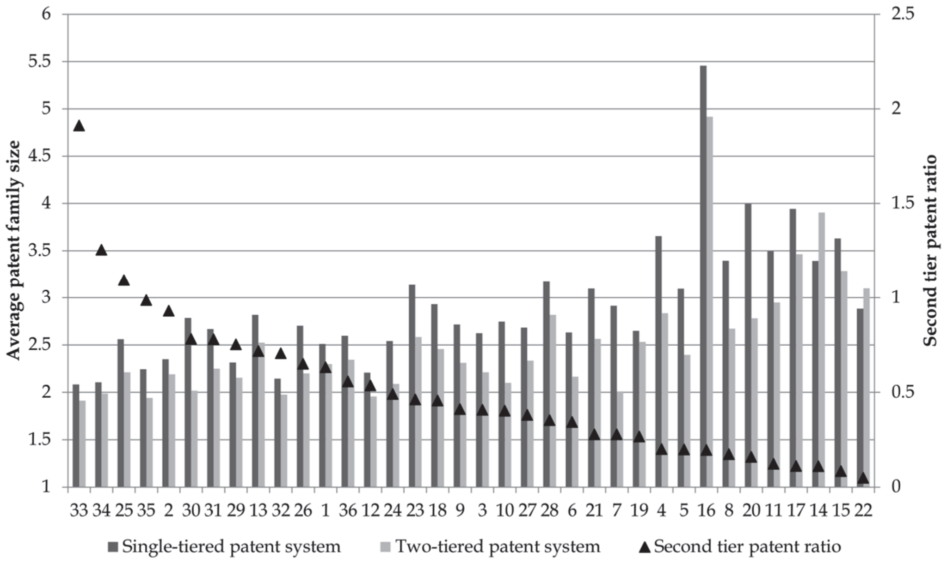
FIGURE 6 Average patent family size 2000–2012



Notes: Left axis indicates the patent family size of priority patents and second tier patents at DOCDB family level. Black bars indicate the average patent family sizes in countries that have single-tiered patent systems. Countries that shifted from single-tiered system to two-tiered patent system (RO, RS) or vice versa (NL, BE) during 2000–2012 are not reported. Greece is excluded due to missing data after year 2001.

Figure 7 shows the average patent family sizes across technology fields in single- and two-tiered patent systems. As for forward citations in Figure 5, the average patent family size is larger in almost all technology fields in single-tiered patent systems in comparison to two-tiered patent systems and there exists a negative association between second tier patent ratio and quality of regular patents in two-tiered patent systems (correlation: -0.57). This evidence is in contrast to Hypothesis 2.

FIGURE 7 Average patent family size by technology field 2000–2012



Notes: Left axis indicates the average patent family size of national priority patent filings in sample countries between 2000 and 2012. Right axis indicates second tier patent ratios and numbers on x-axis refer to technology fields in Table A.8 in the Appendix 2.

To sum up, at the country-level (Figures 2, 4 and 6) we observe that all invention quality indicators suggest inventions protected with second tier patents to be systematically of lower quality compared to patent-protected inventions. They receive, on average, less citations, are part of smaller patent families and have smaller inventor teams. At technology field level, Figures 3, 5 and 7 further suggest that the use of second tier patents is associated with low quality inventions: The higher the second tier patent ratio to patents, the lower is the average quality of regular patents in the technology field. The observations are in line with the common view that second tier patents are used to protect incremental inventions (Janis, 1999; Beneito, 2006, Kim et al., 2012; Hamdan-Livramento & Raffo, 2016). However, no clear quality differences are found between regular patents in single-tiered and two-tiered patent systems. In line with Hypothesis 2, the average number of inventors in regular patents is somewhat higher in two-tiered patent systems but, in contrast to Hypothesis 2, the average number of forward citations received by regular patents and the average patent family size of regular patents are smaller in two-tiered patent systems than in single-tiered patent systems.

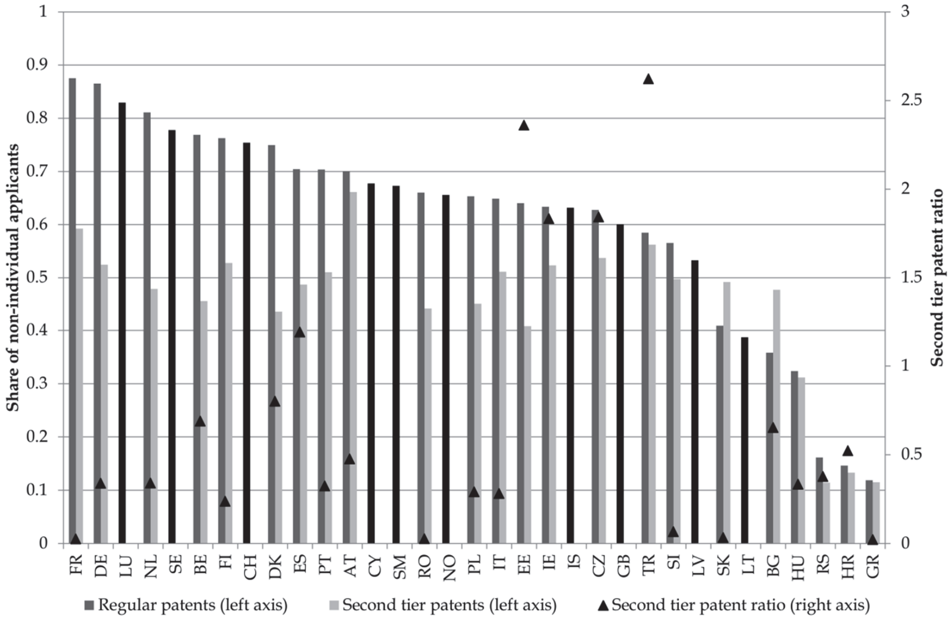
3.2.2 Sorting and applicant type

Figure 8 looks at the sorting by applicant type—that is, the self-selection of individual and non-individual applicants from 2000 to 2012. It shows that in two-tiered patent systems the share of non-individual applicants is higher for regular patents (mean: 58.6%) than for second tier patents (mean: 44.6%). In contrast to Hypothesis 4, the share of non-individual applicants in regular patents is slightly lower, on average, in countries with two-tiered patent systems than in countries with single-tiered patent systems (mean: 65.2%).

Figure A.7 in the Appendix shows the portions of individual and non-individual applicants for all priority filings: approximately 80% of regular patent filings in countries with two-tiered patent system between 2000 and 2010 were filed by non-individual applicants whereas in single-tiered countries the respective share was a bit more than 60%. Of all second tier patent priority filings a bit more than half were filed by non-individual applicants. Figure A.8 depicts that the evolution of non-individual applicant shares in regular and second tier patents has remained relatively constant over time. This observation is consistent with Hypothesis 1 and explanation that financially constrained applicants choose more often cheaper second tier patent protection instead of patents.

Figures A.9–A.11 in the Appendix present distributions of invention quality indicators separately for non-individual and individual applicants. They show that most patent filings by non-individual applicants are of higher quality than filings by individual applicants. Most priority patent filings by individual applicants have only one inventor (>80%), they are typically singleton patent families (>80% have no subsequent filings) and majority (ca. 75%) receive no forward citations. In contrast, in regular patent filings by non-individual applicants only little more than 40% have only one inventor, less than half of them are singletons and more than half of them are cited. All these observations are consistent with the expectation that inventions protected by individual applicants are of lower quality (Bessen, 2008).

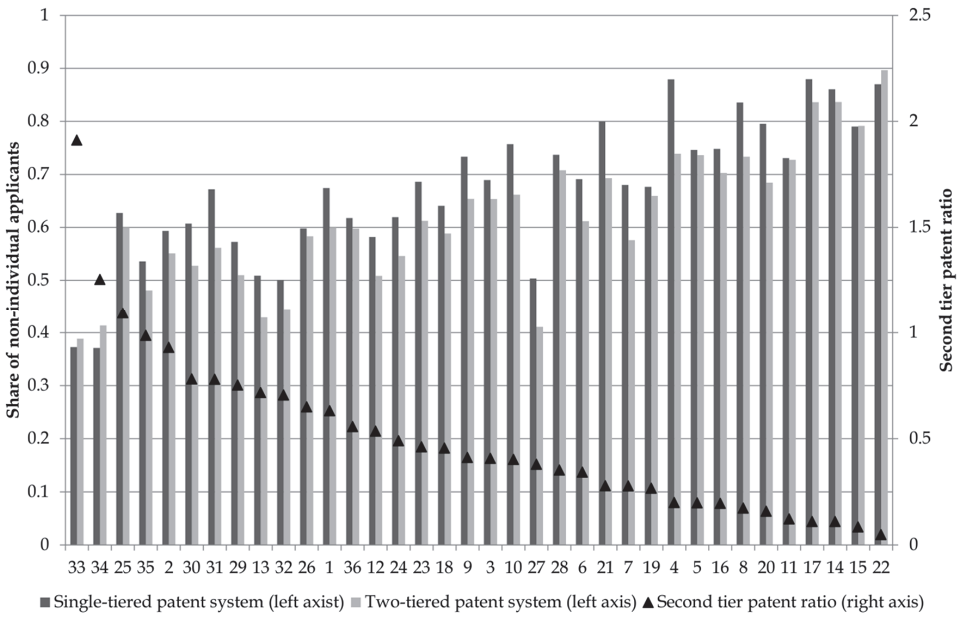
FIGURE 8 The share of non-individual patent filings 2000–2012



Note: The Y-axis measures the share of priority filings with non-individual applicants between 2000 and 2012. "Non-individual" filing refers to filings in which at least one of the applicants is not an individual—that is, is either a company, university, government, nonprofit organization, or hospital.

Figure 9 shows that the average share of non-individual applicants is systematically higher in countries with single-tiered patent systems in all technology fields. This contradicts Hypothesis 4. Furthermore, we find that the higher is the second tier patent ratio the lower is the share of non-individual applicants in regular patents in two-tiered patent systems (correlation: -0.77). The high relative share of regular patents filed by individual applicants in two-tiered patent systems indicates that financial constraints do not deter patent filings by individual applicants and force them to substitute patent filings with cheaper second tier patents. The descriptive analyses in this section have not taken into account country characteristics, for instance, the level of technological development. Next, we test Hypotheses 1–4 by estimating regression models which control simultaneously for country characteristics and technology field fixed effects.

FIGURE 9 Share of non-individual patent filings, 2000–2012



Notes: Left axis indicates the share of non-individual applicants of priority patent and second tier patent filings. Right axis indicates second tier patent ratios and numbers on x-axis refer to technology fields in Table A.8 in the Appendix 2.

3.3 Empirical model and results

3.3.1 Choice between patents and second tier patents

We test Hypotheses 1 and 3 by estimating the following equation:

$$y_{ijct} = \alpha + \beta_1 \mathit{Teamsize}_i + \beta_2 D(\mathit{Non\text{-}individual})_i + \theta_j + \gamma_c + \eta_t + \varepsilon_{ijct}$$

where y_{ijct} is a dummy variable, which is 1 if filing i is a second tier patent and 0 if it is a patent. $\mathit{Teamsize}_i$ is the number of inventors in filing i. $\mathit{Non\text{-}individual}_i$ is a dummy, which is 1 if any applicant in patent filing is not an individual and 0 otherwise. θ_j is technology field fixed effect, γ_c is country fixed effect, and η_t is application filing year fixed effect. ε_{ijct} is a filings-specific error term. We estimate probit models using maximum likelihood and report average marginal effects in Table 2.

TABLE 2 Choice between patents and second tier patents

Dependent variable			*Pr(Second tier patent=1)*			
Sample	Priorities	Priorities	Priorities	Singletons	Singletons	Singletons
Model	Probit	Probit	Probit	Probit	Probit	Probit
Estimates	M.E	M.E	M.E	M.E	M.E	M.E
	(1)	(2)	(3)	(4)	(5)	(6)
TEAMSIZE	-0.048***		-0.070***	-0.050***		-0.057***
	(0.001)		(0.001)	(0.001)		(0.002)
D(NON-INDIVIDUAL)		-0.184***	-0.042***		-0.171***	-0.048***
		(0.001)	(0.001)		(0.001)	(0.001)
Germany excluded	Yes	No	Yes	Yes	No	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology field dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	418429	1094149	377866	236776	597163	209416
Log likelihood	-143786.36	-483573.17	-129978.81	-107912.74	-326980.27	-97721.91
Pseudo R2	0.27	0.19	0.29	0.23	0.15	0.23

Notes: Average marginal effects reported. Heteroscedasticity robust standard errors in parentheses. The sample consists of EU and EPO member states with second tier patent protection systems over the period 2000–2012 (Austria, Denmark, France, Finland, Germany, Ireland, Italy, Spain). In models 1-3 the estimates are reported for national priority filings sample and in models 4-6 for national singleton filings (priority filings, which patent family size is one) sample. *** refers to 1% significance level. Germany is excluded in models 1, 3, 4 and 6 because in PATSTAT the inventor number information is missing for Ger-man utility models.

The results indicate that team size—that is, the number of inventors—is statistically significantly and negatively associated with the choice of second tier patent. The estimates are similar for the priority filing sample (models 1–3) and for the subsample of singleton filings (models 4–6). When applicant status and country, year, and technology field fixed effects are controlled for, it is estimated that the likelihood of choosing a second tier patent is decreased by 6–7 percentage points when team size is increased by one inventor. We also find that non-individual applicants tend to choose second tier patents less often in comparison to individual applicants. The likelihood of choosing a second tier patent is estimated to be 4–5 percentage points lower for non-individual applicants than for individual applicants when team size and country, year, and technology field fixed effects are controlled for. Both Hypotheses 1 and 3 are supported. Next, we explore the consequences of these micro-level choices in two-tiered patent systems on the aggregate invention and applicant-type differences between regular patents in single- and two-tiered patent systems.

3.3.2 Sorting by invention quality and applicant type

We estimate the following equation to test Hypotheses 2 and 4 concerning sorting by invention quality and applicant type:

$$y_{ict} = \alpha + \beta Two\_tiered_{ct} + \mathbf{x}_{ct}'\boldsymbol{\gamma} + \theta_i + \eta_t + \varepsilon_{ict}$$

When analyzing sorting by invention quality, the dependent variable y_{ict} is a logarithm of either 1) the average number of inventors, 2) the average number of forward citations or 3) the average patent family size in regular patents in technology field i in country c in year t. When analyzing sorting by applicant type, the dependent variable y_{ict} is the share of all regular patent filings by non-individual applicants in technology field i in country c in year t. α is constant. Two_tiered_{ct} is a dummy variable: 1 if country c has a two-tiered patent system in year t and 0 otherwise. $\mathbf{x}_{ct}$ is a vector of country-level controls. θ_i is technology field indicator, and η_t is filing year indicator. ε_{ict} is technology field, country, and year specific error term. As in previous section, the models are estimated for two samples: 1) a sample consisting of priority patent filings and 2) a sample consisting of singleton patents. The standard errors are clustered at the level of country and technology fields.

We estimate the coefficient of interest, β, using ordinary least squares regression. The identification of β relies on between-country and across-time variations in the status whether the country has a two-tiered patent system or a single-tiered patent system. The hypothesis that in countries with two-tiered patent systems, the quality of normal patents is higher is supported if we find that $\beta > 0$ and if the estimate is statistically significant. It is likely that the choice patterns between patents and second tier patents differ across technology fields (see section 3.2) and time. Hence, we control for them by including technology field and time dummies. Table 3 reports the results considering sorting by invention quality for priority filings and Table 4 for singleton filings.

TABLE 3 Sorting by invention quality, priority filings

Dependent variable	*Log(Average number of inventors in regular patents)*		*Log(Average number of citations in regular patents)*		*Log(Average patent family size of regular patents)*	
Model	OLS	OLS	OLS	OLS	OLS	OLS
Estimate	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
	(1)	(2)	(3)	(4)	(5)	(6)
D(Two-tiered patent system)	0.032**	-0.007	-0.165***	-0.183***	-0.131***	-0.130***
	(0.013)	(0.014)	(0.032)	(0.018)	(0.023)	(0.014)
D(EPO member)		-0.084***		0.078***		0.010
		(0.019)		(0.023)		(0.016)
D(EU member)		0.147***		0.132***		0.057***
		(0.018)		(0.018)		(0.015)
log(GDP)		0.011**		0.124***		0.067***
		(0.005)		(0.006)		(0.005)
log(R&D share)		-0.057***		0.336***		0.298***
		(0.014)		(0.013)		(0.010)
Technology field dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.471***	0.107	1.055***	0.974***	1.296***	1.792***
	(0.046)	(0.109)	(0.089)	(0.111)	(0.054)	(0.091)
Observations	11655	11087	11746	11176	11746	11176
Clusters	1110	1097	1116	1103	1116	1103
Countries	33	32	33	32	33	32
R2	0.25	0.27	0.19	0.52	0.09	0.45

Notes: The sample consists of EPO member states in 2012 (excluding Albania, Liechtenstein, Malta, Monaco and Former Yugoslav Republic of Macedonia) over the period 2000–2012. Cluster robust standard errors clustered at country- and technology field-level in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

Table 3 shows contradictory estimates regarding the quality differences of regular patents between single-tiered and two-tiered patent systems. Model 1 indicates that the number of inventors in regular patents in two-tiered patent systems is higher, similar to descriptive findings in Section 3.2.1, but Model 2 shows that this association is not robust and vanishes when we control for some country characteristics. Models 3–6 indicate negative associations between two-tiered patent system and the average number of citations and the average size of patent families even after controlling for country characteristics. They suggest that the quality of regular patents is lower in two-tiered countries. It is estimated that a shift from single-tiered patent system to two-tiered patent system would be associated with a decrease of 18% in the average number of citations in regular patents (Model 4) and with a decrease of 13% in the average patent family size (Model 6). Table 4 estimates models 1–4 using subsample of singleton patents.

TABLE 4 Sorting by invention quality, singleton filings

Dependent variable	*Log(Average number of inventors in regular patents)*		*Log(Average number of citations in regular patents)*	
Model	OLS	OLS	OLS	OLS
Estimate	Coeff.	Coeff.	Coeff.	Coeff.
	(1)	(2)	(3)	(4)
D(Two-tiered patent system)	0.022**	-0.005	-0.043**	-0.072***
	(0.010)	(0.010)	(0.017)	(0.013)
D(EPO member)		-0.054***		0.039***
		(0.013)		(0.010)
D(EU member)		0.102***		0.044***
		(0.011)		(0.010)
log(GDP)		-0.002		0.085***
		(0.003)		(0.005)
log(R&D share)		-0.075***		0.032***
		(0.009)		(0.008)
Technology field dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Constant	0.935***	0.635***	0.260***	-0.590***
	(0.031)	(0.072)	(0.047)	(0.078)
Observations	10723	10220	10853	10348
Clusters	1082	1079	1090	1087
Countries	33	32	33	32
R2	0.23	0.26	0.06	0.37

Notes: The dependent variables are calculated for singleton patents. The sample consists of EPO member states in 2012 (excluding Albania, Liechtenstein, Malta, Monaco and Former Yugoslav Republic of Macedonia) over the period 2000–2012. Cluster robust standard errors clustered at country- and technology field-level in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

The results in Table 4 using subsample of singleton patent filings are similar to those in Table 3. Again, we do not find association between two-tiered patent system indicator and the average number of inventors when we control for a set of country characteristics (Model 2). The negative association between two-tiered patent system and the average number of citations in regular patents is found also for singleton patent subsample although the association is weaker. A shift from a single-tiered to a two-tiered patent system is estimated to be associated with ca. 7 % decrease in the average number of citations in singleton patents. Clearly, Hypothesis 2 is not supported. Instead, we find suggestive evidence that the quality of inventions protected with regular patents in two-tiered countries is rather lower than higher in comparison to single-tier patent systems.

The ambiguous association between number of inventors and other invention quality measures, forward citations and patent family size, indicate that they may measure different aspects of patent quality. Nevertheless, Table A.3 in the Appendix shows, in line with findings by Breitzman & Thomas (2015), that at the country-level the average number of inventors in regular patent filings is positively associated with the average number of forward citations and the average patent family size in regular patents. Moreover, the estimated signs of control variables differ between models. Being a member of the EU and market size (GDP) are positively associated with all patent quality measures. However, R&D intensity is found to be positively associated with the average number of forward citations and patent family size but negatively associated with the average number of inventors.

In Table 5, we measure sorting by applicant type. Models 1–2 analyze the association between two-tiered patent system status and the share of filings by non-individual applicants for the priority patent sample and models 3–4 present the same estimates for the singleton patent sample. Non-individual applicants are mainly companies, which we expect to have, on average, higher IPR know-how and more resources, including R&D investments, than individual applicants. We find a negative association, suggesting that in countries with two-tiered patent systems, the share of non-individual applicants in regular patent filings is lower than in countries with a single-tiered patent system. The observation is consistent with descriptive evidence presented in section 3.2.2. The finding contradicts our reasoning that a two-tiered patent system would induce a larger share of more financially constrained individual applicants to choose second tier patent protection instead of regular patents. Thus, Hypothesis 4 is not supported. One potential explanation for this sorting by applicant type is that second tier patents are not substitutes for regular patents. Rather, second tier patents could be used as the first "stepping stones" in accumulating IPR know-how so that it is then easier for individual applicants to also use patent protection later (cf. Kim et al., 2012).

The signs of control variables show statistically significant positive associations between the share of filings with non-individual applicants and EPO membership, EU membership, GDP, and R&D share of GDP.

TABLE 5 Sorting by applicant type

Dependent variable	***Share of regular patent filings with non-individual applicants***			
Sample	Priorities		Singletons	
Model	OLS		OLS	
Estimate	Coeff.		Coeff.	
	(1)	(2)	(3)	(4)
D(Two-tiered patent system)	-0.075***	-0.078***	-0.032***	-0.034***
	(0.013)	(0.011)	(0.012)	(0.012)
D(EPO member)		0.060***		0.069***
		(0.014)		(0.016)
D(EU member)		0.062***		0.050***
		(0.015)		(0.016)
log(GDP)		0.051***		0.040***
		(0.004)		(0.004)
log(R&D share)		0.137***		0.085***
		(0.010)		(0.011)
Technology field dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Constant	0.645***	0.613***	0.556***	0.421***
	(0.050)	(0.087)	(0.046)	(0.093)
Observations	11309	10752	10335	9843
Clusters	1102	1089	1073	1070
Countries	33	32	33	32
R2	0.13	0.35	0.13	0.25

Notes: The sample consists of EPO member states in 2012 (excluding Albania, Liechtenstein, Malta, Monaco and Former Yugoslav Republic of Macedonia) over the period 2000–2012. In models 1 and 2 the sample includes priority patents and in models 3 and 4 singleton patents. Cluster robust standard errors clustered at country- and technology field-level in parentheses. *** refers to 1% significance level.

3.4 Robustness checks and limitations

3.4.1 Robustness checks

Choice between patents and second tier patents

We tested whether the results are driven by any specific country. We estimated our preferred model, model 3 in Table 2 (priority patent filings), for all sample countries separately. The results are reported in Table A.2 in the Appendix. They are consistent with the results in Table 2 and confirm Hypotheses 1 and 3: the larger the team size, the smaller the likelihood of choosing a second tier patent, and if the applicant is a non-individual, the smaller the likelihood of choosing a second tier patent. Thus, the patterns in the choice between patents and second tier patents are similar across sample countries.

Country and technology field–level analysis

First, it is well-known that patenting differs across industries and technology sectors. However, we re-estimate our preferred models in Tables 3, 4 and 5 using country-level data instead of technology field and country–level data. Table A.4 in the Appendix reports the estimates. Although these models do not control for country-level differences in the composition of patent filings by technology fields, the signs and magnitudes of the estimated β coefficient are qualitatively similar. We do not find association between two-tiered patent systems indicator and the average number of inventors in regular patents but the estimates corroborate negative association between two-tiered patent system and the average number of forward citations, the average patent family size and the share of non-individual applicants that were observed in Tables 3 , 4 and 5.

Second, the quality difference in inventions protected with regular patents between single-tiered and two-tiered patent systems may vary across technology fields depending on the intensity of second tier patent use. Hence, we estimated the results separately for high and low intensity technology fields. High intensity technology fields are defined as fields with higher than median second tier patent to patent ratio and low fields are fields with equal or less than median second tier patent to patent ratio (see Table A.8 in the Appendix 2). Table A.5 in the Appendix presents the results, which show that estimates in Table 3 are robust to this sample split. We do not observe significant differences between high and low second tier patent ratio fields.

Third, in order to check whether the results are driven by observations from individual countries, we re-estimated models 2, 4 and 6 in Table 3 by leaving out observations from one sample country at a time. Again, we do not find a significant association between two-tiered patent system and the average number of inventors in regular patents (Model 2) in 30 out of 32 cases. However, when Romania is left out, we estimate the average number of inventors in regular patents in two-tiered patent systems to be 2.5% higher (at 10 % significance level) in comparison to single-tiered. On the contrary, when Great Britain is left out, the estimate indicates that two-tiered patent system is associated with 3.3% lower average number of inventors (at 5% significance level). The estimates for average forward citations (Model 4) range from -0.127 to -0.211 and are always statistically significant at 1% significance level. The estimates for average patent family size (Model 6) range from -0.096 to -0.151 and are always statistically significant at 1% significance level.

3.4.2 Limitations and future research

If less advanced economies are more likely to have two-tiered patent systems, then the lower quality of regular patents in two-tiered patent systems compared to single-tiered patent system may reflect differences in the level of technological development. Indeed, Table 1 shows that, in particular, several Eastern European countries adopted two-tiered patent systems in 1990s. Figure A.12 in the Appendix shows the trends in GDP and R&D between single-tiered and two-tiered patent systems. It depicts that countries with two-tiered patent systems have been on average larger and have had lower R&D share of GDP. We aimed to account for the level of technological development by including R&D share in the regression models but it is an imperfect proxy of the level of technological development. R&D is also a problematic control variable as the aim of the two-tiered patent system is to incentivize R&D and, thus, increase in R&D can be an outcome of having a two-tiered patent system.

In most European countries, second tier patents can be used to protect products and not processes (Prud'homme, 2014; Radauer et al., 2015). Hence, the substitution between patents and second tier patents should be more pronounced for product inventions. Based on the current data, we are not able to explore whether this is the case. Technically, this would be possible by identifying from patents' titles and abstracts the words "process", "method" and the like in national languages (cf. Heikkilä & Verba, 2017). This exercise is left for future studies.

Due to complex institutional details and data limitations (i.e., incomplete data on which patents and second tier patents are granted and kept in force over time), our study did not consider how patents and second tier patents are used jointly. There exists at least four different outcomes when a patent and a second tier patent applications are filed concurrently for the same invention in a country: 1) both the patent and the second tier patent are granted and kept in force ("fast, long and broad protection"); 2) the second tier patent is not renewed when the patent is granted, and only the patent is kept in force; 3) the second tier patent is granted and kept in force, but the patent application is rejected ("protection of last resort"); or 4) both the patent and the second tier patent application are rejected. The possibility to protect the same invention with both a patent and a second tier patent or to flexibly transfer patent applications to second tier patent applications and even vice versa presumably undermines the screening function of two-tiered patent systems (cf. Atal & Bar, 2014).[139] Patent applicants that are knowledgeable about these strategic options can "take the best out of both systems". It is likely that the ones with relevant know-how are experienced large incumbent firms rather than young inexperienced small firms or individual inventors. An important topic for future research is, therefore, the analysis of whether two-tiered patent systems distort the competition between more knowledgeable and resource-abundant incumbents and resource-constrained and less knowledgeable new entrants.

The demand for patents is sensitive to patent fees (de Rassenfosse & van Pottelsberghe, 2013; de Rassenfosse & Jaffe, 2014; Thompson, 2017). Presumably, the substitution between national patents and second tier patents is equally

[139] In other words, the initial choice between patents and second tier patents reveals less information about the quality of the underlying invention. Applicants with low-quality inventions may first file patents and wish the patent office to make a Type II error. If the patent office rejects their patent application, they may still file a second tier patent application.

likely to be affected by fee changes. Thus, a more comprehensive analysis of the sorting function of two-tiered patent systems would require information on the evolution of patent and second tier patent-related fees at the national patent offices. Data on patenting fees would also enable the analysis of how the revenue streams of patent offices between single-tiered and two-tiered patent systems differ.

Finally, this study did not consider how the accession to the European patent convention (EPC) affects the relative importance of national patents, national second tier patents and EPO patents and how this "three-tiered patent systems" induces applicants to self-select between alternative protection methods and filing routes. Hall & Helmers (2012) have shown that majority of foreign applicants shift to file patents at the EPO instead of national patent offices after a country joins EPC. Presumably, inventions for which EPO patent applications are filed are of highest quality and have the highest share of non-individual applicants. The question "Do three-tiered patent systems induce sorting?" is left for future research.

4 Discussion and conclusions

This study provides empirical evidence that two-tiered patent system induce sorting by invention quality and applicant type. First, second tier patents are chosen for more marginal inventions and more often by individual applicants in comparison to regular patents. This is consistent with the view that second tier patents are appropriate protection methods for incremental inventions, while patents are more suitable for more radical inventions. Second, the ratio of second tier patents to regular patents is the highest in technology fields in which the average quality of inventions protected with regular patents is the lowest. Third, we find ambiguous evidence on the quality differences between regular patents in single-tiered and two-tiered patent systems. The results suggest contrary to our expectations that inventions protected with regular patents are, on average, of lower quality in countries with two-tiered patent systems. Significant heterogeneity across countries and technology fields indicates the need for further patent-system-specific case studies, which take into account national institutional differences. Fourth, a higher share of singleton and priority patent filings in countries with two-tiered patent systems is applied by individual applicants than in countries with single-tiered patent systems. This observation contradicts the hypothesis that individual applicants, which presumably are more likely to be financially constrained, would apply for cheaper second tier patents, while non-individual applicants would choose more expensive patent protection.

The self-selection of applicants between patents and second tier patents has implications for studies that analyze the propensity to patent. The propensity to patent can be measured on different levels (e.g., industry, technology field, and firm), and it can be measured as the ratio between patent output and R&D

input (Scherer, 1983), as the share of inventions that are patented (Mansfield, 1986), as the sales-weighted percentages of innovations for which a patent application is filed (Arundel & Kabla, 1998), or as the likelihood that an invention is patented (Heger & Zaby, 2013). All of these propensity-to-patent measures are affected by the choice of whether the propensity to use second tier patents and substitution between patents and second tier patents is taken into account or not. Industry- and firm-level comparisons of propensity to patent overestimate the propensity if second tier patents are considered regular patents, whereas they underestimate the propensity to protect inventions with some type of patents if second tier patents are excluded altogether. The distortion is likely more pronounced for product inventions, as in most countries, second tier patents cannot be used to protect process inventions. Thus, it is important that regular patents and second tier patents are transparently distinguished from each other in firm-level surveys and analyses.

To conclude, two-tiered patent systems may serve an important role as screening devices. A topic for future research is the analysis of whether documented sorting enables more efficient allocation of examination efforts at the patent office: when low-quality inventions are sorted to use second tier patent protection, patent examiners can potentially allocate more attention to the examination of high-value inventions and decrease the backlog and pendency times of regular patent applications. The sorting between patents and second tier patents has also implications for patent offices' revenue streams. On one hand, if applicants shift in large amounts from more expensive patents to cheaper second tier patents, which have also lower renewal fees and maximum terms of duration, a self-funding patent office may end up having decreased revenues. On the other hand, if second tier patents are mainly used to protect inventions with low inventive step that would not be protected with regular patents, then the patent office may increase its revenues.

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Appendix 1

TABLE A.1 Identification of short-term patents

Country	Publn_kind on table TLS211	Type of Document
Belgium (BE)	A6	6 year patent-original text
	A7	6 year patent-modified text
Croatia (HR)	B3	Short term consensual patent
Ireland (IE)	A2	Short term patent application
	B2	Short term patent
The Netherlands (NL)	C1	Patent without search report - 6 years valid
Slovenia (SI)	A2	Short term patent

Source: EPO data (PASTAT) "Kind code concordance list"
Available at: https://www.epo.org/searching-for-patents/helpful-resources/raw-data/data/tables/regular.html

TABLE A.2 Choice between patents and second tier patents by country 2000–2012

Dependent variable			*Pr(Second tier patent=1)*		
Country	Austria	Denmark	Finland	France	Germany
Model	Probit	Probit	Probit	Probit	Probit
Estimate	M.E	M.E	M.E	M.E	M.E
TEAMSIZE	-0.030***	-0.047***	-0.042***	-0.007***	N.A.
	(0.004)	(0.009)	(0.003)	(0.001)	
D(NON-INDIVIDUAL)	-0.053***	-0.226***	-0.096***	-0.029***	-0.244***
	(0.010)	(0.012)	(0.005)	(0.001)	(0.001)
Observations	9976	5387	28464	150951	697921
Log likelihood	-5704.25	-3185.93	-12154.56	-15285.61	-330873.8
Pseudo R2	0.06	0.14	0.13	0.10	0.16

Dependent variable		*Pr(Second tier patent=1)*		
Country	Ireland	Italy	Portugal	Spain
Model	Probit	Probit	Probit	Probit
Estimate	M.E	M.E	M.E	M.E
TEAMSIZE	-0.012	-0.048***	-0.048***	-0.108***
	(0.010)	(0.002)	(0.008)	(0.003)
D(NON-INDIVIDUAL)	-0.106***	-0.099***	-0.067***	-0.067***
	(0.023)	(0.002)	(0.018)	(0.004)
Observations	1921	119790	2518	56179
Log likelihood	-1209.25	-57295.83	-1191.49	-29798.57
Pseudo R2	0.05	0.05	0.15	0.23

Notes: Average marginal effects reported. Heteroscedasticity robust standard errors in parentheses. The samples consist of national priority filings. All models include year and technology field dummies. *** refers to 1% significance levels respectively.

TABLE A.3 Number of inventors as a predictor of forward citations and patent family size

Dependent variable	*Forward citations*		*Log(1+Forward citations)*	
Model	Neg. bin.		OLS	
Estimate	Coeff.		Coeff.	
	(1)	(2)	(3)	(4)
Log(Number of inventors)	0.445***	0.322***	0.200***	0.154***
	(0.004)	(0.004)	(0.001)	(0.001)
D(Non-individual applicant)		0.783***		0.259***
		(0.007)		(0.002)
Constant	-1.786***	-2.272***	0.500***	0.371***
	(0.050)	(0.053)	(0.005)	(0.005)
Observations	1201846	1133885	1201846	1133885
Pseudo R2			0.25	0.26
Log pseudolikelihood	-1950243.3	-1869852.1		

Dependent variable	*Patent family size*		*Log(Patent family size)*	
Model	Neg. bin.		OLS	
Estimate	Coeff.		Coeff.	
	(5)	(6)	(7)	(8)
Log(Number of inventors)	0.268***	0.194***	0.232***	0.169***
	(0.002)	(0.002)	(0.001)	(0.001)
D(Non-individual applicant)		0.446***		0.333***
		(0.003)		(0.002)
Constant	0.241***	-0.022***	0.141***	-0.043***
	(0.006)	(0.007)	(0.004)	(0.004)
Observations	1201846	1133885	1201846	1133885
Pseudo R2			0.15	0.18
Log pseudolikelihood	-2388338	-2251419		

Notes: The sample consists of EPO member states in 2012 (excluding Albania, Liechtenstein, Malta, Monaco and Former Yugoslav Republic of Macedonia) over the period 2000–2012. All models include year and technology field dummies. Heteroscedasticity robust standard errors in parentheses. *** refers to 1% significance level.

TABLE A.4 Country-level estimates

Dependent variable	*Log(Average number of inventors in regular patents)*		*Log(Average number of forward citations in regular patents)*	
Sample	Priorities	Singletons	Priorities	Singletons
Model	OLS	OLS	OLS	OLS
Estimate	Coeff.	Coeff.	Coeff.	Coeff.
	(1)	(2)	(3)	(4)
D(Two-tiered patent system)	0.009	-0.005	-0.155***	-0.062***
	(0.028)	(0.026)	(0.032)	(0.023)
D(EPO member)	-0.106*	-0.100**	0.109**	0.047
	(0.057)	(0.043)	(0.053)	(0.031)
D(EU member)	0.194***	0.110***	0.141***	0.027
	(0.034)	(0.033)	(0.038)	(0.023)
log(GDP)	-0.022***	0.001	0.071***	0.085***
	(0.008)	(0.009)	(0.010)	(0.009)
log(R&D share)	-0.070***	-0.070***	0.416***	0.051***
	(0.024)	(0.023)	(0.024)	(0.015)
Year dummies	Yes	Yes	Yes	Yes
Constant	0.495***	0.666***	-0.489***	-0.168*
	(0.162)	(0.170)	(0.133)	(0.100)
Observations	388	388	388	388
Countries	32	32	32	32
R2	0.14	0.09	0.79	0.39

Dependent variable	*Log(Average patent family size of regular patents)*	*Share of regular patent filings with non-individual applicants*	
Sample	Priorities	Priorities	Singletons
Model	OLS	OLS	OLS
Estimate	Coeff.	Coeff.	Coeff.
	(5)	(6)	(7)
D(Two-tiered patent system)	-0.105***	-0.082***	-0.043*
	(0.023)	(0.021)	(0.023)
D(EPO member)	0.029	0.073**	0.071*
	(0.037)	(0.036)	(0.041)
D(EU member)	0.074**	0.078***	0.050*
	(0.031)	(0.028)	(0.030)
log(GDP)	0.018**	0.030***	0.019***
	(0.008)	(0.006)	(0.007)
log(R&D share)	0.342***	0.148***	0.100***
	(0.018)	(0.018)	(0.020)
Year dummies	Yes	Yes	Yes
Constant	2.578***	0.889***	0.747***
	(0.168)	(0.136)	(0.160)
Observations	388	390	390
Countries	32	32	32
R2	0.69	0.47	0.18

Notes: The sample consists of EPO member states in 2012 (excluding Albania, Liechtenstein, Malta, Monaco and Former Yugoslav Republic of Macedonia) over the period 2000–2012. Heteroscedasticity robust standard errors in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

TABLE A.5 Sorting by invention quality, high and low second tier patent ratio

Dependent variable	*Log(Average number of inventors in regular patents)*		*Log(Average number of citations in regular patents)*		*Log(Average patent family size of regular patents)*	
Second tier patent ratio	High	Low	High	Low	High	Low
Method	OLS	OLS	OLS	OLS	OLS	OLS
Estimate	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
	(1)	(2)	(3)	(4)	(5)	(6)
D(Two-tiered patent system)	-0.024	0.010	-0.153***	-0.214***	-0.120***	-0.135***
	(0.018)	(0.022)	(0.021)	(0.029)	(0.018)	(0.020)
D(EPO member)	-0.056***	-0.122***	0.100***	0.051	0.032*	-0.015
	(0.021)	(0.032)	(0.027)	(0.039)	(0.016)	(0.028)
D(EU member)	0.116***	0.183***	0.108***	0.162***	0.044**	0.074***
	(0.020)	(0.030)	(0.022)	(0.030)	(0.018)	(0.025)
log(GDP)	0.016**	0.006	0.116***	0.132***	0.054***	0.083***
	(0.007)	(0.008)	(0.007)	(0.009)	(0.006)	(0.007)
log(R&D share)	-0.045**	-0.070***	0.308***	0.366***	0.276***	0.322***
	(0.018)	(0.020)	(0.015)	(0.021)	(0.012)	(0.016)
Technology field dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.118***	0.137	0.877***	1.038***	1.819***	1.708***
	(0.138)	(0.158)	(0.128)	(0.186)	(0.117)	(0.135)
Observations	5817	5270	5849	5327	5849	5327
Clusters	530	567	534	569	534	569
Countries	32	32	32	32	32	32
R2	0.15	0.22	0.57	0.49	0.46	0.45

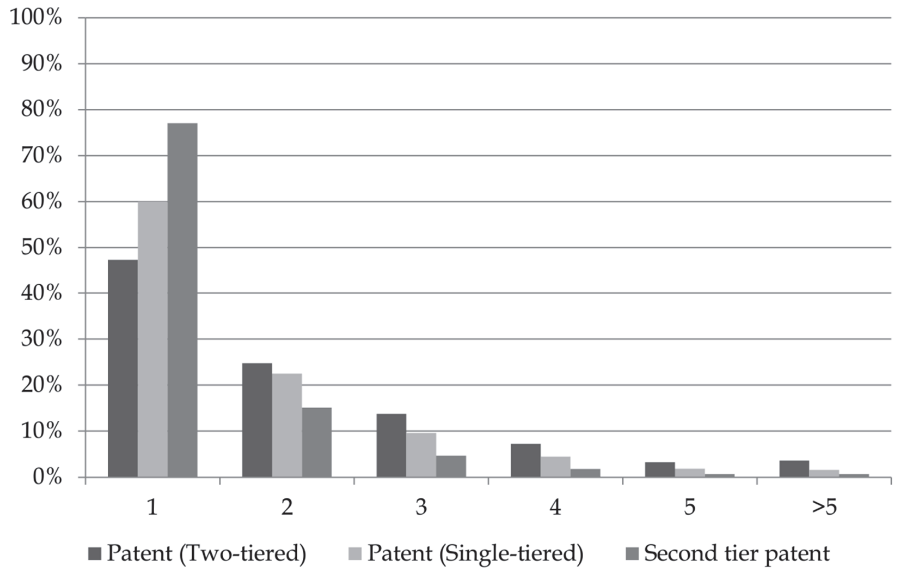
Notes: The sample consists of EPO member states in 2012 (excluding Albania, Liechtenstein, Malta, Monaco and Former Yugoslav Republic of Macedonia) over the period 2000–2012. Models 1, 3 and 5 ("High") are estimated for technology fields in which the second tier patent ratio is above median ratio of technology fields and models 2, 4 and 6 ("Low") are estimated for technology fields in which the second tier patent ratio is below median (see Table A.8 in the Appendix 2). Cluster robust standard errors clustered at country and technology field level in parentheses. ***, ** and * refer to 1%, 5% and 10% significance levels respectively.

TABLE A.6 Patent system type and country characteristics

Dependent variable	*Pr(Two-tiered patent system)*	
Model	Probit	OLS
Estimate	M.E.	Coeff.
log(GDP)	0.065***	0.066***
	(0.017)	(0.018)
log(R&D share)	-0.106***	-0.109***
	(0.036)	(0.039)
D(EPO member)	0.061	0.066
	(0.083)	(0.098)
D(EU member)	0.126**	0.132*
	(0.063)	(0.072)
Year dummies	Yes	Yes
Constant		-0.645**
		(0.299)
Observations	391	391
Countries	32	32
Log pseudolikelihood	-220.55	
(Pseudo) R2	0.07	0.08

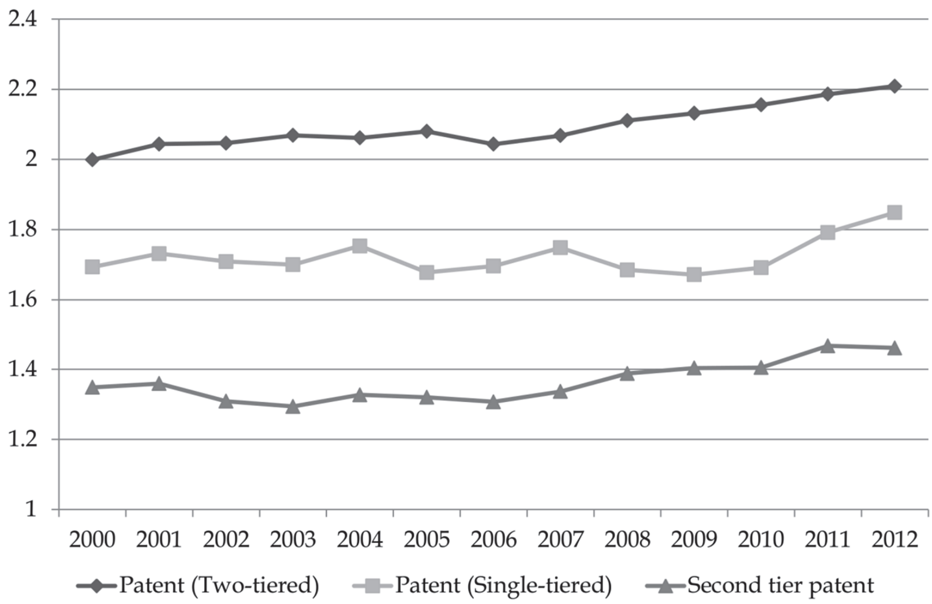
Notes: The sample consists of EPO member states in 2012 (excluding Albania, Liechtenstein, Malta, Monaco and Former Yugoslav Republic of Macedonia) over the period 2000–2012. Probit model reports average marginal effects. Heteroscedasticity robust standard errors in parentheses. ***, ** and * refer to 1%, 5%, and 10% significance levels respectively.

FIGURE A.1 Distribution of number of inventors 2000–2012



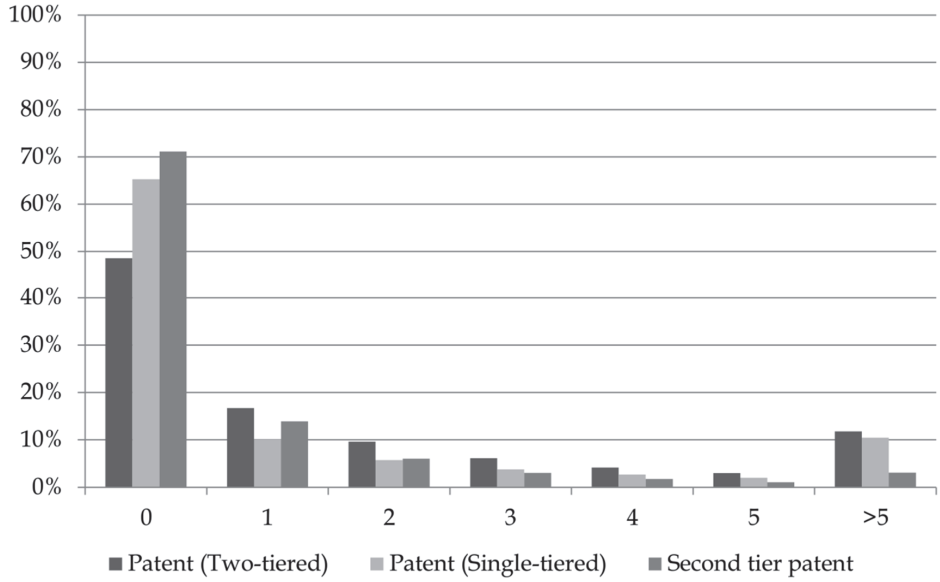
Notes: Patent filings with missing inventor information (0 inventors) are excluded. Total number of priority filings is 1201846, of which 938807 are regular patents in two-tiered countries, 130527 regular patents in single-tiered countries and 132512 second tier patents.

FIGURE A.2 The average number of inventors 2000–2012



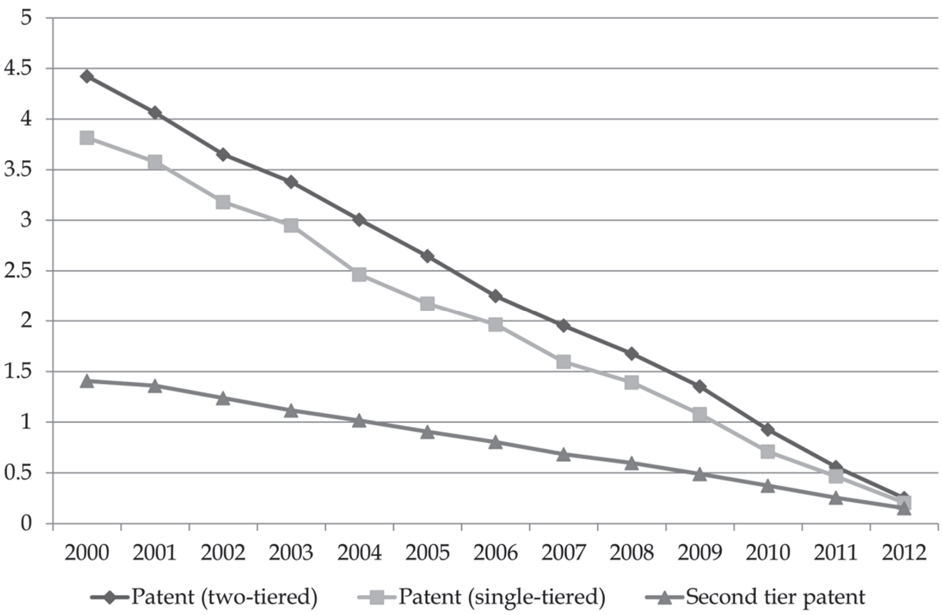
Notes: Patent filings with missing inventor information (0 inventors) are excluded.

FIGURE A.3 Distribution of forward citations 2000–2012



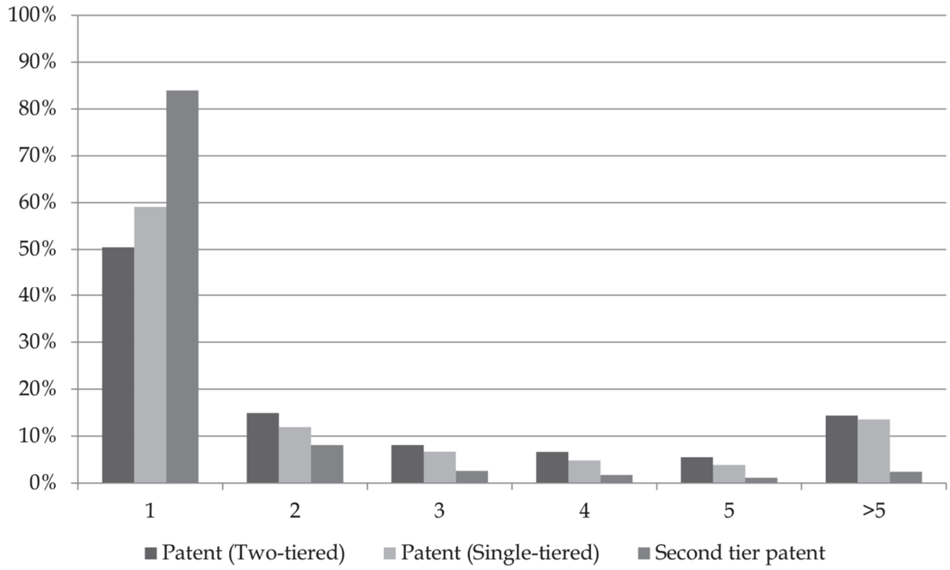
Notes: Total number of priority filings is 1606549, of which 972140 are regular patents in two-tiered countries, 311290 regular patents in single-tiered countries and 323119 second tier patents.

FIGURE A.4 The average number of forward citations 2000–2012



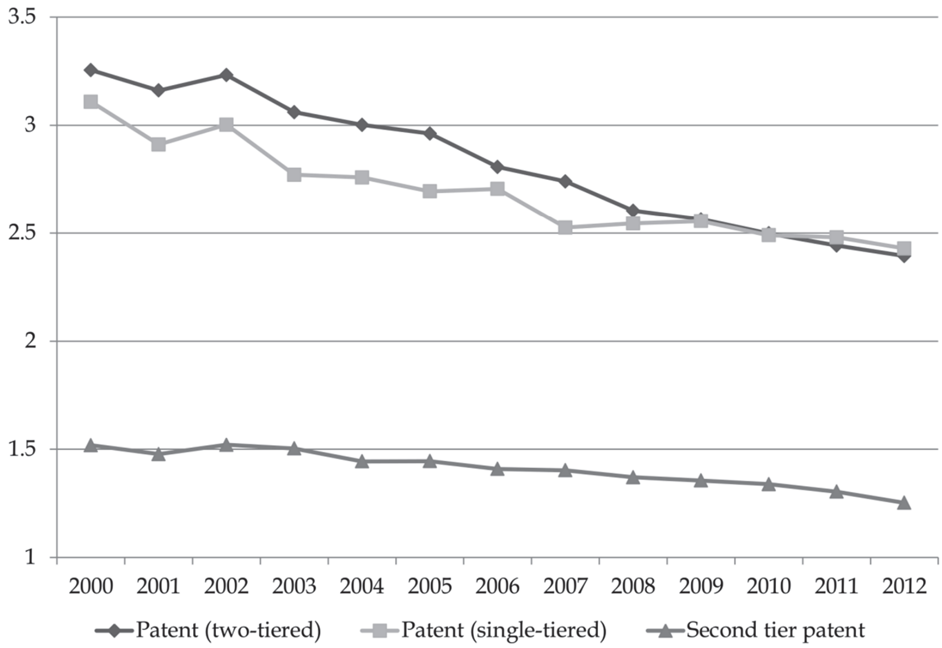
Notes: Number of citations refers to the number of forward citations that the patent family of the priority filing has received (PATSTAT 2016 April edition).

FIGURE A.5 Distribution of patent family size 2000–2012



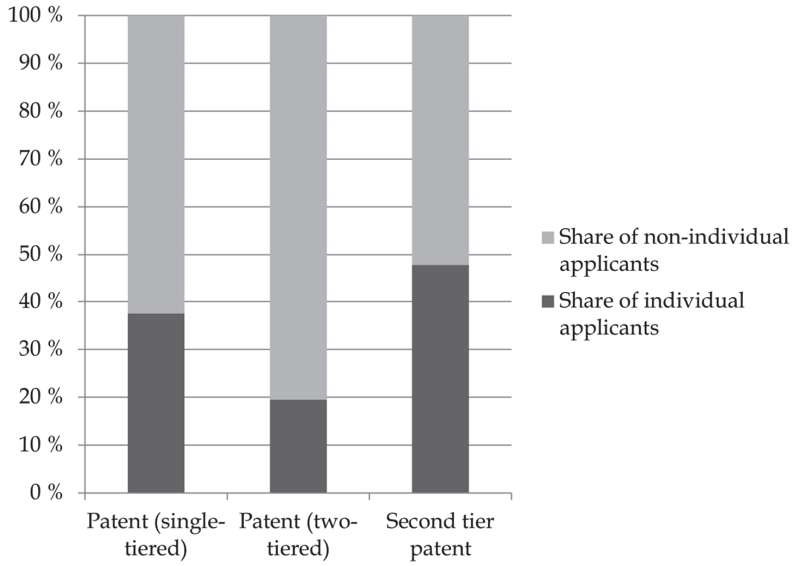
Notes: Total number of priority filings is 1606549, of which 972140 are regular patents in two-tiered countries, 311290 regular patents in single-tiered countries and 323119 second tier patents.

FIGURE A.6 The average patent family size 2000–2012



Notes: Filings for which PATSTAT (April 2016 edition) reported patent family size to be zero are excluded.

FIGURE A.7. The average share of non-individual inventors 2000–2012



Notes: Total number of priority filings is 1527709, of which 925830 are regular patents in two-tiered countries, 303671 regular patents in single-tiered countries and 298208 second tier patents. Non-individual applicants refer to priority filings, in which any of the applicants is not an individual (i.e., company, government, nonprofit organization, university, or hospital).

FIGURE A.8 The average share of non-individual applicants 2000–2012

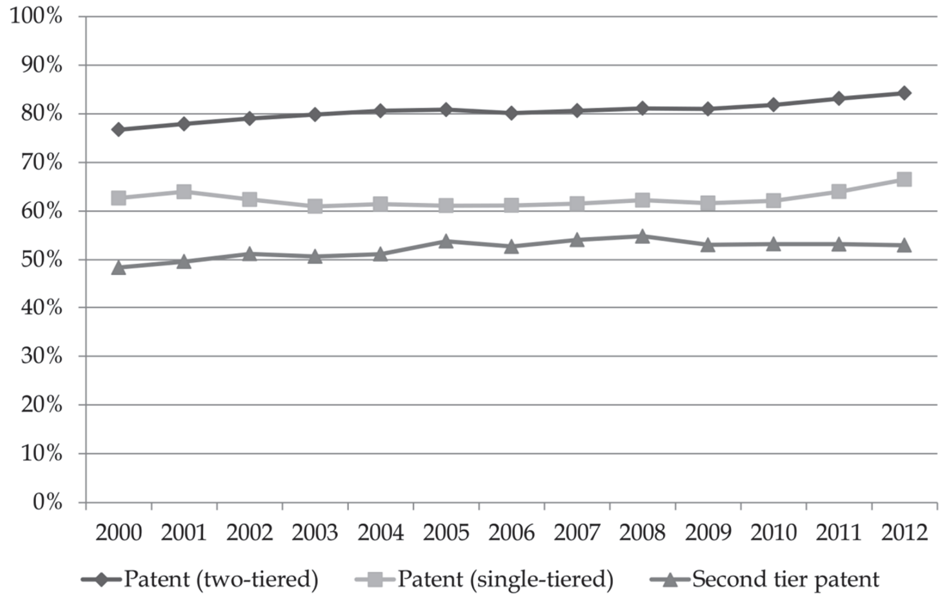
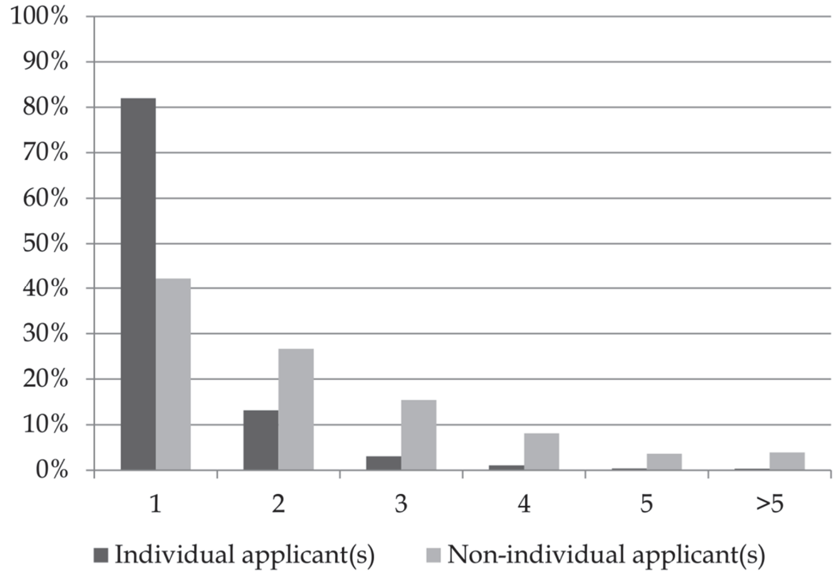
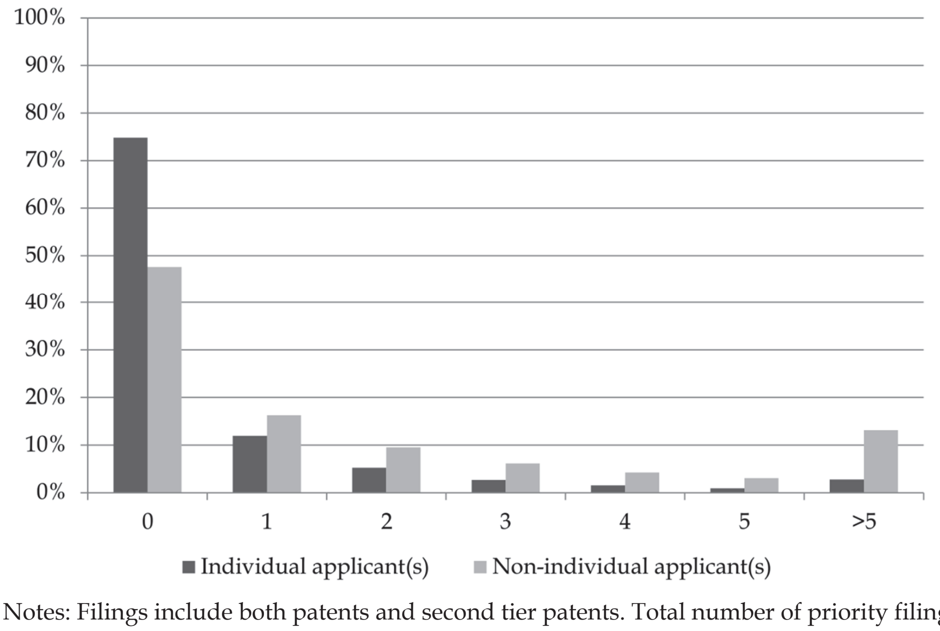


FIGURE A.9 Distribution of number of inventors by applicant type 2000–2012



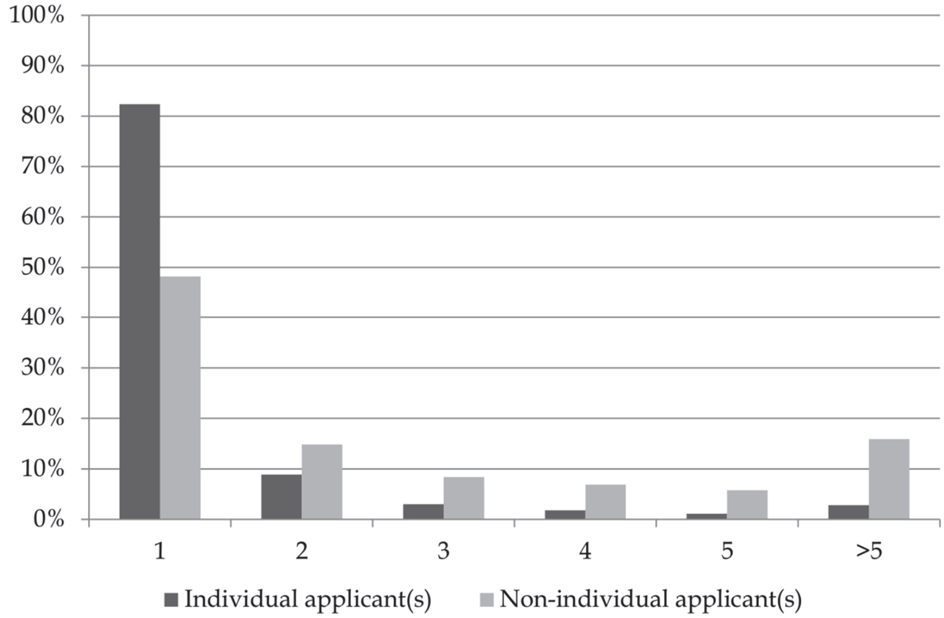
Notes: Filings include both patents and second tier patents. Filings, in which the number of inventors is zero, are excluded. Total number of priority filings is 1133885 of which 264011 are filed by individual applicants and 869874 by non-individual applicants.

FIGURE A.10 Distribution of forward citations by applicant type 2000–2012



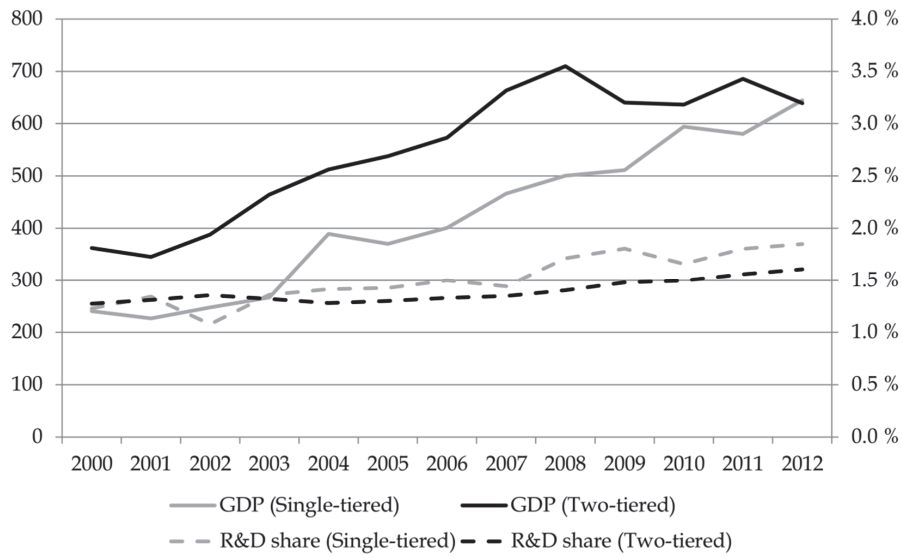
Notes: Filings include both patents and second tier patents. Total number of priority filings is 1527709 of which 437200 are filed by individual applicants and 1090509 by non-individual applicants.

FIGURE A.11 Distribution of patent family size by applicant type 2000–2012



Notes: Filings include both patents and second tier patents. Total number of priority filings is 1527709 of which 437200 are filed by individual applicants and 1090509 by non-individual applicants.

FIGURE A.12 GDP and R&D shares of GDP 2000–2012



Notes: GDP figures are billions of constant 2005 dollars. R&D figures are annual R&D investments divided by GDP. Authors' calculations. Data source: World Bank's DataBank.

Appendix 2

Second tier patent ratio

There exists evidence that the relative importance between regular patents and second tier patents varies across technology fields and countries (see Radauer et al., 2015; Hamdan-Livramento & Raffo, 2016). Furthermore, the intensity of second tier patent use is expected to be associated with the quality difference between regular patents and second tier patents. Table A.7 shows the ratio of priority second tier patent filings to priority patent filings.

TABLE A.7 Second tier patent ratios in two-tiered patent systems 2000–2012

	Priority patent filings	Priority second tier patent filings	Total priority filings	Second tier patent ratio
AT	14879	7070	21949	0.475
BE	2353	1620	3973	0.688
BG	1965	1282	3247	0.652
CZ	8085	14893	22978	1.842
DE	525822	177815	703637	0.338
DK	3239	2593	5832	0.801
EE	380	897	1277	2.361
ES	27337	32531	59868	1.190
FI	23627	5583	29210	0.236
FR	166130	4121	170251	0.025
GR	6029	128	6157	0.021
HR	1595	833	2428	0.522
HU	9158	3046	12204	0.333
IE	770	1411	2181	1.832
IT	114743	32171	146914	0.280
NL	12215	4149	16364	0.340
PL	32616	9447	42063	0.290
PT	2331	753	3084	0.323
RO	4122	105	4227	0.025
RS	1101	415	1516	0.377
SI	3205	210	3415	0.066
SK	2054	66	2120	0.032
TR	8384	21979	30363	2.622
Total	972140	323118	1295258	

Notes: Priority filings, which are members of patent families with PCT filings, are excluded. Second tier patent ratio is simply the number of priority second tier patent filings divided by the number of second tier patent filings. For countries that shifted between single and two-tiered paten system during the period, the ratios are calculated for the two-tiered patent system period: RO, 2008–2012; NL, 2000–2008; BE, 2000–2008; RS, 2004–2012). For GR the ratio is calculated for 2000–2001 due to missing data.

Next, we calculate the ratio of second tier patent filings to regular patent filings in technology field in countries with two-tiered patent systems during 2000–2012 as follows:

$$\text{Second\_tier\_patent\_ratio}_{i,2000-2012} = \frac{1}{N}\sum^{C}\frac{Second\ tier\ patent\ filings_{ic,2000-2012}}{Patent\ filings_{ic.2000-2012}}$$

where N is the number of countries in the sample and C = {AT, BE, BG, CZ, DE, DK, EE, ES, FI, FR, GR, HR, HU, IE, IT, NL, PL, PT, RO, RS, SI, SK, TR}

The ratio is a simple average and each country has the same weight. Table A.8 presents the average ratios across countries of second tier patent filings to patent filings in technology fields. The ratios are in line with those reported by Hamdan-Livramento & Raffo (2016) despite the fact that our sample consists of priority filings in European countries while Hamdan-Livramento & Raffo (2016) report the figures for all filings and for a larger set of countries around the world. Second tier patents are relatively most often used in technology fields such as Furniture, games (33), Other consumer goods (34) and Handling (25) whereas relatively least often used in fields such as Microstructural and nanotechnology (22), Biotechnology (15) and Organic fine chemistry (14). In general, the use of UMs is relatively more intensive in mechanical engineering and instruments sectors and less intensive in electrical engineering and chemistry sectors. Alternatively, the technological-field-specific second tier patent ratios were calculated by dividing second tier patent filings by regular patent filings in each technology field. The ratios were qualitatively similar and the ranking across technology fields was almost unchanged.

Table A.9 shows the second tier patent ratios for each country and technology field separately. Clearly, there is significant heterogeneity both across countries and technology fields.

TABLE A.8 Ratio of second tier patents to patents by technology fields

	Technology field	Sector	Ratio of second tier patent filings to patents in countries with two-tiered patent systems
1	Electrical machinery, apparatus, energy	Electrical engineering	0.631
2	Audio-visual technology	Electrical engineering	0.930
3	Telecommunications	Electrical engineering	0.407
4	Digital communication	Electrical engineering	0.199
5	Basic communication processes	Electrical engineering	0.198
6	Computer technology	Electrical engineering	0.342
7	IT methods for management	Electrical engineering	0.277
8	Semiconductors	Electrical engineering	0.173
9	Optics	Instruments	0.411
10	Measurement	Instruments	0.402
11	Analysis of biological materials	Instruments	0.122
12	Control	Instruments	0.535
13	Medical technology	Instruments	0.716
14	Organic fine chemistry	Chemistry	0.109
15	Biotechnology	Chemistry	0.084
16	Pharmaceuticals	Chemistry	0.195
17	Macromolecular chemistry, polymers	Chemistry	0.110
18	Food chemistry	Chemistry	0.455
19	Basic materials chemistry	Chemistry	0.266
20	Materials, metallurgy	Chemistry	0.158
21	Surface technology, coating	Chemistry	0.278
22	Micro-structural and nano-technology	Chemistry	0.048
23	Chemical engineering	Chemistry	0.461
24	Environmental technology	Chemistry	0.490
25	Handling	Mechanical engineering	1.093
26	Machine tools	Mechanical engineering	0.649
27	Engines, pumps, turbines	Mechanical engineering	0.380
28	Textile and paper machines	Mechanical engineering	0.352
29	Other special machines	Mechanical engineering	0.752
30	Thermal processes and apparatus	Mechanical engineering	0.781
31	Mechanical elements	Mechanical engineering	0.779
32	Transport	Mechanical engineering	0.706
33	Furniture, games	Other fields	1.911
34	Other consumer goods	Other fields	1.254
35	Civil engineering	Other fields	0.986
36	Non-classified	Non-classified	0.557

Notes: In PATSTAT data (April 2016 edition) patent filings are assigned typically several technology fields with weights. Technology field 36, "Non-classified", is structured to consists of filings for which there were no "dominant" technology field– that is, a technology field with weight > 50%.

TABLE A.9 Ratio of second tier patents to patents by technology fields across countries

	Patent office	AT	BE	BG	CZ	DE	DK	EE	ES	FI	FR	GR	HR	HU	IE	IT	NL	PL	PT	RO	RS	SI	SK	TR
	Time period	2000-2012	2000-2008	2008-2012	2000-2012	2000-2012	2000-2012	2000-2012	2000-2012	2000-2012	2000-2012	2000-2001	2000-2012	2000-2012	2000-2012	2000-2012	2000-2008	2000-2012	2000-2012	2008-2012	2005-2012	2000-2012	2000-2012	2000-2012
	Technology field																							
1	Electrical machinery, apparatus, energy	0.360	0.641	0.315	1.648	0.331	0.731	2.222	1.443	0.231	0.028	0	0.882	0.410	2.895	0.245	0.260	0.350	0.343	0.019	0.405	0.074	0.013	2.970
2	Audio-visual technology	0.608	1.263	1.353	4.375	0.611	0.538		2.875	0.249	0.023	0.071	0.929	0.620	2.000	0.478	0.439	0.737	1.375	0.091	1.100	0.129	0	2.815
3	Telecommunications	0.702	2.833	0.480	2.561	0.257	0.450	2.000	0.731	0.062	0.011	0	0.154	0.232	2.091	0.191	0.326	0.427	0.171	0	0.063	0.047	0.182	1.402
4	Digital communication	0.263	0.600	0	0.633	0.043	0.429	0.667	0.015	0.015	0.002	0	1.250	0.147	2.857	0.006	0.304	0.015	0.121	0	0.500	0	0	0.406
5	Basic communication processes	0.292		0.500	1.824	0.062	0.500	0	0.220	0.010	0.001	0	0.500	0.077		0.010	0.050	0.042	0.182	0	0	0	0	1.286
6	Computer technology	0.370	1.455	0.241	1.520	0.189	0.464	4.500	0.368	0.055	0.017	0	0.533	0.097	1.861	0.066	0.550	0.058	0.186	0.020	0.077	0.020	0	0.966
7	IT methods for management	1.619	5.333	0.857	1.094	0.117	1.333	4.750	0.109	0.093	0.016	0	0.583	0	2.364	0.027	0.582	0	0.235	0.080	0	0	0.056	0.342
8	Semiconductors	0.444	0.667	0.032	1.313	0.063	0		0.273	0.010	0.007	0	2.000	0.118	0.800	0.038	0.113	0.054	0.188	0	0	0	0	0.471
9	Optics	0.297	1.714	0.684	1.066	0.198	0.294	0.500	0.806	0.082	0.022	0	0.400	0.100	15.00	0.299	0.252	0.168	0.118	0	1.333	0	0	2.690
10	Measurement	0.337	1.320	0.370	1.991	0.152	0.229	1.000	0.403	0.085	0.018	0	0.857	0.237	1.647	0.098	0.283	0.128	0.040	0.018	0.410	0.050	0.082	1.515
11	Analysis of biological materials	0.136		0	1.769	0.124	0.500	0.667	0.066	0	0.014	0	0	0	1.250	0	0.188	0.089	0	0		0	0	0.429
12	Control	0.537	2.533	0.821	2.538	0.276	1.033	4.167	0.971	0.134	0.024	0	0.622	0.359	3.889	0.267	0.280	0.150	0.283	0.045	0.071	0.053	0	1.993
13	Medical technology	0.397	0.794	0.630	1.836	0.487	0.515	3.308	1.285	0.241	0.023	0	0.440	0.332	2.846	0.199	0.308	0.245	0.324	0.011	0.590	0.027	0.064	2.416
14	Organic fine chemistry	0.091	2.250	0.379	0.159	0.053	2.000	2.000	0.005	0.082	0.001	0	0.255	0	1.273	0	0.366	0	0	0	0	0.024	0	0.051
15	Biotechnology	0.034	0.400	0.167	0.671	0.067	0	0.167	0.008	0.006	0.002	0	0.667	0.051	0.059	0	0.200	0.010	0.015	0	0.250	0	0	0.038
16	Pharmaceuticals	0.245	2.000	1.191	0.643	0.110	0.308	0.857	0.007	0.044	0.004	0	0.391	0	0.500	0.005	0.333	0	0	0	0	0.071	0	0.011
17	Macromolecular chemistry, polymers		0	1.333	0.821	0.024	0	0.143	0	0.023	0			0	0.250	0	0.133	0.001	0	0	0	0	0.029	0.156
18	Food chemistry	0.827	0.895	1.143	3.516	0.604	0.545	4.833	0.151	0.158	0.015	0	1.310	0.011	1.324	0.124	0.199	0.043	0.047	0	0	0.074	0.182	0.373
19	Basic materials chemistry	0.240	1.750	0.412	1.498	0.119	1.053	1.065	0.105	0.136	0.007	0	0.769	0.061	1.091	0.018	0.178	0.019	0	0.012	0	0	0.068	0.236
20	Materials, metallurgy	0.176	0.077	0.195	0.894	0.092	0.143	0.400	0.061	0.013	0.006	0	0.412	0.049	0.667	0.024	0.357	0.016	0.015	0.013	0.063	0.045	0.014	0.335
21	Surface technology, coating	0.295	0.043	0.348	1.010	0.153	0.353	1.333	0.570	0.092	0.007		0.333	0.346	1.250	0.058	0.076	0.050	0.115	0	0.750	0	0	1.022
22	Micro-structural and nano-technology	0		0	0.200	0.009	0		0	0	0.008	0		0		0	0	0	0	0		0.333	0	0
23	Chemical engineering	0.282	0.484	0.641	1.610	0.326	0.345	1.308	0.874	0.136	0.018	0.091	0.429	0.182	2.000	0.118	0.261	0.214	0.196	0.024	0.154	0.182	0	2.987
24	Environmental technology	0.274	0.619	0.386	1.584	0.281	0.567	1.091	1.068	0.173	0.040	0.059	0.349	0.172	1.583	0.132	0.271	0.167	0.286	0	0.174	0.038	0.013	2.632
25	Handling	0.514	0.766	1.481	3.801	0.652	0.928	4.667	2.733	0.277	0.026	0.111	0.348	0.674	2.250	0.254	0.316	0.797	0.971	0.063	0.694	0.152	0.032	5.885
26	Machine tools	0.352	0.548	1.047	1.658	0.433	0.783	2.182	1.348	0.264	0.060	0.067	0.703	0.329	1.333	0.141	0.289	0.230	0.263	0	0.652	0.063	0	2.964
27	Engines, pumps, turbines	0.325	0.468	0.307	1.080	0.108	0.148	2.182	0.442	0.054	0.040	0	0.311	0.115	1.545	0.102	0.503	0.091	0.094	0.016	0.165	0.058	0.019	1.353
28	Textile and paper machines	0.138	0.289	1.167	0.510	0.141	0.127	2.333	0.698	0.097	0.018	0	0.429	0.295	1.667	0.118	0.134	0.123	0.132	0	0.667	0.136	0.125	1.854
29	Other special machines	0.548	0.446	1.263	2.312	0.463	0.796	1.833	1.492	0.373	0.021	0	0.674	0.436	2.094	0.201	0.215	0.422	0.525	0.036	0.247	0.054	0.012	4.412
30	Thermal processes and apparatus	0.332	0.414	1.389	2.287	0.433	0.568	3.600	1.032	0.351	0.022	0	0.585	0.311	2.000	0.296	0.303	0.443	0.417	0.063	0.281	0.071	0.013	2.812
31	Mechanical elements	0.350	0.290	0.660	1.846	0.251	0.470	4.250	1.791	0.247	0.024	0	0.340	0.359	1.636	0.238	0.245	0.343	0.500	0.019	0.350	0.114	0	3.985
32	Transport	0.471	1.222	0.344	1.707	0.245	1.203	5.500	1.657	0.351	0.037	0	0.384	0.345	2.200	0.300	0.427	0.376	0.510	0.071	0.432	0.047	0.050	2.229
33	Furniture, games	0.708	1.296	1.361	4.966	1.701	2.262	11.43	5.060	0.891	0.077	0	0.453	0.724	2.531	0.634	0.600	1.013	0.949	0.113	0.978	0.090	0.050	9.141
34	Other consumer goods	0.918	1.170	1.813	4.191	1.121	2.232	8.500	3.910	0.768	0.051	0	0.435	0.689	5.875	0.529	0.688	0.725	1.153	0.056	1.292	0.094	0.050	2.861
35	Civil engineering	0.635	0.460	1.029	3.305	0.893	1.165	5.111	2.063	0.573	0.025	0	0.506	0.595	1.664	0.315	0.365	0.680	0.616	0.065	0.627	0.068	0.034	5.284
36	Non-classified	0.641	0.667	0.486	1.471	0.263	0.744	1.810	0.364	0.243	0.017	1.208	0.641	0.427	1.755	0.294	0.361	0.253	0.191	0.038	0.322	0.048	0.042	1.088

Notes: The reported numbers are second tier patent ratios (i.e., number of second tier patent filings/number of regular patent filings) at national patent offices.

Color codes: 0 ≤ ratio < 0.1; 0.1 < ratio < 0.5; 0.5 ≤ ratio < 1; 1 ≤ ratio

SUMMARY IN FINNISH (YHTEENVETO)

Empiirisiä tutkimuksia eurooppalaisista aineettomien oikeuksien instituutioista

Väitöskirja koostuu johdantoluvusta ja viidestä empiirisestä tutkimuksesta, jotka käsittelevät eurooppalaisia aineettomien oikeuksien instituutioita. Luvut 2, 3 ja 4 ovat mikrotason tutkimuksia ja näkökulma siirtyy makrotasolle luvuissa 5 ja 6. Luvut 2, 3, 5 ja 6 käsittelevät kaksitasoisia patenttijärjestelmiä ja luku 4 mallioikeusjärjestelmää.

Luvussa 2 tutkitaan saksalaisista yrityksistä koostuvalla innovaatiokyselyaineistolla yritysten valintaa patenttien ja hyödyllisyysmallien välillä. Tutkimuksessa havaitaan, että yrityksillä, jotka raportoivat tuotteidensa vanhenevan nopeasti, on suurempi todennäköisyys hyödyntää hyödyllisyysmalleja. Lisäksi suuret yritykset hyödyntävät sekä patentteja että hyödyllisyysmalleja pieniä yrityksiä useammin innovaatioidensa suojaamisessa, mikä saattaa viitata suurten yritysten parempaan kykyyn hyödyntää aineettomien oikeuksien järjestelmän tarjoamat suojauskeinovaihtoehdot.

Luvussa 3 tutkitaan hyödyllisyysmallien roolia kansainvälisessä patentoinnissa. Tutkimus kuvailee, miten hyödyllisyysmalleja käytetään osana patenttiperheitä. Havaitsemme, että suurinta osaa hyödyllisyysmalleista käytetään suojaamaan keksintöä paikallisesti yhdessä maassa. Toisaalta havaitsemme, että hyödyllisyysmalleja käytetään myös osana kansainvälisiä patentointistrategioita, muun muassa PCT-hakemusten sekä Eurooppa-patenttien prioriteettihakemuksina. Tutkimus osoittaa, että Eurooppa-patenttihakemuksissa kuvattujen keksintöjen, joissa prioriteettihakemus on kansallinen hyödyllisyysmalli, laatu on keskimäärin alempi kuin Eurooppa-patenttihakemuksissa kuvattujen keksintöjen, joissa prioriteettihakemus on kansallinen patentti.

Luvussa 4 tutkitaan mallioikeuksien merkitystä toimialan innovaatiotoiminnassa ja kilpailussa. Toimialaksi on tarkoituksellisesti valittu suomalaiset kiukaita valmistavat toimijat. Tutkimuksen havainto, että mallioikeuksilla on vain pieni merkitys innovaatioiden suojaamiskeinona, on linjassa aikaisempien järjestelmää koskevien selvitysten ja tutkimusten kanssa. Dokumentoimme tapahtumat, jotka tarjosivat alan toimijoille tilaisuuksia päivittää uskomuksiaan mallioikeuksien suoja-alojen laajuuksista. Tutkimuksessa havaitaan myös, että epävarmat mallioikeudet voivat lisätä yrittäjien optimistisuutta. Ylioptimistisuutta on mahdollista vähentää tarjoamalla puolueetonta tietoa mallioikeuksien suoja-alan tulkinnasta paremmin kaikkien toimijoiden saataville.

Luvussa 5 tutkitaan, kuinka Alankomaiden luopuminen kaksitasoisesta patenttijärjestelmästä oli yhteydessä kansalliseen patentointiaktiivisuuteen ja patenteilla suojattujen keksintöjen laatuun. Menetelmänä käytetään synteettisen kontrollin menetelmää, joka soveltuu erityisen hyvin vaikutusarviointiin tilanteessa, jossa otoskoko on pieni ja jossa politiikkamuutos kohdistuu vain yhteen yksikköön. Tulokset osoittavat, että kaksitasoisesta patenttijärjestelmästä luopuminen oli yhteydessä väliaikaiseen kansallisen patentointiaktiivisuuden las-

kuun, mutta pidemmällä aikavälillä eroa Alankomaiden ja sen synteettisen kontrollin välillä ei havaittu. Järjestelmän poistamisen ei havaittu vaikuttaneen yksiselitteisesti patenteilla suojattujen keksintöjen laatuun.

Luvussa 6 tutkitaan eurooppalaisista maista koostuvalla aineistolla hakijoiden valintaa patenttien ja hyödyllisyysmallien tai vastaavien ”toisen tason patenttien” välillä sekä sitä, kuinka maan valinta yksi- ja kaksitasoisen patenttijärjestelmän välillä on yhteydessä patenteilla suojattujen keksintöjen laatuun. Tutkimuksessa havaitaan, että kaksitasoisissa patenttijärjestelmissä eri laatuiset keksinnöt valikoituvat hyödyntämään eritasoisia suojamuotoja: hakijat valitsevat patentin laadukkaammille keksinnöille ja hyödyllisyysmallin tai vastaavaan toisen tason patentin vähemmän laadukkaille keksinnöille. Lisäksi henkilöhakijoilla on suurempi todennäköisyys valita hyödyllisyysmalli. Kaksitasoisissa patenttijärjestelmissä tavallisilla patenteilla suojataan keskimäärin laadukkaampia keksintöjä kuin toisen tason patenteilla. Tulokset koskien patenteilla suojattujen keksintöjen laatueroja yksi- ja kaksitasoisissa patenttijärjestelmissä eivät ole yksiselitteisiä.

Väitöskirjan tavoitteena on ollut tuottaa objektiivista tutkimustietoa aineettomien oikeuksien instituutioiden kehittämisen tueksi. Useat Euroopan maat ovat tähän mennessä ottaneet käyttöön kaksitasoisen patenttijärjestelmän, vaikka sen hyödyistä ei ole dokumentoitua empiiristä näyttöä kehittyneissä maissa. Väitöskirjan tutkimustulokset osoittavat, että kaksitasoiset patenttijärjestelmät eivät välttämättä vaikuta patentointiaktiivisuuden tasoon, mutta toisaalta niillä on merkitystä keksintöjen ja hakijoiden valikoitumisessa. Jos vähempiarvoiset keksinnöt valikoituvat käyttämään toisen tason patentteja, kuten hyödyllisyysmalleja, valikoitumisen seurauksena patentin signaali suojatun keksinnön laadusta esimerkiksi sijoittajille voi olla selkeämpi. On kuitenkin syytä pitää mielessä, että aineettomien oikeuksien instituutiot ovat vain osa kansallisia innovaatiojärjestelmiä. Siksi niiden vaikutusta kansalliseen innovaatiotoimintaan arvioitaessa on otettava huomioon kansallinen konteksti eli IPR-järjestelmien vuorovaikutus muiden innovaatiotoimintaan vaikuttavien instituutioiden kanssa.

Tutkimuksen keskeinen implikaatio patenttijärjestelmiä käsitteleville tutkimuksille on, että niiden tulisi ottaa analyyseissä huomioon hyödyllisyysmallit ja muut ”toisen tason patentit”. Vähintäänkin tilastollisissa analyyseissä tulisi raportoida ovatko hyödyllisyysmallit mukana vai eivät. Eurooppalaiset aineettomien oikeuksien järjestelmät ovat edelleen monimutkaisia ja kansalliset erot maiden välillä ovat merkittäviä. Tästä johtuen pienemmät toimijat saattavat olla suuria toimijoita heikommassa asemassa IPR-järjestelmien hyödyntämisessä. Pienten, nuorten ja vähäresurssisten toimijoiden välistä tietämys- ja osaamiskuilua suhteessa suuriin, kokeneisiin ja runsasresurssisiin kilpailijoihin on mahdollista pienentää yksinkertaistamalla ja harmonisoimalla kansallisia järjestelmiä sekä tarjoamalla IPR-järjestelmistä luotettavaa, objektiivista ja helposti ymmärrettävää tietoa sekä tilastoja verkossa.