EUROPEAN DOCTORATE IN LAW AND ECONOMICS

Patent Strategies and R&D in Complex Product Industries

PhD Thesis

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CHAPTER 1. INTRODUCTION

1.1. Introduction

Economists have argued that when there is a single and isolated innovation in prospect, patents are efficient tools to promote innovative activity. However, innovation does not necessarily occur in isolated settings as previous innovations often stimulate subsequent improvements. Furthermore, the production of many new high-technology products often requires numerous complementary innovative components, each of which may be protected by one or more patents. These facts give rise to a proliferation and fragmentation of intellectual property (IP) rights.

This complexity of modern technology has forced firms to interact over patent portfolios that have allegedly resulted in various inefficiencies. For instance, some commentators believe that patent portfolio races are mainly derived from strategic purposes, such as to negatively affect competition and to increase the transaction costs for firms operating in the same or similar technological areas (Hall et al., 2007a, Regibeau and Rockett, 2011). The fact that these portfolio races are taking place in industries that did not traditionally rely on patent protection has raised the question as to whether the current IP system is adequately functioning or additional policy actions are necessary to lessen the effect of certain externalities that have emerged. Among these proposals are measures to prevent large volumes of patent applications, limit the scope of patent protection or to apply stricter regulation of licensing practices via competition rules.

The above context might raise the question of whether optimization can be reached by changing the innovation policy. However, before any policy change is made, one should be fully aware of the functioning of institutions and their interaction with firm behavior. In spite of numerous contributions by many prominent scholars, there is no generally accepted theoretical framework for conceptualizing the dynamics between R&D and patent portfolios. Informal analyses of cumulative and complementary innovations abound in the literature; however, there is need for a more precise and analytically articulated analysis of firms' preferences on accumulating patents. This thesis aims at filling this gap by providing analytical and quantitative models of the consequences of patent proliferation and patent portfolios.

The cost structure of firms holding multiple patents for a certain product is particular; therefore, it needs a particular analysis. First, this setting does not exactly fit the theory of patents as monopolies. This is because a firm which does not possess all the necessary components to develop a product cannot monopolize a market. Second and more importantly, fragmentation entails the need to bargain and cooperate with the other complementary patent holders. For that reason, the bargaining process of firms cannot be left out of the economic analysis of IP rights. Third, the bargaining process is conducted under the shadow of litigation; hence, the patent enforcement strategies also become an important element of the analysis. None of these decisions works independently from each other, hence there is no clear answer about how R&D, patenting and licensing activities are shaped in the existence of fragmented property rights. Our claim is that only after a specific analysis of these dynamics, is it possible to identify patenting strategies that are not a part of innovation decisions and take necessary measures (if ever needed).

As a starting point of the analysis, this study stresses that the cumulative and complementary nature of innovation results in overlapping patent claims and underlines the importance of private market solutions in moderating litigation threats due to fragmented property rights. The analysis focuses on how these factors affect bargaining and how this influences innovation incentives. In addition, a cross-industrial study is performed to highlight the technological dynamics involved in different sectors. Such a study clarifies the effects of these differences on the outcome of ex-post cooperative licensing agreements and provides insights into how innovation policy can be tailored according to technology-specific needs. This identification is important because a stricter approach toward ex-post cooperative licensing agreements should require a demonstration of inefficiency derived from these arrangements. The review of the legal treatment of licensing agreements, which particularly take place in high-technology industries, aims to assess whether the current rules are in line with the economic findings of the thesis and address the possible effects of certain rules on firm behavior.

1.2. Description of the Problem

Over recent years there has been a dramatic increase in patent applications both in United States (US) and Europe, especially in high-technology industries such as semiconductor, software, biotechnology and electronic equipment. The intense activity of firms buying or exchanging patents is reminiscent of avid collectors. In many high-technology sectors, companies no longer hold a single patent to protect an innovation; rather, they rely on patent portfolios, which can be described as an aggregation of a large number of related patents. A patent portfolio provides certain market and technological advantages to its owner. As a result, patents have become rather complicated instruments of competition, which provide defensive and offensive uses against competitors (Parchomovsky and Wagner, 2005).

The use of patent portfolios was first documented in the semiconductors and electronics industries by Grindley and Teece (1997). Later on, the pioneering study by Hall and Ziedonis (2001) shows that an industry-wide explosion in patenting activity was initiated by semiconductor producers, who built up large patent portfolios. Subsequent contributions focused on analyzing related questions about the explosion in patenting propensity of semiconductor firms. For instance, Ziedonis (2004) explored the determinants of patent explosion, Somaya (2003) and Ziedonis (2003) studied the effects on patents' litigation and settlements, whereas Siebert and Von Graevenitz (2010) analyzed the effects on licensing. Other high-technology industries witnessed similar trends in proliferation of IP rights. Firms' patenting strategies in the software industry have been studied by Noel and Schankerman (2006) and Bessen and Hunt (2007). In the field of biomedical research, Heller and Eisenberg (1998) posed the questions of whether patenting strategies in this industry are negatively affecting the innovation incentives.

The empirical work in this line of literature is very new and yet there is still no clear consensus about the effects of the surge in patenting on firms. Perhaps, the main conclusion derived from this literature is that there is an obvious need for more analysis of the present situation as understood from the proliferation of publications on this matter. Some scholars argue that specific technology areas within the patent system are negatively affected by the competition among the firms for building large patent portfolios. In particular there are concerns that these portfolio races have increased transaction costs and that socially wasteful investments may be directed towards the creation and management of these patent portfolios. It is argued that firms increasingly patent for strategic purposes due to the pressure of keeping up with their competitors in technology markets. Such strategic patenting - described as systematically employing patent portfolios and the procedures of the patent system to raise the production costs of their competitors - is claimed to damage welfare (Hall et al., 2007a). One of the outcomes of portfolio races is the dubious patent quality which is believed to negatively affect the functioning and effectiveness of the patent system (Guellec and Van Pottelsberghe de la Potterie, 2007; Farell and Shapiro, 2008).[1] Another concern is the risk of deterred innovation incentives due to certain behaviors of market participants. These

[1] This is because the proliferation of patent applications increases the workload of patent examiners. As patent examination is constrained by limited resources, this can cause a quality decline in granted patents. In return, the perception of lower patentability thresholds might encourage filing of more patents. It is further argued that this vicious cycle increases the ambiguity of patent protection, which, in turn, affects firms' innovation incentives.

behaviors relate to the patent hold-up created by *injunction threats* and *royalty stacking*. Such risks emerge from the complex structure of the modern patent landscape (Lemley and Shapiro, 2007).

In general, the major evidence indicating that patent portfolio strategies may not be welfare improving is the increase in the number of patents that does not correspond to an increase in aggregate R&D levels. Chart 1.1 contrasts the growth of patent applications at the European Patent Office (EPO) and the growth of R&D spending in OECD countries.

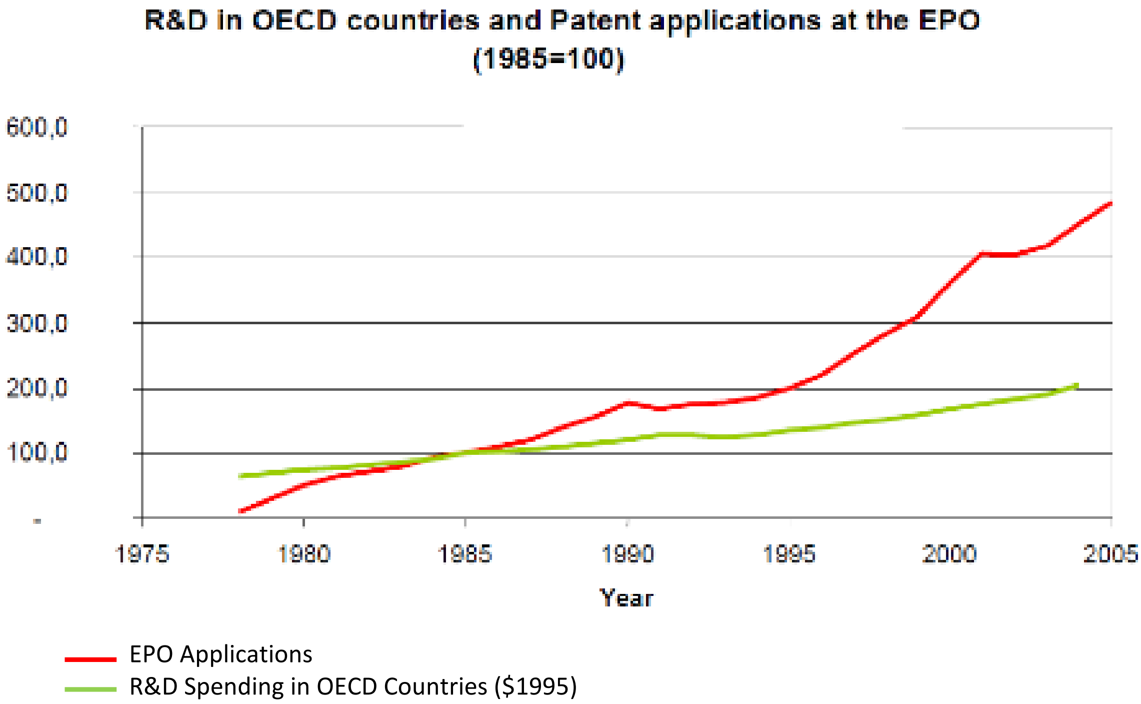

Chart 1.1. R&D in OECD Countries and Patent Applications at the EPO (1985=100), Source: Hall et al. (2007a) based on their calculation from EPO Annual reports (various years) and EPOLINE -Data provided by the EPO

Hall et al. (2007a) has calculated that patent applications at the EPO increased from 70,955 to 145,241, corresponding to an annual growth rate of 7.4%, whereas real expenditure on R&D increased from \$398 to \$555 billion, corresponding to an annual growth rate of only 3.4%. This implies that the number of applications has grown twice as fast as aggregate R&D investments. In addition to this, the empirical evidence suggests that there is a decrease in R&D efficiency/productivity rates (Hashimoto and Haneda, 2008).[2] Moreover, the decline in renewal activity since the 1990s across most categories of patent ownership and country of patent origin is used as an argument to show that the increase in patent applications is a result

[2] Hashimoto and Haneda (2008) ascertain a 50% R&D efficiency loss in the Japanese pharmaceutical industry between the years 1983 and 1992. They state that even though firms continued to increase their R&D expenditure every year, R&D efficiency did not improve.

of portfolio races and not of socially desirable R&D investments (Brown, 1995; Parchomosky and Wagner, 2005).

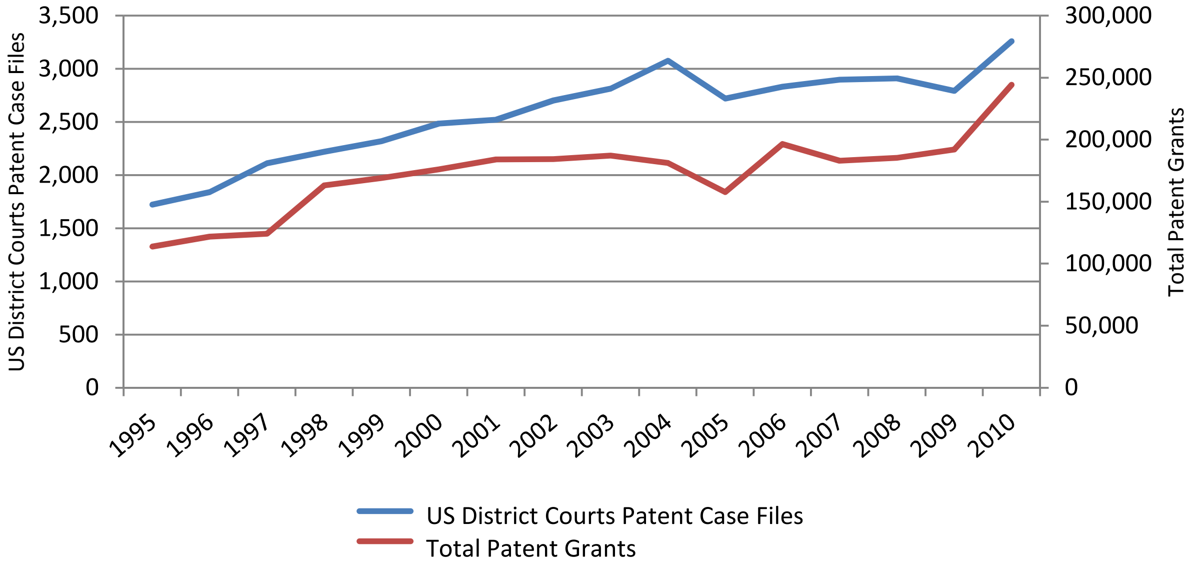

Chart 1.2. Patent Case Filing and Grants, Sources: USPTO: Performance & Accountability Report and US Courts: Judicial Facts & Figures include both US and private cases

Another evidence is that the increase in patent applications has been followed by an increase in patent litigation, which raises doubts about patent portfolio races occurring because of strategic reasons. For instance, Chart 1.2 shows that between 1995 and 2010, the number of patents granted by the US Patent and Trademark Office (USPTO) has increased significantly, from 113,834 to 244,341 patents, which corresponds to an annual compounding growth rate of 4.88%. In the same time interval, the total number of patent cases filed in the US District Courts has also increased from 1,723 to 3,269 cases, corresponding to a similar annual compounding growth rate of 4.06%. Patent litigation is highly costly, and it also involves many indirect costs which are socially wasteful. Bessen and Meurer (2008a) in a study analyzing patent lawsuit filings find that the expected joint loss of litigating parties is probably much larger than the expected attorneys' fees due to indirect business costs. The main concern about these direct and indirect costs is that the risk of infringement can negatively affect the R&D efforts of firms and hence act as a tax on innovation.

Patent litigation occurs in numerous technology areas; however, the most costly litigation takes place in complex technology industries. Chart 1.3.a below shows the distribution of the cases in different sectors. On the other hand, interestingly, the median damages awarded do not follow this distribution and it is observed that high-technology areas go ahead in the damages granted by courts in patent litigation cases (as shown in Chart 1.3.b). The telecommunications sector, where standardization efforts are quite important in technology development, takes the lead in this statistic, followed by other high-technology industries.

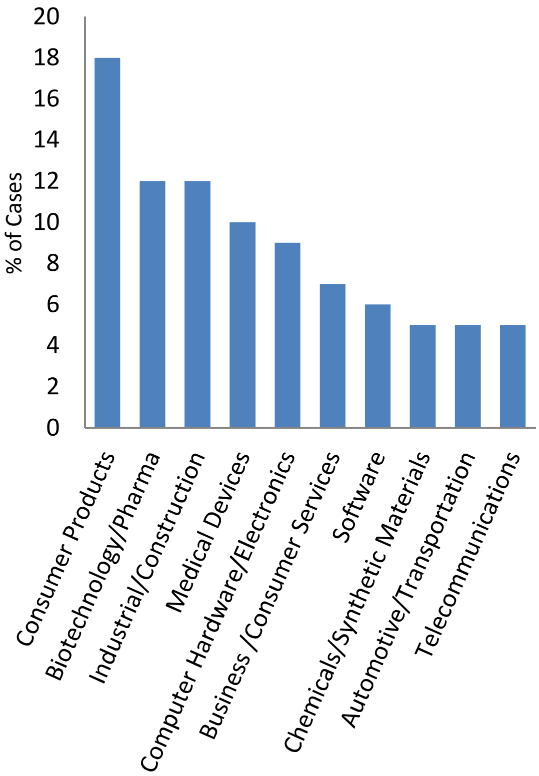

Chart 1.3.a. Distribution of cases: Top ten industries, 1995 to 2010

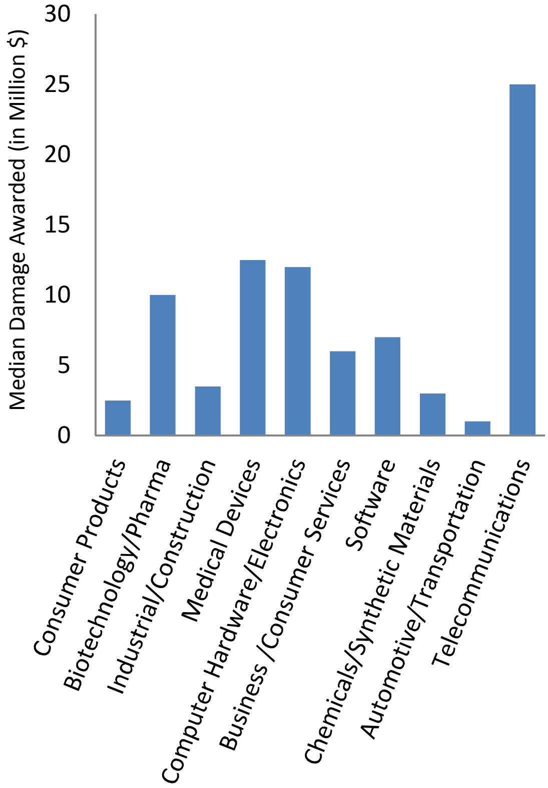

Chart 1.3.b. Patent holder median damages awarded: Top ten industries, 1995 to 2010

Source: PricewaterhouseCoopers, 2011 Patent Litigation Study, Patent Litigation Trends as 'America Invests Act' Becomes Law

We observe that costly litigation is taking place in industries where the growth rates of patent applications are immense. For instance, between 1990 and 2000, the strongest increase in the number of patent applications at the EPO was observed in Telecommunications (253%), Information Technology (174%) and Electrical Devices (91%). In these industries, patents have traditionally not been important in the appropriation of rents from innovation (Grindley and Teece, 1997). Surveys indicate that in such industries patents are considered to be one of the least efficient protection tools to harvest return from investments compared to, for example, lead time, secrecy or manufacturing and design capabilities (Levin et al., 1987; Cohen et al., 2000; Hall and Ziedonis, 2001). Therefore, it is believed that the motivation for obtaining patents in these industries should differ from the traditional view of patent protection and should be based on the aim of acquiring strategic benefits (Hall et al., 2007a).

This negative view has been recently challenged by Arora et al. (2008), who have shown that an increase in the mean of the patent premium distribution for a typical US manufacturing firm significantly stimulates its own R&D efforts. This is certainly true in industries where the patent premium tends to be already high, such as drugs, biotech and medical instruments followed by machinery, computers, and industrial chemicals. But even in industries where the patent premium is lower, such as electronics and semiconductors, the elasticity is still positive, though smaller. Table 1.1 shows their estimation results:

			% change in R&D and patenting associated with a one-tenth-point patent premium increase	
Industry	Expected Patent Premium	Conditional Patent Premium	R&D	Patent Applications
Medical instruments	1.11	1.62	10.2	16.4
Biotechnology	0.99	1.58	9.6	17.5
Drugs and medicines	0.96	1.57	9.2	17.8
Office and computing equipment	0.73	1.49	7.7	19.9
Machinery	0.72	1.49	7.6	19.9
Industrial chemicals	0.66	1.48	7.1	20.6
Other electrical equipment	0.57	1.46	6.5	21.4
Communication equipment	0.56	1.45	6.3	21.6
Semiconductors	0.55	1.45	6.2	21.5
Instruments, exc. medical	0.46	1.42	5.6	22.3
Electronic components	0.40	1.41	5.0	23.2
Average	**0.60**	**1.47**	**6.6**	**21.2**

Table 1.1. Patent Premiums in Different Technology Areas, Source: Arora et al. (2008)[3]

Thus, contrary to what has been argued, in those industries where the patent premium is lower and firms rely on means other than patents to protect their innovations, patents still stimulate R&D investments. This means that the traditional view of patents, which reflects the innovativeness of the underlying technology and the degree to which it provides protection from imitation determined by the patent system, also works in complex product industries. Therefore, the important question is how the effectiveness of patents in appropriating rents from innovation is affected by the complexity of modern technology in such industries. In other words, how does the patent system function given the market structure and the strategies of industry players?

[3] Arora et al. (2008) finds that the average patent premium for all innovations for the sample is about 0.6. Thus, the analysis shows that for the US manufacturing sector, the expected value of the typical innovation if patented is 40% lower than without patenting. This unconditional patent premium is greater than unity in only one industry, medical instruments, and it is about unity in biotech and drugs. An unconditional average patent premium less than unity suggests that the opportunity cost of patenting, including the cost of information disclosure, the likelihood of inventing around, and perhaps the cost of enforcement are substantial. Although the typical innovation may not be profitable to patent, conditional upon patenting an innovation, the patent premium is, however, large. Conditional upon having patented an innovation, firms expect to earn almost 50% more on average than if they had not patented those innovations. The conditional premium is highest in industries such as medical instruments, biotechnology, and drugs and medicines and lowest in food and electronics. As expected, the variation is also much smaller for the conditional than for the unconditional premium.

The main problem presented with concerns regarding the negative effects of patent portfolios is that they underestimate the changes in the modern technology and the growing multi-component nature of many new products. A striking example is the semiconductor chips that are used to store and process data. Due to competition in the product market that requires the chip manufacturing to be smaller and smaller, the design, facilities and processes needed to create microchips have become much more complex. A circuit design can cost tens of millions of dollars, not to mention the fact that the design of a new generation of microprocessor takes years of planning. Construction can amount in total more than $4 billion (Burk and Lemley, 2003). Despite all these investments, to be able to manufacture this tiny device a firm has to incorporate at least 100 different patents, owned not necessarily by the firm itself but most probably by its competitors.

This is because complex technologies are often modular. A modular technology is one which can be separated into various components, each of which is related to others through a given set of design rules or interfaces. Therefore, improvements of separate components are possible through individual efforts. As a complex product is composed of many complementary patents, which have to be combined for it to function, modularity may cause these complementary technologies to be held by different parties (Von Graevenitz et al., 2011a). Fragmentation of property rights and mutual interdependences arise due to separate patentable elements of one product belonging to different parties.

More patenting emerges as a natural consequence of this process in multi-component industries. Thus, as argued in Shapiro (2001a), firms in industries based on such complex technologies face a growing "patent thicket": "a dense web of overlapping patents in which a firm often comes up against other firms that hold patents which may block the use of its own patents." Hence, in such circumstances, the generation of a well-designed patent portfolio is justified by the operational and technological freedom it provides to its owner via minimizing the risk of infringing on other patents. It also facilitates market mechanisms such as cross-licensing agreements and patent pools when interdependence due to complementarities is inevitable.

1.3. Purpose of the Study

There is so far no accepted theoretical model on the interaction of firms' R&D incentives and the design of the patent system. Therefore, more research is necessary on the optimal design of the patent system in the face of explosion in patenting. This thesis aims to provide evidence that the explosion in patenting has been accompanied by fundamental changes in the process of technological change. This change has indeed fostered the fragmentation of property rights and associated problems. A proper analysis should take into account the private market solutions, which have emerged to clear these problems in technology markets.

The costly litigation structure in complex product industries deserves special focus regarding the interaction of the patent system and firm strategies. The patent portfolio races might be triggering some transaction costs for the functioning of the system; hence, proliferation of patents indeed contributes to the fragmentation of intellectual property rights, which increases the probability of not only infringing competitors' patents but also being infringed by others. On the other hand, such patenting strategies are also used to mitigate the risk of inadvertent litigation. The literature mostly deals with the former argument; hence, more research is necessary to highlight the interaction between these two effects, specifically the impact of voluntary market mechanisms used in the light of patent explosion.

For the purpose of this study, ex-post R&D expenses are used as an important measure to illustrate the necessity of patenting in the dynamics of complex technologies. This is because if explosion in patenting was only a result of strategic reasons that aims to harm competitors, then we would not have observed an R&D increase after firm interaction, for instance after licensing arrangements. Studies linking strategic patenting and licensing with R&D data are quite rare and hence how innovation and R&D incentives are affected by these activities is yet controversial.

In addition, it is important to separately analyze technologies and sectors in which potential problems might occur due to proliferation and fragmentation of patent rights. Industries can highly differ with respect to the nature of innovation, structure of the market or the degree of appropriability.[4] As a result, innovation policy may need to be tailored according to these technology-specific needs. Thus, for an optimal policy to be implemented, it is necessary to know the interaction between these factors. The same is true for the regulation of licensing practices due to their increasing importance as the fragmentation problems have become larger and as regulatory framework has particularly strong effects in these sectors. More

[4] Burk and Lemley (2003) categorize these differences as the following: Nature of innovation can be different in terms of average cost of R&D projects (capital intensity), speed of innovation, uncertainty in R&D, technological complexity, degree of cumulative innovation, existence of research spillovers and relevance of technological standardization. Market structure can change depending on market concentration, size of the market or nature of competition (price vs. quantity). Lastly, the degree of appropriability can vary due to cost of imitation, effectiveness of alternative appropriation mechanisms, the nature of the production process and the existence of certain regulatory compliances.

research is necessary on this issue as licensing practices are not well understood empirically since data on contracts are not readily available. The thesis contributes to fill this gap in the literature.

1.4. Scientific and Social Relevance

As licensing agreements affect the competition between firms, as well as patent enforcement rules, patent licensing is also regulated under antitrust rules. The regulatory agencies strike a balance between the protection of competition and the protection of intellectual property rights, with the aim of providing an area of certainty for efficiency improving licensing agreements. Private market solutions often involve cooperative technology transfer agreements in a wide range of high-technology sectors. The technology and market structure as well as business models can induce different incentives for firms which are engaging in licensing agreements of this kind. Therefore, it is important that the regulatory approach that organizes firm behavior in complex product industries adequately address the dynamics in these industries.

Licensing practices in complex product industries are regulated by antitrust guidelines in the US and a block exemption on technology transfers and accompanying guidelines in the European Union (EU). The scientific and social relevance of this research increases as the EU block exemption and guidelines will expire on 30 April 2014. In order to prepare the regime to be applied after that date and to ensure that it both reflects current market realities and facilities the participation of different market participants to enter into technology transfer agreements, the Commission invites stakeholders to present their views on their experiences in applying the block exemption and the accompanying guidelines in practice. An analysis of the EU rules in comparison to its US counterparts, as presented in this thesis, aims to provide insights regarding improving policy in enhancing innovation incentives.

Lastly, cross-licensing and patent pooling activities are often used in industries where cooperative standardization activity is intense (Geradin et al., 2008; Blind et al., 2011). This process can be affected by the deficiencies in the patent law and the tendencies to solve these problems with antitrust rules. However, the different dichotomy between the two policies can create some problems in terms of dynamic efficiency. In this respect, the potential sources of disputes that have emerged in the standard-setting processes should be assessed taking into account that these problems, namely patent ambush and royalty stacking, are a result of interconnected problems of patent explosion and fragmented property rights. Some recent policy proposals have emerged to prevent these cases. However, more empirical study is necessary on licensing before implementing these reforms, because certain regulation of licensing can affect the already existing market mechanisms at work. Therefore, the potential costs of regulation can only be addressed when one is fully aware of the functioning of the system. If the proposals solve only some market failures but run the risk of generating additional negative externalities, then preserving the status quo might be a better policy. In this regard, the thesis aims to highlight the potential costs of some proposals given the contemporary innovative structure of the system.

1.5. Research Questions

As previously mentioned, there is a gap in the literature regarding the role of IP protection in complex product industries. Therefore, there is need for more research that investigates the following question:

"How does the patent system function in complex product industries in the light of fragmented property rights and cooperative market mechanisms?"

In order to provide an answer to this question the technical dynamics of portfolio patenting should be clarified through the following auxiliary questions.

i. How different is the use of patents in complex product industries from the traditional view of patents?

ii. Are patent portfolio races a cause or a consequence of fragmented property rights? To what extent can both incidences act as an indirect tax on innovation?

iii. How do firms cope with the consequences of fragmented property rights and do these strategies restore innovative incentives?

The investigation of these questions will provide an extensive analysis of the functioning of the patent system in complex product industries. This will offer insights in the policy discussion evolving around the costs of explosion in patenting and provide answers to the following questions:

"To what extent has the new technological order affected the patent expansion in certain industries? How does this relate to the degree of appropriability of patents in different complex product industries?"

Finally, by the findings of the economic analysis it will be possible to evaluate the regulatory framework towards the practices emerged in complex product industries and to comment on possible effects of recent policy or policy proposals concerning the functioning of the system in general. The analysis aims to provide solid economic foundations for the policy debates on the regulatory framework towards the practices emerged in complex product industries and asks in particular:

"Do current and proposed rules regarding IP licensing adequately address the innovation dynamics in complex product industries?"

1.6. Methodology

The methodology followed in this thesis is somewhat different from the classical law and economics approach in the sense that the starting point of the research is not an identified market failure but rather an investigation on whether such a failure actually exists as speculated. The necessity of this approach stems from the fact that regulating one part of the system can negatively affect other parts due to the complexity of interaction between different institutions. Identifying such effects can be eluded due to the rapid change observed in these technology markets, which amplifies the understanding of the workings of the system.

Putting the problem in a more general framework, every real institution has some problems; hence a perfect institution is simply not achievable. That is why institutional choices should not be about a search for perfection, but rather about comparing particular costs and benefits of actually available options (Aoki, 2001). As put forward by Demsetz (1969), rather than identifying mere market failures, one should compare the outcomes of markets to alternatives that are achievable in the real world. The reason is that the correction of an identified market failure does not necessarily result in a perfect world, a common belief he names as "nirvana fallacy". Alternatively, comparative institutional analysis is suggested, by comparing the working of the current system with relevant alternatives instead of an unrealistic argument.

Whether it is due to technological or market evolutions, some economic interactions are inherent with uncorrectable market failures. In such cases, actions to solve market failures in one part of the system may have an impact on other related segments. As a result, even though the intent is to increase overall economic efficiency, the final outcome may actually decrease it. Instead of trying to correct either problem, it may be better to let market imperfections be cancelled out through market responses. This suggests that economists need to study the details of the situation before jumping into the theory-based conclusion that an improvement in market imperfection in one area implies a global improvement in efficiency. This is known as the theory of second best which has been put forward by Lipsey and Lancaster (1956).[5] This means institutional choices have different implications, positive and negative, for different problems; therefore, it is important to pay attention to means as well as ends (Kieff, 2006). As suggested in the description of the problem, the mere identification of a market failure does not justify a call for resolution. Instead, policy should be derived from the implementation of a comparative analysis among truly available options (Aoki, 2001, Kieff, 2006).

Taking into account that each institution and organization has certain benefits and costs, this study highlights how the strategies helping firms to make use of their IP rights in complex product industries are enhanced while the costs are reduced. In addition, it analyzes the ways which various remedies for solving certain market failures that dominate the literature can have counterproductive effects. To realize this goal, it provides economic applications displaying why particular features of the present IP right regimes and strategies may be working well, while others should be reformed. The practical implication of using this methodology is to raise skepticism about not only certain regulations already in effect but also frequently discussed policy proposals. This may help to analyze future debates about institutional choices and in what manner they should be changed.

Given these reasons, the analysis conducted still falls with-in the framework of the law and economics approach as it applies economic methods to the analysis of law. Namely, economic methods are used to explain the effects of some rules, to assess whether related regulations currently in effect are economically efficient, or to predict which legal rules can be efficiently implemented. While doing so, the economic analysis of innovation policy in this thesis is indirect as the positive descriptions of the effects of certain rules are predicted after the economic analysis of the phenomena. Because of informational problems and transaction costs, departures from the ideal type of perfect markets by actual market organizations may serve economizing purposes (Coase, 1972; Williamson, 1985). Consequently, the research first depicts how the market works under the current rules and investigates the efficiencies generated from the status quo. Based on these findings, the study then highlights the transaction costs of certain policy proposals in reference to overcoming some potential problems. This is necessary because, as stated by Easterbrook and Fischel (1991), "regulation

[5] For a review of the second-best theory, see Markovits (1997).

is more failure prone than markets, as there are few automatic forces that correct regulation".[6] From this respect, the investigation shows how firms can efficiently organize their operations under private regulation, and the potential costs of interruption to the system. The policy recommendations are given based on this assessment. For that reason, the analysis also incorporates normative elements.

1.7. Structure of the Thesis

The thesis is organized as follows: Chapter 2 presents the developments of economic analysis of IP rights, starting from initial models of the economic justification of IP, followed by the current considerations in the literature. The discussion will evolve around auxiliary research question *i,* questioning how different the contemporary use of patents is from the traditional economic view. Particular emphasis will be given to the modern patent landscape and facilitators of patent accumulation decisions of firms. This will generate a general framework to tackle the auxiliary research question *ii*, illustrating the interaction between the new technological order, fragmented property rights and patent portfolio races.

In Chapter 3, a formal theoretical model is developed to understand the private market solutions emerged to overcome the problems as a result of fragmented property rights, which is the focus of auxiliary research question *iii*. The analysis of Chapter 2 will provide inputs for the necessary parameters and the setting of the model. The model aims to illustrate the interaction of firms' R&D incentives and the design of the patent system. Different from the previous literature, like Hunt (2006), firms are assumed to devote separate resources for patenting and R&D activities. The analysis focuses on the bargaining outcomes of firms under the threat of litigation.

Chapter 4 empirically tests the relevance of the model and takes the analysis one step further by conducting a cross-industrial analysis. The aim of this section is to disentangle the different innovation and market mechanisms inherent in various complex product industries. Through the construction of a novel dataset, the study focuses on the impact of ex-post cooperative agreements on further R&D incentives and investigates the nature of the impact in different industries. Ex-post is used in the sense that cooperative technology agreements involve already existing patents whose R&D expenses have already sunk. The conclusions highlight the determinants of the use of market mechanisms in different industries.

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[6] Easterbrook and Fischel (1991) states the regulatory system lacks a competitor and often suppresses the information which makes it difficult to detect regulatory failure.

Chapter 5 explores the regulatory framework concerning the private market solutions that have emerged in the light of modern patent landscape. Based on the theoretical and empirical findings of the previous chapters, this section analyzes the US and EU rules regarding IP licensing. In addition, as complex product industries are highly affected by standardization activities, the second part of the chapter investigates the extent of some frequently mentioned disturbances during standard-setting procedures and then evaluates certain proposals under the insights gathered from the economic analysis.

In Chapter 6, a summary of the major findings of the study are presented. This illustrates to what extent legal innovation is aligned with the technological innovation. Lastly, limitations of the current analysis and suggestions for further research are discussed.

CHAPTER 2. MODERN ECONOMIC ANALYSIS OF IP RIGHTS: THEORY AND APPLICATION

2.1. Introduction

Inappropriability of knowledge makes it difficult to optimally organize its production and distribution through a decentralized system; that is why there is a close link between economic analysis of knowledge and policy. Starting from Arrow (1962), economic theory has contributed significantly to the understanding of patent law. Patents are proposed as a solution to the market failure of inappropriability of knowledge, as they balance the dynamic efficiency gains from innovations and the static efficiency loss due to granted monopoly rights. Enabling firms to absorb a significant gain from their investments through legal protection against imitators, patents enhance the incentives to invest in R&D.

In this perspective, the first contribution of the economic analysis of IP focused on the R&D incentives in general, without really distinguishing between different and potentially conflicting economic players and analyzing the details of the intellectual property regime implemented. It was not until the 1990s that the question of patent design became a prime focus of the economics of innovation literature (Gilbert and Shapiro, 1990; Klemperer, 1990; Waterson, 1990; Gallini, 1992; Denicolo, 1996). The main assumptions in these early models were that a single patent would protect a well-defined innovation and that it would automatically grant an economic monopoly to its owner.

The recognition that innovation does not occur in isolated settings showed the need to go beyond the monopoly theory of patents. The existence of early and late innovations implies that patents do not confer full monopoly rights and creates an issue of the optimal division of profit in order to properly reward early innovators without deterring follow-on ones (Merges and Nelson, 1990; Scotchmer, 1991; Green and Scotchmer, 1995; Denicolo, 2000). Nonetheless, the models of the 1990s also had little to say about patent enforcement considering the patent law as a system. Only in the last decade or so have economists realized that in reality, patent protection does not work perfectly and started to analyze the welfare economics of patents taking into account the possible deficiencies in the system.

The aim of this chapter is to show the evolution of the economic theory of IP rights. This will help to show both the differences and the similarities between the contemporary use of patents and the traditional economic view. These insights are important to identify the current dynamics of the patent system as a whole and to find out how the problems of the modern patent landscape and firm behavior are mutually connected. Thus, the review will provide the ingredients for the following economic analyses.

2.2. Economic Analysis of IP Rights: Theoretical Considerations

2.2.1. Patent Races

The economic analysis of IP initially started with models on innovation using non-cooperative game theory techniques depicting competition between firms with particular attention given to the supply-side of R&D (e.g. Loury, 1979; Dasgupta and Stiglitz, 1980; Lee and Wilde; 1980; Reinganum, 1981a,b; Gilbert and Newbery, 1982). The end-consumers and licensees which demand that technology were not taken into account.[7] The main assumption in these models was that a given R&D project yields a constant income, which is lower than social welfare. The variation in these studies stemmed from incorporation of several different factors that mainly generated a difference between private and social returns, aimed to illuminate the connection between R&D incentives and market structure, which was an initial question posed by Schumpeter (1934, 1942).[8]

Arrow (1962) made one of the first contributions of economic analyses of IP rights to incorporate exclusive rights into an R&D competition model and to show that a monopolist without an actual or potential competitor has less incentive to invest in R&D compared to a firm in a competitive industry. Contrary to the Schumpeterian view which argues that concentrated markets generally promote innovation by providing more suitable conditions to extract returns from R&D, Arrow stated that a firm in a competitive industry does not forgo any pre-invention profits as a monopolist does by replacing its old technology; and this results in the net payoff of the monopolist to be lower compared to a competitive firm, which in turn leads to lower incentives to invest in R&D.

On the other hand, a monopolist that is already well-established in a market may have incentives to invest in R&D itself to preempt potential competitors. This finding emerges in Gilbert and Newbery (1982) as they allow the monopolist to face some competition either in

[7] In general, these models use a common functional form of expenditure linked with discovery. When the race is dynamic, a Poisson style memoryless discovery function links the probability making the discovery with current rather than past expenditure.

[8] Pollock (2008) identifies these specific market structures as: (1) an incumbent monopolist, (2) an incumbent monopolist facing new entrants or (3) new entrants with no incumbent. See Loury (1979), Dasgupta and Stiglitz (1980), Lee and Wilde (1980), Reinganum, (1981a,b).

the product market or in research and development. They show that the incentive to preempt may be stronger than Arrow's replacement effect; hence, a monopolist can have a greater incentive to invent than a competitive firm, if it is likely to preempt competition.[9]

Other particular questions in this literature examined how the amount of R&D per firm varied with respect to the number of firms, how the total amount of R&D varied with respect to the number of firms and how these levels of R&D relate to optimum.[10] The answers to these questions depended on the particular values of the parameters of the models, resulting in R&D levels to be either too high or too low. One basic result that emerged from this literature was that competition in R&D in a winner-takes-all approach generated increased and sometimes excessive incentives compared to a monopoly situation, as competition encourages the premature introduction of innovations (Pollock, 2008).

What, however, was lacking in this R&D literature was an analysis of the downstream product market which shows how the innovator's rents are obtained and how these rents depend on the intellectual property regime implemented. The first formal model on the optimal intellectual property policy was provided by Nordhaus (1969) examining the trade-off between the benefits of increased innovative activity and the cost of deadweight losses. He showed that, at the optimum, the marginal benefit of increased protection in the form of incentives for a firm to invest in a cost saving innovation should exactly equal the extra deadweight losses to a society by granting that firm the monopoly power for longer, thus suggesting that the optimal term of protection is finite. Subsequent studies examined the potential for competition in the final product, which could occur through imitation, introducing the discussion on patent breadth and patent length (Gilbert and Shapiro, 1990; Klemperer, 1990; Waterson, 1990; Gallini, 1992; Denicolo, 1996).

Patent breadth determines the scope of protection legally provided to the innovator. There are two main approaches in modeling patent breadth. In the first one, the impact of patent breadth on the patent holder's profits is represented in a single function, whereas in the second approach the relation between imitators and innovators is studied in the form of location

[9] Following the contributions of Reinganum (1983,1989), it has been shown that, uncertainty in the link between rival firms' investments and their R&D success can undermine preemption incentives. An incumbent firm has no incentive to preempt its rivals if probability that its rivals' R&D efforts will fail is large.

[10] For the variation of amount of R&D per firm with respect to the number of firms, see Loury (1979), Dasgupta and Stiglitz (1980), Delbono and Denicolo (1991), Lee and Wilde (1980) and Reinganum (1983). For the variation of total amount of R&D variation with respect to number of firms, see Loury (1979), Lee and Wilde (1980), Dasgupta and Stiglitz (1980). For the optimum level of R&D, see Fudenberg et al. (1983), Harris and Vickers (1985), Reinganum (1985).

models. In Gilbert and Shapiro (1990), patent breadth is increasingly costly in terms of social welfare, so the conclusion is that, the breadth, rather than the length, of patents should be limited. In Klemperer (1990) welfare losses can occur not only because of pricing decisions but also due to the travel cost incurred by customers. The travel cost represents the distance between the variety that consumers prefer and the patent holder produces. Therefore, depending on the distribution of valuations and transport costs, an optimal patent can either be long and narrow, or short and wide. In a similar vein, Waterson (1990), using a simple hotelling model, considers the breadth of a patent as an exclusion zone for an imitator and analyzes its impact on incumbent profits and product differentiation. In this case, if product differentiation is essential, then narrower patents are optimal; on the other hand, if prevention of imitation is more important, then broader patents will maximize innovators' profits.

Gallini (1992) incorporates the length of a patent into the strategic decisions of imitators. She points out that if patent length is made longer while breadth is reduced, this will give incentives to imitators to invent around the innovation. This will, in turn, reduce the patents' actual life, which brings the conclusion that broad but short-term protection is optimal. Denicolo (1996) emphasizes that the structure of the product market is what actually determines the optimal scope of protection. Contrary to the previous authors that have assumed a pre-specified socially optimal R&D level, he investigates the choice of level of the R&D investments by separating the decisions of the patent race that occurs between many firms and product market competition. As a general answer to the problem he suggests, narrowing patent scope should be justified if the increase in social welfare due to additional competition brought to the market is higher than the reduction that occurs in welfare due to lessened incentives to innovate. If these two factors are in balance, then a patent should be given the maximum breadth. This brings the general condition that broad and short-term patents are socially more optimal if the competition in product market is less efficient.

2.2.2. Cumulative Innovation

Later developments in the economic theories of innovation have challenged the notion that innovations are isolated and emphasized the cumulative nature of innovation. This implies that the social value of innovations should include the value of subsequent innovations that have been built upon. In the cumulative innovation literature, the patent breadth is reinterpreted as a distance along a quality ladder where new innovations are considered as quality advancements along this line (Pollock, 2008). In this context, new innovations infringe with previous property rights, which require licensing. Therefore, the cumulative innovation literature sheds light on a new kind of social cost, in addition to the monopoly cost, which is the impact of already existing innovations on future incentives to innovate. This formulation accounts for the greater strategic dependency between various participants in the market. In the existence of such externality, the cost of stronger intellectual property rights might be higher than in a single innovation context. At the same time, however, the cost of weak intellectual property rights can substantially affect the incentives in the first stage of innovation, which, in turn, affects the follow-on inventions.

As one of the initial models, Scotchmer (1991) points out that early innovators can be undercompensated given the 'option value' of their innovation in the form of providing the possibility of follow-on improvements.[11] Conversely, Merges and Nelson (1990) elaborate on the issue of hold-up that is the exclusion of follow-on innovations.[12] Green and Scotchmer (1995) focus on the interaction between ex-ante and ex-post licensing and analyze the incentives to innovate at different stages in a setting of perfect information on values and costs. The efficient bargaining does not leave room to hold-up in the form of second stage innovators not investing and provides an explanation as to why broad protection is optimal.[13]

By incorporating patent races into the setting of Green and Scotchmer (1995), Denicolo (2000) assumes that broader breadth granted to the first-stage innovators retards the rate of second stage innovation. Assuming that a large number of firms can participate in the patent race, he rules out the option for ex-ante agreements and also allows the first generation inventors to participate in the second generation innovation race. Contrary to Merges and Nelson (1990), he finds out that narrow protection for the first innovation is desirable when the non-appropriable value of the second innovation is relatively high, while broader protection is desirable when the private return of the second innovation is high. This is due to the winner-takes-all effect of patent races where there is less need to protect highly profitable

[11] For similar concerns also see Chang (1995), Scotchmer (1996), and Matutes et al. (1996). To some extent, broad patents are also supported by the arguments of O'Donoghue et al. (1998), who study patent breadth in a model with an infinite sequence of improved products (quality ladder).

[12] See also Merges and Nelson (1994) and Heller and Eisenberg (1998).

[13] On the contrary, Bessen (2004) shows that when development of second round innovation is private knowledge, patent holder may not offer ex-ante agreements. In addition, he finds that the optimal patent regime may require these types of agreements not to be offered and that, even in the existence of such agreements, hold-up may still be a problem. In addition, Bessen and Maskin (2009) show that in a setting of asymmetric information and a sequence of innovations that might occur between two firms, patent hold-up can arise in the form of too high royalty rate set to the high cost innovator. This may prevent the high cost firm from participating in the following stage. In particular ,they show that, with cumulative innovation that involves complementarities, in contrast to what occurs in a 'one-shot' model, IP may reduce rather than increase innovation.

innovations, whereas strong protection is desirable when a large fraction of the returns to innovation are non-appropriable.

These economic intuitions emerge in a framework that can be applied to certain market and innovative structures. The complexities of the modern products, however, resulted in additional considerations that were not yet present in this literature.

2.2.3. Complementary Innovation and Growing Multi-component Nature of Products

Modern products in innovative industries require the incorporation of many different complementary patents that can be held by different firms. Cohen et al. (2000) classify industries according to whether they are “complex” (in which the value is generated from complementary components) or “discrete” (so that commercialized products are covered by single patents). Based on this description, for example, they classify telecommunications equipment and electronics as complex industries, while pharmaceuticals and chemicals are classified as discrete.

The theoretical literature on complementary innovation produces various conclusions about optimal patent design depending on the setting and assumptions of models. Some authors focus on research firms which are only capable of achieving different complementary inventions (Shapiro, 2008; Denicolò, 2007; Denicolò and Halmenschlager, 2010), while others cases assume firms can develop all the necessary components for the new product or processes (Green and Scotchmer, 1995; Ménière, 2008; Bessen and Maskin, 2009; Gilbert and Katz, 2011). Some focus on simultaneous investments, while others presume sequential investment in components. Regardless of the setting, the complementary innovation approach acknowledges fragmentation of the property rights and the outcome of more patenting than what would have normally occurred.

The main problem with fragmentation of patent rights is that it increases transaction costs and may lead to pricing inefficiencies (Merges and Nelson; 1990, Heller and Eisenberg; 1998, and Shapiro, 2001a). Transaction costs can occur due to the difficulties that arise in multi-party contracting, also known as “the tragedy of anti-commons”. Heller and Eisenberg (1998) have suggested that when multiple owners share the rights to property, as every one of them has the right to exclude others, the tragedy that can result is the under-use of resources. The idea is that, if it is costly to collect all the rights, then it is most likely that research requiring this costly process will be avoided. In addition, the diverse interests between right holders can cause coordination problems, which may make it difficult for the parties to agree on a common solution.

A second source of transaction costs might be due to a dense web of overlapping among patent claims between multiple right holders, which is the definition of patent thickets used by Shapiro (2001a). Overlapping may occur due to different sources. First, multiple patents might be technologically essential for the development of a product or process. Each patent might cover different aspects of the technology required to produce a new product or process, resulting in technical complementarity between patents (Hall et al., 2007a). Second, the overlapping may occur due to wording of claims, which determines the boundaries or scope of protection. If there are similar patents in a given technology area, it is likely that the boundaries of such patents overlap. Therefore, a firm with a valid patent covering a certain component of a new product might fear infringing another firm's patent of similar underlying technologies. This creates the risk of mutually blocking property rights. In these situations, access to the other firm's patent is not technologically necessary, but required for a firm to proceed with R&D under legal certainty (Barton, 2002). Lastly, legal concepts like doctrine of equivalents may also increase the chance of patent overlaps. This is a legal rule that allows a court to hold a party liable for patent infringement even though the infringing device or process does not fall within the literal scope of a patent claim, but nevertheless is equivalent to the claimed invention.[14] In the presence of complementarities, it becomes much easier to interpret overlapping among patents due to this doctrine.

The solution of the theoretical literature to mitigate overlapping among patents has been to make it more difficult to get patent protection for some complementary innovations without much said on how to make this distinction between components (Denicolo, 2008). In reality, it is also difficult to make clear-cut distinctions between complementary patents. This fact has pushed firms to hold diverse patent portfolios to minimize the costs and delay that can incur in case they lack certain complementary patents.

2.3. Patent Portfolios

An important risk for innovators of multi-component products is being held-up by other patent owners. This has resulted in portfolio patenting in complex product industries. Based on responses from the Carnegie Melon Survey in the US and Japan, Cohen et al. (2000) and Cohen et al. (2002) report that firms in complex product industries are more likely to file

[14] Source: http://en.wikipedia.org/wiki/Doctrine_of_equivalents

patents for protection against litigation than firms in discrete product industries. Patenting for similar technologies decreases, as much as possible, the risks of infringing on patents of others; thus, it significantly reduces the risk of costly patent litigation and hold-up. This functions as a strategy used to broaden the scope of protection of valuable technologies. In addition, it mitigates hold-up risks that provide the certainty to invest for subsequent innovations.

Furthermore, firms can build large patent portfolios to improve their bargaining position in negotiations with third parties to show they have credible counter-threat positions in case of infringement.[15] Cohen et al. (2000) indicates that the value of holding rivals hostage through controlling patents embodied in their products enables them to have more favorable terms in license agreements. As long as the marginal increase in the value of the portfolio is greater than the acquisition cost, firms continue to obtain patents. As Williamson (1983) suggests by credibly threatening a reciprocal harm through litigation, firms are able to reach truce equilibrium and reduce the risks of bilateral expropriation.

A different analysis is needed for firms holding patent portfolios because the cost structure of firms holding multiple patents for certain products has different elements. First, this setting does not exactly fit the monopoly theory of patents as a firm which does not possess all the components necessary to develop a product cannot monopolize a market. Second and more importantly, fragmentation entails the need to bargain and cooperate with the other complementary patent holders. Therefore, the bargaining process of firms cannot be left out of the economic analysis of IP rights in the context of complex products. Third, the bargaining process is conducted under the shadow of litigation; hence, the patent enforcement strategies also become an important element of the analysis. These problems result in several sources of externalities that an innovator may impose on others, which distorts the functioning of the patent system.

Given the complexity of the phenomena, economists resorted to empirical studies. Recent empirical research has focused on the structure of firms' patent portfolios and the bargaining

[15] Another form of patenting can be deliberately preventing competitors from applying for patents on technological developments, named as offensive patenting; which restricts competitors' future technological opportunities (Arundel and Patel, 2003; Blind et al., 2009). Blind et. al. (2009) find out that the characteristic of a firms' patent portfolio differs based on which strategic patenting motive the firm is using. If the average number of citations of the patents in a portfolio is high, it may be an indication that the patents are acquired for defensive reasons, whereas offensive patents tend to get more opposition from rivals. Defensive patents are similar to the patents acquired for the base technology; therefore, they are cited more often. On the other hand, offensive patents tend to cover less valuable technologies. Defensive patents face less opposition because the rivals' probability to declare the patent invalid is generally low; whereas this probability is higher for offensive patents.

strength in negotiations. A strong bargaining power for a firm provides certain strategic advantages: (1) it avoids risky litigation either as party being infringed or as a potential infringer and (2) it encourages settlements, such as cross-licensing or patent pools, which may lead to the situation where a self-resolving mechanism allocates the patent ownership where its value is maximized. The bargaining power of a firm in this literature is measured as the capability of a firm to overcome the patent thicket. The extent of a patent thicket is measured by making use of the patent statistics. In general terms, these studies analyze the interaction between patenting and R&D strategies.

2.4. Empirical Literature on Patent Portfolios

Empirical literature on portfolio patenting recognizes the fact that patent strategies are an important element of firms' innovation decisions. With this respect a special focus has been given to measure the extent of patent thickets and to analyze how the patent landscape affects firms' bargaining process.

There are different approaches to measure patent thickets. For instance, Ziedonis (2004) develops a fragmentation index measuring the dispersion of the ownership structure of non-self backward citations of the patents in a portfolio owned by a firm in a given year.[16] This fragmentation measure reveals some of the technological background of a certain patent and also indicates potential licensors of the cited patents. Her study has shown that in some cases accumulation occurs as a defensive strategy to contribute to the freedom to operate without the threat of hold-up, and it is more preferable to ex-ante contracting due to the potential transaction costs and delays. She finds that capital intensive firms patent five times more aggressively in response to average levels of fragmentation compared to firms with average capital intensity, even after controlling for R&D spending and firm size. She concludes that patent portfolio races are mostly driven by a subset of capital intensive firms. On the other hand, one point that has been neglected is that capital intensity can also induce firms to engage in more defensive actions to overcome fragmentation, which is a legitimate business conduct that aims to protect R&D investments. In addition, fragmentation of patent rights

[16] The fragmentation index is calculated as a firm's total number of non-self references cited by the patents of that firm divided by the total number of citations listed in patents assigned to each firm. For instance, if a firm's all patent applications in a given year cites only one other firm, then the fragmentation index is zero, whereas if it cites patents that are each owned by a different firm, then the index is 1, which is the maximum value. High fragmentation indexes indicate the legal rights, which can potentially exclude the firm, are dispersed across many firms.

among manufacturers' has also resulted in increased cross-licensing negotiations. As a result, firms are also increasing their level of patenting to have better bargaining positions.

On the other hand, Siebert and Von Graevenitz (2010) introduce a measure capturing the likelihood of mutual blocking relationships between patent holders.[17] Therefore, a further distinction is made by disentangling the effects of fragmentation and blocking patents. In this way, fragmentation is considered to capture the concentration of patents across competitors in technology markets, whereas patent thickets are defined as instances in which firms' patents mutually block the use of important technologies. It is observed that lower levels of blocking induce firms to license ex-ante, and higher levels induce them to license ex-post (Siebert and Von Graevenitz, 2010). Therefore, licensing allows rivals to either avoid or resolve hold-up from blocking patents. On the other hand, Von Graevenitz et al. (2011a) use a different index for European patent applications considering X and Y references, indicating a patent that will potentially be blocked.[18,19] It is found that only in complex product industries does licensing have a positive correlation with the blocking index, whereas no consistent evidence is present in terms of discrete product industries, which suggests technology licensing can serve as a tool to mitigate hold-up problems. Therefore, an important conclusion that arises from this literature is that the transaction costs in multi-component products has not yet led to significant hold-up problems that cannot be overcome by the private market solutions in these industries.

In addition, no significant evidence was found regarding coordination failures in bargaining between market participants. For instance, challenging the anti-commons view, Lichtman (2006) found evidence that fragmentation of property rights can actually facilitate negotiations and improve technology diffusion. The idea is that when an innovator has to collect a variety of patent inputs that are held by different licensors, the value at stake in each

[17] Von Graevenitz et al. (2011a) investigate the joint effect of technological complexity measured as the extent of blocking relationship and technological opportunity on determination of firm's patenting choices. Their unit analysis is firm pairs; hence, in their construction of technological complexity measure, they only consider the overlapping between two firms. However, due to this unit analysis, they do not investigate R&D incentives of firms.

[18] EPO Guidelines for Examination (Chapter X, 9.2) state that category X reference is applicable where a patent document is such that when taken alone a claimed invention cannot be considered novel or cannot be considered to involve an inventive step. In addition, a Y reference is applicable where a patent document is such that a claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other documents of the same category, such combination being obvious to a person skilled at art.

[19] The method that Von Graevenitz et al. (2011b) have developed is based on identifying firm triples which have mutually blocking patents. This is done by identifying all firms whose patents are referenced by a given firms' patents. They identify the cases where such citations are "X or Y types". This is done for all firms active in the technological area. The last step is to identify pairs in which each party can block at least one patent belonging to the other and later all groups of three firms which are part of mutually blocking firm pairs. The count of the number of such triples gives a measure of patent thickets.

negotiation is lower, so patent holders have a lower incentive to litigate. The author argues that such a situation can lead to faster settlement of patent disputes and accelerate technology transfer rather than retard it. The speeding up advantage occurs at a per negotiation base, so this positive effect may disappear as the number of required negotiations (which is related with the size of the thicket) increases. In addition, Galasso and Schankerman (2010) emphasize that the timing of the negotiations highly affects the conclusion that patent thickets retard the pace of innovative diffusion. They claim that the anti-commons view only holds when negotiations are sequential, so that each dispute is settled one after another. On the other hand, if the negotiations are held simultaneously, fragmentation reduces delay per dispute and the total negotiation time.[20]

An important indication of possible bargaining failures in complex product industries can also be found in declined R&D incentives of firms. The empirical evidence does not provide significant evidence on this aspect either. Noel and Schankerman (2006) analyze the impact of strategic patenting on R&D spending by incorporating two components of such patenting activity: portfolio size to capture the bargaining power, and fragmentation of patent rights to capture the transaction costs of enforcing patent rights. Their analysis provides evidence for strategic patenting but the findings are not very strong when the consequences of this act are considered. For instance, they find a strong R&D spillover effect on both patenting and market value of rival firms within a close technology field. In addition, they observe that patenting increases a firm's market value, which suggests the existence of a strong patent premium and the importance of patents in the software industry as means of appropriating innovation rents. On the contrary, they also show that higher levels of fragmentation in citations increases firms patenting but lowers a firm's market value.[21] This indicates that the expected negotiation costs with more parties may negatively affect the market value of a firm (Noel and Schankerman, 2006; Geradin et al., 2008). But more importantly, they do not find evidence of any negative effect of strategic patenting on R&D. This result decreases the chances of speculated coordination failures in industries since its existence would probably decrease R&D investments. It also underlines that the market-based solutions do create pro-competitive and pro-innovative outcomes.

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[20] It should also be noted that both Lichtman (2006) and Galasso and Schankerman (2010) presume that all blocking patent right holders have the same value at stake in disputes, which is only true if the parties have the same bargaining position.

[21] Fama (1970) points out that under the efficient market theory a firm's stock price reflects all the available information about the firm and its ability to earn profits. It is calculated from the discounted present value of the firms' future expected cash flows. Increased licensing fees in that sense can cause a firm's market value to decrease (Geradin et al., 2008).

Last but not least, in their analysis of the allegedly anti-commons problem in biotechnology industry, Epstein and Kuhlik (2004) argue that if the anti-commons theory were a problem in practice for biomedical research, we would have expected a decline in the levels of R&D, the value of new patented materials and the number of patents filed or granted. Yet, there is little evidence pointing to such lower levels. In addition, Arora et al. (2003), by conducting interviews with stakeholders of the biomedical research, did not find evidence of regular breakdowns in negotiations over IP rights. The origin of this survey was to examine social costs associated with access restrictions to some research tools. However, they acknowledge that the deficiencies in the patent granting system can result in many patents being filed on similar subjects (which can be due to lack of sufficient prior art that can result in low non-obviousness thresholds). Nevertheless, when more thorough patent clearance reviews for licensing are conducted, firms often find that the patents from the initial search can be eliminated, which decreases the number of firms to negotiate a license.

The conclusions that emerge from these studies conducted in different complex product industries are that there is no significant evidence (1) that firms are not able to avoid or resolve hold-up problems via market mechanisms and (2) that technology diffusion is distracted, hence innovation is retarded. Nevertheless, there are still concerns regarding the functioning of the patent system in these industries. The following section describes these concerns and elaborates on the extent of the problems to better understand how necessary a policy change is required. It also discusses how the changes can possibly affect the current working of the system.

2.5. Main Concerns of the Modern Patent Landscape

Due to the recent developments in the technology markets, two main concerns emerge with respect to the modern patent landscape:

(a) Dubious Quality Patents

(b) Deterred follow-on Innovation Incentives

2.5.1. Dubious Quality Patents

The dubious patent quality is a source of concern affecting the functioning and effectiveness of the patent system. In practice, such patents can emerge due to strategic patent filing strategies, such as divisional applications, continuations of applications and other filing strategies that might obscure disclosure function of patents and increase the risk of inadvertent infringement. The aim in such practice can be to make patents more comprehensive, longer and complicated by adding claims or to increase the number of divisional and parent patents with the same priority date. Detecting patents used as such strategic instruments is difficult in the mass proliferation of patents. This is also due to the public good aspect of litigation; that is, the detection of these instruments is in the hands of the market rather than the patent authorities (Hall et al., 2007a).

Dubious quality patents are strongly related with the proper application of the patentability standards. The USPTO issues about 15,000 patents monthly, which should supposedly be given to 'novel' and 'non-obvious' innovations. However, on average, each patent application takes 15-20 hours of evaluation and a major proportion of these patents, which are later re-evaluated, are claimed invalid (Farell and Shapiro, 2008). The workload of the patent office is one reason why patentability standards cannot be executed properly. On the other hand, one can also argue that a vicious cycle has taken place, in the sense that knowing the workload and low standards applied by patent offices, firms have increased their rate of doubtful applications which increases the workload of patent offices and hence reduces efficiency in granting valid patents (Guellec and Van Pottelsberghe de la Potterie, 2007).

There are, however, arguments suggesting that investing more in increasing the efficiency of patent examination procedures is wasteful. Lemley (2001) states that, instead of carefully examining each patent application, the patent office can lower the examination standards in the belief that private parties who are already more efficient in detecting low quality patents will eventually challenge them at court. Chiou (2008) claims that this hypothesis has a limitation because, as he states, private enforcement will go after strong patents and may ignore weak ones.[22] He also suggests that weak patents might be the reason for the mass proliferation in issued patents since they are more successful in escaping from challenges.

Dubious quality patents create uncertainty about the extent of the exclusivity rights. Shapiro (2003) lists the sources of uncertainty as: (1) such patents may be found invalid in whole or in part; (2) such patents may be found not to be infringed by a given product or process of

[22] By weak patents, Chiou (2008) refers to patents covering technologies which are already in public domain and by strong patents, he means patents issued by true inventors. A true innovator with a solid patent will never settle at the bargaining table and a settlement deal is harder to reach. On the other hand, an opportunistic patent holder's highest possible payoff from litigation is smaller than the lowest possible payoff from settlement, so there is a high incentive for these types to settle. As a result, weak type patent holders escape from court challenge. A case selection pattern as such will lead private enforcement to litigate against true inventors and settle with weak types; therefore, a true inventor may be harassed while trying to enforce its patent rights. As a result, private enforcement efforts are directed towards strong patents, which create more litigation risk for these patents.

another firm; (3) it may be easy to invent around such patents; (4) enforcing such patents entails higher litigation costs and delays; and (5) it may not be possible to receive a remedy covering all the losses from infringement. In the end, even though such patents can be claimed invalid in case of infringement, they still entail social costs as they increase infringement risks of firms and result in wasteful resources on litigation. Proliferation of patents causes the necessity for firms to undergo extensive patent search and due diligence processes to identify such patents. In addition, due to imperfect information regarding patent quality, reaching the most efficient outcome from licensing negotiation between parties can be obscured (Anton and Yao, 2003).[23] More detrimentally, the uncertainties about patents can mitigate innovation incentives of competitors.

A better functioning of patent prosecution is indeed the first best solution for the problems of complex product industries which will enhance the certainty of the system. On the other hand, resolving problems through the patent enforcement process is not likely to reduce lower quality patents. As described above, some problems are inherent in the nature of innovation so even under a specially tailored policy, there is still the chance of blocking patents and overlapping claims. In such cases, market mechanisms seem to be effectively resolving the disputes in the system. Therefore, the patent prosecution system should also take into account the market solutions to the problem. The economic model developed in the following chapter provides some insights about the design of this system.

2.5.2. Deterred Follow-on Innovation Incentives

The second problem with the modern patent landscape is the risk of deterred innovation incentives due to certain behaviors of market participants. Special concerns relate to patent hold-up due to the *injunction threats* and *royalty stacking*. In terms of patent hold-up, the concern is that royalties negotiated between patent holders and downstream manufacturing firms can be too high since licensing terms are determined in the shadow of litigation. The threat of an injunction can enable a patent holder to negotiate royalties far in excess of the patent holder's true economic contribution. This is the case when the infringer has already invested heavily in design, manufactured and marketed, or sold the product with the allegedly

[23] Anton and Yao (2003) study the relation between patent validity and disclosure signaling. Patents are designed to promote disclosure and information sharing, in exchange for providing exclusivity to its owner. But, they state that if the validity of the patent is not certain, which results in uncertainty in exclusivity rights, firms may have doubts about their level of disclosure, and as a result, in the amount of technology transfer. When the capability of the innovator is private information, disclosure may be used as a signaling device of one's capability and the competitor may be unwilling to take aggressive behavior during the market competition if it perceives the innovator as advantageous in terms of cost.

infringing feature. The claim is that such excessive royalties can act as a tax on new products incorporating the patented technology, thereby impeding rather than promoting innovation. Lemley and Shapiro (2007) suggest that these threats can greatly affect licensing negotiations, especially in cases where the injunction is based on a patent covering one small component of a complex, profitable, and popular product.

Another often raised issue is royalty stacking, which refers to situations in which a single product potentially infringes on many patents, and thus bears multiple royalty burdens. The term "royalty stacking" reflects the fact that, from the prospective of the firm making the product in question, all of the different claims for royalties must be added or "stacked" together to determine the total royalty burden if the firm aims to sell that product free of patent litigation. In determining the royalty rate to charge for its IP rights, patent holders may not fully take into account that an increase in its royalty is likely to result in a cumulative royalty rate, which may be too high for the licensee. More likely to be observed in standard-setting procedures, the adverse outcome occurs when the aggregate royalty fee for licensing all of the required pieces of the standard adds up to a very large amount. It may be so large that it is no longer economical for the downstream company to implement and commercialize the standard (Sanders, 2010).

That is why in recent years, there has been a growing concern regarding deterred innovation incentives in multi-component industries. An antitrust dimension emerges due to the fact that the behavior of patent applicants and holders within IP's own regulatory process has impact on market competition. Furthermore, some behavior can be found to be abusive if a patent holder aims to deceive the IP system with the intent and/or effect of hampering competition (Regibeau and Rockett, 2011). Therefore, there is a close interaction between competition and patent law.

Several policy changes have been proposed to tackle these problems; the most controversial one being limiting injunctive relief to certain classes of patent holders. Shapiro (2010), for instance, proposes that non-competing patent holders can be denied injunctive relief so that without the threat of a plant shut-down, patent-holders are in a weakened negotiation position, which decreases the chances of patent hold-up. Moreover, Lemley and Shapiro (2007) support this conclusion based on case studies in two standard-setting processes (3G cellular technology and WDMA) applied to the royalty stacking processes.

The major problem with the patent hold-up and royalty stacking arguments is that the adverse outcomes as a result of these practices are likely to hold under very restrictive assumptions.[24] In reality, it is very difficult to make distinctions between the values of components, especially if they have complementary features. If the infringed patents are essential, rather than minor components, it is likely that not only downstream manufacturers but also patent holders are subject to hold-up, given they undergo tremendous amounts of R&D expenditures before they contract (Denicolo et al., 2008). Another weak point of the view is that non-practicing firms are also eager to resolve disputes as their major source of income is licensing agreements. However, it is only possible to reach efficient solutions if firms can bargain under equal conditions, which usually depend on the power granted by patents in the form of injunctions. In the absence of such protection, firms' innovation incentives can be seriously hampered. In the presence of patent thickets, all parties have an incentive to sit down and negotiate licensing terms. Such bargaining leads to a multilateral agreement that maximizes the "size of the pie" being shared by all, namely, the agreement leads to the same total price as if there were a single owner of all rights (Regibeau and Rockett, 2011). However, this outcome is most likely to be reached if parties bargain under similar conditions. For that reason, fear of competition law can prevent the relevant parties from engaging in truly multilateral negotiations.

In order to apply such a policy change, first we should know the true effect of patent protection in the bargaining process of multi-component product industries. If this effect works in favor of settlements of disputes and also restores R&D incentives of firms, an interruption can only be justifiable if the benefits of a policy change exceed the cost of the status quo. However, it not easy to calculate the real magnitude of benefits and costs of policy changes due to the counterfactual situation of each effect. Perhaps the ideal methodology for such an analysis would be to find a natural experiment regarding policy changes. However, finding natural data suitable for experimental design is highly difficult. That is why studies regarding patenting strategies of firms usually construct their own databases by means of different sources. Nevertheless, in Chapter 4, we investigate the effect of market mechanisms

[24] Denicolo et al. (2008) argue that the adverse conclusions of the model rely on quite restrictive assumptions and discuss the effects of regularly limiting of injunctive relief on innovative incentives. They claim that most of the time the comparison between royalty rates that would have been agreed by the parties ex-ante and the one determined ex-post (after the manufacturer had already designed its product and started to commercialize it) is counterfactual. That is why they believe patent hold-up and related licensing problems are highly case specific and most often debatable.

on R&D incentives, which can be considered as a second-best measure suggesting the magnitude of costs in case of certain policy changes.

In addition, even when patent hold-up and royalty stacking are assumed to occur with certainty, and in each case entail social costs, the costs of the adverse outcomes should be multiplied with their frequency to measure the real magnitude of the problem. However, statistics show that only 4.6% of lawsuits are trialed, whereas the remaining ends earlier in the process, which is an indication that firms are inclined to settle without lawsuits (Kesan and Ball, 2006). Moreover, this is an aggregate data which does not differentiate between the sources of disputes. Therefore, if only potential hold-up disputes are considered, this ratio will even be lower. For that reason, a policy change can only be justified if the degree of benefits, when multiplied with their frequency, overpasses the cost of chilled long-term innovation incentives. This result is unlikely if settlements which have a higher frequency lead to proven dynamic incentives. In this respect, the remaining chapters aim to provide evidence on the effect of settlements of dynamic innovation incentives.

2.6. Final Remarks

This chapter reviews the evolution of the economic analysis of patents to understand the source of the current problems in the modern patent landscape. The review starts with the economics of intellectual property rights, underpinning the difficulty to design an optimal patent even under the simple assumption of isolated innovations. Then, the discussion focuses on the fact that the development of knowledge exhibits different characteristics; therefore, simple monopoly theory of patents may not be adequate to understand the current dynamics of the patent system. Lastly, special emphasis is given to the theories on modern patent landscape and emerging market responses.

Patent law is a general set of legal rules that govern a wide variety of technologies. In reality, however, given the complex nature of innovation, each stage of the patent system in setting and applying legal standards can differ. The aim of this chapter was to understand the dynamics of the system and the firm behavior as a response to technological change. The potential benefits of patent portfolio races illustrate that the term often used as strategic patenting is mostly a necessity of the current technological and market order. For that reason, it is highly difficult to identify which patenting activities should be prevented from a policy perspective as these strategies are also a part of firms' innovation decisions. In addition, this is in line with the findings derived from the current empirical literature, in particular about how fragmentation affects patenting strategies and, in turn, firm behavior.

Firm behavior is shaped taking into account certain institutional settings as given. For that reason, after displaying the potential challenges in the patent system of complex product industries, the second part of the chapter aimed to underline the fact that policy changes to overcome such challenges should be executed if firm responses are not adequate to overcome certain market failures. The following chapters explore whether there is theoretical and empirical evidence on firms not being able to do so, namely whether their long-term R&D incentives in complex product industries are actually retarded. These studies will provide two legal implications: first, the effect of patent protection in complex product industries and second, the extent of regulation of voluntary market mechanisms.

CHAPTER 3: BARGAINING AND APPROPRIATION IN THE SHADOW OF LITIGATION: A MODEL OF R&D, PATENT PORTFOLIOS AND CROSS-LICENSING

3.1. Introduction

The patent system is designed to stimulate innovation by granting inventors a legal exclusivity period wherein they can recoup their research expenditures without the fear of being copied by rivals. With the advancement in many technologies and the growing complexity of knowledge production, protection from imitation has become only one of the reasons why firms seek patent protection. In two surveys conducted by Yale (Levin et al., 1983*)* and Carnegie Mellon (Cohen et al., 2000) universities, R&D managers in the semiconductors industry reported that patents are one of the least efficient protection tools to harvest returns from R&D investments compared to lead time, secrecy or manufacturing and design capabilities, despite the vast increase in patenting propensities. As a result, the value of a patent is not only measured by the invention itself but also by the benefits it provides in terms of how it restricts the technological opportunities of the rivals and keeps these rivals away from the market of new products or services. In addition to the financial costs and benefits of a patent, recent patent valuation methods also combine various qualitative factors, such as legal status, technology, market conditions and the assessment of the strategic purpose of the patent and how it is intended to be used.[25]

The economic implication of these developments is that firms may devote different resources and use separate strategies for determining their investments in R&D and how to patent, as some patenting activity incorporates additional strategic considerations of appropriation. The separation between the two strategies also stems from differences in the nature of innovation. As noted earlier, complex products require the assembly of many different patents. Most of the times, firms do not possess all the relevant patents required for the manufacturing of these products. That is why many new products are likely to infringe upon multiple patents, creating an overlapping set of patent rights called the patent thicket problem. The overlapping is a result of the cumulative nature of innovation; as the patents are covering complementary goods, it therefore becomes more likely that the patent claims will be overlapping.[26]

[25] EPO IPScore Manual, available at: http://www.epo.org/searching/free/ipscore.html

[26] Moreover, when property rights are not exactly overlapping but there are many parties holding patent rights, as such in the biotechnology industry, then the anti-commons problem can emerge. Patentees in this sector have

In complex product industries, firms interact over patent portfolios rather than over individual patents. Typically, each firm holds an extensive patent portfolio that might infringe upon the patents of rivals, while its patents are also infringed by others. The threat of litigation is credible, but litigation rarely happens due to the possibility of a counter suit (Barton, 2002). Most of the times, the outcome is a cross-licensing deal where firms give each other the permission to use their patent portfolios. The patent portfolios of the parties involved in these transactions can either be broad, which can be based on the exchange of the complete or a portion of the portfolio, or it may be accompanied by a royalty payment by the party who has a weaker portfolio. Whatever cross-licensing is done, it is clearly negotiated under the threat of litigation (Bessen, 2003). The semiconductors and software industries are often given as examples where such trends are common.[27] In the agricultural biotechnology industry, which is a relatively emerging sector, there is evidence that firms are also using mergers in order to settle disputes (Barton, 2002).[28]

Actually, the case that a patent litigation goes to trial is quite rare. Kesan and Ball (2006), analyzing patent lawsuit termination data available from the administrative office of the federal judiciary, find that among approximately 5,200 lawsuits, only 4.6% of lawsuits reached trial, 8.5% of lawsuits terminated with a summary judgment, dismissal with prejudice, or confirmation of an arbitration decision, whereas the remaining majority of 86.9% of lawsuits ended earlier in the process, which is an indication that firms are inclined to settle without lawsuits. This is because litigation is costly to plaintiffs. According to the 2001 survey of American Intellectual Property Law Association, which asks patent litigators to estimate the fees associated with patent lawsuits under different scenarios, the total legal cost through trial are found to be $500,000 when the stakes are less than $1 million, $1.5 million when the stakes are between $1 million and $25 million, and $3 million when the stakes are over $25 million.[29]

However, legal costs are only a small portion of the actual costs incurred, especially considering the financial costs associated with being a public firm. Lerner (1995), using a

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acquired thousands of patents on DNA sequences that cover specific genes or in some cases fragments of genes, so the problem is mainly the density of the number of patents more than the scope (Barton, 2002). Rai (2001) warns that eventually biotechnology patents will also overlap creating patent thickets

[27] For semiconductor patents, see Hall and Ziedonis (2001), Galasso (2007). For software patents, see Bessen and Hunt (2006), Noel and Schankerman (2006).

[28] Barton (2002) points out that mergers are more of an option when firms are new entrants that have to aim to change their corporate structure. It is a mechanism that leads to more concentration in the market, which can be used to reduce the Cournot complements problem associated with anti-commons.

[29] Source: AIPLA 2001 Report of the Economic Survey

sample for biotechnology firms, finds that the loss of wealth due to market share declines for a firm upon a law suit filing is on average $67.9 million and $20 million as median. For a more general sample of firms that includes other sectors, Bessen and Meurer (2008a) calculate the same average as $52.4 million and the median as $4.5 million. This corresponds to the expected loss in the investor's profits. However, there are also other costs associated with disturbance of regular business practices.[30] As a proxy for such costs, they estimate the average cost of litigation to an alleged infringer in the form of the amount the firm has to invest in order to increase its value to the level prior the lawsuit as $28.7 million on average and $2.9 million as median. They interpret this amount as litigation tax on investment to innovation.[31] They also find out that the ratio of annual litigation costs constituted on average 14.0% of the annual aggregate R&D cost for the period during 1996-99. Moreover, these numbers are mostly based on lawsuits that actually do not go to trial. According to the Pricewaterhouse Coopers 2011 report, the annual median damage awards in patent infringement cases ranged from $1.8 million to $15.6 million between 1995-2010, which does not even include the business costs of the injunction to the infringer and legal costs.[32] For instance, in a recent case, Dish Network and EchoStar have agreed to pay TiVo $500 million for a settlement in a lawsuit on TiVo's "time warp" technology. The TiVo settlement came after a contempt ruling that would have required Dish and EchoStar to pay TiVo $90 million in damages, and shut down all of the DVRs with the disputed technology.[33]

These examples illustrate the extent to which litigation can be costly, even though the threat itself is rarely realized. Still, some industries are more prone to the risk of litigation than others. Hunt (2006) has shown that when competing firms' technologies overlap and acquiring patents is relatively cheap compared to doing research, incremental reductions in the cost of obtaining patents result in less R&D than would otherwise occur. In industries where these conditions are satisfied, the assembly of large patent portfolios could be more

[30] Bessen and Meurer (2008a) list these indirect costs as: First, litigation can cause the efforts of managers and researchers to be devoted to case related activities rather than focusing on the operations of the business. Second, litigating parties forgo an opportunity of cooperative technology development that can result in new products or better processes. Third, patent litigation affects the market value of public companies and might cause declines in their share values. Fourth, there might also be some reputational costs, where customers stop buying the allegedly infringing product if a lawsuit poses some risk that the product will be withdrawn from the market. Lastly, litigation is a time consuming process. Hence during this time if preliminary injunctions are granted while the litigation is pending, production can be shut down and sales can be prohibited.

[31] The time range is 1984-1999, and the amounts are deflated by 1992 dollars. This amount is found dividing the expected wealth loss by Tobin's Q (which is calculated as firm value divided by the inflation adjusted aggregate sum of accounting assets) and R&D (replacement value of capital including R&D). Assuming constant returns to scale, an additional investment of a dollar should increase the firm value of an amount equal to Tobin's Q.

[32] Calculated as 2010 dollars.

[33] See Hsu (2011),"Tivo Settlement: Dish Network, EchoStar to Pay TiVo $500 Million".

inclined to strategic patent behavior. Due to extensive litigation risks, firms can accelerate their rate of patenting relative to the R&D expenditure with the aim of securing a strong position in possible future legal disputes. Nevertheless, some market mechanisms, such as cross-licensing or patent pools, have emerged as a natural way of coping with the adverse effects of such a patent landscape. Assuming that these types of agreements can be negotiated without additional transaction costs, the adverse effects of excessive patenting can be lowered. As a result, cross-licensing can increase the incentives to invest in research even though the new technology developed infringes upon competitors' patents (Barton, 2002).

This chapter studies the patent accumulation and R&D investment decisions in a framework in which firms' cross-license under the threat of litigation. The model presented in this study extends the analysis of Hunt (2006), which models the patent accumulation process as firms' attempt to better protect their inventions and hence extract more rents. Contrary to most economic models where achieving an innovation automatically results in rent extraction, Hunt models patenting as a separate activity from conducting R&D. The contribution of this chapter is to incorporate legal uncertainty into the model and analyze how firms settle out of court.

Although Hunt underlines that technological overlap increases the likelihood of patent infringement, he does not explicitly study its consequences. In his model, the degree of technological overlap, the breadth of patents and the effectiveness of patent protection are summarized by one variable. Yet the impact of these different factors can be relatively dissimilar, so they should not be summarized in a single variable. To distinguish between these effects, a new parameter - the probability that the court finds infringement in case of litigation - is introduced to help to disentangle technological choices from policy choices. For instance, a higher probability might be resulting from different applications in the patentability standards that may have an indirect effect on the probability of infringement. In addition, procedural and substantive rule changes in patent prosecution (such as for instance those put in place after the formation of Court of Appeals for the Federal Circuit (CAFC) in the US) can also lead to higher infringement probabilities (For example, the CAFC broadened the interpretation of patent scopes, increased evidentiary standards making it more difficult to invalidate existing patents, demonstrated a favorable attitude in granting preliminary injunctions, and tended to give large damage awards to infringing parties (Ziedonis, 2000).

The model shows that when the technologies in which firms invest overlap, leading mutual patent litigation threats, firms invest more in R&D with the option of cross-licensing than in the absence of cross-licensing. If there is no option to cross-license, firms can refrain themselves from investing in R&D as some of the profits generated will be transferred to the competitor due to overlapping technology. Coordinated efforts of firms lessen this negative externality which firms pose on each other and restore the incentives to invest in R&D. The amount they invest in R&D grows as the degree of technology overlap is higher and as the likelihood of patent litigation increases. This is because being the loser of a patent litigation case can lead to a situation that is worse than the case when no cross-licensing occurs. In addition, the model supports the view that firms' patenting decisions revolve around a prisoners' dilemma when the technology is fragmented. Firms obtain more patents as the risk of infringement increases and this effect is higher when the degree of technology overlap is high. As shown in Hunt (2006), this can lead patenting to crowd out R&D in cases where the cost of obtaining patents is low. Our model shows that, if firms are allowed to cross-license, implementing a patent policy that is more favorable to infringement can solve this negative externality and may direct firms to invest in R&D rather than in patents. For a social planner that is only concerned with the level of innovation, higher litigation threats are also more efficient.

These insights trigger the issue of what should be the optimal patent policy in complex product industries with fragmented property rights. The interpretation of patent rights that determine patent scope can be an appropriate mechanism to tailor patent policy in order to meet the needs in such industries. In practice, patent office's make patent scope decisions when they determine the patent's claims, and the courts make decisions about the patent's scope when issues of patent infringement are decided. While what is and is not patentable is determined on the basis of legal principles and the nature of the invention, in many cases the patent office can use discretion to decide which claims are allowable. In addition, once a patent is granted and allegedly infringed, there is still room for discretion for courts on how to apply legal principles and interpret the evidence.[34]

[34] Once the patent is granted and allegedly infringed, the patent holder has to prove that the infringers' product falls within the boundaries of its invention which has been specified with the claims, and any difference between the infringers' product and the invention constitutes as infringement. The alleged infringer, on the other hand, will argue that the patent does not meet the patentability standards, thus claim that the patent is invalid. If the court decides that the patent is valid then the later step for the infringer is to prove that its product does not infringe the patent. See Merges and Nelson (1990) for other appropriate tools in the patent system where Agencies analyze and exercise discretion over patent scope.

Given these options for the use of discretion in patent policy, the results of the model imply that courts can apply stricter patent enforcement rules so that patent infringement is more likely. Alternatively, patent offices can require a higher non-obviousness or inventive step standard (which dictates that an invention should involve an inventive step upon prior art that must not be obvious to a person skilled in the art). A high non-obviousness standard will result in few broad patents to be given in the technology area. Broader patents translate into stronger patent rights and hence higher infringement probabilities. More elaboration on these policy issues follows in the later sections.

3.2. Related Literature

Cross-licensing agreements and patent pools have been analyzed with respect to the effects of the terms of these agreements on competition (Gilbert, 2002; Lerner and Tirole, 2004; Choi, 2010). Despite these contributions, the dynamic aspect of cross-licensing has drawn less consideration compared to the static aspects. There are few theoretical papers that study the impact of blocking patents and cross-licensing agreements on innovation. Fershtman and Kamien (1992) developed a model in which two firms engage in a patent race for two complementary patents. They show that although it takes more time to achieve both innovations if cross-licensing is not allowed, such agreements are not as efficient as a centralized coordination due to the strategic behaviors by firms.[35] They also show that cross-licensing improves the efficiency of the R&D investments by eliminating the duplication of efforts, but it also favors price collusion between the firms. Therefore, if firms expect ex-post cross-licensing of complement patents, they can invest less in innovation when compared to a single firm developing both technologies itself. In practice, however, this is not the proper benchmark if there are indeed complementarities between patents, but more generally, there is "technology overlapping". When the market product is complex, firms aim at acquiring multiple patents to be able to appropriate as much as possible from the final product. This means a firm is not totally cut out of the market even if it does not possess all the relevant patents that should be attained. This is also an interpretation closer to the empirical literature on patent portfolios.[36] In this technology structure, the right comparison, then, should be between the case in which firms know that cross-licensing will take place if technologies are

[35] For instance, the firms try to retard the development of the technology in which they have a cost advantage, and seek to patent the other technology in order to deter their competitor.
[36] See Hall and Ziedonis (2001), Galasso (2007), Noel and Schankerman (2006), Von Graevenitz et al. (2011a), Siebert and Von Graeveitz (2008).

complementary and the case where firms can only rely on their own technology. The decision of how much to invest in R&D and how many patents to obtain will be influenced by the degree of overlapping between competitors, which is one of the key focuses of the analysis presented in this chapter.

In addition, Meniere and Parlene (2004) consider the complementarities between the patents of upstream patent holders, who also compete at the downstream market. However, contrary to Fershtman and Kamien (1992), the complementarities in their model are probabilistic. Their R&D race setting includes not only a stage of R&D investment for patents, but also a stage of product development upon patenting. Before competing in the product market, a firm has the option to use its basic patent to sue its competitor for infringement. If the basic patents are broader, the investments in the second stage are lower. In their model, firms cross-license for two reasons. The first is to clear strongly blocking patents, which are characterized by high patent strength especially when the product development stage is costly. Second, when patents are likely to be held unessential and the cost of R&D is low, which is the case when cross-licensing can be a source of collusion. In its absence, firms have higher R&D investments and they compete away their profits.

The cost and benefits of overlapping patent portfolios depending on the infringement penalties are studied in Meniere and Parlane (2008). They analyze the effect of threat of litigation on R&D levels and show that the threat of litigation mitigates the overinvestment incentives that occur in a standard R&D race and aligns it towards a more socially optimal investment level. Their contribution is to introduce infringement fees into the analysis. When these penalties are small and patent portfolios are quite symmetric, the hold-up that occurs due to overlapping technologies can lead to efficient R&D levels. On the other hand, as the infringement fees increase, the problem of free-riding arises and each firm prefers the other to invest and develop, and later sue it. However, in their analysis the patent portfolios of firms are given and the option to bargain is not taken into consideration.

Some empirical studies analyze the reasons for patent accumulation. For instance, Hall and Ziedonis (2001) point out that the accelerated patenting rates especially in complex technologies can be a response by firms to reduce the risk of technology hold-up so that by excessive patenting firms make sure that they have enough bargaining strength in negotiations in case of disputes. In addition, Lanjouw and Schankerman (2004a) found that an infringement suit is less likely to be filed for a patent owner that holds a larger patent portfolio. A larger patent portfolio can either be used to attack competitors as it increases the probability of infringement of rivals, or defend one's own patent portfolio by decreasing the chances of infringing on others patents.

The idea has also been formally studied by Bessen (2003). In his model he assumes that companies that have a stronger patent portfolio also have a better bargaining position in case of patent disputes as patents reduce the risk of costly litigation. In this line of reasoning, the more patents a firm obtains, the more it is able to increase the strength of its patent portfolio, which in turns increases the probability of infringement and also the probability to win at court. Patenting occurs after some R&D costs are sunk; however, the patent race to discover a single innovation occurs only after these stages.[37] Although the model makes realistic assumptions with regard to the timing of R&D and the patenting decisions, in the sense that firms make different R&D investments depending on whether they intend to assert their patents or not, it does not specify the nature of the rival technologies, so it is not clear what the litigation is based upon. As an outcome of litigation, a party can completely block its competitor. Due to the technology overlapping assumption in our analysis, this result does not arise and we focus on the comparison between different alternatives, namely when firms cross-license and when they do not.

Departing from the previous studies, Hunt (2006) takes into account the nature of technology by incorporating technology overlapping. This is also similar to assume as there are research spillovers in the industry, which means a firm can benefit from others' R&D efforts while the same is true for competitors. This externality affects firms' R&D decisions. Moreover, in his model, patents are used to increase the rents earned on rivals' inventions whereas to prevent similar behavior. Firms are assumed to follow different strategies in their decision to invest in R&D and obtain patents; therefore, if certain conditions are met, he finds that firms can allocate some of their resources to more patenting, which could have been allocated to R&D instead. Given these assumptions, capturing the characteristics of complex product industries to a significant extend, our model explores the impact of cross-licensing in such a setting. Furthermore, the introduction of litigation threats leads to alternative strategies in R&D and patenting.

[37] He assumes firms first obtain patents to protect a portion of the technology before they develop all the necessary knowledge for the whole product.

The rest of the chapter is organized as follows. The next section presents the baseline setting and introduces the model in which firms have the option to cross-license their patent portfolios. Section 3.4 presents the equilibrium results in case of cross-licensing. Section 3.5 compares the results between cross-licensing and the baseline model where firms do not have the option to cross-license. Section 3.6 investigates an alternative scenario in which firms merge instead of cross-license. Section 3.7 analyzes the welfare implications. Section 3.8 discusses the policy implication of the model. Finally, section 3.9 concludes the chapter.

3.3. The Model

3.3.1. Baseline Model

The setting of the model is based on Hunt (2006). There are two firms engaged in technological competition. Firms share similar technologies, and they invent and obtain property rights over their inventions. They simultaneously invest x_i in R&D, where $i = 1,2$ stands for the firm, and generate a measure of final goods invented, or improvements in the form of higher product quality, given by $f(x_i) = x_i^{\alpha}$ with $0 < \alpha < 1$. Consumers have unit a demand for the final output (inventions). The term α in the R&D production function can be interpreted as the success rate of innovation. Not every dollar spent on R&D turns out to be a successful innovation; the firm generates only a fraction of innovative output from the total amount spent on R&D.[38]

In order to appropriate rents from their R&D investments, firms seek a number of patents of n_i. Let $\theta(n_i)$ denote the share of rents earned from one's own investments as a function of n_i. Following Hunt (2006), this is assumed to have an exponential specification, that is $\theta(n_i) = 1 - e_i^{-n}$. As a result, the potential profits generated by the R&D investments for a firm is $\theta(n_i)f(x_i)$. The remainder $[1-\theta(n_i)]f(x_i)$ is unprotected and can be obtained by a group of competitive imitators which do not do any R&D.

The innovation structure of the industry is complementary, which means that even though both firms have their own patent portfolios, the technologies they use can overlap. The degree of technological overlap between the two patent portfolios is an exogenous variable denoted

[38] Previous literature has used Poisson stochastic process to picture the uncertainty in innovation. However, the ultimate payoffs that can be attained in these models are discrete monopoly, duopoly or competitive market that are normalized to one, a half or zero respectively (e.g. Bessen, 2003). On the other hand, Hunt (2006) assumes that a firm has to obtain a certain quantity of patents in order to appropriate a share from its investments.

by β which is between 0 and 1. In addition to the profits earned from its own investments $\theta(n_i)f(x_i)$, firm *i* also earns a portion of firm *j*'s investments proportional to the degree of overlap. This includes a share both from the rents of firm *j*'s patented inventions $\theta(n_i)f(x_j)$ and from those that are supplied by the competitive imitators $\lfloor 1-\theta(n_j)\rfloor f(x_j)$, which is equivalent to $\beta\theta(n_i)f(x_j))$. However, the same is true for other firm; therefore, each firm loses rents from its own patented inventions according to the degree of overlap and the strength of the patent portfolio of its competitor.

It is assumed that there is a constant marginal cost of R&D, denoted by *R*, and a constant marginal cost of patenting, denoted by *C*. The inputs are purchased from the competitive market and they are included in the social cost of R&D and patenting. The firms move simultaneously deciding on how much R&D to perform and the number of patents to seek. Under these assumptions, the payoff structure of the firms is $(i, j = 1,2)$:

$$(1) \qquad V_i = f(x_i)\theta(n_i) + f(x_j)\theta(n_i)\beta - f(x_i)\theta(n_i)\theta(n_j)\beta - Rx_i - Cn_i$$

Patents are essential in protecting the firms' returns from R&D investment; otherwise, such returns will be wiped out by imitators. Equation (1) says that each firm is able to extract rent from the other's innovation in an amount proportional to its patent portfolio and the degree of technological overlap. However, it also loses rents from its competitor in a symmetric way.

3.3.2. Litigation and Cross-licensing

The degree of technological overlap has an effect on the risk of infringement. Therefore, if $\beta > 0$, it is reasonable to assume that a firm might decide to go to court claiming the rival firm has infringed its patents. Having developed its own patent portfolio, the remaining firm, in such a case, will typically respond by opening a counter suit with a similar claim. In the last couple of years, especially in complex product industries, litigation over a set of infringing patents (rather than individual patents) is observed more commonly.[39] This section introduces into the model two new ingredients which do not appear in Hunt (2006), i.e. the threat of litigation and the option of cross licensing. The aim is to study how these factors change the incentives to invest and to patent.

[39] For instance, a recent case in terms of such a patent war is between Apple and Nokia. The conflict began in October 2009 when Nokia sued Apple, alleging that the company had infringed on 10 of its patents with the iPhone. Apple countersued in December 2009, claiming that Nokia was in violation of 13 of its patents. See Pachal (2010), "Patent Wars Begin as Apple, Nokia Square Off".

If there is litigation, the chance that the court decides there is an infringement is an exogenous probability denoted by p. The previous literature has assumed that the probability to win an infringement case is positively related with the patent portfolio strength.[40] In other words, the number of patents of a firm is a determinant of the probability of infringement by competitors. If this is so, when firms apply for an additional patent, they consider two factors at the margin. The first is the contribution of the additional patent to the total probability of infringement. The second factor, which has been given less emphasis so far in the literature, is the ability to appropriate rents in bargaining. Since the aim of this analysis is to emphasize the firms' ability to appropriate rents in bargaining due to their patents, we nullify the first factor.

In the setting of the current model, the parameter p is a policy variable that aims to capture the courts' influence on how strong the patent portfolio of a firm should be, reflecting the patent regime implemented. If p is high, this can be due to the guidelines followed in granting procedures by patents offices or patentability requirements that affect breadth of patents.[41] In addition, it can also be due to post-grant procedures that results in more favorable patent enforcement, referring to patent strength.[42]

For each firm, there are four possible outcomes of litigation:

(a) the firm has not infringed the other firms' patents, but the other has;
(b) the firm has infringed the other firms' patents, but the other has not;
(c) both firms have infringed;
(d) neither firm has infringed .

[40] Meniere and Parlane (2008) assume an exogenous patent portfolio strength that determines the probability to win an infringement suit. On the other hand, in Bessen (2003), the probability of winning an infringement suit at court is assumed to be an increasing concave function of the firm's patent portfolio size.
[41] Generally speaking, these requirements are novelty, non-obviousness, utility, disclosure and patentable subject matter.
[42] Ginarte and Park (1997) formulate a patent right index for different countries, and find out that patent rights are stronger in countries which have more R&D activity. The index is composed of several policy elements of the patent systems that are related to coverage, duration and requirements for loss of protection and enforcement of patents. For instance, if a country imposes compulsory licensing or revocation of non-working patents, it is presumed that this will have a negative impact on the patent strength, whereas provisions such as preliminary injunctions, contributory infringement pleading and burden of proof reversals have a positive impact on the patent strength of the country.

The following figure (3.1) illustrates the patent race between the firms:

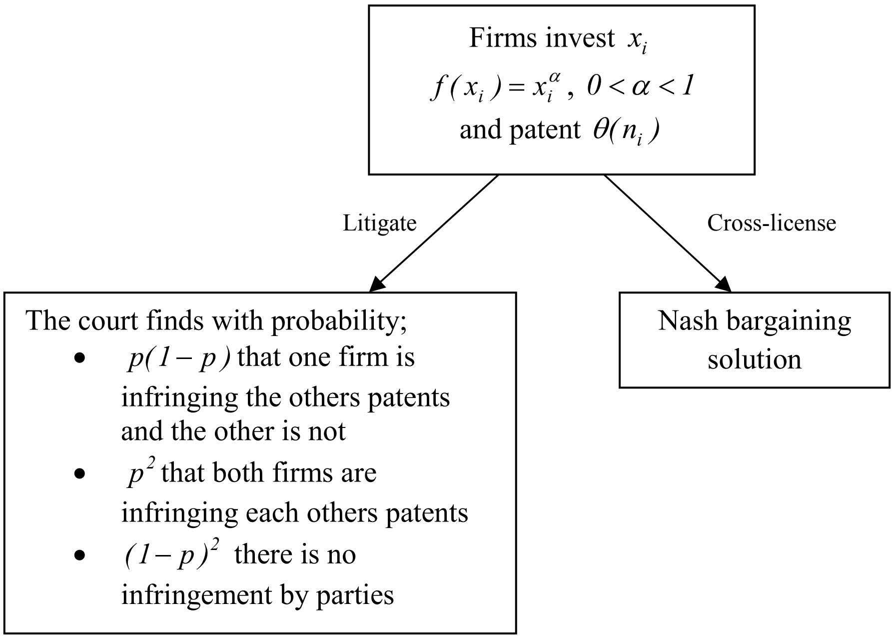


Figure 3.1. Structure of the model

Ignoring R&D and patenting costs, the payoffs for a firm in each of these cases are:

Firm 1 does not infringe (NI) but firm 2 does infringe (I):

$$(2) \qquad V_1^{NI} = f(x_1)\theta(n_1) + f(x_2)\theta(n_1)\beta$$

$$V_2^{I} = f(x_2)\theta(n_2) - f(x_2)\theta(n_2)\theta(n_1)\beta + f(x_1)\theta(n_2)(1-\theta(n_1))\beta$$

Firm 1 infringes but firm 2 does not:

$$(3) \qquad V_1^{I} = f(x_1)\theta(n_1) - f(x_1)\theta(n_1)\theta(n_2)\beta + f(x_2)\theta(n_1)(1-\theta(n_2))\beta$$

$$V_2^{NI} = f(x_2)\theta(n_2) + f(x_1)\theta(n_2)\beta$$

These equations say that the firm that has been found not to infringe the other firms' patents continues to extract rents from the rival's innovations (both patented and non-patented) and prevents the same to be done to its patented inventions. By contrast, the infringing firm is prevented to extract rents from the rival's patented inventions but cannot stop the rival to extract its own patented rents. Nevertheless, it can extract a share from the rivals' unpatented inventions due to β .

When the courts find that each firm has infringed the patents of the other, it is assumed that firms can no longer benefit from the overlapping patented technologies. Thus each firm can only collect rents from its own patented innovations and a share from the rival technology provided by the competitive imitators.[43] In this case the payoffs are:

(4)
$$V_1^I = f(x_1)\theta(n_1) + f(x_2)\theta(n_1)(1-\theta(n_2))\beta$$
$$V_2^I = f(x_2)\theta(n_2) + f(x_1)\theta(n_2)(1-\theta(n_1))\beta$$

On the other hand, when the court decides that there is no infringement, it is assumed that we are back to the baseline model and the firms continue to mutually extract rent from each other. In this case, the payoff structure is:

(5)
$$V_1^{NI} = f(x_1)\theta(n_1) - f(x_1)\theta(n_1)\theta(n_2)\beta + f(x_2)\theta(n_1)\beta$$
$$V_2^{NI} = f(x_2)\theta(n_2) - f(x_2)\theta(n_2)\theta(n_1)\beta + f(x_1)\theta(n_2)\beta$$

The firms can also choose to settle out of court. Similar to Bessen (2003), it is assumed that the expected outcome from litigation serves as the threat point to the bargaining problem and that both firms have equal bargaining power in the negotiations. Given that the probability that court finds infringement p is the same for both firms, the threat points (T_i) that represent the expected profit for a firm if it does not bargain and pursue litigation instead are:

(6)

$$\begin{aligned} T_1 = {} & (1-p)p\left[f(x_1)\theta(n_1) + f(x_2)\theta(n_1)\right] \\ & - p(1-p)\left[f(x_1)\theta(n_1) - f(x_1)\theta(n_1)\theta(n_2)\beta + f(x_2)\theta(n_1)(1-\theta(n_2))\beta\right] \\ & + p^2\left[f(x_1)\theta(n_1) + f(x_2)\theta(n_1)(1-\theta(n_2))\beta\right] \\ & + (1-p)^2\left[f(x_1)\theta(n_1) - f(x_1)\theta(n_1)\theta(n_2)\beta + f(x_2)\theta(n_1)\beta\right] \end{aligned}$$

$$\begin{aligned} T_2 = {} & (1-p)p\left[f(x_2)\theta(n_2) + f(x_1)\theta(n_2)\right] \\ & - p(1-p)\left[f(x_2)\theta(n_2) - f(x_2)\theta(n_2)\theta(n_1)\beta + f(x_1)\theta(n_2)(1-\theta(n_1))\beta\right] \\ & + p^2\left[f(x_2)\theta(n_2) + f(x_1)\theta(n_2)(1-\theta(n_1))\beta\right] \\ & + (1-p)^2\left[f(x_2)\theta(n_2) - f(x_2)\theta(n_2)\theta(n_1)\beta + f(x_1)\theta(n_2)\beta\right] \end{aligned}$$

[43] For instance, if Nokia wins, Apple could lose the right to sell the iPhone in the US, whereas if Apple wins, Nokia's devices could be shut out of the US market altogether. Therefore, if both Apple and Nokia win a verdict on their infringement claims, both companies can be hindered in terms of their operations in the US market.

On the other hand, if firms cross-license, they can effectively collude so their joint profits will be:

$$(7) \qquad V_{max} = f(x_1)\theta(n_1) + \beta\theta(n_1)[1-\theta(n_2)]f(x_2) + f(x_2)\theta(n_2) + \beta\theta(n_2)[1-\theta(n_1)]f(x_1)$$

This is larger than the joint expected profit from litigation, so if a firm asserts its patents, firms will always negotiate a cross-license rather than litigate (Bessen, 2003). Equation (7) also means that, if firms' cross-license, they can no longer extract rents from their rivals' patented technologies due to the technology overlapping, but continue to do so from the rents of the unpatented technology of the rival which is supplied by the imitators.

3.4. Equilibrium

3.4.1. Bargaining

The model is solved proceeding backwards. Therefore, I first look for the solution of the Nash bargaining problem. Using the standard bargaining solution with equal bargaining weights, the following objective function is derived:[44]

$$(8) \qquad V_1 = f(x_1)\theta(n_1) + f(x_1)\theta(n_1)\theta(n_2)\beta + f(x_2)\theta(n_1)\beta + p\beta\theta(n_1)\theta(n_2)[f(x_1) - f(x_2)] - Rx_1 - Cn_1$$

Then using equation (8), we proceed to the first stage of the game to derive the equilibrium R&D and patenting levels.

3.4.2. R&D Investments and Patenting

In the first stage of the game, firms choose x and n so as to maximize their profits (V_1).The first order conditions with respect to (w.r.t.) x_1 and n_1 are:

$$(9) \qquad \frac{\partial V_1}{\partial x_1} = V_x^1 = f'(x_1)\theta(n_1) + f'(x_1)\theta(n_1)\theta(n_2)\beta + p\beta\theta(n_1)\theta(n_2)f'(x_1) - R = 0$$

$$(10) \qquad \frac{\partial V_1}{\partial n_1} = V_n^1 = f(x_1) + f(x_1)\left(\frac{d}{dn}\theta(n_1)\right)\theta(n_2)\beta + f(x_2)\left(\frac{d}{dn}\theta(n_1)\right)\beta + p\beta\left(\frac{d}{dn}\theta(n_1)\right)\theta(n_2)[f(x_1) - f(x_2)] - C = 0$$

[44] Standard bargaining solution is found as $V_i = T_i + 1/2(V_{max} - T_i - T_j)$.

Rewriting and rearranging terms, equations (9) and (10) respectively can be expressed as:

$$(11) \qquad f'_1\,\theta_1(1-\beta\theta_2+p\beta\theta_2)-R=0$$

$$(12) \qquad (1-\theta_1)\left[f_1-\beta f_1\theta_2+\beta f_2+p\beta\theta_2(f_1-f_2)\right]-C=0$$

Assuming symmetry ($x_1 = x_2$ and $n_1 = n_2$) the equilibrium levels x_C^* and θ_C^* for the case of cross-licensing are found as:

$$(13) \qquad V_x = f'\theta(1-\beta\theta+p\beta\theta-R=0$$

Inserting $f(x)=x^{\alpha}$ in (13) yields;

$$(14) \qquad x_C^* = \left(\frac{\alpha\theta_C(1-\beta\theta_C+p\beta\theta_C)}{R}\right)^{\frac{1}{1-\alpha}}$$

In addition, it is possible to derive an expression for the equilibrium patenting level as in (16):

$$(15) \qquad V_n=(1-\theta)f\left[1+\beta(1-\theta)\right]-C=0$$

$$(16) \qquad \theta_C^* = \frac{1}{2}\frac{2\beta+1-\sqrt{1+\dfrac{4\beta C}{f(x_C)}}}{\beta}$$

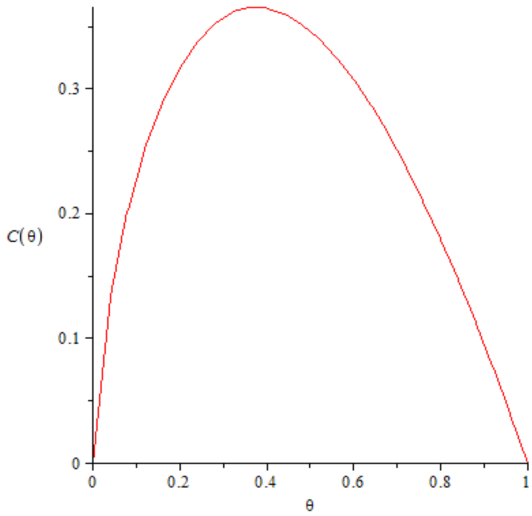
The proof that the second order conditions of the maximization problem are satisfied is relegated to Appendix 3.1. A sufficient but not necessary condition for second order condition to hold is $\theta_i > \alpha$.[45]

Due to functional form of θ_C^*, it is not possible to get an explicit solution for the level of patenting. However, inserting equation (14) into (15), a condition for the equilibrium level x^* and n^* can be derived. Hunt (2006) calls this equation as the critical cost of obtaining patent (in terms of R, β, p, α and θ). This is the threshold below which there is some patenting. For the symmetric case this cost level, in case cross-licensing takes place is:

$$(17) \qquad \tilde{C} = \left(\frac{\alpha\theta(1-\beta\theta+p\beta\theta)}{R}\right)^{\frac{\alpha}{1-\alpha}}(1-\theta)(1+\beta(1-\theta))$$

[45] If the second order condition is not satisfied, the given critical point of V_i corresponds to a saddle point. This means it is not certain that there is an unique local maximum in symmetric strategies.

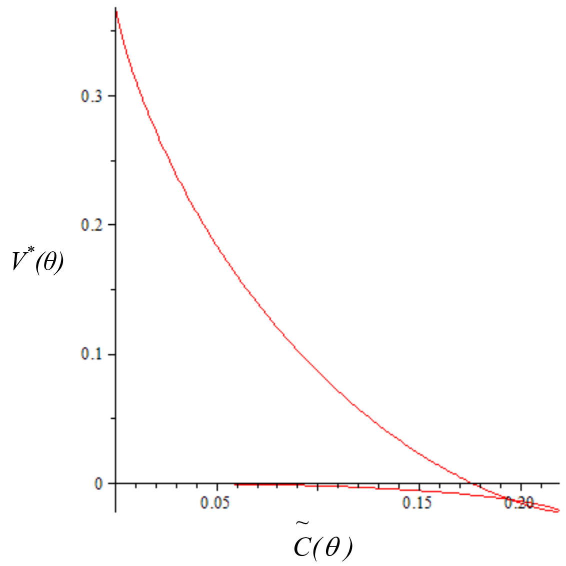
This equation can also be used to determine the equilibrium values of θ. For a general analysis of the problem θ is treated as an exogenous variable and we check how $\tilde{C}$ behaves. A typical behavior of $\tilde{C}$ as a function of θ is shown below for some parameter values. Note that when $p = 0$, we are back to the benchmark case analyzed by Hunt (2006).



Graph 3.1. Parametric plot for *C(θ)* and *θ* for the values *(R, α, β, p) = (0.8, 0.4, 0.2, 0)*

Graph 3.1 shows that the maximum value allowed for $\tilde{C}$ (call it C_{max}) is 0.365 (corresponding *θ=0.364*). This value changes with the set of parameters employed. For a given $\tilde{C} < C_{max}$, there are two solutions for θ. The smaller of these values corresponds to a saddle point $(\Delta < 0)$ and the larger one corresponds to a maximum $(\Delta > 0)$.

The functional form of θ causes other possible non-convexities for the maximization problem. That is why it is also necessary to check whether the participation constraint of the maximization problem is satisfied; in other words, whether the maximized profit is positive. Graph 3.2 displays the parametric plot between the objective function $V(x^*, n(x^*))$ and $\tilde{C}(\theta)$ using the same parameter set above.



Graph 3.2. Parametric plot between $V^*(\theta)$ and $\tilde{C}(\theta)$

V^* is positive only for $\tilde{C} < 0.171$. Say, $\tilde{C}$ at which $V^*(\theta) = 0$, is called $\bar{C}_{max}$; at this point there are two θ values. When $\theta_s = 0.135$ (*s* stands for small), $V^*(\theta)$ is negative and when $\theta_l = 0.713$ (*l* stands for large), $V^*(\theta)$ is zero. For all values $\tilde{C} < \bar{C}_{max}$, V^* is negative at θ_s values, which corresponds to the lower curve, and positive for θ_l values, which corresponds to the upper curve.[46] Since the θ_s values correspond to a saddle point, this situation is ruled out and the focus is placed on θ_l values that are situated at the right-hand side of the curve in Graph 3.1. As a result, only if the cost of obtaining patents is sufficiently low, there exists a unique symmetric equilibrium in pure strategies.

3.5. Comparative Statics

3.5.1. Comparative Statics of Equilibrium with Cross-Licensing

The comparative statics analysis of the symmetric equilibrium is in Appendix 3.2. From this analysis the following result emerges:

[46] At the lower curve, θ values are between *(0, 0.356)*, and at the upper curve between *(0.356, 1)*.

Proposition 1: The equilibrium number of patents n_C^* is decreasing in cost of obtaining patents, the cost of R&D and the degree to which technologies overlap, whereas it is increasing in the risk of litigation. The equilibrium level of R&D x_C^* is decreasing in the cost of doing R&D and the degree to which technologies overlap, whereas it is increasing in the risk of litigation. In addition, x_C^* is decreasing in cost of obtaining patents only when $(1-p) < 1/(2\beta\theta)$ and $\beta\theta > 1/2$.

In Appendix 3.2, it is shown that as the technological overlap parameter β increases, patenting decreases. Patenting also increases as p increases. In Graph 3.1.a in Appendix 3.2, it is observed that the second effect offsets the first effect and overall, the introduction of p increases patenting. Normally, firms prefer to obtain fewer patents in order to decrease the rent extraction that occurs with high technology overlapping. However, it appears that the risk of litigation mitigates this effect. The result is in line with the defensive theory of patent portfolios which suggests that firms hold large patent portfolios as a cushion for the risk of litigation.

In addition, as technology overlap increases, incentives to invest in R&D decrease (see Graph 3.2.a in Appendix 3.2). On the other hand, litigation threats increases the innovation incentives. We observe that under the possibility of cross-licensing, if p is not high enough patenting might still crowd-out R&D. Normally, we would expect that as the cost of patenting decreases, R&D investments increase. In the appendix, it is proven that $\partial x / \partial C > 0$, when $p > 1 - 1/(2\beta\theta)$. The condition can be rewritten as $\theta > 1/(2\beta(1-p))$. Since it is known that $\theta < 1$, the condition requires $2\beta(1-p) > 1$. As $1-p < 0$, it is possible to conclude that when $\beta > 1/2$, we have the situation that $\partial x / \partial C > 0$. As patents are necessary to appropriate returns from innovation, we would expect that reductions in the cost of obtaining patents should encourage more R&D. When $\beta > 1/2$, which means a firm can extract a substantial share from its rivals' inventions; however, we observe that the decrease in cost of patenting can actually reduce R&D (Hunt, 2006). On the other hand, note that even at high β values where the effect is at work more severely, the introduction of the variable p can solve the problem entirely. Therefore, by adjusting p according to $p > 1 - 1/(2\beta\theta)$ and $\beta\theta > 1/2$, it is possible to overcome this problem.

This finding is intuitive for the discussion about the strategic proliferation of patent portfolios and their adverse effect. It is observed that if probability of infringement is strong enough, the adverse effects of fragmented property rights in the form of necessity to engage in excessive patenting can be mitigated. Cross-licensing reduces the associated transaction costs and firms R&D incentives are restored. However, if litigation threats are weak, patenting would be preferable compared to doing R&D and firms will prefer to invest more on strategic rent extraction from each other.

3.5.2. Comparison of Equilibria with and without Cross-licensing

Here, a comparison between the equilibrium results when cross-licensing is allowed and when it is not, as in the case of the baseline model, is given. The solution of the baseline model can be found in Appendix 3.3. Since $\partial n / \partial p > 0$ we can conclude that:

Proposition 2: For $p > 0$, the equilibrium level patenting in cross-licensing is higher than in the benchmark case.

The equilibrium R&D investment levels for the cases in question are summarized in the following table:

Baseline Model (2006) (x_B^*)	**Cross-licensing** (x_C^*)
$\left(\dfrac{\alpha\theta_B(1-\beta\theta_B)}{R}\right)^{\frac{1}{1-\alpha}}$	$\left(\dfrac{\alpha\theta_C(1-\beta\theta_C+p\beta\theta_C)}{R}\right)^{\frac{1}{1-\alpha}}$

Table 3.1. **Equilibrium R&D levels**

Comparing the results one can observe that,

Proposition 3: When technologies are overlapping and patents are essential for firms to appropriate returns, cross-licensing increases R&D investments, $(x_C^* > x_B^*)$. The equilibrium level of R&D investment with cross-licensing is higher than in the benchmark case with no option to bargain.

Proof: Follows from the comparison (14) and (11.a) in the appendix. Recall that when $p = 0$, we are at the baseline model. From proposition 2 we know that, assuming everything else equal, $\theta_C > \theta_B$. Since $\partial x / \partial p > 0$, it is possible to conclude that the cross-licensing equilibrium R&D level is higher than the benchmark case.

Given the results of the comparative statics in the previous section it is possible to conclude that the higher level of patenting when p is greater than zero is due to higher R&D levels. The intuition for higher R&D levels is that firms boost their R&D investment anticipating that there will be cross-licensing, even though the technology developed infringes the rival's patents. In the absence of cross-licensing, firms have profit loss due to overlapping technologies, which refrains them from investing in R&D. When cross-licensing takes place, firms internalize this negative externality that they impose on each other and their coordinated efforts lead to more investment. In addition, in the previous section it was seen that substitution of R&D by more patenting can disappear as p increases. This means that if the risk of infringement is strong enough, at the margin it is no longer profitable to acquire additional patents at the expense of reducing R&D. However, when the risk of infringement is low, the situation is closer to the benchmark case, so the firms have a stronger tendency to rely on appropriating returns from each other's technology due to overlapping rather than investing themselves.

3.6. An Alternative Case: Merger

There is a third option for the firms, which is to merge rather than engage in cross-licensing. The benefit of merger is that the newly formed single firm will profit from the technology overlapping of the two R&D labs without any rent extraction due to the fragmented property rights. With cross-licensing, the joint profits created did not incorporate rents from the patented rival technology (it only included rents extracted from the imitators), whereas in case of merging, we assume that firms benefit both from the patented and unpatented technology of the rival. The decision to merge is also given under the threat of litigation; therefore, the threat points in equation (6) still hold. In this scenario, however, the joint profit that can be attained is:

$$(18) \qquad f(x_1)\theta(n_1) + \beta\theta(n_1)f(x_2) + f(x_2)\theta(n_2) + \beta\theta(n_2)f(x_1)$$

The solution of the equilibrium levels can be found in Appendix 3.5. The equilibrium level of R&D and patenting derived are:

$$(19) \qquad x_M^* = \left(\frac{\alpha\theta_M(1 - \frac{1}{2}\beta\theta_M + p\beta\theta_M)}{R} \right)^{\frac{1}{1-\alpha}}$$

$$(20) \qquad \theta_M^*(n) = 1 - \frac{C}{f(x_M)(1+\beta)}$$

Due to the complexity of equations, we resort to a numerical exercise for the comparative statics analysis of the case of merger and its comparison with the cases of no cross-licensing and cross-licensing. This analysis can be found in Table 3.1.a in the appendix. The comparative statics results are the same as in the case of cross-licensing apart from the one regarding the degree of overlapping of the technologies. If p is sufficiently small, we observe that the R&D incentives are decreasing as the degree of overlapping increases; otherwise it is increasing. From the comparison of the equilibrium level of R&D investment and patenting, it is seen that merging provides both more R&D investment and patenting than in the case of cross-licensing ($x_M^* > x_C^*$ and $\theta_M^* > \theta_C^*$). The reason is that the level of internalization of externalities which firms impose on each other in case of merger is higher and possible rent extractions are lower. In addition, we continue to observe that the risk of infringement has a positive effect on R&D investment incentives as it makes merger a better alternative. Lastly, since patents are necessary to generate rents from R&D investments, higher R&D levels result in higher patenting rates.

3.7. Social Welfare Analysis of Litigation Behavior

Following Hunt (2006), social welfare is defined as $W = f(x^*) - Rx^* - Cn(x^*)$ where $(x^*, n(x^*))$ represent the R&D and patenting level in the private symmetric equilibrium. In the appendix it is shown that $W_C(x^*) > V_C(x^*)$. This is because the social planner only cares about the level of innovation, and is not concerned with the level of patenting.

The social planner can also use p so that the low R&D effectiveness at low C levels does not occur. Using the Chain Rule of differentiation, the first order condition of the social planner's problem w.r.t. C is:

(21) $$\frac{\partial W}{\partial C} = W_x \frac{\partial x^*}{\partial C} - W_\theta \frac{\partial n^*}{\partial C} = 0$$

$$= (\alpha x^{\alpha-1} - R)\frac{\partial x^*}{\partial C} - C\frac{dn^*}{dC} = 0$$

As long as $dn^* / dC < 0$, the first order condition can be satisfied if $\partial x^* / \partial C < 0$. In the appendix it is shown that $dn^* / dC < 0$, so the first order condition can be satisfied if $p > 1 - 1/(2\beta\theta)$ and $\beta\theta > 1/2$ as suggested in proposition 2.

Proposition 4: Crowding out of R&D by patenting $\partial x^* / \partial C > 0$ can be avoided by positive litigation threats ($p > 0$), which also maximizes social welfare .

In the appendix it is also shown that welfare is higher in the case of cross-licensing when $p > 0$ since $x_C^* > x_B^*$ given in proposition 3. It is demonstrated that higher R&D levels are also reflected on social welfare at higher p levels. In addition, it was previously shown in Graph 3.4 that the social planner prefers less overlap. Hunt (2006) assumes that the social planner can have an impact on this variable because besides being interpreted as technological overlap, this parameter can also represent breadth of patent claims. In this analysis, it is assumed that the social planner can only affect the strength of patents through p, which has an influence on the bargaining outcome.[47]

One shortcoming of the model is that in terms of social welfare, all that matters is the number of innovations. The conventional deadweight loss due to patents is not discussed. This is why the pricing policies such as the possibility of parallel pricing above the competitive level (especially when the concentration of the oligopoly is high) are not analyzed. However, the aim of the paper is to focus on the dynamic aspect of the problem which mainly makes it necessary to diverge from the classical theory of patents which is more appropriate to single product industries where an individual patent acquires all the monopoly profit in the industry. When multi-patents are needed to appropriate returns, the monopoly assumption is less likely to hold.

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[47] The numerical exercise in the appendix presents that the higher levels of R&D is also reflected on the social welfare in case of merger.

3.8. Policy Implications

Hunt (2006) has shown that when the degree of technological overlap is large and the cost of obtaining patents is low, patenting crowds out R&D investments. To alleviate this problem, he proposes to increase patenting costs (e.g. through a patent tax) or to raise the patentability requirements.[48] Our model shows that an alternative option is available when firms cross-license, i.e. to implement a patent policy that is more favorable to infringement. On the one hand, the social planner prefers less technological overlap. On the other hand, when the technological overlap cannot be avoided, infringement threats should be credible enough to induce a firm to cooperate, which in turn has a positive effect on their incentives to invest in R&D. The model fits well to industries where the cost of patenting is quite low compared to cost of R&D and for firms investing in parallel research lines, which often obtain patents on similar inventions with overlapping claims. In the analysis, it is shown that a strict interpretation of patent rights by the courts can actually make the region where patenting crowds out R&D disappear. This is because litigation threats compensate the decline in cost of patenting and corrects strategic behavior.

In the setting of the model, the choice of patent scope decisions can be made by courts in the form of high probability of infringement or by the patent granting system through the non-obviousness standard. Regarding the first policy tool, courts analyze infringement in two steps. First, they address the question of whether there is literal infringement. If the answer is no, then they address the question of whether there is infringement under the doctrine of equivalents, which is determined by equivalence on the degree of advance over the art the original patent represents. For instance, when the patent is broad then the patent is entitled to a wider range of equivalents so the court may find infringement even by products whose characteristics are not within the boundaries of the literal claims. This suggests that courts can use discretion towards a more broad interpretation of this doctrine regardless of the patent strength. On the other, the decision to interpret this doctrine broadly can also be determined endogenously. Through applying a high level of non-obviousness standard, which leads trivial improvements upon prior art not to qualify for patent protection, broader protection can be granted. Such a protection will increase the likelihood of a potential infringer to be prosecuted under the doctrine of equivalents and in general will make infringement more likely.

[48] He proposes to implement a patent tax when the cost of acquiring these patents is too low. In addition, he suggests increasing the inventive step so that obvious improvements do not qualify for patent protection.

In the US, the different application of standards is observed especially in the biotechnology and software industries.[49] For instance, the current Federal Circuit jurisprudence lowers obviousness barriers for biotechnology innovations to encourage marketable inventions. This is because biotechnology is a high-cost and high-risk industry; therefore, firms need to be incentivized to innovate. For software industry, the jurisprudence aims at having a few broad patents by applying a high non-obviousness standard. By this, the Federal Circuit encourages software patents to be drafted broadly, so that the probability of infringement in allegations is higher and hence fewer patents are created (Burk and Lemley, 2003).

However, there are critics of the current jurisprudence on the non-obviousness standard. For instance, Burk and Lemley (2003) claim that due to the cumulative nature of innovation in the software industry, protection for incremental inventions should be relatively easy to acquire in order to reward improvements, which means that actually the non-obviousness standard should be lower and as a result patents should be narrow (not extending to coming product generations). On the other hand, if one assumes there is not only cumulativeness but also complementarity between patents, then cross-licensing is a common strategy used by firms to avoid patent thickets. The model shows that when bargaining is taken into account, in order to induce settlement, broad protection is preferable.

In addition, the model has shown that cross-licensing can solve adverse outcomes only if patent infringement threats are strong. Technology overlapping can lead to lower levels of R&D but having more patents as bargaining mechanisms facilitates cross-licensing. This is possible if enforcement is plausible, which is ensured with equal bargaining positions; otherwise, cross-licensing may still not induce more R&D. In case of fragmented IP rights, firms decide on their R&D decision under the shadow of litigation and courts should encourage mandating mechanisms, such as patent pools and standard-setting activities that aim to clear extensive overlapping patent rights. This finding can also sheds light on the discussion on limiting injunctive relief to patent holder members of a standard-setting organization in case of infringement (Miller, 2007; Lemley and Shapiro, 2007; Lemley, 2007). For instance, in 2006 wireless handset maker Nokia Corp. sued Qualcomm Inc., which licenses many patents essential to practicing wireless telephony standards. Nokia filed the suit after Qualcomm sued Nokia for patent infringement in different courts. Nokia claimed that the Court to order Qualcomm to abide by its written contractual obligations to international

[49] See Burk and Lemley (2003), for a comparison of the policy levers that can be found in patent law even though conceptually the statute does not distinguish between different technologies.

standard-setting bodies to license intellectual property essential to the telephony standards on RAND terms, more importantly to affirm that Qualcomm is not entitled to injunctive relief in relation to alleged infringement of patents declared essential to a standard.[50] The implementation of such a policy can weaken the bargaining position of patent holders - who have already undergone tremendous amount of risky R&D - in negotiations and therefore can significantly harm the R&D incentives in the long run. [51]

3.9. Conclusions

This chapter investigates the relationship between firms' R&D and patenting decision in the presence of litigation. The technologies in which firms invest have overlapping elements that creates scope for patent litigation, and firms are assumed to be able to go to court and sue their competitor for infringement. In practice, however, it is observed that this rarely happens; more often, firm's cross-license their patent portfolios taking into account the threat of litigation. The model shows that in the presence of potential litigation and an option of cross-licensing, firms actually invest more in R&D than in the absence of cross-licensing, even though the technologies patented infringes with each other. In the absence of cross-licensing, the existence of overlapping technologies causes firms to lose some profits and firms refrain themselves from investing in R&D. By cross-licensing their patent portfolios, firms internalize this externality.

The model also shows that firms seek more patents as the risk of infringement increases, and that the larger this increase is, the greater the degree of technological overlap. This is an indication that firms engage in defensive patenting. On the other hand, infringement probabilities also serve to alleviate the problem of crowding out of R&D by more patenting when cost of patenting is low. Put differently, strong infringement probabilities lead to an increase of investment levels if firms can ex-post cross-license each other's patent portfolios. For a social planner that is interested in the number of innovations in the market, higher infringement probabilities lead to welfare improvements due to increased level of R&D.

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[50] Source: http://nokia.com/14136001?newsid=1068193

[51] It should be noted that as the first designer CDMA-based cellular base station, since 1990 Qualcomm has significantly invested and contributed to the development of 3G technologies (Source: http://en.wikipedia.org/wiki/Qualcomm).

Appendix 3

A.3.1. Proof of second order condition of equation (8):

The conditions for the stationary points of the objective function are given in (13) and (15). The Hessian elements are:

$$(11) \qquad f'_1\,\theta_1(1-\beta\theta_2+p\beta\theta_2)-R=0$$

$$(12) \qquad (1-\theta_1)\left[f_1-\beta f_1\theta_2+\beta f_2+p\beta\theta_2(f_1-f_2))\right]-C=0$$

$$(1.a) \qquad V_{x_1x_1}=f_1''\theta_1(1-\beta\theta_2+p\beta\theta_2)=(f''/f')(V_x+R)$$

$$(2.a) \qquad V_{n_1n_1}=-(1-\theta_1)\left[f_1-\theta_2\beta f_1+\beta f_2+p\beta\theta_2(f_1-f_2)\right]=(-V_n+C)$$

$$(3.a) \qquad V_{x_1n_1}\ \&\ V_{n_1x_1}=f_1'(1-\theta_1)(1-\beta\theta_2+p\beta\theta_2)>0$$

At all stationary points where equations (13) and (15) are satisfied, $V_{x_1x_1}=(f''/f')R<0$ for $\alpha<1$, and $V_{n_1n_1}=-C<0$. Thus, a given critical point corresponds to either a maximum or a saddle point of (8). Since $V_{x_1x_1}<0$, (8) does not have a minima and the condition for a maxima depends on whether $\Delta>0$ at the critical point where,

$$(4.a) \qquad \Delta=V_{x_1x_1}V_{n_1n_1}-(V_{x_1n_1})^2$$

Which means the following condition must hold:

$$(5.a) \qquad \begin{aligned}&-f_1''\theta_1(1-\beta\theta_2+p\beta\theta_2)(1-\theta_1)\left[f_1-\theta_2\beta f_1+\beta f_2+p\beta\theta_2(f_1-f_2)\right]\\&-\left[f_1'(1-\theta_1)(1-\beta\theta_2+p\beta\theta_2\right]^2>0\end{aligned}$$

Substituting $f(x)=x^\alpha$ yields;

i. $$\begin{aligned}&\alpha(1-\alpha)x_1^{\alpha-2}\theta_1(1-\beta\theta_2+p\beta\theta_2)(1-\theta_1)\left[x_1^\alpha(1-\beta\theta_2+p\beta\theta_2)+\beta f_2(1-p\theta_2)\right]\\&-\left[\alpha^2x_1^{2\alpha-2}(1-\theta_1)^2(1-\beta\theta_2+p\beta\theta_2)^2\right]>0\end{aligned}$$

ii. Call, $\mu=1-\beta\theta_2+p\beta\theta_2$

iii. $(1-\alpha)\theta_1\mu\left[x_1^\alpha\mu+\beta f_2(1-p\theta_2)\right]-\left[\alpha x_1^\alpha(1-\theta_1)\mu^2\right]>0$

Naming $\tau=\beta f_2(1-p\theta_2)>0$, we obtain:

iv. $(1-\alpha)\theta_1\mu\left[x_1^\alpha\mu+\tau\right]>\left[\alpha x_1^\alpha(1-\theta_1)\mu^2\right]$

v. $x_1^\alpha\mu^2(\theta_1-\alpha)+(\theta_1-\theta_1\alpha)(\mu\tau+x_1^\alpha\mu+\tau)>0$

Therefore, in order to have Δ positive is it possible to conclude; $\theta_1 > \alpha$, is a sufficient, but not necessary condition for the second order condition to hold.

A.3.2. Comparative Statics Analysis:

To conduct the comparative statics of the symmetric equilibrium, we make use of the implicit function theorem provided that the Jacobian determinant of the system does not vanish at the initial equilibrium. The first order conditions of the symmetric equilibrium were given in equation (13) and (15) as:

$$(6.a) \qquad V_x = f'\theta(1-\beta\theta+p\beta\theta)-R=0$$

$$(7.a) \qquad V_n = (1-\theta)f\left[1+\beta(1-\theta)\right]-C=0$$

Thus, the Jacobian matrix can be written as:

$$\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix} = \begin{vmatrix} \theta f''(1-\beta\theta+p\beta\theta) & (1-\theta)f'(1-2\beta\theta+2p\beta\theta)) \\ (1-\theta)f'(1+\beta(1-\theta)) & -(1-\theta)f(1+2\beta(1-\theta)) \end{vmatrix}$$

The Jacobian determinant $|J|$ must be found from:

$$|J| = -\theta(1-\theta)f''f(1-\beta\theta+p\beta\theta))(1+2\beta(1-\theta))-(1-\theta)^2(f')^2(1+\beta(1-\theta))(1-2\beta\theta+2p\beta\theta))$$

$$|J| = \theta(1-\alpha)(1-\beta\theta+p\beta\theta))(1+2\beta(1-\theta))-(1-\theta)\alpha(1+\beta(1-\theta))(1-2\beta\theta+2p\beta\theta))$$

Assuming $\theta > \alpha$, which is a range where the second order condition is satisfied for sure, it can be said that $|J| > 0$ since:

$(1+2\beta(1-\theta)) > (1+\beta(1-\theta))$

And

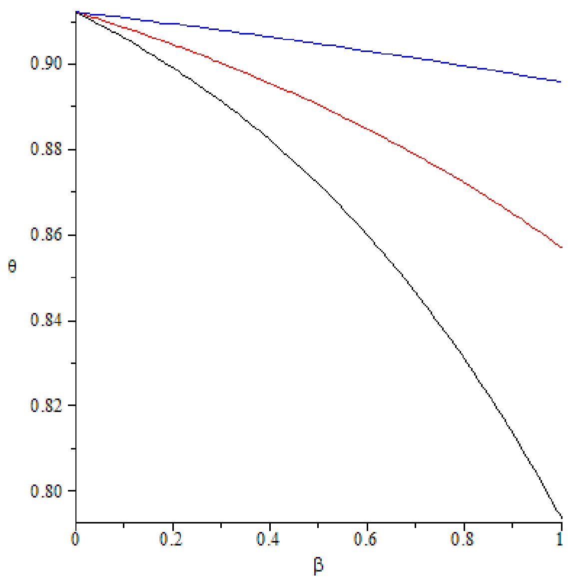
$1-\beta\theta+p\beta\theta-1+2\beta\theta-2p\beta\theta = \beta\theta-p\beta\theta > 0$.

$$\frac{\partial n^*}{\partial R} = -\frac{\begin{vmatrix} V_{xx} & -1 \\ V_{nx} & 0 \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = \frac{-1}{|J|}(1-\theta)f'(1+\beta(1-\theta)) < 0$$

$$\frac{\partial n^*}{\partial C} = -\frac{\begin{vmatrix} V_{xx} & 0 \\ V_{nx} & -1 \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = \frac{-1}{|J|}\left[-\theta f''(1-\beta\theta + p\beta\theta\right] < 0$$

$$\frac{\partial n^*}{\partial \beta} = -\frac{\begin{vmatrix} V_{xx} & \frac{\partial V_x}{\partial \beta} \\ V_{nx} & \frac{\partial V_n}{\partial \beta} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = -\frac{\begin{vmatrix} \theta f''(1-\beta\theta + p\beta\theta)) & \theta^2 f'(p-1) \\ (1-\theta)f'(1+\beta(1-\theta)) & (1-\theta)^2 f \end{vmatrix}}{|J|} < 0$$

$$\frac{\partial n^*}{\partial p} = -\frac{\begin{vmatrix} V_{xx} & \frac{\partial V_x}{\partial p} \\ V_{nx} & \frac{\partial V_n}{\partial p} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = -\frac{\begin{vmatrix} \theta f''(1-\beta\theta + p\beta\theta)) & f'\theta^2\beta \\ (1-\theta)f'(1+\beta(1-\theta)) & 0 \end{vmatrix}}{|J|} = \frac{-1}{|J|} - \left[(1-\theta)f'(1+\beta(1-\theta))f'\theta^2\beta\right] > 0$$



Graph 3.1.a. Variation of *β* and *θ* for vales of *p*. For the parameter set *(C, R, α)=(0.05,0.8,0.5)*; black: *p=0.25*, red: *p=0.5*, blue: *p=0.75*

$$\frac{\partial x^*}{\partial R} = -\frac{\begin{vmatrix} -1 & V_{xn} \\ 0 & V_{nn} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = \frac{-1}{|J|}(1-\theta)f(1+2\beta(1-\theta)) < 0$$

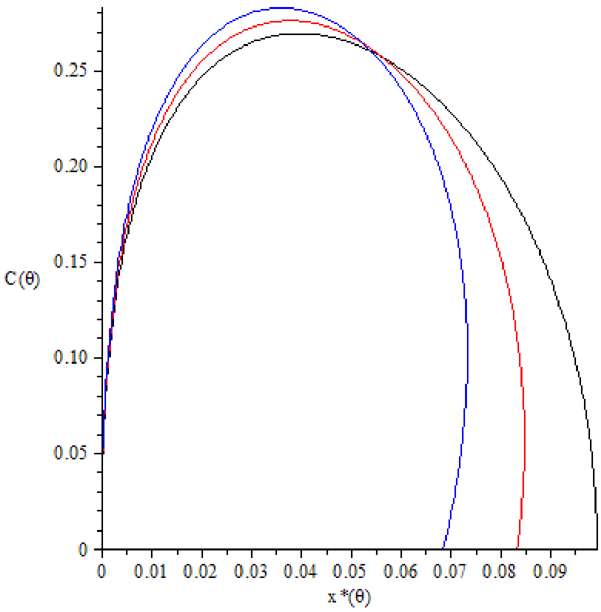
$$\frac{\partial x^*}{\partial C} = -\frac{\begin{vmatrix} 0 & V_{xn} \\ -1 & V_{nn} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = \frac{-1}{|J|}(1-\theta)f'(1-2\beta\theta+2p\beta\theta)<0, \text{ if } \quad 1-2\beta\theta+2p\beta\theta>0$$

Which is ensured if $(1-p)<1/(2\beta\theta)$.

$$\frac{\partial x^*}{\partial \beta} = -\frac{\begin{vmatrix} \frac{\partial V_x}{\partial \beta} & V_{xn} \\ \frac{\partial V_n}{\partial \beta} & V_{nn} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = -\frac{\begin{vmatrix} \theta^2 f'(p-1) & (1-\theta)f'(1-2\beta\theta+2p\beta\theta)) \\ (1-\theta)^2 f & -(1-\theta)f(1+2\beta(1-\theta)) \end{vmatrix}}{|J|}, \text{ indeterminate.}$$

$$\frac{\partial x^*}{\partial p} = -\frac{\begin{vmatrix} \frac{\partial V_x}{\partial p} & V_{xn} \\ \frac{\partial V_n}{\partial p} & V_{nn} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = -\frac{\begin{vmatrix} f'\theta^2\beta & (1-\theta)f'(1-2\beta\theta+2p\beta\theta)) \\ 0 & -(1-\theta)f(1+2\beta(1-\theta)) \end{vmatrix}}{|J|} > 0$$

The result for $\partial x^*/\partial\beta$ is ambiguous from the above analysis so we resort to a numeric analysis. The graphs below shows the relationship between x^*, β and p.



Graph 3.2.a. Parametric plot between *C(θ)* and *x*(θ)* for values of *β*. For the parameter set *(R, α, p) =(0.8, 0.4, 0.8)*, black *β =0.5*, red: *β =0.55*, blue: *β =0.6* (solution area is the right-hand side of the curves so that the participation constraint is satisfied and *Δ>0*)

A.3.3. Baseline Model:

Using (1) and assuming symmetry, the first order conditions for firm 1 are:

$$(8.a) \qquad f_1'\theta_1(1-\beta\theta_2)-R=0$$

$$(9.a) \qquad (1-\theta_1)\left[f_1-\beta f_1\theta_2+\beta f_2\right]-C=0$$

Assuming symmetric behavior and simplifying (9.a) we obtain:

$$(10.a) \qquad \theta_B^{\ *}=\frac{1}{2}\frac{2\beta+1-\sqrt{1+\dfrac{4\beta C}{f(x_B^{\ *})}}}{\beta}$$

Substituting for $f(x)=x^{\alpha}$ in (8.a) and assuming symmetric behavior we obtain:

$$(11.a) \qquad x_B^{*}=\left(\frac{\alpha\theta_B(1-\beta\theta_B)}{R}\right)^{\frac{1}{1-\alpha}}$$

Substituting (11.a) into (10.a), we obtain the critical cost of obtaining patents.

$$(12.a) \qquad \tilde{C}_B=\left(\frac{\alpha\theta_B(1-\beta\theta_B)}{R}\right)^{\frac{\alpha}{1-\alpha}}(1-\theta_B)(1+\beta(1-\theta_B))$$

A.3.4. Social Welfare:

The private equilibrium profit in case of cross-licensing is calculated as:

$$(13.a) \qquad \begin{aligned} V_C(x^*)=&\left(\frac{\alpha\theta_C}{R}(1-\beta\theta_C+p\beta\theta_C)\right)^{\frac{\alpha}{1-\alpha}}(\theta_C)(1-\beta(\theta_C-1))-R\left(\frac{\alpha\theta_C}{R}(1-\beta\theta_C+p\beta\theta_C)\right)^{\frac{1}{1-\alpha}} \\ &+\left(\frac{\alpha\theta_C}{R}(1-\beta\theta_C+p\beta\theta_C)\right)^{\frac{\alpha}{1-\alpha}}(1-\theta_C)(1+\beta(1-\theta_C))ln(1-\theta_C) \end{aligned}$$

$$(14.a) \qquad \begin{aligned} W_C(x^*)=&\left(\frac{\alpha\theta_C}{R}(1-\beta\theta_C+p\beta\theta_C)\right)^{\frac{\alpha}{1-\alpha}}-R\left(\frac{\alpha\theta_C}{R}(1-\beta\theta_C+p\beta\theta_C)\right)^{\frac{1}{1-\alpha}} \\ &+\left(\frac{\alpha\theta_C}{R}(1-\beta\theta_C+p\beta\theta_C)\right)^{\frac{\alpha}{1-\alpha}}(1-\theta_C)(1+\beta(1-\theta_C))ln(1-\theta_C) \end{aligned}$$

Comparing the two values it is seen that $W_C(x^*)>V_C(x^*)$.

For equation (21) to hold, the proof of proposition 4 requires that,

$$\frac{dn^*}{dC}=\frac{\partial n^*}{\partial C}+\frac{\partial n^*}{\partial x}.\frac{\partial x^*}{\partial C}=\frac{1}{|J|}\left\{[\theta f''(1-\beta\theta+p\beta\theta)-(1-\theta)f'(1-2\beta\theta+2p\beta\theta).\left(-\frac{\frac{f'}{f}(1-(\frac{f+4BC}{f})}{2.\sqrt{\frac{f+4BC}{f}}.\sqrt{1+\frac{f+4BC}{f}}}\right)\right\}$$

If $\partial x^* / \partial C < 0$, dn^* / dC is also smaller than zero.

In addition, we know when $p = 0$ we can derive $W_B(x^*)$. For the comparison of the two cases we write

$W_C(x^*) - W_B(x^*)$ as;

$\left[f(x_C^*)-f(x_B^*)\right]-R(x_B^*-x_C^*)+(1-\theta)(1+\beta(1-\theta))\left[f(x_C^*)-f(x_B^*)\right]>0$, since $x_C^* > x_B^*$.

A.3.5. Extension: Case of Merger

A.3.5.1. Equilibrium

Once again solving the Nash bargaining problem and assuming equal shareholder ratio, the expected profits from merger for firm 1 is:

$$(15.a)\qquad \begin{aligned} V_M &= f(x_1)\theta(n_1)+\beta\theta(n_1)f(x_2)-\frac{1}{2}\beta\theta(n_1)\theta(n_2)\left[f(x_1)-f(x_2)\right] \\ &+p\beta\theta(n_1)\theta(n_2)\left[f(x_1)-f(x_2)\right]-Rx_1-Cn_1 \end{aligned}$$

The first order condition w.r.t. x_1 is:

$$(16.a)\qquad \frac{\partial V_M}{\partial x_1}=f'(x_1)\theta(n_1)-\frac{1}{2}\beta\theta(n_1)\theta(n_2)f'(x_1)+p\beta\theta(n_1)\theta(n_2)f'(x_1)-R=0$$

Applying symmetry, R&D investment level for a single technology *i* (*i=1,2*) can be written as:

$$(17.a)\qquad x_M{}^*=\left(\frac{\alpha\theta_M(1-\frac{1}{2}\beta\theta_M+p\beta\theta_M)}{R}\right)^{\frac{1}{1-\alpha}}$$

As far as the analysis of patenting is concerned we examine:

$$(18.a)\qquad \frac{\partial V_M}{\partial n_1} = f(x_1)(1-\theta(n_1)) + \beta(1-\theta(n_1))f(x_2) - \frac{1}{2}\beta(1-\theta(n_1))\theta(n_2)[f(x_1)-f(x2)] + p\beta(1-\theta(n_1))\theta(n_2)[f(x_1)-f(x2)] - C = 0$$

Applying symmetry, we obtain:

$$(19.a)\qquad \theta_M^*(n) = 1 - \frac{C}{f(x_M)(1+\beta)}$$

A.3.5.2. Comparative Statics of Merger

In case of merger, the equilibrium number of patents n^* is decreasing in cost of obtaining patents and cost of R&D, whereas it is increasing in degree of overlapping technologies and the risk of litigation. The equilibrium level of R&D, x^* is decreasing in cost of obtaining patents and cost of R&D, whereas it is increasing in the risk of litigation. It is also increasing in degree of overlapping technologies only if p is sufficiently small.

The proof can be attained following the same steps of cross-licensing.

$$(20.a)\qquad V_x = f'\theta(1-\frac{1}{2}\beta\theta + p\beta\theta) - R = 0$$

$$(21.a)\qquad V_n = (1-\theta)f[1+\beta] - C = 0$$

The Jacobian matrix can be written as:

$$\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix} = \begin{vmatrix} \theta f''(1-\frac{1}{2}\beta\theta + p\beta\theta) & (1-\theta)f'(1-\beta\theta+2p\beta\theta)) \\ (1-\theta)f'(1+\beta) & -(1-\theta)f(1+\beta) \end{vmatrix}$$

The Jacobian determinant $|J|$ is found from:

$$|J| = -\theta(1-\theta)f''f(1-\frac{1}{2}\beta\theta + p\beta\theta))(1+\beta) - (1-\theta)^2(f')^2(1+\beta)(1-\beta\theta+2p\beta\theta))$$

which reduces to;

$$|J| = \theta(1-\alpha)(1-\frac{1}{2}\beta\theta + p\beta\theta)) - (1-\theta)\alpha(1-\beta\theta+2p\beta\theta))$$

If $\theta > \alpha$ then $|J| > 0$.

$$\frac{\partial n^*}{\partial R} = -\frac{\begin{vmatrix} V_{xx} & -1 \\ V_{nx} & 0 \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = \frac{-1}{|J|}(1-\theta)f'(1+\beta) < 0$$

$$\frac{\partial n^*}{\partial C} = -\frac{\begin{vmatrix} V_{xx} & 0 \\ V_{nx} & -1 \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = \frac{-1}{|J|} - \theta f''(1 - \frac{1}{2}\beta\theta + p\beta\theta) < 0$$

$$\frac{\partial n^*}{\partial \beta} = -\frac{\begin{vmatrix} V_{xx} & \frac{\partial V_x}{\partial \beta} \\ V_{nx} & \frac{\partial V_n}{\partial \beta} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = -\frac{\begin{vmatrix} \theta f''(1 - \frac{1}{2}\beta\theta + p\beta\theta) & \theta^2 f'(p - \frac{1}{2}) \\ (1-\theta)f'(1+\beta) & (1-\theta)f \end{vmatrix}}{|J|} \text{ (ambiguous)}$$

$$\frac{\partial n^*}{\partial p} = -\frac{\begin{vmatrix} V_{xx} & \frac{\partial V_x}{\partial p} \\ V_{nx} & \frac{\partial V_n}{\partial p} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = -\frac{\begin{vmatrix} \theta f''(1 - \frac{1}{2}\beta\theta + p\beta\theta) & f'\theta^2\beta \\ (1-\theta)f'(1+\beta) & 0 \end{vmatrix}}{|J|} > 0$$

$$\frac{\partial x^*}{\partial R} = -\frac{\begin{vmatrix} -1 & V_{xn} \\ 0 & V_{nn} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = \frac{-1}{|J|}(1-\theta)f(1+\beta) < 0$$

$$\frac{\partial x^*}{\partial C} = -\frac{\begin{vmatrix} 0 & V_{xn} \\ -1 & V_{nn} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = \frac{-1}{|J|}(1-\theta)f'(1-\beta\theta+2p\beta\theta) < 0$$

$$\frac{\partial x^*}{\partial \beta} = -\frac{\begin{vmatrix} \frac{\partial V_x}{\partial \beta} & V_{xn} \\ \frac{\partial V_n}{\partial \beta} & V_{nn} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = -\frac{\begin{vmatrix} \theta^2 f'(p - \frac{1}{2}) & (1-\theta) f'(1 - \beta\theta + 2p\beta\theta)) \\ (1-\theta)f & -(1-\theta)f(1+\beta) \end{vmatrix}}{|J|}$$

If $p > 1/2$, then $\frac{\partial x^*}{\partial \beta}$ is positive. If not, for $\frac{\partial x^*}{\partial \beta} > 0$, then $(\frac{1}{2} - p) \leq \frac{(1-\theta)(1-\beta\theta+2p\beta\theta)}{\theta^2(1+\beta)}$ should hold.

$$\frac{\partial x^*}{\partial p} = -\frac{\begin{vmatrix} \frac{\partial V_x}{\partial p} & V_{xn} \\ \frac{\partial V_n}{\partial p} & V_{nn} \end{vmatrix}}{\begin{vmatrix} V_{xx} & V_{xn} \\ V_{nx} & V_{nn} \end{vmatrix}} = -\frac{\begin{vmatrix} f'\theta^2\beta & (1-\theta)f'(1-\beta\theta+2p\beta\theta)) \\ 0 & -(1-\theta)f(1+\beta) \end{vmatrix}}{|J|} > 0$$

The numerical exercise below, better illustrates the comparative statics and equilibrium results for the case of merger.

Variable	Values (given R=0,8, C=0,1, α=0,5)											
β	0.2	0.5	0.8	0.2	0.5	0.8	0.2	0.5	0.8	0.2	0.5	0.8
p	0	0	0	0.3	0.3	0.3	0.5	0.5	0.5	0.8	0.8	0.8
θ_C	**0.76**	**0.69**	**0.61**	**0.78**	**0.74**	**0.70**	**0.78**	**0.76**	**0.74**	**0.80**	**0.80**	**0.80**
x_C	**0.40**	**0.28**	**0.19**	**0.43**	**0.34**	**0.26**	**0.45**	**0.38**	**0.32**	**0.48**	**0.46**	**0.43**
θ_M	**0.82**	**0.83**	**0.84**	**0.83**	**0.86**	**0.88**	**0.84**	**0.88**	**0.90**	**0.89**	**0.89**	**0.98**
x_M	**0.47**	**0.41**	**0.34**	**0.50**	**0.49**	**0.47**	**0.52**	**0.54**	**0.56**	**0.58**	**0.63**	**0.75**
W_C	**0.17**	**0.18**	**0.19**	**0.16**	**0.17**	**0.18**	**0.15**	**0.17**	**0.17**	**0.14**	**0.15**	**0.15**
W_M	**0.29**	**0.29**	**0.29**	**0.28**	**0.29**	**0.28**	**0.28**	**0.29**	**0.29**	**0.28**	**0.27**	**0.26**

Table 3.1.a. Numerical example for the comparison of the results in case of merger and cross-licensing

CHAPTER 4. AN EMPIRICAL ANALYSIS OF EX-POST LICENSING AND R&D IN COMPLEX PRODUCT INDUSTRIES: DETERMINANTS OF COMPETITIVE COOPERATION

4.1. Introduction

Currently hundreds of agreements link the R&D efforts of firms, either with domestic or international partners. During the last twenty years there has been a dramatic increase in the number as well as in the variety of forms of cooperative R&D projects, as firms respond to the increasing complexity and cost pressures of the new product or process development needs. It has become more and more difficult to produce knowledge internally and resorting to external sources for advancing technology has become a more common practice. On the other hand, R&D is expensive and rivalry is fierce, so firms have to protect their proprietary knowledge as much as possible in order to take the lead in competition.

The fact that the relationship between different knowledge flows and R&D cooperation can vary makes it difficult to assess the consequences of these cooperative arrangements on innovation. Appropriability of R&D investments can take various forms and besides covering intellectual property protection it can also include research spillovers, lead time or secrecy. Some organizational scholars believe that imperfect appropriability of a firm's own innovative efforts increases the incentives for cooperative R&D agreements, especially in the presence of large research spillovers (d'Aspremont and Jacquemin, 1988; Fershtman and Kamien, 1992; de Bondt, 1997).[52] Others counter that such imperfections can increase firms' incentives to free-ride on each other's R&D investments (Katz, 1986).[53] The challenge in knowledge transfers arises due to the complex nature of information. Nevertheless, when there are means to prevent the appropriation of rents from knowledge, firms become more prone to sharing it. Many scholars have suggested that strong patent protection enhances the effectiveness of licensing contracts (Anand and Khanna, 2000; Gallini and Scotchmer, 2002; Gans et al., 2002; Bessen and Maskin, 2009).

[52] Other potential advantages of cooperative agreements are: capturing economies of scale, complementarities and synergies, favoring the diffusion of know-how and R&D output between the partners, and avoiding the duplication of efforts.

[53] For the effect of cooperation on the competition in the product market and welfare analysis, see Katz (1986), d'Aspremont and Jacquemin (1988), Suzumura (1992), Fershtman and Kamien (1992), Combs (1993), Choi (1993), Beath et al. (1998) and Katsoulakos and Ulph (1998).

The timing of collaboration (i.e., before they develop the product/process or later) can depend on the interplay of many different factors, such as product market competition, degree of technological opportunities in the industry and strength of patent protection. For instance, firms relying on ex-ante arrangements, namely research joint ventures, are more prone to opportunistic behavior. As a result, these agreements occur when profits are not likely to erode due to free-riding between firms' innovative efforts after cooperation, which can be assured in case of stronger property rights (Anand and Khanna, 2000; Pastor and Sandonis, 2002). On the other hand, when firms are strong rivals in different markets, R&D is intensive and patent landscape is complex; ex-post cooperation in the form of cross-licensing can be an efficient form of contracting as these agreements not only concern the exchange of technologies but also strategies used by firms to overcome difficulties due to fragmented property rights.

Cooperative agreements in complex product industries are a special case that needs to be closely examined as they also serve the reduction of transaction costs and inefficiencies related to fragmentation of property rights. In what we call "complex industries," products typically require the assembly of many different patents, which most of the time are not possessed by a single firm. When patents cover complementary technological knowledge, it is also more likely that the patent claims will be overlapping. For these reasons, many new products are likely to infringe upon multiple patents. A common strategy employed by firms in these circumstances is to hold extensive patent portfolios so that firms are able to cross-license or pool each other's patents in order to avoid any patent interference. Some scholars have found a causal relationship between the increase in patenting propensity in these industries and the patent portfolio races used for such purposes (Hall and Ziedonis, 2001). Semiconductor, electronics, communication equipment and software are examples of industries where cross-licensing and patent pools represent a coordination mechanism that allows the owners of overlapping patent portfolios to mitigate litigation costs.[54] For these reasons, cooperation mechanisms (especially ex-post ones) are usually considered not as a source of technology transfer but rather as a tool for parties that are interested in having access to each other's technology without the risk of infringement (Nagaoka and Kwon, 2006). However, this should not be taken to deny the usefulness of this conduct. In fact, the market evolution in these high-tech sectors made the adoption of such practices almost inevitable (Grindley and Teece, 1997).

[54] Clark et al. (2000) state that in patent law, a patent pool is a consortium of at least two companies agreeing to cross-license patents relating to a particular technology.

As ex-post cooperation mechanisms that involve bilateral or consortium of cross-licensing agreements have become a common practice, it is important to investigate the usefulness of this activity. As a general aim, this chapter attempts to test the effect of cross-licensing agreements on R&D. Empirical proof that such agreements have a positive effect on R&D incentives can justify the lenient treatment of these agreements by authorities.[55] The second objective is to analyze if the effect differs across sectors. Various empirical studies have focused on individual sectors. In this study, by contrast, a cross-industry analysis is conducted to find differences in the outcome of these deals in different sectors. This, in turn, can provide insights on how policy can be tailored to the specific needs of different sectors.

Our analysis identifies some cross-industry differences in the effects of cross-licensing agreements on future R&D incentives. A significant positive effect is found in electronics and communication equipment, computer manufacturing and software industries. In semiconductors, biotechnology and instruments sectors we fail to provide evidence of any significant effect. Although it is difficult to reconcile all the regularities of a cross-industry analysis into a general framework, a suggestive explanation for this result can stem from the purpose of the agreements being “freedom to design” and “freedom to operate” (Grindley and Teece, 1997). Industries can be categorized in this respect depending on the nature of technology and the product development process. We will discuss the implications of this categorization for future R&D incentives at the end of the chapter.

The rest of the chapter is structured as follows: The following section gives a brief summary of related literature. Section 4.3 introduces the hypotheses to be tested. Section 4.4 explains the construction of the dataset and methodology. Section 4.5 explains the variables used in the analysis and section 4.6 presents the analysis. Section 4.7 provides the results of the empirical study. Finally, section 4.8 provides a brief summary of the results and a discussion on the related policy issues.

4.2. Theoretical Background

The theoretical literature on ex-post cooperation as regards its impact on R&D spending is very scarce. Early contributions, have mainly focused on the comparison of ex-ante R&D

[55] The relevant regulations are; DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property and 2004/C 101/2-Technology Transfer Block Exemption Regulation and the Accompanying Guidelines for Technology Transfer Agreements. A detailed analysis of these two guidelines will be provided in the following chapter.

cooperation and competition in the existence of knowledge spillovers.[56] For instance, d'Aspremont and Jacquemin (1988) and Fershtman and Kamien (1992) compare various forms of ex-ante R&D cooperation and they find that this format can provide better R&D performance than competition, as it leads to the internalization of R&D spillovers, which can withhold firms from investing in research. To our knowledge, the first study that analyzes the effect of ex-post cooperation on R&D performance is Fershtman and Kamien (1992). With the aim to clarify the social trade-off underlying cross-licensing agreements, they have shown that cross-licensing of complementary technologies improves the efficiency of the R&D investments by eliminating the duplication of efforts, but, on the other hand, it favors price collusion between the firms. In addition, Eswaran (1994) develops a model that shows that cross-licensing of imperfect substitute technologies can be used to sustain collusion in the market. A later contribution by Von Graevenitz (2005) compares the welfare losses that arise under ex-ante (e.g. joint ventures) and ex-post (e.g. cross-licensing) R&D cooperation. He finds ex-ante R&D cooperation is preferable to ex-post R&D cooperation in terms generating more innovation incentives where technological opportunity is high and product market competition is weak and vice versa.

To some extent, other contributions take into account that cooperative R&D agreements are a consequence of modern patent landscape and that different patent strategies can influence the outcome of the deals. For instance, Choi (2010) analyzes the incentives to form patent pools or to engage in cross-licensing under the shadow of patent litigation. Chiou (2006a) develops a model of strategic patenting due to fragmented IP rights, and finds that cross-licensing does not have a positive effect on late comers' development incentives. In addition, Shapiro (2001a) and Lerner and Tirole (2004) highlight the antitrust problems caused by cross-licensing and patent pools. On the other hand, extending the model of Eswaran (1994), Kultti et al. (2006) shows that cross-licensing is irrelevant for a firm's ability to sustain collusion and even if it is, they find that these agreements also stimulate R&D incentives.[57]

While the theoretical literature mostly focuses on the comparisons of the outcomes of cooperative and non-cooperative R&D agreements, the empirical literature has investigated the determinants of engaging in various forms of licensing contracts such as technological,

[56] In addition, for the comparison between R&D competition and cooperation in the presence of spillover effects see Spence (1984) and Katz (1986). For a general summary of strategic investments with spillovers, see de Bondt and Veugelers (1991). For an analysis that involves more than two firms, see Suzumura (1992).

[57] This is both true for firms with symmetric and asymmetric patent portfolios (in case which require side payments that reflect strength of each party's patent portfolios). In addition, even if tacit collusion is attained they find out that this can also stimulate incentives to innovate.

market and legal conditions. For instance, Anand and Khanna (2000) analyze the licensing behavior in different industries based on contractual clauses such as exclusive or cross-licensing, contrasting ex-ante and ex-post technology transfers and licensing to parties related and unrelated to the licensor.[58] They suggest that the diverse licensing behavior across sectors can be associated with the different strength of the intellectual property rights in different industries, which generates differences in the ability to appropriate the returns from R&D. One of their findings is that joint ventures mostly occur in weak IP rights industries so that it is easier to monitor and control activities of partners, whereas licensing contracts usually occur in stronger IP rights environments.[59] Moreover, when there is a strong incentive to invent around competitors' patents, they observe that cross-licensing is an efficient contracting arrangement, providing access to each other's technology without the need for reverse engineering.

Other empirical studies focus specifically on determinants of cross-licensing agreements. Köhler (2011), using a survey conducted on German firms, analyzes what factors affect patent cross-licensing of large and small firms. The main finding is that smaller firms use cross-licensing or patent pools due to IP rights dependence and hence provide themselves some technological freedom to operate. Larger firms, by contrast, having more means to achieve technological turnaround, mainly use their patent portfolio as a weapon against litigation threats. Nagaoka and Kwon (2006) also highlight that cross-licensing agreements are more likely to be signed between large and symmetric firms. Torrisi (2011) analyzes the relationship between cross-licensing as a motivation for patenting and a number of characteristics of the patent, the patent holder and the technology. He tests whether cross-licensing is associated with the cumulativeness of patented inventions and the number of overlapping claims with other patents, concluding that cross-licensing is more likely with high concentration and complexity of the main technology field of the patent. His results can also be extended to patent pools. Galasso (2007) studies the choice between litigation and cross-licensing in the semiconductors industry. He finds that high sunk costs increase the incentives to cross-license, whereas intermediate levels of asset specificity may induce litigation that aims to attain a better bargaining position at negotiations.

[58] They observe that the bulk of the licensing contracts occur in the three 2-digit SIC industries, which are Chemicals (28), Electronics (35) and Computer (36).

[59] They also find out that ex-ante contracting is lower when IP rights over future technologies are weak and vice versa. Also, if IP rights are strong, it is easier to choose an unrelated party as a licensee since sanctions of other forms is not so important. Furthermore, in case of strong IP rights, exclusive contracts can guarantee the exclusivity to the licensee, since it is more difficult for the unlicensed parties to invent around the technology.

There are also a few studies that consider the effect of patent strength or policies on R&D at the firm level. Sakakibara and Branstetter (2001) analyze the effect of a 1988 patent policy change in Japan, from a policy of one claim per patent to the one which allowed multiple claims per patent. They interpret this policy change as an increase in patent strength, related to broader patent scopes. However, the panel data analysis using a sample of Japanese manufacturing firms does not provide strong evidence on the impact of this change on R&D incentives. On the other hand, Lerner and Zhu (2007) find that companies' reliance on patents rather than copyright protection of software innovations in the early 1990s can be associated with higher firm level R&D investments. Another empirical study that focuses on the interaction between R&D spending and patenting in the existence of strategic factors is conducted by Bessen and Hunt (2007). They explore the reasons for the increase in patenting propensity in the software industry. They find evidence of a positive correlation between patents' cost effectiveness and increase in patenting propensity, which can lead to lower levels of R&D intensity. On the other hand, Noel and Schankerman (2006), in a study that analyzes the effect of strategic patenting on R&D in the computer software industry, do not find any evidence that the expansion of software patenting led firms to reduce R&D. On the contrary, they find that large technology spillovers among software firms and lower fragmentation of patent rights reduce both R&D and patenting.

To sum up, the literature is largely inconclusive. Probably, the strongest consensus can be found in the theoretical literature, which argues that ex-ante R&D cooperation produces more incentives in R&D than non-cooperation. The results of the models that focus on ex-post cooperation vary depending on the different focus of the studies. The empirical literature, on the other hand, provides some descriptive evidence on the likelihood of these agreements but does not provide conclusive evidence on the usefulness of these activities. Finally, the empirical literature that focuses on the impact of the patent system on R&D expenditures provides conflicting evidence, probably due to different assumptions made in their analyses. As a result, there is still room for further research on the economic effects of ex-post cooperative agreements.

4.3. Hypotheses

Ex-post cooperative agreements such as cross-licensing and patent pools are widely regarded as tools to diminish the risks associated with patent interference. As a result, compared to ex-ante licensing, it is argued that they do not imply a significant technology transfer but rather provide access to other firm technology during their own technology development while mitigating litigation risks (Torrisi, 2011). Although the product development processes in complex product industries can differ, we know that the main externalities persistent in these industries are due to the need to integrate different components into the final product. This has lead firms to patent for different reasons, one of which is using patents as bargaining chips in negotiations in case of overlapping patent rights (Blind et al., 2006). Some scholars link patent explosion to the need to engage in cross-licensing deals and argue that this sort of patenting is not directly related to R&D activities (Hall and Ziedonis, 2001; Nagaoka and Kwon, 2006).

On the other hand, the assurance provided against the risk of inadvertent infringement can actually influence R&D decisions. When a complex product or process is covered by many interrelated patents, any holder of a patent may block the production or impede further technological development, which can jeopardize return on investments. Uncertainty about future litigation can withhold firms from investing in R&D. In addition, if one accepts that patents spur innovation by conveying monopoly rights, limitations on patents, including how they are licensed, can undermine these rights and reduce R&D efforts. In the absence of cross-licensing in these industries, transaction costs can be larger than having such licenses. This is because first, firms may have to invent around many different patents. Second, they may need to negotiate separate licenses for these patents, which involve expensive patent searches and higher total negotiation costs (Beard and Kaserman, 2002). These extra transaction costs can crowd out R&D. One way to test this is to examine, at a general level whether cross-licensing firms invest more in R&D than non-cross-licensing firms.

Hypothesis 1.a.: Firms that engage in ex-post cooperation invest more in R&D than those that do not.

On the other hand, such a result can derive from different reasons. For instance, more R&D intensive firms may more often engage in cross-licensing agreements than non-cross-licensing firms. For that reason, a within firm analysis that compares the R&D spending levels of a firm before and after a cross-licensing is signed would enable to control for unobservable effects of this kind. A positive significant effect would imply that these agreements are not only used as bargaining chips but also as an integral part of R&D strategy of a firm. This argument is hypothesized as:

Hypothesis 1.b.: The R&D spending of firms is higher after ex-post cooperative agreements.

What also affects the R&D decisions of firms in complex product industries is the degree of technological overlap between patent portfolios of firms. Similarities between firms' R&D efforts can create technology spillovers. The effect of existence of the technological spillovers on the R&D investments may differ depending on the nature of innovation. This discussion starts with Spence (1984), who states an increase in spillovers, measured by the fraction of R&D that is effectively utilized by competitors, reduces the incentives to invest in R&D. On the other hand, Levin (1988) points out that this result is more valid in discrete product industries, where innovations are stand-alone and R&D efforts of firms are perfect substitutes. In other words, when one firms' R&D efforts strengthens the rival, this may lower the incentives to conduct R&D and instead direct resources to different activities. On the other hand, they find that when spillovers generated from R&D efforts of other firms' complements an innovator's own investment and raises its marginal return, spillovers may actually encourage more R&D investment. As we are concerned with firms operating in complex product industries, we expect firms that have patent portfolios with higher degree of technology overlap to invest more in R&D.

Hypothesis 2.a: A high degree of technological overlap increases R&D incentives of firms.

A more novel contribution will be to investigate how the degree of technological overlap affects the R&D levels after a cross-licensing agreement is signed. For the ex-ante cooperation setting, d'Aspremont and Jacquemin (1988) find that when the spillover effects are large enough, there are more R&D incentives when compared to a non-cooperation situation. Katz (1986) and Reinganum (1981a,b) also attain similar results in the sense that intense product market competition and high technological spillovers induce higher R&D investment incentives under cooperative decision-making. When there are large spillovers, free-riding on the competitors' R&D efforts may become a severe problem, in the sense that in equilibrium firms invest less than the social optimum. Cooperation leads to the internalization of this externality.

The effect of technology overlapping on ex-post cooperation is less studied. Siebert and Von Graevenitz (2010) find that increases in technology blocking (which reflects the proportion of patents owned by each firm that overlaps with patents held by the rival firm) influences R&D incentives in case of ex-post licensing but does not have an effect under ex-ante licensing. In a theoretical model they find that equilibrium R&D investments under ex-post licensing grow as the expectation of blocking decreases. Moreover, in a study in the software industry, Noel and Schankerman (2006) has found out that lower levels of fragmentation can reduce R&D efforts. Their interpretation of this result is that in case of less fragmentation of patent rights, the benefits of having a larger patent portfolio are lower as a tool to resolve disputes. As the need for cooperation increases with the technological overlaps due to higher infringement threats, it might also be the case that cross-licensing agreements will provide a higher net positive impact on innovation as this variable grows. These arguments will be tested via the following hypothesis:

Hypothesis 2.b: As the degree of technological overlap increases, R&D incentives of firms after ex-post cooperation also increase.

Cost of patenting is an important measure affecting the use of patents as a strategic tool. Bessen and Hunt (2007) find evidence that show the increase in patent propensity corresponding to the changes that had an effect on cost effectiveness in patenting. What they mean by this is that firms find it more attractive to patent a higher proportion of inventions because the cost of doing so has declined. They argue that the elimination of the subject matter exclusion and reduction of the non-obviousness and enablement requirements may have made software patents much easier and less costly to obtain.[60] They imply that the decline in cost of patenting that made them cheaper to acquire can decrease the private incentive to engage in R&D. In addition, Hunt (2006) also shows that when technology overlaps are high, incremental reduction in cost of obtaining patent may result in less R&D than would otherwise occur. Considering that, technology spillovers tend to be high in complex product industries, the following hypothesis will be tested by our dataset:

Hypothesis 3.a: A low degree of cost of patenting decreases R&D incentives of firms.

Low cost of patenting is shown as one of the main reasons of strategic patenting. It is argued that firms that increase their patenting for strategic reasons by systematically employing patent portfolios may have the general aim of raising the production costs of their

[60] For the review of the case law that reduces the non-obviousness and enablement requirements of software patents, see Burk and Lemley (2002) and Burk and Lemley (2003). Starting from 1981, *Diamond v.Diehr* (450 US 175, 1981), the Supreme Court clarified the applicability of patent protection for inventions involving software used in industrial processes. In *In re Alappat* (33 F. 3d 1526, 1994), the Federal Circuit held that subject matter limitations did not apply if the software produced "a useful, concrete, and tangible result," even if that result was just on a computer screen.

competitors. Patenting of this kind is not considered to be welfare improving (Hall et al., 2007a). The analysis in the previous chapter has shown that too much patenting as a result of low rates in cost of obtaining patents, may induce lower R&D spending even in existence of a cross-licensing agreement. Finally, we will test this effect in the following hypothesis:

Hypothesis 3.b: As the cost of patenting decreases, R&D incentives of firms after ex-post cooperation also decrease.

4.4. Data Source and Methodology

The data used in this study combine several sources. The first source used is the SDC (Securities Data Company) Platinum database, a well-known data source for empirical studies on strategic alliances and merger and acquisitions (M&As). The reason why this database is so popular (although others are also available, such as MERIT-CATI) is that it is very rich, providing a lot of information on the alliances. The database includes alliances and M&As by firms across all sectors and contains more than 85,000 strategic alliances and 670,000 M&As. SDC Platinum covers the period 1986-2008; however, the coverage of alliance activity in earlier and late years has been less systematic.

Systematic data gathering starts in 1989, whereas after 1999 there is a sudden sharp decrease in the number of deals per year (close to 50%), which continues throughout the following years. This might be due to a decline in corporate reporting requirements or a change in the database identification system. SDC collects information from publicly available sources, such as SEC filings, newswires, press, trade magazines or professional journals. Due to inadequate corporate reporting requirements or a change in the database system, it might be possible that the database does not cover all the deals executed in the relevant time period (although it is certainly much more comprehensive than any available alternative data set). Missing data on deals can cause false negatives (identifying firms which have engaged in a cross-licensing deal in the relevant time period when they actually have not) that can undermine the validity of the findings. To alleviate this potential problem, we focus on the time period from 1990 to 1999, for which the coverage of the database seems reasonably good.

The type of alliances in the database includes deals such as licensing contracts, joint ventures, R&D agreements, marketing agreements, equipment manufacturing or supply agreements, and possible combinations. The information provided on these contracts includes the type of the contract (i.e. joint venture, licensing, marketing, production), the identities of the participants (including the identity of the parent company when the deal is sign by a subsidiary), the Standard Industrial Classifier (SIC code) of the firms, the nationality of the firms, the date of agreement, the status of the deal (i.e. completed, renegotiated, terminated, pending) and even a short synopsis of the text of the contract.

For the purpose of this study, we identified those agreements that involved an exchange of at least one patent. More precisely, we extracted from the database the cross-licensing (CL) and cross-technology transfer (CTT) agreements involving at least one US or Canadian participant and signed during the period 1990-1999. SDC defines CTT (1) as alliances in which more than one participant transfers technology to another participant or to the alliance. In addition, the alliance includes a CL agreement (2) if more than one participant grants a license to another participant. If there is an exchange of patented technologies in these transactions, then SDC marks alliance activity as licensing services. Hence, alliances associated with joint production or marketing objectives, rather than the pooling of R&D resources, are not included in the sample. This restricts the number of observations but enables to focus on mutual technology sourcing strategies.[61] We have chosen to consider only US and Canadian firms in order to eliminate country specific effects due to different IP rights policies in countries so as to obtain a sound comparison between industries. Most Canadian companies have international operations especially in the US, which is a larger consumer market than Canada. Therefore, they extensively seek patent protection in the US and are listed in the US markets.

The methodology employed is similar to Anand and Khanna (2000), who also conducted a cross-industry analysis. The purpose of their study, however, was to identify the determinants of engaging in various types of licensing agreements (e.g. ex-ante vs. ex-post, exclusive vs. non-exclusive or royalty-free vs. royalty based) and focused on a much shorter period (1990-1993). In this study, we focus on a longer time span and are concerned with ex-post cooperative agreements, as our main interest is to investigate the effects of these deals on R&D incentives.

[61] On the other hand, we do not take into account whether or not the technologies in exchange are equal so that compensating royalties are integrated in the agreements. In addition, no distinction is made between current and prospective technology transfers, since a handful of the agreements included a combination of both ex-ante and ex-post transfers. In addition, we do not label for exclusivity clauses, since this variable is more of a concern of one-way technology transfers, which is essentially a market based mode of technology acquisition.

CL and CTT agreements occur in many industries, but the bulk of the arrangements occur where technologies are complex and IP rights are claimed to be fragmented. Chart 4.1 below shows that the majority of the CL and CTT deals happen within intra-industry companies or related industries (apart from chemicals). The intra-industry deals are most frequent in drug/biotechnology and software industries.

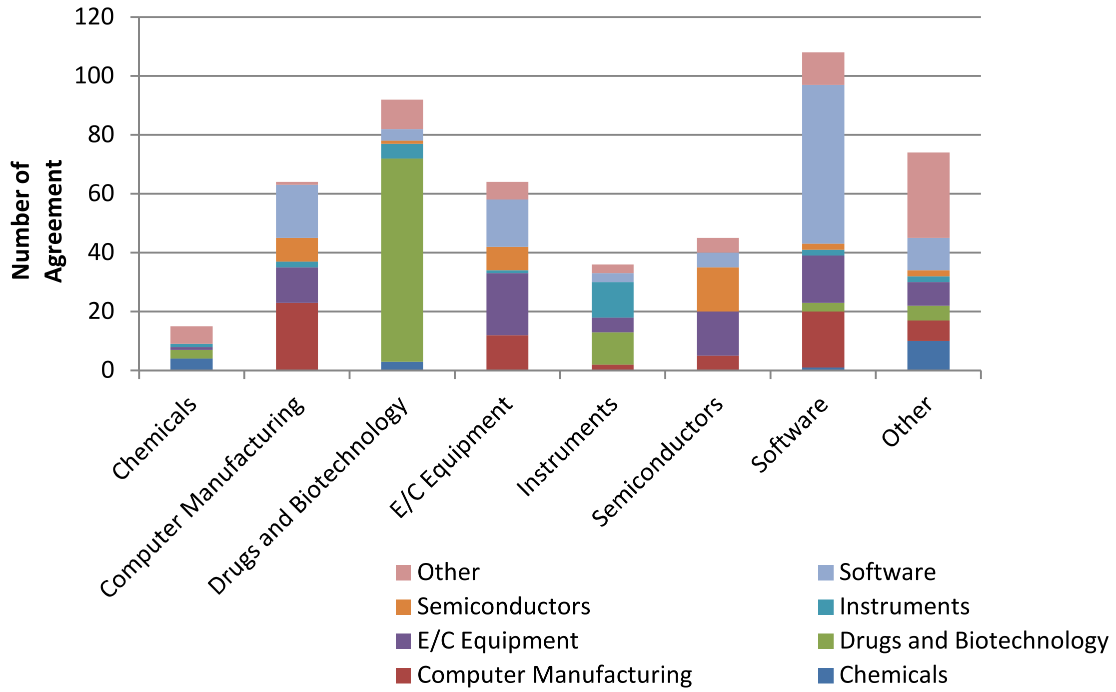


Chart 4.1. From agreements between 1990-1999, involving a maximum of two participants (Source: SDC Platinum)

The analysis includes CL and CTT agreements between two or more parties. The number of deals between 1990-1999 across industries is presented in Table 4.1.

Industry	Number of Deals
Drugs and Biotechnology	129
Chemicals	24
Computer Manufacturing	104
Electronics (except computers)	26
Communication Equipment	49
Semiconductors	68
Instruments	31
Medical Instruments	26
Software	183
Total	**640**

Table 4.1. CL and CTT agreements between 1990-1999 that had at least one US or Canadian participant from the specified industries (Source: SDC Platinum)

The fact that the distribution of the deals is spread among various industries provides an opportunity to investigate whether the purpose of these arrangements differ across sectors, especially considering the effect on R&D investments. A common feature of these sectors is that innovation is cumulative and property rights are fragmented. However, there is still significant difference in the nature of technologies across sectors. For instance, semiconductor and biotechnology research is significantly more specific and specialized compared to other sectors. Therefore in these industries, fragmented property rights restrict the firms' operational capabilities. On the other hand, in electronics and communication equipment and computer manufacturing, research can be much more general as products in these industries require integration of different components. The fierce competition in providing a variety and differentiated products combined with short product life cycles requires firms to innovate as quickly as possible in order to meet the needs of demand. Software research, on the other hand, is relatively cheaper and less uncertain than all the other sectors, to the point that there is much controversy on whether patent protection is actually even necessary in this field or not. However, the nature of innovation is highly cumulative; therefore access to other knowledge is important for further development. Hence, the cross-industry study can point out what dynamics are more prevalent in different sectors.

The identification of the firms which have been engaged in any sort of technology transfer agreement as defined above points out that the bulk of the contracts are signed in the following SIC codes: SIC 283 and 8731-drug and biotechnology, 28 except 283-chemicals, SIC 357- computers, SIC 35 except 357, SIC 366 and 481-communication equipment, SIC 3674-semiconductors, SIC 36 except 366 and 3674-electronics, SIC 384-medical instruments, SIC 38 except 384-instruments, SIC 73-software.[62] The chemical sector is excluded from the analysis since, according to our criteria; it may not be considered as a complex product industry. In any case, since the deals in this sector constitute a small portion of the total agreements signed, its exclusion should not significantly alter the conclusions. Due to industry similarities, electronics and communication plus instruments and medical instruments are combined into a single sector.

One of our aims is to compare the characteristics of firms that engage in ex-post cooperative agreements with other firms conducting R&D. To create the universe of firms doing R&D, the Wharton Research Data Services' (WRDS) access to Compustat North America is used. This allowed us to extract all the firms with the specified SIC codes from Compustat North

[62] Detailed 4-digit SIC Codes are in the appendix (Source: SDC Platinum).

America, which is a database providing fundamental and market information on more than 24,000 active and inactive US and Canadian publicly held companies for the years ***1990-2002***.[63] The selection of this time period is based on our decision to investigate the R&D spending of a firm throughout the three years following the agreement signed. Among the companies publicly traded, only firms that reported uninterrupted series of necessary information are included in the sample. There are *3710* such firms, and *263* of them are in the list of firms engaging in CTT or CL at some point during the time period *1990–1999.*

Since one of our aims is to measure the impact of ex-post cooperation on R&D spending, firms with no R&D data and firms that are detected to be engaged in a merger during that period are excluded from the sample. Firm specific information, such as R&D expenses, sales, cost of goods sold, plant, property and equipment and number of employees are extracted on an annual basis from Compustat. The firm-year serves as the unit of analysis because the dependent variable is defined at firm level. This data is deflated using (2005) US dollars to ensure standardization within the sample. For Canadian firms, the 2005 Canadian deflator is used and it is then multiplied with appropriate average yearly exchange rate.[64]

The patent information is gathered from the National Bureau of Economic Research (NBER) database. Identifying all patents held by each firm has its own challenges. A parent firm may register a patent under its own name or under the name of one of its subsidiaries. The parent firm's name itself may also be registered by using different formats. The fact that subsidiaries can be bought and sold makes matching the patent data of the parent firm even more difficult. Hall, Jaffe and Trajtenberg (2005) matched patent assignees to the parent firm for patents granted during the period of 1963-2006. The resulting database is known as the NBER patent database. The database matches all the possible name formats into a single code, one of which is the CUSIP code of the firm. The data collected from this database are number of yearly patent applications, number of backward citations and number of claims of those patents.

[63] The name changes of companies are identified from CRSP/COMPUSTAT Merged Database that allows for concurrent database access to CRSP's stock data and Compustat's fundamental data. The CRSP Link maps many-to-many relationships over time between CRSP's unique permanent identifiers (PERMNO and PERMCO), and Compustat's unique permanent identifier (GVKEY), which enables a flawless time series examination of CRSP and of Compustat companies, regardless of CUSIP or ticker changes. This method serves well since Compustat restores information only with the current version of the company name. As a result, using only Compustat firms for the construction of the control variables many not be enough since the firm in the SDC database might possess a different current name than in Compustat. The parent firms of the participants of the agreement are excluded if they are already a participant.

[64] A full list of the sample firms is available from the author.

In order to maintain consistency, reliability, and comparability, the analysis uses US patent data for all firms, including the foreign firms that are publicly available in the US stock market in the sample. This is necessary as patenting systems differ across nations in their application of patentability standards, system of granting patents, and extent of protection provided. The United States represents one of the largest markets for complex product industries, and typically firms which commercialize their inventions in the US also patent there. In addition, studies by Dosi et al. (1990) and Basberg (1983) show empirically that US patent data provide a good measure of foreign firms' innovativeness. Prior research using patent data on international samples has also followed this strategy of using US patent data for international firms (e.g., Stuart and Podolny, 1996; Patel and Pavitt, 1997).

Among the list gathered from the Compustat as described above, the firms that have patenting activity in the NBER database are included in the final sample. The final industry distribution of the sample is presented below in Table 4.2:

Industry	**Number of Firms**
Computer Manufacturing	36
Drugs and Biotechnology	64
Electronics or Communication Equipment	32
Instruments (inc. Medical)	29
Semiconductors	32
Software	52
Total	**245**

Table 4.2. Industry distribution of the final sample

In the end, ***1167*** firms are left as a comparison group as these firms have not exchanged licenses during the defined time period ***1990-1999.*** The reason for the decline in the overall number of firms in the sample is due to the matching with the NBER database. This means firms with no patent information were also excluded from the final sample.

4.5. Variables

To test whether ex-post cooperative agreements have an impact on innovation incentives, the logarithm yearly R&D expenditure (log R&D) is used as the *dependent variable* of this study. This information is collected from the Compustat Annual income statement section under the name R&D expense. The *independent variables* in the analysis are (logarithm of) patent stock, non-self backward citations stock/ patent stock, number of claims stock/patent stock, plus sector dummies and a dummy on whether a firm is a cross-licensing firm (that includes both CTT and CL deals) or not (*cl*).[65]

Patent portfolio size affects the bargaining power of firms in cross-licensing agreements. Studies have identified using patents as bargaining chips in negotiations as one of the important motivations for patenting (e.g. Hall and Ziedonis, 2001; Blind et al., 2009). As the bargaining power affects the outcome of these arrangements, patent portfolio size has an impact on their future R&D decisions. Since the stock of patents and their strength cannot be measured directly from the firm's yearly patent applications, proxies are obtained from current and past flows of patent applications and patent-related variables. The grant of a patent can take a couple of years after application, which creates lags between its relationships with R&D spending. For that reason, following the common approach in the literature, patent application dates are used instead of patent grant dates.

Patent stocks (PS) are obtained using a declining balance formula and the past history of patent applications (Hall et al., 2007b):

$$(1) \qquad PS_t = PA_t + (1-\delta)PS_{t-1}$$

In the above equation, *PA* represents the number of applications in year *t,* and δ is the depreciation rate. Similar to earlier work in the literature, a usual 15% depreciation rate is chosen. The initial available patent counts are not discounted to obtain the initial patent stock because USPTO patents data starts in 1976, and no systematic data is collected before that date.

The cumulative nature of innovation prompts firms to enter into cross-licensing or patent pool agreements to minimize transaction costs and mitigate the risk of infringement. In principle, product complexity is also associated with cumulativeness of inventions, defined as the degree to which current innovations rely on previous innovations, as new complex products are likely to build upon previous several or complementary innovations. This results in many citation links among patents.[66] Among these citation links, the ones which refer to previously

[65] The dummy *cl* includes firms which were identified both as CL and CTT from SDC Platinum.

[66] On the other hand, some scholars indicate that cumulativeness is not necessarily an indicator of a high IP rights fragmentation as it is in the case of complexity. Complexity shows to what extent a firms inventions fall into different technological classes. For finding the potential technology spillovers from R&D, a standard approach was introduced by Jaffe (1986). He measures the technological proximity between firms as the un-centered correlation coefficient between their patent distributions across patent classes and then calculating spillovers as a weighted sum of R&D by other firms using this measure. Noel and Schankerman (2006) develop a similar measure by using distribution of a firm's backward patent citations across different patent classes instead of distribution of patenting by each firm. In addition, to measure the patent thicket effect, they construct a

granted patents by other firms increases the likelihood of overlapping claims. Backward citations, i.e., citations of 'prior art' that is relevant to a patent, serve an important legal function, since they limit the scope of the property rights awarded to the patent. Thus, if patent B cites patent A, it implies that patent A represents a piece of previously existing knowledge upon which patent B builds, and over which B cannot have a claim. Citations to other patents (non-self citations) then can be considered as evidence of spillovers or knowledge flows between patented inventions. Sørensen and Stuart (2000) have found that as firms age they become more likely to produce self-citing patents than non-self citing patents. They connect this finding to the fact that mature firms rely less on environmental fit which is interpreted as the interest of other producers to the organization's new technologies. In other words, they consider non-self backward citations also as an indicator of technology spillovers. Lanjouw and Schankerman (2001) also acknowledge that non-self-backward citations, which show the presence of others working in a similar area, will most likely produce technology spillovers.[67]

The stock of backward citations (BCS) in year *t* is calculated in a similar fashion to patent stock. This value is then divided by the patent stock in year *t*. The ratio BCS_t/PS_t can be taken as a measure of the average degree of technological overlap of the patent portfolio with previous patents held by others. Firms that score high in this ratio probably have a patent portfolio that is like those of other firms.

One issue is that the data for early patents suffer from truncation problems (checking the data, there are many zero backward citation counts until the year 1989) due to the fact that the NBER only takes into account patents granted since 1976. Fortunately, since the analysis uses the data of 1990s, the effect of these early patents is limited and therefore the issue is ignored.

A similar proxy is calculated using the total number of claims of the patent applications (CS) made in year *t*. Finding an exact measure for cost of patenting is not easy; nevertheless, previous studies have shown that the number of claims of a patent can be an indicator of cost of patenting. Van Pottelsberghe de la Potterie and François (2009), in a study observing the US, EU and Japanese patents systems, have found that cost of patenting is negatively related with the average number of claims of the total patents granted. They decompose cost of patenting into four components which are: (1) process costs: composed of procedural fees

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concentration index of the degree to which patents cited by firm (non-self backward citations) are held by relatively few firms.

[67] Lanjouw and Schankerman (2001) also acknowledge the possibility that large numbers of citations to others can suggests that the particular innovation is likely to be more derivative in nature.

(filing fees, search, examination, country designation, grant fees and validation fees); (2) translation costs: consist of translation services often provided by patent attorneys; depends on the number of pages of the patent specification and the geographical scope of protection; (3) external expenses: consist of service costs associated with the writing of the patent and the filing to a patent office[68]; and (4) maintaining costs: which are renewal fees to keep the patent valid during a maximum period of 20 years. Larger patents that are known to have more claims tend to be more expensive in terms of both translation and external cost. In addition, if the patent aims to have a wider geographical coverage, voluminous patents in terms of number of claims can have higher procedural fees. Based on this literature, we take the average number of claims of the patent applications made in year t (CS_t/PS_t), as a proxy for cost of patenting in a given year.

The nature of the innovation can fundamentally diverge on such grounds as the average cost of R&D projects, the speed of innovation, the uncertainty in R&D, the difficulty of innovation (technological opportunity), and the degree of research spillovers. For instance, semiconductor R&D projects are typically much more expensive than software R&D investments. Biotechnological innovations usually take longer than other research projects as they are subject to many safety and health regulations, as well as to rigorous testing. Uncertainty in R&D is high in almost every sector, apart from software. Due to the cumulative nature of innovation research spillovers are much larger in semiconductors and software industry. On the other hand, the cost of imitation is extremely low in semiconductors. In software, it is not as low as one might think, due to rules governing reverse engineering. In addition, given the complex nature of innovation, each stage of the patent process can also differ significantly depending on particular industry circumstances. As a result, firms might use different strategies in deciding to seek protection, obtaining a patent, setting the scope of the patent, deciding to enforce it and determining litigation outcomes (Burk and Lemley, 2003). Such heterogeneity may also contribute to creating differences among different industries and we aim to capture these industry-specific effects by incorporating industry dummies into the analysis.

Finally, a set of annually updated firm level variables are included in the analysis as *control variables*. Specifically, the firm-level controls we use are: firm size (measured by logarithm of number of employees), firm capital intensity (measured by the logarithm of gross value of

[68] The costs of these services include the expenses associated with all actions implemented for a patent: filings, payment of fees, monitoring translations and procedural actions (time spent in oral or written communication with the patent office).

plants, and property and equipment divided by number of employees). In addition, in order to pick up demand shocks, the annually updated logarithm of sales or cost of goods sold lagged by one year relative to the dependent variable are also included in the model. Any remaining time trend and inter-firm heterogeneity are controlled with year dummy indicators and firm fixed effects.

4.6. Analysis

Table 4.3 provides descriptive statistics of the sample.

Table 4.3. Descriptive Statistics for Sampled Firms During 1990-2002

Variable	N	Mean	SD
log R&D $_{t}$	14,086	1.859	2.127
log Employment $_{t}$	14,188	5.305	2.066
log PS $_{t-1}$	10,751	1.615	1.968
log BCS/PS $_{t-1}$	9,413	1.941	0.906
log CS/PS $_{t-1}$	10,751	2.761	0.552
log COGS $_{t-1}$	12,455	3.244	2.282
log Sales $_{t-1}$	12,359	3.699	2.592
log PPE/Employment	13,296	1.626	0.500
Dummy Elec.& Comm. Equipment	14,188	0.157	0.364
Dummy Instruments (inc. Medical)	14,188	0.266	0.442
Dummy Drugs & Biotechnology	14,188	0.250	0.433
Dummy Computer Manufacturing	14,188	0.098	0.297
Dummy Software	14,188	0.149	0.357
Dummy Semiconductors	14,188	0.080	0.271
Dummy Agreement $_{t-1}$	14,188	0.022	0.147
Dummy Agreement $_{t-2}$	14,188	0.022	0.146
Dummy Agreement $_{t-3}$	14,188	0.021	0.142
Dummy Cross-licensing Firm	14,188	0.190	0.392

An initial look at the data reveals that the total R&D spending of firms which have engaged in ex-post cooperation is higher than in the comparison group, which includes the firms that have not engaged in such deals.

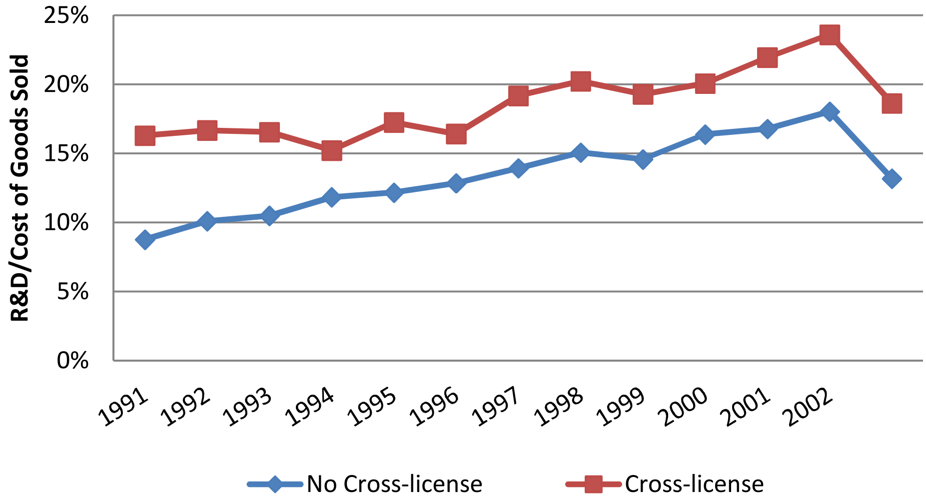

Chart 4.2. Yearly R&D efficiency of cross-licensing firms and the comparison group

4.6.1. The Effect of Cross-licensing Agreements

We now want to determine whether this preliminary observation survives a closer analysis of the data. The empirical specification below is used to test whether there is any impact of ex-post cooperative agreements on upcoming R&D spending.

(2) $\log R\&D_{it} = \beta_0 + \beta_1 A_{it-1} + \beta_2 A_{it-2} + \beta_3 A_{it-3} + \beta_4 D_{SIC^*} A_{it-1} + \beta_5 D_{SIC^*} A_{it-2} + \beta_6 D_{SIC^*} A_{it-3} + \beta_8 X'_{it-1} + \beta_9 Z'_{it-1} + \epsilon_{it}$

A_{it} refers to a dummy variable, which is coded as 1 if an agreement is signed, and 0 if otherwise in year *t*. X_{it} refers to the independent variables: (logarithm of) patent stock, non-self backward citations stock/ patent stock, number of claims stock/patent stock, plus sector dummies and a dummy on whether a firm is a cross-licensing firm or not (*cl*). Z_{it} refers to control variables as described above. Since the impact of the agreements is likely to be felt over a number of years, we use a distributed lag model (Judge et al., 1988). To capture the lag effects, the effects of the first, second and third periods of the agreement are included as covariates in the model. Thus, the distributed lag model tests the impact of the agreement for up to 3 years after the year the agreement is originally signed. For instance, the model assumes that the R&D performance of a firm in year 1995 is potentially influenced by the agreement signed in 1994, 1993, and 1992. This lag structure allows us to observe the effect on R&D spending at different time periods. For example, if the agreement contributes to the first 2 years of R&D but does not lead to further improvement afterward, the 1 and 2 year lagged variables will be positive while the rest will be insignificant. The interaction between the sector dummy and the lags of agreement dummy aims to capture whether there is a sector specific trend of the impact of *cl* on R&D incentives.

4.6.2. The Effect of Technology Overlap and Cost of Patenting

To test the impact of technology overlapping and cost patent portfolios, the following model is used:

$$(3) \quad \log R\&D_{it} = \beta_0 + \beta_1 A_{it-1} + \beta_2 A_{it-2} + \beta_3 A_{it-3} + \beta_4 BCS/PS_{it-1} * A_{it-1} + \beta_4 BCS/PS_{it-1} * A_{it-2} + \beta_4 BCS/PS_{it-1} * A_{it-3} + \beta_4 CS/PS_{it-1} * A_{it-1} + \beta_4 CS/PS_{it-1} * A_{it-2} + \beta_4 CS/PS_{it-1} * A_{it-3} + \beta_8 X'_{it-1} + \beta_9 Z'_{it-1} + \epsilon_{it}$$

The meaning of the variables is as stated previously. This time, instead of the interaction between the industry codes and the agreement dummy, we look at the interaction between technology overlap and cost of patenting indices. The distributed lag effect is also used here by incorporating an interaction between the agreement dummy and one year lagged BCS and CS ratios ($BCS/PS_{it-1} * A_{it-1,2,3}$ and $CS/PS_{it-1} * A_{it-1,2,3}$ respectively). As stated above, the model measures to what extent the previous year's degree of technological overlap and cost of patenting affects the impact of the agreement signed for instance in 1994, 1993, and 1992 on the R&D performance of a firm for the year 1995.

An alternative specification is that the total impact of the agreement is distributed over several periods and may not be statically specific to a certain period. In order to calculate this average total impact, a dummy variable is created; taking the value 1 for the following three years after the agreement is signed. In other words, the impact of the agreement is assumed to be distributed over the upcoming three years.

$$(4) \quad \log R\&D_{it} = \beta_0 + \beta_1 A_{it-3'} + \beta_4 BCS/PS_{it-1} * A_{it-3'} + \beta_4 CS/PS_{it-1} * A_{it-3'} + \beta_8 X'_{it-1} + \beta_9 Z'_{it-1} + \epsilon_{it}$$

4.7. Results

The log linear models are tested using panel data regression that may allow for either fixed effects or random effects. Fixed effect models control for unobserved heterogeneity in the form of time-invariant variables. The inclusion of firm fixed effect explains within firm variation in R&D spending over time rather than inter firm variation. Moreover, since the firms' industry affiliations do not change over-time, a fixed-effect estimate will cause the industry dummy variables to drop out along with the firm effects.

Random effects estimators are used to check the variation between observations, as these estimators can be written as the weighted average of between and within estimator. The random effect model lumps unobserved heterogeneity of observations into the composite error term. Therefore, if the unobserved heterogeneity is correlated with the regressors, then the regressors might be correlated with the error term, which violates the consistency of estimators.

At any rate, the results show that the differences between the two models are small. This mitigates the concerns about the consistency of both models.[69] The analysis of panel data also raises concerns about auto-correlation of residuals, which may deflate standard errors and inflate significance levels. To overcome this bias, robust standard errors are used.[70]

4.7.1. Results from the Fixed Effect Estimation

The fixed effect model in Table 4.4 (column 1) shows a significant positive effect of the deal signed in the previous year on R&D spending of the current year ($\beta=0.082$, $p<0.01$). However, there seems to be no significant effect of the deals signed in earlier years. In addition, if we look at the average total fixed effects shown in Table 4.5 in column 3, we continue to observe a slightly less but still positive effect of the agreement ($\beta=0.052$, $p<0.05$). This provides some evidence for Hypothesis 1.b using equation (2). On the other hand, in the regression given in Table 4.5 column 1, we observe that the signs of the coefficients of the agreement dummies are positive; however, they are not significant.

The model predicting the pooled industry fixed effects in Table 4.4 column 2 reveals that in electronics and communication equipment, the agreements signed in all the previous 3 years have a positive and significant effect on R&D ($\beta_1=0.334$, $p<0.01$, $\beta_2=0.179$, $p<0.05$, $\beta_3=0.245$, $p<0.01$). For the software industry, the same is true for the previous 2 years only ($\beta_1=0.155$, $p<0.05$, $\beta_2=0.108$, $p<0.05$). Lastly, we observe a positive impact in computer manufacturing for the agreements signed only 3 years before the current time ($\beta_3=0.174$, $p<0.05$). Surprisingly, we do not observe a significant effect of cross-licensing deals in drugs and biotechnology, instruments as well as semiconductors, and the sign of the coefficients appear negative.

[69] Nevertheless, the Hausman tests implemented for the empirical specifications reveal that fixed effects techniques are more suitable for the models.

[70] In order to control for correlation between current and lagged values of R&D spending, Arellano-Bond (1991) dynamic specification using GMM estimator has also be implemented to the models. Although similar coefficients have been attained, the results were less significant than the static models.

Table 4.4. Effect of the Cross-licensing Agreement (Equation (2))

Dependent Variable: log R&D $_t$	**(1)Deal Effect Fixed Effects**	**(2)Pooled Effect Fixed Effects**	**(3)Deal Effect Random Effects**	**(4)Pooled Effect Random Effects**
Intercept	-2.852*** (0.221)	-2.852*** (0.221)	-3.098*** (0.215)	-3.095*** (0.215)
Firm Fixed Effects & Year Dummies	included	included	included	included
Sector Dummies	included	included	included	included
log PS $_{t-1}$	0.086*** (0.010)	0.086*** (0.010)	0.117*** (0.009)	0.117*** (0.009)
log BCS/PS $_{t-1}$	0.066*** (0.017)	0.067*** (0.017)	0.053*** (0.015)	0.053*** (0.015)
log CS/PS $_{t-1}$	-0.041† (0.023)	-0.039† (0.022)	-0.021 (0.021)	-0.020 (0.021)
log Employment $_t$	0.671*** (0.027)	0.670*** (0.027)	0.665*** (0.024)	0.664*** (0.021)
log PPE/Employment $_t$	0.096 (0.059)	0.096 (0.059)	0.101† (0.053)	0.101† (0.053)
log Sales $_{t-1}$	0.030** (0.011)	0.031** (0.011)	0.032** (0.010)	0.032** (0.010)
log COGS $_{t-1}$	0.134*** (0.014)	0.134*** (0.014)	0.159*** (0.013)	0.158*** (0.013)
Dummy Cross-licensing Firm			0.642*** (0.081)	0.642*** (0.081)
Dummy Agreement $_{t-1}$	0.082** (0.032)		0.085** (0.032)	
Dummy Agreement $_{t-2}$	0.039 (0.038)		0.036 (0.037)	
Dummy Agreement $_{t-3}$	0.033 (0.033)		0.029 (0.033)	
Dummy Agreement $_{t-1}$ x Elec. & Comm. Equipment		0.334** (0.109)		0.332** (0.103)
Dummy Agreement $_{t-1}$ x Instruments (inc. Medical)		0.140 (0.012)		0.131 (0.109)
Dummy Agreement $_{t-1}$ x Drugs and Biotechnology		-0.050 (0.053)		-0.046 (0.044)
Dummy Agreement $_{t-1}$ x Semiconductors		-0.042 (0.057)		-0.042 (0.055)
Dummy Agreement $_{t-1}$ x Software		0.155* (0.073)		0.155* (0.083)
Dummy Agreement $_{t-1}$ x Computer Manufacturing		0.079 (0.077)		0.093 (0.072)
Dummy Agreement $_{t-2}$ x Elec.& Comm. Equipment		0.179* (0.077)		0.176* (0.078)
Dummy Agreement $_{t-2}$ x Instruments (inc. Medical)		-0.174 (0.242)		-0.177 (0.229)
Dummy Agreement $_{t-2}$ x Drugs & Biotechnology		0.011 (0.067)		0.006 (0.062)
Dummy Agreement $_{t-2}$ x Semiconductors		0.033 (0.078)		0.027 (0.076)
Dummy Agreement $_{t-2}$ x Software		0.108* (0.054)		0.098† (0.055)
Dummy Agreement $_{t-2}$ x Computer Manufacturing		0.039 (0.078)		0.049 (0.074)
Dummy Agreement $_{t-3}$ x Elec. & Comm. Equipment		0.245** (0.083)		0.250** (0.085)
Dummy Agreement $_{t-3}$ x Instruments (inc. Medical)		-0.075 (0.075)		-0.076 (0.068)
Dummy Agreement $_{t-3}$ x Drugs and Biotechnology		-0.099 (0.072)		-0.102 (0.075)
Dummy Agreement $_{t-3}$ x Semiconductors		0.044 (0.065)		0.042 (0.064)
Dummy Agreement $_{t-3}$ x Software		0.002 (0.079)		-0.004 (0.082)
Dummy Agreement $_{t-3}$ x Computer Manufacturing		0.174* (0.079)		0.172** (0.077)

$^{\dagger}p<0.1$; $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$, Standard errors in parentheses.

Table 4.5. Effect of Technology Overlapping and Cost of Patenting (Equation (3) and (4))

Dependent Variable log R&D $_t$	**(1)Fixed Effects**	**(2)Random Effects**	**(3)Fixed Effects**	**(4)Random Effects**	**(5)Fixed Effects**	**(6)Random Effects**
Intercept	-2.849*** (0.222)	-3.258*** (0.216)	-2.284*** (0.221)	-3.096*** (0.215)	-2.284*** (0.221)	-3.098*** (0.215)
Firm Fixed Effects & Year Dummies	included	included	included	included	included	included
Sector Dummies	included	included	included	included	included	included
log PS $_{t-1}$	0.085*** (0.010)	0.117*** (0.009)	0.085*** (0.010)	0.117*** (0.009)	0.085*** (0.010)	0.117*** (0.009)
log BCS/PS $_{t-1}$	0.064*** (0.017)	0.050** (0.015)	0.067*** (0.017)	0.053*** (0.015)	0.064*** (0.017)	0.051** (0.015)
log CS/PS $_{t-1}$	-0.041† (0.023)	-0.019 (0.021)	-0.040† (0.023)	-0.021 (0.021)	-0.039† (0.023)	-0.018 (0.021)
log Employment $_t$	0.671*** (0.027)	0.664*** (0.024)	0.671*** (0.027)	0.664*** (0.024)	0.670*** (0.027)	0.664*** (0.024)
log PPE/Employment $_t$	0.096 (0.106)	0.100† (0.053)	0.096 (0.059)	0.101 (0.053)	0.096 (0.059)	0.100† (0.053)
log Sales $_{t-1}$	0.030** (0.011)	0.032** (0.010)	0.030** (0.011)	0.032** (0.010)	0.031** (0.011)	0.032** (0.010)
log COGS $_{t-1}$	0.135*** (0.014)	0.159*** (0.013)	0.134** (0.014)	0.159*** (0.013)	0.134*** (0.014)	0.159*** (0.013)
Dummy Cross-licensing Firm		0.664*** (0.081)		0.645*** (0.081)		0.645*** (0.081)
Dummy Agreement $_{t-1}$	0.006 (0.283)	0.007 (0.200)				
Dummy Agreement $_{t-2}$	0.145 (0.668)	-0.054 (0.305)				
Dummy Agreement $_{t-3}$	0.517 (0.366)	0.604 (0.421)				
Dummy Agreement $_{t-1}$ x log BCS/PS $_{t-1}$	0.031 (0.037)	0.025 (0.036)				
Dummy Agreement $_{t-2}$ x log BCS/PS $_{t-1}$	0.010 (0.045)	0.006 (0.045)				
Dummy Agreement $_{t-3}$ x log BCS/PS $_{t-1}$	0.111** (0.038)	0.103** (0.040)				
Dummy Agreement $_{t-1}$ x log CS/PS $_{t-1}$	0.029 (0.084)	0.010 (0.071)				
Dummy Agreement $_{t-2}$ x log CS/PS $_{t-1}$	0.055 (0.127)	0.026 (0.115)				
Dummy Agreement $_{t-3}$ x log CS/PS $_{t-1}$	-0.244† (0.135)	-0.270† (0.155)				
Dummy Agreement $_{t-3'}$ effects			0.052* (0.025)	0.046† (0.024)	0.021 (0.155)	0.123 (0.156)
Dummy Agreement $_{t-3'}$ effects x log BCS/PS $_{t-1}$					0.057† (0.029)	0.050† (0.029)
Dummy Agreement $_{t-3'}$ effects x log CS/PS $_{t-1}$					-0.027 (0.057)	-0.060 (0.058)

$^{†}p<0.1$; $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$, Standard errors in parentheses.

In Table 4.4 column 1, it is also possible to comment on what factors affect R&D spending in general. For instance, the patent stock of the previous year has a positive impact on R&D expenditures ($\beta=0.086$, $p<0.001$). In addition, the technology overlapping of one's own patent portfolio with others have a positive impact on R&D spending ($\beta=0.066$, $p<0.001$). On the other hand, as the average number claims in the patent portfolio increases, we observe a negative impact on firm R&D spending ($\beta=-0.041$, $p<0.1$). Therefore, we find supporting evidence for Hypothesis 2.a and 3.a.

As far as Hypothesis 2.b is concerned, the fixed effects model in Table 4.5 column 1, which uses the specification in equation (3), suggests that the effect of the agreement signed 3 years in advance has a greater positive impact on current R&D spending if the technology overlapping in the previous year is higher ($\beta_3=0.111$, $p<0.01$). Whereas, the opposite is true for the average claims of the portfolio stock, which is taken as a proxy for cost of patenting, indicating that the effect of the agreement signed 3 years in advance has a greater negative impact on current R&D spending if cost of patenting is lower, suggesting some evidence for Hypothesis 3.b. ($\beta_3=-0.244$, $p<0.1$).

In addition, regarding Hypothesis 2.b., using equation (4), the fixed effect model in column 5 of Table 4.5 shows, considering the average total effect of the agreements, that it is possible to observe a significant positive impact of overlapping technologies on following R&D expenditures ($\beta=0.057$, $p<0.1$). Lastly, there is no significant evidence on the impact of the cost of the patent portfolio on R&D spending after an ex-post cooperative agreement is signed; therefore, using this specification, we fail to provide evidence for Hypothesis 3.b.

4.7.2. Results from the Random Effects Estimation

In Table 4.4 columns 3 and 4, the random effects estimation shows that firms which have been engaged in a cross-licensing deal over 1990-1999 have spent on average 64.2% more on R&D than firms which have not (significant at $p<0.001$). However, since firms are engaged in a variety of activities such as in-house R&D, joint ventures or research agreements apart from ex-post cooperation, it is unclear whether this difference can be attributed entirely to the impact of cross-licensing deals. In addition, it might also be the case that the firms which are able to enter in such deals have a higher level of R&D intensity than the industry average. Nevertheless, we find supporting evidence for Hypothesis 1.a using equation (2).

The model predicting the pooled industry random effects in Table 4.4 column 4 presents almost the same results as the fixed effects estimation. Again, in electronics and communication equipment, the agreements signed in all the previous 3 years have a positive and significant effect on R&D (β_1=0.332, p<0.01, β_2=0.176, p<0.05, β_3=0.250, p<0.01). For the software industry, the same is true for the previous 2 years only (β_1=0.155, p<0.05, β_2=0.098, p<0.1). Lastly, a positive impact in computer manufacturing for the agreements signed only 3 years before current time is observed (β_3=0.172, p<0.01). In drugs and biotechnology, instruments and semiconductors, the sign of the coefficients appear negative but they are insignificant.

In Table 4.4 columns 3 and 4, it is observed that the patent stock of the previous year has a positive impact on R&D expenditures (β=0.117, p<0.001). In addition, the technology overlapping of one's own patent portfolio with others have a positive impact on R&D spending (β=0.053, p<0.001). On the other hand, as the average claims in the patent portfolio increases, we continue to observe a negative impact on firm R&D spending but this time the effect is not significant. Therefore, using equation (3), we find supporting evidence for Hypothesis 2.a, yet fail to do so for Hypothesis 3.a in the random effects model.

The random effects model in Table 4.5 column 2 suggests that the effect of the agreement signed 3 years in advance has a greater positive impact on current R&D spending if the technology overlapping in the previous year is higher (β_3=0.103, p<0.01). Still, the opposite is true for the average number of claims of the portfolio stock, indicating that the effect of the agreement signed 3 years in advance has a greater negative impact on current R&D spending if the patent portfolio of the previous year was cheaper to acquire (β_3=-0.270, p<0.1). This indicates some evidence for Hypothesis 2.b and 3.b. respectively using equation (3).

Moreover, the random effects model in column 6 of Table 4.5 shows, considering the average total effect of the agreements (equation (4)), that it is possible to observe a significant positive impact of overlapping technologies on following R&D expenditures (β=0.05, p<0.1); however, as in the case of the fixed effects model, there is no significant evidence on the impact of cost of patent portfolio on R&D spending after an ex-post cooperative agreement is signed. As a result, using this alternative specification, we find supporting evidence for Hypothesis 2.b, but not for Hypothesis 3.

4.8. Discussion: Differentiation of Cross-licensing Agreements and Their Outcomes

The paper investigates whether ex-post cooperative agreements induce additional innovative efforts. Supporting evidence is found of a positive impact on R&D spending following such an agreement. The effect is significant in electronics and communication equipment, software and computer manufacturing, whereas it is non-significant in semiconductors, drugs and biotechnology, and instruments. The reason why the analysis did not provide significant effect on R&D incentives in the instruments industry might be due to the diversity observed in this sector (see Table 4.1.a in the appendix). Here more research is necessary to provide definitive answers. However, as far as the other industries are concerned, a suggestive explanation for this result can stem from the notions of "freedom to design" and "freedom to operate" proposed by Grindley and Teece (1997).

In the electronic and communication equipment industry, innovative products often require the integration of many aspects of computing, telecommunications, software, system design or mechanical engineering. In this framework, maintaining design freedom is perhaps the major reason for ex-post cooperative practices. That is, firms try to ensure that their own technology is not blocked by competitors, and that they have access to outside patents. The same pattern emerges in the computer manufacturing industry, where in this sector different components have to be integrated in the manufacturing of products. IBM, for instance, openly states in its licensing policy guidelines that the main objective is to "ensure the right to manufacture products" (Grindley and Teece, 1997). As the products are composed of complex systems, it may be impossible for any single firm to develop the full range of required technologies. Hence, securing their freedom to design through bilateral or multilateral cross-licensing is essential. In the absence of such freedom, firms might refrain from investing in research and development.

The situation in the semiconductors industry is quite different as IP is an integral and essential part of competition in this industry. In semiconductors, firms have to integrate a huge number of patents into products that might also be coming from related technological areas. Given the rapid technological development and the large number of industry participants, the main purpose of ex-post cooperation is to ensure freedom to operate, by minimizing the probability of infringement. For instance, a typical cross-license includes all patents that licensees may own in a given field-of-use, permitting each other the freedom to infringe existing and future patents for a given period. Such licenses are typically non-exclusive and rarely include any trade-secret or know-how transfer or sublicensing rights. The main difference from the electronic equipments and computer manufacturing industry is that know-how is usually not transferred, as each party is capable of using the technology in question without assistance. Firms usually gain access to the relevant technology either by developing it themselves, or by other means such as reverse engineering, hiring consultants, other technical agreements or publications. Ex-post cooperation primarily provides the right to use the patented technology without being sued for infringement which avoids monitoring costs and adjusts royalty payments of parties in exchange of the right to benefit from the overall IP stock (Grindley and Teece, 1997).

In the biotechnology industry, fragmented property rights are common in the form of blocking patents. Nicol (2010) in a survey conducted on biotechnology firms states the underlying objective in the cross-licensing deals is to ensure freedom to operate, such as the following:

> *'…the commercial production, marketing and use of a product, process or service do not infringe the patent rights of others (so-called 'third party patent rights'). An 'undue burden' exists when the number of 'third party patent rights' are a substantial obstacle on your organization's path to research, product development and/or the provision of (clinical testing) services.'*

The example provided by Nicol (2010) is as follows: A company may have a patent on small interfering RNA (siRNA) product that silence a particular target, whereas another company may have a different one on a method of treating a disease by using siRNA to silence that same target. In this situation, neither company would be free to market a siRNA product to treat that disease without infringing the other's patent, which means the companies have blocking patents (Harlin and O'Connor, 2008). Similar to semiconductors, the know-how of product development is already possessed by companies. What ex-post cooperation achieves is that both companies give up some of their exclusivity rights, so that they can both be able to launch their product without the risk of infringement. This means that at the time an agreement is signed, the products have already been developed, which is perhaps the reason why the risk of infringement is not reflected on R&D incentives.

The software industry is unique in that research is less uncertain and the development process is typically less costly. Inventions are likely to have a fast, cheap and clear-cut development cycle. On the other hand, the innovation process is highly cumulative, and often is the case that a license or more from different companies might be required to develop a code.

However, contrary to what one might imagine, software firms do not have easy access to the relevant codes, due to difficulty of reverse engineering in this industry. Software devices usually require an access to a human-readable source code in order to be understood. In the US, the Federal Circuit does not require software patentees to disclose this implementing source code; and as a result patent specifications of software patents do not disclose much information. In addition, due to the broad definition of infringement in the patent statue, the reverse engineering techniques used in software industry may raise some infringement problems.[71] For instance, reverse engineering of a patented computer program, may fit in one of the broad categories of prohibited conduct, as the decomposition of the program may be regarded as the 'making' of the patented program which might fall under as patent infringement (Burk and Lemley, 2003). Due to the uneasy access of relevant technology development, ex-post cooperation in the software industry provides freedom to design. Design freedom might have a positive impact on firms' R&D expenses, as they are able to conduct the further research that was not possible before an agreement.

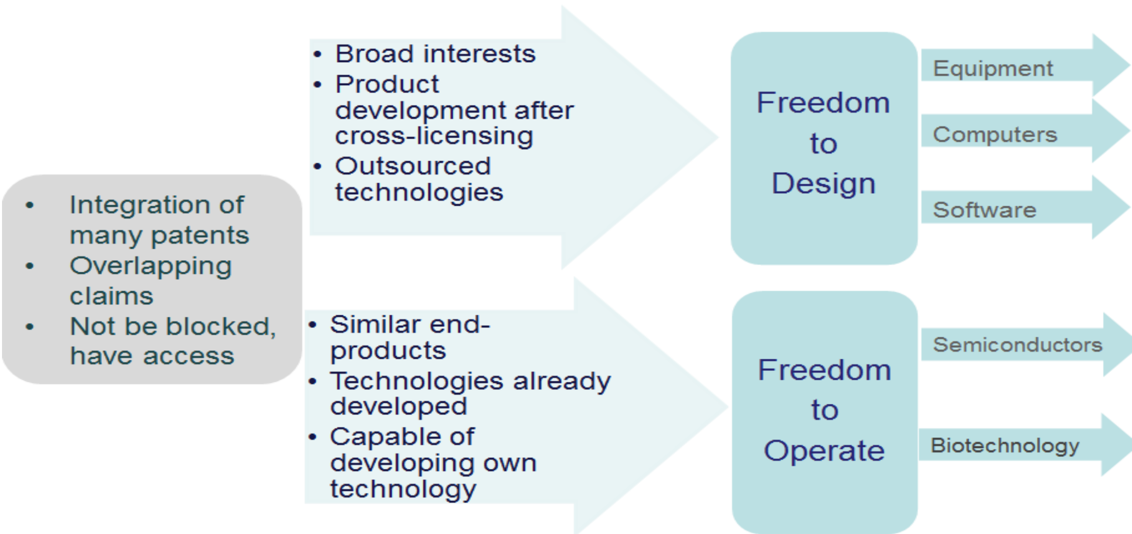

Figure 4.1. Summary of Implications

To sum up, the general distinction between cooperative agreements has been simply ex-ante and ex-post cooperation. The current analysis provides evidence that ex-post cooperation might also be divided into two types according to the objective of the agreement. This distinction is important in evaluating the dynamic aspect of these arrangements. When the aim of the agreement is design freedom, even though the firm has already developed many

[71] 35 USC §271 (a) (2000), it encompassed anyone who "makes, uses, offers to sell, …,sell, …, or imports", as to constitute for patent infringement.

technologies by itself, the development of the final product may still require the assembly of different components, hence cross-licensing enables further technology development. On the other hand, freedom to operate is important when the patent landscape is highly fragmented and it has direct effects on how firms do business. Due to rapid technological change, new patents, even developed independently, can inevitably overlap with previously patented technologies. Cross-licensing or patent pools in this context provide protection against inadvertent infringement and hence greater operational freedom. This might be the intuition why no significant evidence was found regarding increased R&D levels in sectors in which such forces are dominant. However, this result should not undermine the usefulness of these practices as patent litigation, at least in the US, is highly slow and costly.

Our findings can also provide some guidance in the so-called "patent misuse defense", which is occasionally raised in antitrust cases against cross-licensing and patent pool activities.[72] For instance, package license is sometimes viewed by the antitrust authorities as a tying arrangement[73]. At other times, certain restrictions in cross-licensing or patent pools agreements have been considered anticompetitive.[74] This antitrust policy, however, may ignore the fact that these licensing clauses might be required in new competitive order. In what we have called "complex" industries, transaction cost to license individual patents for specific products are too high; therefore licensing occurs on a portfolio basis (Grindley and Teece, 1997).

In addition, antitrust limitations regarding agreements between non-competitors may ignore the fact that the efficiency gains generated by these arrangements can exceed the potential losses due to the restrictive provisions. In general, antitrust guidelines state that these losses can occur due to reduction in competition, facilitation of collusion or increase in barriers to entry. Due to the broad interests of electronics/communication equipment and computer manufacturing industries, it is often possible to observe such cross-licensing or patent pooling agreements between firms which are not direct competitors. Our study suggests that, when investigating these claims, the antitrust authorities should also take into account the positive impact of the agreements on dynamic efficiency. A starting point for such an analysis might

[72] Leaffer (2010) states that patent misuse is designed to limit the anti-competitive effect of patent grants. The doctrine is often used in patent licensing, when the patent owner is accused of improperly expanding the physical and temporal scope of patent grant with an anti-competitive effect. If the alleged infringer can prove that the patent owner has engaged in prohibited conduct, the patent can be rendered as unenforceable despite its validity.

[73] e.g. *In the Matter of Certain Recordable Compact Discs and Rewritable Compact Discs* (337-TA-474, ICT Investigation, 2004)

[74] EU Antitrust (2003), "Commission settles allegations of abuse and clears patent pools in the CD market".

be whether firms are intending to further develop new products or processes after giving each other access to use their patent portfolios. This finding will be further discussed in the following section.

Appendix 4

Table 4.1.a. SIC codes and their description

SIC Code	Description	Number of Deals
Drugs and Biotechnology		**129**
2833	Medicinal Chemicals and Botanical Products	2
2834	Pharmaceutical Preparations	54
2835	In Vitro and In Vivo Diagnostic Substances	16
2836	Biological Products, Except Diagnostic Substances	33
8731	Commercial Physical and Biological Research	24
Chemicals		**24**
2812	Alkalies and Chlorine	1
2819	Industrial Inorganic Chemicals, Not Elsewhere Classified	4
2821	Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers	6
2841	Soap and Other Detergents, Except Specialty Cleaners	1
2844	Perfumes, Cosmetics, and Other Toilet Preparations	1
2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments	3
2869	Industrial Organic Chemicals, Not Elsewhere Classified	1
2873	Nitrogenous Fertilizers	1
2879	Pesticides and Agricultural Chemicals, Not Elsewhere Classified	4
2899	Chemicals and Chemical Preparations, Not Elsewhere Classified	2
Computer Manufacturing		**104**
3571	Electronic Computers	41
3572	Computer Storage Devices	17
3575	Computer Terminals	2
3577	Computer Peripheral Equipment, Not Elsewhere Classified	38
3578	Calculating and Accounting Machines, Except Electronic Computers	5
3579	Office Machines, Not Elsewhere Classified	1
Electronics		**26**
3671	Electron Tubes	1
3672	Printed Circuit Boards	1
3679	Electronic Components, NEC	5
3612	Power, Distribution & Specialty Transformers	1
3625	Relays and Industrial Controls	3
3651	Household Audio & Video Equipment	7
3652	Phonograph Records & Prerecorded Audio Tapes & Disks	1
3691	Storage Battaries	3
3692	Primary Battaries, Dry and Wet	1
3699	Electronic Equipment, Marchinery and Supplies, not elsewhere Classified	3
Communication Equipment		**49**
3661	Telephone & Telegraph Apparatus	14
3663	Radio & TV Broadcasting & Communications Equipment	17
3669	Communications Equipment, NEC	7
4812	Radiotelephone Communications	1
4813	Telephone Communications (No Radiotelephone)	10
Semiconductors		**68**
3674	Semiconductors & Related Devices	68
Instruments		**31**
3812	Search, Detection, Navigation, Guidance, Aeronautical Sys	8
3821	Laboratory Apparatus & Furniture	1
3822	Auto Controls For Regulating Residential & Comml Environments	1
3823	Industrial Instruments For Measurement, Display, and Control	2
3825	Instruments For Meas & Testing of Electricity & Elec Signals	3
3826	Laboratory Analytical Instruments	8
3827	Optical Instruments & Lenses	3
3829	Measuring & Controlling Devices, NEC	2
3861	Photographic Equipment & Supplies	3
Medical Instruments		**26**
3841	Surgical & Medical Instruments & Apparatus	15
3842	Orthopedic, Prosthetic & Surgical Appliances & Supplies	2
3845	Electromedical & Electrotherapeutic Apparatus	9
Software		**183**
7371	Computer Programming Services	31
7372	Prepackaged Software	113
7373	Computer Integrated Systems Design	19
7374	Computer Processing and Data Preparation and Processing Services	1
7375	Information Retrieval Services	13
7376	Computer Facilities Management Services	2
7379	Computer Related Services, Not Elsewhere Classified	4
	TOTAL	**649**

Table 4.2.a. Pair wise Correlations for Sampled Firms During 1990 2002

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	log R&D $_t$	1.000																	
2.	log Employment $_t$	0.589***	1.000																
3.	log PS $_{t-1}$	0.498***	0.305***	1.000															
4.	log BCS/PS $_{t-1}$	0.010***	0.031**	0.042***	1.000														
5.	log CS/PS $_{t-1}$	0.069***	0.004	0.240***	0.273***	1.000													
6.	log COGS $_{t-1}$	0.767***	0.721***	0.390***	0.110***	0.045***	1.000												
7.	log Sales $_{t-1}$	0.723***	0.746***	0.342***	0.071***	0.043***	0.897***	1.000											
8.	log PPE/Employment $_t$	0.572***	0.826***	0.257***	0.032**	0.017†	0.657***	0.707***	1.000										
9.	Dummy Elec.& Comm. Equipment	0.011	0.118***	0.091***	0.026**	0.069***	0.154***	0.146***	0.135***	1.000									
10.	Dummy Instruments (inc. Medical)	0.187***	0.013	0.047***	0.068***	0.055***	0.108***	0.056***	0.043***	0.260***	1.000								
11.	Dummy Drugs & Biotechnology	0.031***	0.216***	0.039***	0.167***	0.034**	0.136***	0.273***	0.248***	0.249***	0.347***	1.000							
12.	Dummy Computer Manufacturing	0.075***	0.075***	0.090***	0.027**	0.034**	0.151***	0.134***	0.100***	0.142***	0.198***	0.190***	1.000						
13.	Dummy Software	0.086***	0.051***	0.088***	0.111***	0.092***	0.046***	0.079***	0.093***	0.181***	0.252***	0.242***	0.137***	1.000					
14	Dummy Semiconductors	0.074***	0.058***	0.148***	0.021*	0.020*	0.078***	0.085***	0.054***	0.127***	0.177***	0.170***	0.096***	0.123***	1.000				
15.	Dummy Agreement $_{t-1}$	0.148***	0.082***	0.131***	0.018†	0.008	0.115***	0.112***	0.058***	0.017*	0.056***	0.006	0.054***	0.024**	0.034***	1.000			
16.	Dummy Agreement $_{t-2}$	0.156***	0.087***	0.143***	0.004	0.019†	0.126***	0.120***	0.072***	0.016†	0.055***	0.006	0.050***	0.024**	0.033***	0.119***	1.000		
17.	Dummy Agreement $_{t-3}$	0.157***	0.091***	0.152***	0.011	0.026**	0.129***	0.128***	0.070***	0.020*	0.053***	0.002	0.044***	0.025**	0.036***	0.076***	0.118***	1.000	
18.	Dummy Cross-licensing Firm	0.346***	0.197***	0.297***	0.032**	0.019*	0.254***	0.253***	0.157***	0.033***	0.161***	0.011	0.070***	0.089***	0.094***	0.311***	0.308***	0.300***	1.000

†p<0.1; *p<0.05; **p<0.01, ***p<0.001

CHAPTER 5. LEGAL FRAMEWORK FOR THE ASSESSMENT OF LICENSING OF TECHNOLOGY TRANSFER AGREEMENTS FOR THE COMPLEX PRODUCT INDUSTRIES

5.1. Introduction

The economic analyses in the previous chapters depicted the relationship between firms' R&D and patenting decisions in complex product industries. Chapter 3 focused on the bargaining process of firms under the threat of litigation due to the overlap between technologies. Two market outcomes in which in the first case firms do not bargain and in the second case firms cross-license are compared. It is found that cross-licensing decreases excessive patenting which can instead result in more R&D for both firms. An important question in the model is how the legal attitude affects firms' bargaining procedure. The findings show that legal rules should be 'patent friendly' in the sense that infringement probabilities should be high. The model predicts that strong IP rights decrease the uncertainty created by the nature of technology, induce settlements and increase the ex-ante incentives to invest in R&D.

In Chapter 4, firms' ex-post licensing strategies were presented in detail. From cooperative technology transfer agreements that involve licensing of patents, firms' R&D and patenting behavior are analyzed in a wide range of high-technology sectors. Findings in this analysis suggest that the impact of these arrangements on follow-on innovation incentives depends on the underlined dynamics of the industry. Mainly, if product development continues after the agreement, a significant positive impact is observed on firms' R&D incentives. This is an important finding regarding industries that rely on vertically integrated business models, such as electronics and communication equipment and computer manufacturing. A positive significant result is also observed in software industry, in which innovation is highly cumulative. Ex-post cooperative licensing in this sector enables firms to develop new codes on existing ones, which are not readily available to competitors due to restrictions on reverse engineering. As a result, firms depend on each other's patents for further code development. On the other hand, in semiconductors and biotechnology sectors, prior to ex-post cooperation, the development of the technologies is most of the time already completed. For that reason, evidence does not point out a significant positive impact on R&D incentives. Contrary to vertically integrated firms which have broad interests, semiconductors and biotechnology firms are capable of developing their own end-products, and a cross-licensing agreement provides extra freedom to carry out their operations without the threat of litigation. This may be the reason why in these sectors no significant evidence was found in terms of increased R&D incentives after a cooperative agreement.

Given the findings of the analytical chapters, this section explores the legal attitude towards the practices that emerged in these industries. Due to the close relationship between competition and innovation, innovation markets have been under the scrutiny of antitrust agencies. Besides patent enforcement rules, patent licensing is also regulated under competition rules; therefore, the regulatory approach followed by these agencies has an impact on innovation incentives. In the first part of this chapter, after laying out the legal framework that organizes firm behavior, namely licensing, a discussion follows on whether the current rules can adequately address the dynamics in these industries, which are described in the previous chapters. Licensing practices are regulated by antitrust guidelines in the US and a block exemption on technology transfers and accompanying guidelines in the EU. The comparison of the US and EU rules indicates that, the US rules are more sensitive towards the specific requirements in vertically integrated sectors, whereas the EU rules, which are under the heavy influence of the common market objectives, can overlook some legitimate practices that have emerged in these industries.

Regarding the treatment of cross-licensing, both jurisdictions acknowledge the benefits of these practices and have produced a favorable legal setting which induces their use. On the other hand, some divergence is observed with regards to the treatment of patent pools. In the US, patent cross-licenses and pools are treated under one set of guidelines. Whereas in the EU approach, a distinction is made between bilateral and multi-lateral agreements, in which the former can be subject to a block exemption, while the latter is analyzed under a rule of reason approach. Moreover, the essentiality standards of patents that are gathered in the patent pool are stricter in the EU compared to the US. The distinction also becomes visible in the two jurisdictions regarding the application of patent misuse doctrine applied in the context of portfolio licensing. The EU approach can be beneficial in terms of deterring potential patent disputes; however, it still raises questions with regard to the dynamic benefits of package licensing.

The second part of the chapter focuses on the private technical standards set by the standard-setting organizations. The standard-setting process is currently shaping the technology development in complex product industries and blocking patents are usual cases in the standard-setting context. For that reason, the economic findings of the previous chapters can contribute to the recent policy proposal discussions in this area. In high-tech industries multiple firms often own patents that are essential to comply with the product standard, which gives each patent owner the power to block others from making compatible products. In this regard, the objective of the standard-setting bodies is to facilitate participants to license any essential patents to enable the production of compatible products. For instance as Shapiro (2001b) describes, if two companies holding blocking patents would like to manufacture certain standard compatible products, they can do so by cross-licensing each other's blocking patents. From competition policy perspective, this cross-licensing would preferably be on a royalty-free basis. Nevertheless, a cross-license with royalty payments is still more efficient than the case in which the patents holders do not cooperate and are unable to produce new products or processes due to an infringement of others patents. In addition, enabling many other firms to make standard compliant products can also be in the interest of patent holders. In this case, patent owners can form a patent pool under which all the blocking patents are licensed in a coordinated way to firms that wish to use pooled technology (Shapiro, 2001b). That is why cross-licensing and patent pooling activities are often used in industries where standardization activity is intense (Geradin et al., 2008; Blind et al., 2011).

Despite these private market solutions, patent disputes related with a standard have accelerated over the past years. The disputes revolve around patent ambush and royalty stacking cases. In order to prevent such patent disputes, there have been some policy proposals concerning both the patent law and the standard-setting procedural rules. The last part of this chapter focuses on these reform proposals. The discussion does not separate the US and EU rules (apart from the patent reform), as most of the issues discussed are yet only policy proposals that are in the agenda of both jurisdictions.

The analysis of these policy proposals discusses to what extent these reforms take into account the technological and market dynamics of complex product industries. The reason to use this approach is because studies on different high-technology sectors fail to address a significant market failure due to transaction costs and inefficiencies of the modern patent landscape (Ziedonis, 2004; Noel and Schankerman , 2006); Epstein and Kuhlik , 2004; Arora et al., 2003). In addition to that, the evidence provided in Chapter 4 also does not point significant inefficiencies in complex product industries. On the contrary, empirical evidence suggests that to a large extent market-based solutions are capable of overcoming the problems inherent in the new technological areas. Therefore, it is important to assess, if implemented, what kind of costs these changes would entail due to their influence on firm behavior.

It should be noted that the technical standard-setting process is highly affected by the deficiencies in the patent law and the tendency is to solve these problems with competition rules. The existence of IP rules provides market dynamism and rivalry as companies compete to be the first to innovate in order to win the legally granted monopoly position. Meanwhile, competition policy restricts firms that aim at foreclosing the market, prevents others from innovating or pricing unreasonably through anti-competitive agreements or practices. Despite being closely related, ultimately both policies aim to promote innovation and consumer welfare; however, the tools they use to achieve these goals are opposing, as one grants and the other restricts monopolies (Kutty and Chakravarty, 2011). The different dichotomy between the two policies can create some problems in terms of dynamic efficiency. The aim of this chapter is to discuss areas of policy where this dichotomy can be especially problematic.

5.2. Historical Development of the Legal Framework for Licensing Agreements for Technology Transfer

On both sides of the Atlantic the general trend towards licensing between firms has been towards a more lenient approach recognizing its possible effects on efficiency and its necessity when conducting business in technology oriented industries. In the US, courts in the 1960s and 1970s were more in favor of per se rules, routinely refusing to enforce patents where the existence of the monopoly-type abuse was proven, requiring no evidence of anticompetitive effects. The US Department of Justice (DOJ) Antitrust Division also demonstrated a general hostility towards patent licensing, initiating the creation of a list of licensing practices, known as the "Nine No-No's", which it presumed to be per se violations of the antitrust laws (Homiller, 2006). Meanwhile, the regulatory framework for the European Community (EC) Competition Policy for IP licensing was influenced by these developments in the US antitrust policy. Prior to the Patent Block Exemption Regulation in 1984, the Commission's policy followed a policy in line with the "Nine No-No's".[75]

[75] Representing the Justice Department's enforcement policy, Homiller, (2006) lists the Nine No-No's as:

(1) Requiring a licensee to purchase unpatented materials from the licensor (tying)
(2) Requiring a licensee to assign to the licensor patents issued to the licensee after the licensing arrangement is executed
(3) Restricting a purchaser of a patented product in the resale of that product
(4) Restricting a licensee's freedom to deal in products or services outside the scope of the patent
(5) Agreeing with a licensee that the licensor will not, without the licensee's consent, grant further licenses to any other person
(6) Requiring that the licensee accept a "package" license
(7) Requiring royalties not reasonably related to the licensee's sales of products covered by the patent
(8) Restricting the licensee's sales of (unpatented) goods made with the licensed patented process
(9) Requiring a licensee to adhere to specified or minimum prices in the sale of the licensed products

In later years, the heavy criticism of the Chicago School toward this strict approach resulted in substantial changes in the US antitrust policy for patent licensing. As a result, the US DOJ and the Federal Trade Commission (FTC) produced the Antitrust Guidelines for Intellectual Property Licensing in 1995. The EU was also influenced by this period which resulted in the Technology Transfer Block Exemption Regulation (TTBER) of 1996. However, it was with the introduction of the new TTBER and the accompanying guidelines in 2004 that the EU regulatory framework for IP Licensing has been in essence aligned with that of the US (Marsden, 2006).

There are significant similarities between the US Guidelines and the EU's TTBER and the accompanying guidelines. Both approaches create safe-harbors and identify naked price fixing, output restraints, and market division among horizontal competitors as per se unlawful or hardcore restrictions. Both weigh the pro-competitive benefits and the anticompetitive effects when evaluating licensing restrictions. Under both regimes, the responsibility for assessing the legality of contractual agreements rests with the licensing parties themselves. On the other hand, TTBER puts extra restrictions regarding agreements between non-competitors compared to the US Guidelines. Moreover, whereas TTBER excludes multilateral agreements from block exemption and leaves its treatment to the guidelines, the US Guidelines cover all kinds of agreements. In this respect, there are different competition rules organizing the formation of patent pools in the two jurisdictions. Similarly, there are differences between the approaches in their consideration of portfolio licensing.

(a) US: Antitrust Guidelines for IP Licensing

The US Antitrust Guidelines for Licensing of IP are based on three basic principles: (1) IP is viewed as any other form of property, (2) contrary to prior thinking patents do not grant automatic monopoly power as other factors are also involved and most importantly, (3) IP licensing is generally efficient and pro-competitive as it integrates complementary IP, speeds up innovation to the market and promotes further investments (Kutty and Chakravarty, 2011). The guidelines also elaborate on specific forms of IP licensing, such as cross-licensing, patent pooling and grant-backs.

The guidelines are based on creating safety zones. This means if the agreement does not obviously restrict competition and the collective market share of the licensor and the licensee is not above 20% of each relevant market significantly affected by the restraint, then the agreement will not be subject to antitrust scrutiny. The approach is to use “rule of reason” when deciding if the restraint is anti-competitive, efficiency gains are achieved and whether these gains outweigh the losses (Kutty and Chakravarty, 2011).

(b) EU: Technology Transfer Block Exemption Regulation and the Accompanying Guidelines for Technology Transfer Agreements

The central rules of the EU correspondent of the US Guidelines are Article 101 and 102 (previously Article 81 and 82) of the Treaty on the Functioning of the European Union (TFEU)[76]. In addition to these laws, the regulatory framework of TTBER sets out the permissible restrictions that can be included in a technology transfer agreement. Agreements which satisfy the conditions set out in the TTBER will be exempt from the anti-competitive prohibitions set out in Article 101. A revised version of TTBER was published in 2004, in addition to Regulation 772/2004 and supporting guidelines on the application of Article 101 of the EC Treaty for technology transfer agreements.[77] The change involved deviation from the legalistic and form-based approach to a more effect-based approach in the regulation of commercial agreements and started to give more weight to the economic analysis of costs and benefits or efficiencies generated from certain restrictions (Marsden, 2006). TTBER ensures that patent and know-how agreements remains exempt from Article 101 and extends the benefits of the block exemption to software copyright agreements. The purpose of the accompanying guidelines (2004/C 101/02) is to provide guidance on the application of the TTBER as well as on the application of Article 101 to technology transfer agreements that fall outside the scope of the TTBER.

The influence of a more economic approach becomes evident by the application of different regulatory regimes for vertical and horizontal licensing agreements in terms of market share limits and hard core restrictions. The guidelines also distinguish whether the parties are actual or potential competitors or no competitors at all. Restrictions of competition resulting from agreements between competitors are usually considered to be more harmful and these

[76] Article 101 of TFEU covers cartels (or control of collusion) and other anti-competitive practices that affect the EU. Article 102 of TFEU covers monopolies (or preventing the abuse of firms' dominant market positions). Aside from the European Commission, all national Competition Authorities are empowered to fully apply these articles. As a result, these rules are repeated in the national law of the Member States.

[77] Bergman (2004) states that the previous TTBER had a three-fold approach: (i) a list of certain clauses with hardcore restrictions which prevent the applicability of the TTBER to an agreement ("black clauses"), (ii) a list of clauses which are admissible ("white clauses"); and (iii) a provision on restrictive clauses which will be exempt under the Current TTBER on condition that they are notified to the Commission and that the Commission does not oppose such exemption ("grey clauses"). She underlines that the current TTBER excludes the white and grey clauses and only contains a list of black clauses (hardcore restrictions) which places the entire agreement outside the scope of the block exemption.

agreements are viewed more suspiciously. In the case of agreements between competitors, the companies may benefit from the TTBER if the combined market share of the parties does not exceed 20% of the relevant product or technology market, whereas when the parties are non-competitors, the market share of each of the parties must not exceed 30% of the relevant product or technology markets. This also means that if one party has a market share more than 30%, the exemption would not apply (Bergman, 2004).

5.3. General Purpose and Scope of Licensing Guidelines

Generally speaking, a technology transfer agreement has several provisions which determine the permissible uses of rights by the licensee. Exclusivity clauses establish whether the license is granted only and exclusively to the licensee, or whether it can be licensed to other parties as well. There may also be clauses specifying whether the license is limited to a particular territory and the extent of this territory or clauses restricting the field of use or specific applications of the licensed technology.[78] Therefore, such provisions can raise concerns of competition authorities, as there might be possible negative effects on the competition in the market or further development of new technologies. However, it is not easy to determine the net effect of these restraints, as in most cases there might be welfare gains as well as losses.

From a competition policy perspective, many clauses in patent and know-how licensing contracts or means of technology transfer may be considered as limiting trade. The main concern is that the licenses include terms that are unrelated to the transfer of monopoly rights granted. Both in the US Antitrust Guidelines and the TTBER and the accompanying guidelines licenses that require the licensee not to compete in unrelated markets, clauses containing illegal tying arrangements, or pooling competing technology to facilitate cartels are prohibited by antitrust rules. In addition, promises within the license agreement (1) not challenging the validity of the licensed IP rights, (2) requiring exclusive dealing, (3) involving restrictions on research, (4) having grant-back provisions, or (5) having restrictions on the use of personnel can raise antitrust concerns (Kutty and Chakravarty, 2011).

5.4. Cross-Licensing

5.4.1. US Rules on Cross-Licensing

In general, the US Guidelines recognize the efficiencies generated by cross-licensing especially in industries characterized by a large number of overlapping patents through

[78] Other important clauses include the price and the extent of the duration of the license.

reducing the risk of litigation and being confronted with actions for injunction. In addition, it is underlined that portfolio cross-licensing may give access to all blocking technologies required for production at lower royalty rates than if each input were independently priced, thus mitigating the problems like royalty stacking.[79] However, there are still competitive concerns that some provisions of these agreements might violate competition rules. The strictest rule in the US Guidelines with respect to cross-licensing agreements concerns arrangements that are used as mechanisms to accomplish naked price fixing or market division, which are challengeable under the “per se rule”.

The guidelines state that when a licensing arrangement affects parties in a horizontal relationship, a restraint in that arrangement may increase the risk of coordinated pricing, output restrictions, the acquisition or maintenance of market power, or a significant risk of retarding or restricting the development of new or improved goods or processes. When the licensor and licensees are in a vertical relationship, the analysis focuses on whether the licensing arrangement may harm competition among entities in a horizontal relationship either at the level of the licensor or the licensees, or possibly in another relevant market. In such cases the concerns are market foreclosure of access, increasing competitors’ costs of obtaining important inputs, or facilitating coordination to raise price or restrict output.[80]

Exclusive licenses restrict the right of the licensee to grant licenses to others and possibly also to use the technology itself. An important rule for the assessment of cross-licensing agreements is that non-exclusive licenses do not present antitrust concerns even in horizontal relationships. However, the agencies are careful in assessing exclusive licenses only if the licensees themselves, or the licensor and its licensees are in a horizontal relationship.[81] In addition, exclusive dealing, which is when a license prevents or restrains the licensee from licensing, selling, distributing, or using competing technologies can also be in conflict with antitrust rules. However, it is also acknowledged that such restraints can also have pro-competitive effects. For example, a licensing arrangement that prevents the licensee from dealing in other technologies may encourage the licensee to develop and market the licensed technology or specialized applications of that technology.[82]

[79] Promoting Innovation and Competition, Chapter 3, Antitrust Analysis of Portfolio Cross-licensing Agreements and Patent Pools, pp.59-61.
[80] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, p.18-19
[81] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, p.19
[82] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, p.19

Another concern is that a portfolio cross-licensing regime can pose a barrier to entry if existing relationships make it harder for new firms to come in and overcome the patent thicket. However, it is stressed that this outcome is quite unlikely as companies which engage in portfolio cross-licensing are generally willing to license their portfolios to all interested parties. Moreover, the extent of the concern becomes smaller as excluded firms can effectively compete in the relevant market for the good incorporating the licensed technologies by developing their own patents with their own R&D.[83] Even in the existence of such concerns, a rule of reason approach is followed in evaluating whether the arrangement's limitations on participation are reasonably related to the efficient development and exploitation of the pooled technologies. The agencies assess the net effect of those limitations in the relevant market.

The guidelines underline that settlements involving the cross-licensing of IP rights can be an efficient tool to avoid litigation and, in general, courts favor such settlements. The agencies consider whether the effect of the cross-licensing agreement, which involves a settlement, is to diminish competition among entities that could have been actual or potential competitors in a relevant market in the absence of the cross-license, only if the agreement is signed between horizontal competitors.[84]

5.4.2. EU Rules on Cross-Licensing

Contrary to the US approach that sets broad policy statements with less detail, the EU Guidelines provide a much more exhaustive guidance on specific licensing practices. A similar “but for” analysis is pursued in the EU Guidelines assessing whether the license agreement restricts actual or potential competition between the parties and competition from third parties that would have existed without the agreement. If so, the agreement may be prohibited by Article 101(1).[85]

The guidelines make a distinction regarding agreements between competitors and non-competitors. The list of hardcore restrictions is stricter for competitors than for non-

[83] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, p.28; Promoting Innovation and Competition, Chapter 3, Antitrust Analysis of Portfolio Cross-licensing Agreements and Patent Pools, p.62.
[84] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, section 5.5., p.28
[85] Guidelines on the Application of Article 81 of the EC Treaty to Technology Transfer Agreements (2004/C 101/02) Bullet 12.a “…For instance, where two undertakings established in different Member States cross-license competing technologies and undertake not to sell products in each other's home markets, (potential) competition that existed prior to the agreement is restricted. Similarly, where a licensor imposes obligations on his licensees not to use competing technologies and these obligations foreclose third party technologies, actual or potential competition that would have existed in the absence of the agreement is restricted.”

competitors. Competition between undertakings that use the same technology is defined as intra-technology competition between licensees and competition between undertakings that use competing technologies is named as inter-technology competition.[86] Another distinction is made between reciprocal and non-reciprocal agreements. Reciprocal agreements are cross-licensing agreements where the licensed technologies are competing technologies or used for the production of competing products. A non-reciprocal agreement means that only one of the parties is licensing its technology to the other party or where, in case of cross-licensing, the licensed technologies are not competing technologies and cannot be used for the production of competing products.[87]

For agreements between competitors, the guidelines underline the risk that parties can use cross-licensing with reciprocal running royalties as a means of coordinating prices on downstream product markets if the agreement does not create any value and therefore has no valid business justification.[88] Clauses restricting the competitor licensee to use its own technology, reciprocal output restrictions regarding how much parties can produce and sell, a reciprocal agreement agreeing not to produce in certain territories or not to sell actively and/or passively into certain territories or to certain customers are considered to be hardcore restrictions and cannot benefit from block exemption.[89]

Nevertheless, the guidelines exhibit a more lenient attitude towards cross-licensing agreements by considering parties owning technologies that are in a one-way or two-way blocking position as non-competitors on the technology market. A one-way blocking position exists when a technology cannot be exploited without infringing another technology. A two-way blocking position exists when neither technology can be exploited without infringing upon the other technology, thus the holders need to obtain a license or a waiver from each other.[90] Licensing including cross-licensing in the context of settlement agreements and non-assertion agreements are also considered not to restrict competition. However, it is warned that the individual terms and conditions of such agreements might be considered as anticompetitive.[91]

Nonetheless, there are still some hardcore restrictions concerning agreements between non-competitors. For instance, fixing prices charged when selling products to third parties,

[86] 2004/C 101/02, Bullet 26
[87] 2004/C 101/02, Bullet 78
[88] 2004/C 101/02, Bullet 80
[89] 2004/C 101/02, Bullet 81, 82, 84
[90] 2004/C 101/02, Bullet 32
[91] 2004/C 101/02, Bullet 204

restriction of territory into which or to whom the licensee may passively sell the products allocated by the licensor after two years and restriction of passive and active sales to end users by a licensee of a selective distribution system that operates in the retail level constitute hardcore restrictions that are per se illegal.[92]

In addition, with respect to technology transfer agreements which are outside the scope of the block exemption either due to high market shares or agreements that involve more than two parties, the European Commission also underlines some concerns, where a rule of reason approach would be applied. Similar to the US Guidelines, it is noted that agreements between competitors can facilitate collusion by increasing transparency in the market, by controlling certain behavior and by raising barriers to entry and thus can create inter technology foreclosure effects.[93] However, contrary to US Guidelines, the Commission is particularly concerned with intra-technology agreements with territorial restrictions preventing licensees to sell in each other's territory, as these provisions can reduce competition, facilitate collusion and raise barriers to entry.[94]

Moreover, the Commission does not apply block exemptions where competitors cross-license and impose running royalties that are clearly disproportionate compared to the market value of the license and where such royalties have a significant impact on market prices, which are assessed according to the relevant royalties paid to substitute technologies.[95] Furthermore, when parties have significant market power and some restrictions that go beyond unblocking mutual blocking positions, the Commission underlines that agreements whereby the parties cross-license each other and impose restrictions on the use of their technologies, including restrictions on the licensing to third parties might raise antitrust scrutiny. This particularly applies when the parties share markets or fix reciprocal running royalties that have a significant impact on market prices.[96]

Lastly, the Commission raises particular concern on arrangements whereby two or more parties cross-license each other and undertake not to license third parties when the package of

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[92] 2004/C 101/02, Bullet 96 (a), (b.ii), (c)
[93] 2004/C 101/02, Bullet 143,144
[94] 2004/C 101/02, Bullet 145
[95] 2004/C 101/02, Bullet 158. Also see 2004/C 101/02, Bullet 163 that states "reciprocal exclusive licensing between competitors who identifies market sharing between competitors is also considered as a hardcore restriction. Reciprocal sole licensing between competitors is block exempted up to the market share threshold of 20 %. Under such an agreement the parties mutually commit not to license their competing technologies to third parties. In cases where the parties have a significant degree of market power such agreements may facilitate collusion by ensuring that the parties are the only sources of output in the market based on the licensed technologies."
[96] 2004/C 101/02, Bullet 207

technologies resulting from the cross-licenses creates a *de facto* industry standard to which third parties must have access in order to compete effectively in the market. The risk is that such a situation can create a closed standard with exclusionary effects reserved for the parties undertaking the agreement and exclude third party participants that compete on an existing product market. It will normally be required that the technologies which support such a standard be licensed to third parties on fair, reasonable and non-discriminatory terms.[97]

5.4.3. Critical Analysis

The main difference between the US and EU approaches emerges from the consideration of licensing practices between non-competing firms. The initial sign of this different treatment arises from the fact that the TTBER and accompanying guidelines are more concerned about characterizing parties as either competitors or non-competitors than its US counterparts, as in the former there are substantive rules on determining how the parties are classified. The US Guidelines focus more on the nature of the license terms and whether the relationship between the parties is vertical or horizontal. When the relationship is horizontal, the US Agencies focus on possible harm to inter-technology competition from licensing arrangements such as elimination of competition between substitute technologies or foreclosing markets by imposing exclusive dealing requirements on licensees. On the other hand, with regard to vertical restrictions, the approach of the US Guidelines is based on a "but for" counterfactual analysis for all licensing restraints that asks whether competition under the licensing agreement would be less than what would occur in the absence of any licensing agreement (Delrahim and General, 2004). By contrast, the TTBER and accompanying guidelines expresses concerns not only on the loss of inter-technology (horizontal) but also on intra-technology (vertical) competition. This becomes obvious as a special section is devoted to the effects of licensing arrangements on competition using licensed technology, and as some licensing restrictions are left out of the scope of block exemption.[98]

The Commission understands the difficulties in case of overlapping intellectual property. For that reason, the guidelines classify parties of the agreements that have a one-way or a two-way blocking relationship as non-competitors. Nonetheless, it refrains from giving such relationship a special status under competition laws, due to the fear that the parties could sham a blocking relationship in order to engage in anti-competitive practices. Thus, the Commission gives extra scrutiny to determine whether a blocking relationship in fact exists,

[97] 2004/C 101/02, Bullet 167
[98] 2004/C 101/02, Bullet 96 (a),(b.ii),(c)

relying on objective factors and independent experts. [99] This means the Commission follows a firm approach to the cross-licensing of blocking patents, which is not explicitly observed in the US Guidelines (Hull and Toro, 2004).

Moreover, when firms are considered to be non-competitors according to the given rules, there are still some restrictions applied for certain provisions. First, the Commission applies the hard-core restrictions to non-competitors that include standard vertical restraints such as territorial and field-of-use limitations even in the existence of mutual blocking relationships.[100] This approach seems to be too severe, as vertical licensing usually enables a product or process innovation which would not have been realized in the absence of an agreement. As it has been observed in Chapter 3, due to the existence of litigation threats as a result of overlapping patent rights, firms have greater incentives to invest in R&D if they are able to engage in cross-licensing activities. This means firms should be incentivized in this manner, rather than hindered. Second, in the case of significant market shares the Commission does not let fixing two-way (reciprocal) royalties clear blocking relationships, which means that the Commission assumes that only royalty-free or one-way royalty cross-licensing can settle patent disputes related to blocking patents.[101] However, in case of vertical relationships such anti-competitive concerns are at minimum, and a two-way royalty may be preferred by parties to maximize the value and use of the technology, which can prompt them to invest in further technology development (Hull and Toro, 2004).

The analysis of Chapter 4 has revealed that cross-licensing practices are highly important for vertically integrated firms in industries such as electronics and communications equipment, and computer manufacturing, which heavily rely on different technologies in their production of new products or processes. In such sectors, exclusivity restrictions may be necessary to induce licensees to invest in the complementary assets that will lead to the technology development. As Gilbert (2004) points out such restrictions can provide the licensees a safeguard against spillovers that may benefit other suppliers which invests neither in development nor in promotion of new technologies. In addition, in case of process innovations, infringements can be difficult to detect; hence, exclusivity can be necessary to encourage licensing of new process technologies. By restricting third party users and the field of use of new processes, patent holders can monitor unauthorized uses of their technology (Gilbert, 2004). Therefore, competition policy should be careful in limiting parties about their

[99] 2004/C 101/02, Bullet 32
[100] 2004/C 101/02, Bullet 207
[101] 2004/C 101/02, Bullet 207

restrictions in agreements regarding the use of their own technologies, as these limitations can hinder parties' incentives to engage in licensing or mitigate their incentives to invest in R&D

The TTBER and guidelines only recognize territorial restrictions promoting innovation and, hence, competition by block exempting some restrictions only for the first two years of a technology licensing arrangement.[102] However, while doing so, it also entails the requirement that each restriction in the agreement must be separately justified by requiring restrictions to be 'indispensable to the improvement of production or distribution'.[103] According to Schwartz and Wellman (1971), this indicates that not only should the situation with the particular restriction be better than it was before, but also that the restriction should provide a means of achieving the desired efficiency superior to that offered by other alternatives. As a result, the availability of a less restrictive alternative at the time when the agreement was signed is considered during the assessment of the competitiveness of the agreement.[104] This can lead to two problems. First, agreements are usually negotiated as a whole. For instance, some cross-licensing agreements are based on broad terms for the parties but may nevertheless include restriction for third-part beneficiaries (Gilbert, 2004). Such agreements are negotiated as broadly as possible in order to minimize potential transaction costs. Second, the acceptance of the less restrictive alternative by the parties at the time of concluding the agreement could well have resulted in a different agreement, such as one with higher royalty rates or other burdensome terms and conditions, or it could have resulted in a decision not to license at all (Delrahim and General, 2004). Therefore, in practice, such counterfactual clauses are difficult to assess for firms, which can impose an extra burden for firms in drafting their licensing agreements.

Surely, as in the case of the US Guidelines, if the parties have significant market power and there are no offsetting efficiencies, licensing contracts that facilitate coordination of other activity, such as price fixing, allocation of markets and customers or licensing to third parties, should not be exempted, as these clauses can hinder long-run innovation incentives.[105] However, these restrictions should not be expanded to allocation of territories for the use of vertically integrated technologies (Gilbert, 2004). Industries where vertical relations are quite important rely on extensive cross-licensing of technologies to achieve the freedom to design without infringing intellectual property rights. As Gilbert (2004) indicates these cross-licenses

[102] TTBER Article 4.2.b.ii
[103] TTBER Bullet 13 states that "This Regulation should not exempt technology transfer agreements containing restrictions which are not indispensable to the improvement of production or distribution."
[104] 2004/C 101/02, Bullet 149; also see Swartz and Wellman (1971), Delrahim and General (2004).
[105] 2004/C 101/02, Bullet 78

often limit where and how technologies may be used. He also points out that these limitations do not necessarily imply that firms have divided customers or markets in ways that increase the prices of the products they produce. It should also be noted that, prices would clearly be higher in many industries if firms were prohibited from entering into these extensive cross-licensing agreements. Most technology licensing is pro-competitive and should be encouraged by competition authorities. In that respect, the EU Guidelines, which exempt hardcore restrictions only in certain circumstances, bare the risk of mitigating innovation incentives.[106]

Lastly, there are also claims that a market share threshold for firms to determine whether block exemption is applicable is not compatible with the needs of a sector that heavily relies on licensing. For example, Louët (2004) indicates that a biotech company that brings an innovative product to the market for a totally new medical need would automatically command a 100% market share and would therefore not benefit from the exemption. This may result in a risk that parties will chose to do their R&D in the countries where antitrust laws are not as restrictive. However, considering the transaction costs savings of the block exemption for many firms and the easy to use nature of a uniform of market threshold, the benefits of such a rule probably outweigh its cost.[107]

5.5. Patent Pools

Another form of technology transfer agreements are patent pools, which refer to licensing agreements where two or more patent holders license their patents to each other or co-license their patents to a third party.[108] Patent pools are usually formed to produce high-technology products where standardization activities are widespread. Both the US and EU Guidelines address the efficiencies generated by patent pools. Yet, both authorities express possible competition concerns about unlawful allocation of markets, controlling the price and output of downstream products, jointly monopolizing the market through exclusive licenses or refusal to license to prevent effective competition in relevant markets with respect to patent pooling

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[106] TTBER Article 4.2.b

[107] Another critique raised by Louët (2004) concerns TTBER's retroactive provisions, as the Commission could examine licensing deals retrospectively, for instance once a product is successful. This can add a level of uncertainty to the long-term validity of licensing agreements. These provisions require that companies have to think about their future market if their market share exceeds the exemption threshold after the agreement has been signed, which means the parties could have to renegotiate the agreement, creating more transaction costs. She claims that companies would then have to define through self-assessment whether they are breaking EC antitrust laws. Therefore, licensors will have the continuing obligation to monitor the relevant criteria of to ensure they are covered under the block exemption.

[108] Promoting Innovation and Competition, Chapter 3, Antitrust Analysis of Portfolio Cross-licensing Agreements and Patent Pools, p.64.

(Kutty and Chakravarty, 2011). However, a careful assessment is necessary when applying antitrust rules on such arrangements in order not to hinder innovation incentives which can be promoted due to integration complementary IP and reduction of transaction costs, dissemination of technology or saving litigation costs.

5.5.1. US Rules on Patent Pools

Section 5.5 of the US Guidelines indicates that a patent pool which integrates complementary technologies, clears blocking positions, reduces transaction costs, avoids costly infringement litigation and promotes the dissemination of technology may be found to be pro-competitive and thus acceptable.[109] However, a patent pool that constitutes a method of fixing prices, allocates customers and markets, excludes or drives competitors from the market, reduces innovation or discourages the participants from engaging in research and development may be found anti-competitive and thus unacceptable.[110]

In addition, by the issuance of the DOJ Business Review Letters for the MPEG-239, DVD-ROM and DVD-Video pools and the 3G patent platform, the guidance for the antitrust treatment of patent pools were expanded.[111] According to the new rules, patents in the pool must be valid, essential and complementary, not substitutes, as determined by an independent expert; any grant-back provision should obligate licensees to grant-back to the pool essential patents on a non-exclusive basis, and at a fair and reasonable royalty. In addition, the pools should not allow unreasonable aggregation of competitive technologies or set a single price for the pooled technologies, thus, disadvantaging competitors in downstream product markets, collude on prices outside the scope of the pool, or impair innovation in the development of rival products or technologies (Ebersole et al., 2005).

Given these concerns, an important part of the pool analysis is whether and to what extent the patents in a pool are complements or substitutes. Different tests have been used for the determination of the essentiality of patents. For instance, the DVD pool has used an "economic test", which is open to more subjectivity, whereas the MPEG-2 pool has applied a

[109] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, Section 5.5., p.28
[110] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, Section 5.5., p.28-29; For instance, *in the matter of Summit Technology, Inc. and VISX, Inc*. (Docket No. 9286, 1999), FTC concluded that the pools that contain substitute technologies cause higher royalty rates since licensees can choose between different technologies that would have occurred if these technologies were not pooled.
[111] See Motion Pictures Coding Experts Group (MPEG_2) Patent Pool Business Review Letter (1997) (a technology designation agreed upon standards for audio and video coding); Digital Versatile Disc's (DVD-ROM and DVD-Video) Patent Pool Business Review Letter (1999) (a technology is used to store large amounts of audio, video and data onto one disc.); 3G Patent Pool Business Review Letter (2002).

more limited approach by using a "technical essentiality test" for licensees.[112] Beeney (2002) defines technical essentiality as the condition that the intellectual property must read directly on the specification of the product defined by the license field of use or it is not essential. On the other hand, he points out that economic essentiality, which also means commercial essentiality, requires that intellectual property be considered essential if it would not be cost-effective or sensible in the real world to design around the intellectual property at issue, so it would be infringed by producing the defined product. In both methods the aim is to determine whether or not the patents in the pool are complements. DOJ noted that it would not challenge the inclusion of substitute patents in a pool without taking into account whether such inclusion creates significant efficiencies.[113]

5.5.2. EU Rules on Patent Pools

The European Commission addresses patent pools in its guidelines on the application of Article 101 of TFEU to technology transfer agreements that may or may not fall under the scope of the TTBER.[114] The Commission states that patent pools can produce pro-competitive effects, in particular by reducing transaction costs and by setting a limit on cumulative royalties to avoid double marginalization. ‘One-stop licensing’ of the technologies in the pool is particularly important in the Commission’s view in sectors where intellectual property rights are widespread and where licenses need to be obtained from a significant number of licensors in order to operate in the market.[115] The guidelines state that the competitive risks and the efficiency enhancing potential of patent pools depend, to a large extent, on the relationship between the pooled technologies and their relationship with technologies outside the pool.[116] A patent pool composed solely or predominantly of substitute or competitive technology amounts to a price fixing cartel, and therefore, is not allowed under Article 101.[117] The creation of a patent pool that is composed only of technologies which are essential

[112] Promoting Innovation and Competition, Chapter 3, Antitrust Analysis of Portfolio Cross-licensing Agreements and Patent Pools, p.77.

[113] Promoting Innovation and Competition, Chapter 3, Antitrust Analysis of Portfolio Cross-licensing Agreements and Patent Pools, p.78 and DVD-ROM and DVD-Video Patent Pool Business Review Letter (1999)

[114] But the individual licenses granted by the pool to third party licensees may benefit from the TTBER safe harbor when the conditions set out in the TTBER are fulfilled.

[115] 2004/C 101/02, Bullet 214; see Merges (1999) which states one step licensing for non-members is an important pool feature.

[116] 2004/C 101/02, Bullet 215

[117] 2004/C 101/02, Bullet 216 defines two technologies are complements as opposed to substitutes when they are both required to produce the product or carry out the process to which the technologies relate. Conversely, two technologies are substitutes when either technology allows the holder to produce the product or carry out the process to which the technologies relate. Also see 2004/C 101/02, Bullet 219.

(therefore, by necessity also complementary) is generally allowed under Article 101.[118] A technology is defined as essential as opposed to non-essential if there are no substitutes for that technology inside or outside the pool, and the technology in question constitutes a necessary part of the package of technologies for the purposes of producing the products or carrying out the processes to which the pool relates.[119]

The inclusion of non-essential patents in a pool, however, may give rise to competition concerns. The Commission finds that the inclusion of non-essential patents in a pool may cause a risk of foreclosure of third party technologies.[120] The reasoning is that once a technology is included in the pool and is licensed as part of a package, licensees are likely to have little incentive to license a competing technology when the royalty paid for the package already covers a substitute technology. In addition, the practice can also force licensees to be forced to pay for unnecessary technology. In an assessment of patent pools comprising non-essential technologies the Commission takes into account whether there are any pro-competitive reasons for including the non-essential technologies in the pool, whether the licensors remain free to license their respective technologies independently, whether the pool offers the technologies only as a single package or whether it offers separate packages for distinct applications, or whether licensees have the possibility of obtaining a license for only a certain part of the package with a corresponding reduction of royalties.[121] Furthermore, grant-back provisions should be non-exclusive and limited to developments that are essential or important to the use of the pooled technology.[122]

5.5.3. Critical Analysis

The DOJ Guidelines are very similar to the Commission's Guidelines. However, as in the case of cross-licensing, the EU's discussion of technology pools is much more comprehensive than the one found in section 5.5 of the US Guidelines which actually consolidates the rules for cross-licensing and patent pools. Although the DOJ Business Review Letters has added additional criteria for the establishment and implementation of pro-competitive patent pools and provided important alignment between the two guidance rules, there are still differences in determining the complementarity and substitutability between patents. In addition, in the

[118] 2004/C 101/02, Bullet 220
[119] 2004/C 101/02, Bullet 216 also states that a technology, for which there are no substitutes, remains essential as long as the technology is covered by at least one valid IP right.
[120] 2004/C 101/02, Bullet 221
[121] 2004/C 101/02, Bullet 222
[122] 2004/C 101/02, Bullet 228

US, if a patent is deemed to be substitute or non-essential, a more lenient approach is followed by authorities towards the inclusions of such patents into the pool.

In the context of complex product industries, reaching clear-cut answers relating to the competitive relationship between patents is not a straightforward task. In the US, essentiality is determined by reference to the technical requirements set by a standard. Ullrich (2005) states that this means the analysis focus on whether the patent in consideration enhances acceptance of that particular technology.[123] In the EU, essentiality is determined with reference to any technology or with respect to any given product or process configuration on which the parties may wish to establish the pool. According to Ullrich (2005), in this specification, as the pool technology becomes subject to competition by alternative technologies, it becomes more difficult to apply such an essentiality criterion. This is because determining the competitive nature of patents within the pool may no longer stand that relevant. This divergence underlines that the competitive relationship can differ according to certain benchmarks used by agencies and creates uncertainty for the same pool members on different sides of the Atlantic.

Essential patents in essence are mutually blocking as they collectively make up a single product; therefore, by definition they are complementary patents that do not compete with each other. On the other hand, non-essential patents may be or have substitutes and the degree of substitutability plays an important role in determining the competitive role of including such patents in a pool. For instance, Beeney (2002) in the DOJ-FTC Antitrust-IP Hearings suggested that, in selected cases, including some substitute technologies in pools may decrease transaction costs and increase the pool's efficiency, at least in circumstances where licensees complying with the standard must infringe one of the substitute technologies in order to produce or create the downstream product.[124] An important criterion in his analysis is that rather than full substitution, if there is only overlapping between some substitute technologies, including these patents in the pool may be welfare enhancing. The overlapping may be due to the existence, for instance, of different manufacturing steps, calculations or processes that must be undertaken in order to produce the defined product that can be performed in different ways. If the product is part of a standard, this means that the standard mandates that the step be performed but does not identify a particular method to do so

[123] Ullrich (2005) describes this process as whether the patent helps to harmonize the standards' elements and interfaces, relate to one or more core features of the system, or of a full line of class of products and services.
[124] Promoting Innovation and Competition, Chapter 3, Antitrust Analysis of Portfolio Cross-licensing Agreements and Patent Pools, p.74-78; see Beeney (2002).

(Beeney, 2002). If policy does not let these overlapping technologies be pooled, licensees will have to individually obtain licenses for each patent separately, which increases transaction costs and the total amount of royalties to be paid. In addition, as it has been observed in Chapter 3, the exclusion of overlapping patents, which would have been used to produce defined products or processes, will lead to the risk of these products or processes infringing these patents to remain in the market. This can lead firms to refrain from investing in better technologies. However, as it will be seen in the following section, such an efficiency argument, which can be successfully used in enforcement action in the US, can be rejected by the EU Authorities as a more rigid policy is employed in terms of strictly excluding non-essential patents from the pool.

5.6. Portfolio Licensing

Portfolio licensing in either cross-licensing or patent pool arrangements is another practice that receives antitrust concerns as these practices can constitute tie-in arrangements that involve IP. This sort of agreements can fall under tying and bundling practices, which means linking IP with other products or with other forms of IP arrangements, such as tying the sale of patented goods with unpatented goods or offering licenses that cover multiple patents. Technological tie-up occurs where the tying and the tied product are bundled together physically or produced in such a way that they are compatible with each other, which is certainly a concern of antitrust policy. Mandatory package licensing of intellectual property, on the other hand, is a result of a combination of the growing multi-component nature of products and patent enforcement system, thus being a common form used in current technology transfer arrangements; therefore, in their antitrust assessment mandatory package licensing agreements should be evaluated taking into account such external conditions.

5.6.1. Portfolio Licensing Policy in the US

The Sherman Act (1) depicts four elements as *per se* illegal ties: (1) the tying and the tied products are two distinct products; (2) there is an agreement or condition, expressed or implied, that establishes a tie; (3) the accused party has an "appreciable economic power in the tying product market" to distort consumers' choices with respect to the tied product; and (4) "the arrangement affects a substantial volume of commerce in the tied market". Depending on the court, a fifth element is possibly required, i.e. anticompetitive effects in the tied market (Kutty and Chakravarty, 2011).

Similar tests are required under Section 5.3 of the Antitrust Guidelines that address tying arrangements. The agencies look at the structure of the market as well as at justifications when assessing tying, tie-in and tied sale, and they consider both the anticompetitive effects and the efficiencies attributable to them.[125] Package licensing, which is defined as licensing of multiple items of intellectual property in a single license or group of related licenses, is considered as a tying arrangement if licensing of one product is conditioned upon the acceptance of a license of another separate product. Prior to the guidelines, the courts in the US required the seller to only have sufficient market power to restrain competition in the tied product market. The issuance of the IP guidelines put an additional requirement, namely that the arrangement actually has an adverse impact in the relevant market for the tied product, and required an explicit weighing of efficiencies and anticompetitive effects in cases of package licensing that involves a tying arrangement (Gilbert et al., 1997). In addition, the guidelines recognize the efficiencies generated by the use of package licensing in the case in which multiple licenses are needed to use any single item of intellectual property, as in the case of complex products.[126]

On the other hand, in some Business Review Letters of several patent pools DOJ has imposed that no obligation should be put on licensees, that only the licensed patents should be used and the licensee must be free to independently develop competitive products. In addition, package licensing should not be deemed mandatory, and patent in the portfolio should be available for independent licensing (Homiller, 2006).[127] Here, again, the essentiality of patents plays an important role, as noted before the general trend being towards only including blocking, thus essential patents into the pools. However, the recent rulings of Federal Circuit, has softened this view and ruled that mandatory package licensing that included at least one non-essential patent did not constitute as patent misuse.[128]

5.6.2. Portfolio Licensing Policy in the EU

In the European system, tying practices are subject to competition rules as restrictive agreements under Article 101, and as abuse of dominant position under Article 102 of TFEU.

[125] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, Section 5.3., p.26
[126] DOJ and FTC, Antitrust Guidelines for Licensing of Intellectual Property, Section 5.3., p.27
[127] See Motion Pictures Coding Experts Group (MPEG_2) Patent Pool Business Review Letter (1997)
[128] Patent misuse is an affirmative defense used in patent litigation when a defendant has been accused of having infringed a patent. It has also been used to mitigate damages following a finding of infringement or to justify a failure to pay contracted royalties. This umbrella term usually describes any of the following: a violation of antitrust laws; improper expansion of the scope or term of the patent; inequitable conduct in the procurement or enforcement of a patent (Source: http://en.wikipedia.org/wiki/Patent_misuse).

In addition, Article 101(1) prohibits agreements between undertakings which have, as their object or effect, an appreciable restriction or distortion of the competition within the common market, provided the interstate trade is affected appreciably. When anticompetitive agreements are concluded, they might, nonetheless, be allowed under Article 101(3) if their efficiency gains outweigh the anticompetitive effects, while allowing consumers to share the resulting benefits. Article 102 addresses unilateral conduct, and prohibits any exploitative or exclusionary abuse of a dominant position by one or more undertakings, where the abuse has an effect on interstate trade.

Article 3 of the TTBER, which limits the application of the block exemption by market share thresholds, ensures that tying and bundling are not block exempted above the market share thresholds of 20% in the case of agreements between competitors and 30% in the case of agreements between non-competitors. When above the market share thresholds, the Commission requires an analysis to be conducted that balances the anti-competitive and pro-competitive effects of tying. In addition, the Commission states that the tie must cover a certain proportion of the market for the tied product for appreciable foreclosure effects to occur.[129] In addition, the guidelines address that besides the pro-competitive reasons for the inclusion of non-essential technologies into the patent pool, the Commission will also consider other factors. For example, in case when the pooled technologies have different applications, some of which do not require the use of all of the pooled technologies, the assessment will consider whether the pool offers the technologies only as a single package or as separate packages for distinct applications. In the latter case, the Commission suggests avoiding the practice of tying technologies, which are not essential to a particular product or process, to essential technologies.[130] A last consideration is whether licensees have the possibility of obtaining a license for only a part of the package with a corresponding reduction of royalties rather than a single package license.[131]

5.6.3. Critical Analysis

There have been recent developments in the US case law regarding the assessment of portfolio licensing; hence the policy discussion is still under development concerning this

[129] 2004/C 101/02, Bullet 193 lists the foreclosure effects as: (1) the licensor maintaining market power in the market for the tying product by raising barriers to entry; (2) licensor to increase royalties, in particular when the tying product and the tied product are partly substitutable and the two products are not used in fixed proportion; and (3) tying prevents the licensee from switching to substitute inputs in the face of increased royalties for the tying product.

[130] 2004/C 101/02, Bullet 222 (a) and (c)

[131] 2004/C 101/02, Bullet 222 (d)

issue. In addition, so far there has not been a similar case in the EU to make a comparison between the two approaches. As a result, the critical analysis will focus on a comparison of economic arguments presented in the US case law.

While it is understandable that there may be circumstances in which package licensing may have anticompetitive effects, it should be remembered that they also serve the pro-competitive purpose of facilitating the commercialization of new technologies by assuring licensees the right to use patents they may need to manufacture products embodying that technology. For this reason, IP guidelines state that such licenses should be evaluated under the antitrust rule of reason, which requires an evaluation of both the potential pro-competitive and anticompetitive effects. However, even though the rules are quite similar in both jurisdictions, the assessment of arrangements can result in different patent pools for the same technology on two sides of the Atlantic. For instance, in its analysis of the Compact Disc (CD-R) and Rewritable Compact Disc (CD-RW) patent pools, the Commission was critical of Philips and Sony's failure to offer individual licenses, so licensing agreements were revised as to only include essential patents (Peña Castellot, 2003). In the US, however, the CD patent pool was formed around the 1990s, before the issuance of the IP guidelines and the DOJ Business Review Letters, and hence was not subject to such limitations.[132]

Even so, the legal ambiguity can also exist under the same jurisdiction. For instance, in 2004, the International Trade Commission (ITC) ruled that the US patents asserted by Philips Corp. are unenforceable for patent misuse per se on the grounds that Philips' practice of mandatory package licensing constituted as a tying arrangement between (1) licenses to patents that are essential to manufacture CD-Rs or CD-RWs according to technical standards of the pool and (2) licenses to other patents that are not essential to that activity. [133] The legal dispute started based on a complaint filed by Philips and ITC investigating nineteen companies, all of which were accused of illegally importing compact discs (CDs) that infringed six of Philips' patents. The patents were condemned as unenforceable due to patent misuse. The six patents were found to be indeed infringed, but the reasoning for patent misuse was that a patent holder owning an essential patent as well as a related non-essential patent must price the non-essential patent separately. Homiller (2006) states that the decision of ITC was based on the economic argument that if a patent owner is allowed to bundle its patents together, then it is

[132] *In the Matter of Certain Recordable Compact Discs and Rewritable Compact Discs*, 337-TA-474, ICT Investigation, 2004, p.3
[133] *In the Matter of Certain Recordable Compact Discs and Rewritable Compact Discs*, 337-TA-474, ICT Investigation, 2004, p.142

able to use his blocking position in one technology to completely foreclose competition between non-essential technologies if such a market exists.

In 2005, in the US Philips Corp. v. ITC, the US CAFC reconsidered the issue in the context of patent pool licensing.[134] The Federal Circuit reversed ITC's decision based on the reasoning that including the non-essential patents in the package did not constitute a violation of the law because: (1) the arrangement did not force a licensee to actually use the non-essential patents, (2) the agreement did not prevent licensees from using technology that competed with the non-essential patents, and (3) there was no evidence that any portion of the royalty charged by Philips was directly attributable to the non-essential patents (Homiller, 2006).

This means that the Circuit puts forward that pooling essential and non-essential patents together does not necessarily constitute unlawful tying. The Federal Circuit clearly recognizes the need for portfolio licensing in complex product industries, stating that in a fixed licensing fee pool, the licensor is simply guaranteeing the licensees that it will not sue them for engaging in any conduct covered by the entire group of patents in the pool.[135] By this way, Federal Circuit distinguishes the patent-to-patent from the patent-to-product tying arrangements.[136]

Homiller (2006) points out that the economic reasoning of FTC is based on fully compensating the patent holder that enables it to charge the maximum amount of a licensee's willingness to pay. Not being able to charge the full amount stems from the fact that licensees have a fixed budget. The patentee who owns only an essential patent can demand the licensee's entire budget, while another patentee might be forced to allocate this fixed amount between an essential and a non-essential patent. This might put the later patentee in a disadvantageous position, if the licensee chooses to decline the offer of the non-essential patent. As a result, the patentee will not be able to obtain the full royalty value of the essential patent. For the patentee in this situation to offer its non-essential patents as part of a package with the essential patent at no additional charge is the same as if providing the non-essential patents royalty-free or as simply declaring that it would not enforce them against persons who licensed the essential patent.[137]

[134] *US Philips Corp. v. International Trade Commission*, 424 F.3 d 1179, 2005
[135] *US Philips Corp. v. International Trade Commission*, 424 F.3 d 1179, 2005, p.1190
[136] *US Philips Corp. v. International Trade Commission*, 424 F.3 d 1179, 2005, pp.1189-1190 (citing *International Salt Co. v. United States*, 332 US 392, 1947).
[137] *US Philips Corp. v. International Trade Commission*, 424 F.3 d 1179, 2005, pp.1191-1192

The decision limits the scope of the patent misuse doctrine and thus has implications on the licensing efforts. The Court has intended to fully compensate the innovators ex-post in order to provide adequate innovation incentives for the licensor ex-ante. This ruling reduces the ambiguity created by the antitrust rules applied in IP matters. The requirements of modern technology development as described in Chapter 2 bear the risk of infringement given the complex patent landscape. Portfolio licensing is a way that aims to mitigate such risks by providing licensees assurance that they will not be sued during the use of patented technology. This significantly reduces the risks of hold-up and restores innovation incentives. In Chapter 3, we have seen the importance of credible threats, also provided by the patent system, induces firms to reach cooperative outcomes in symmetric settings. However, the findings can also be extended to asymmetric settings where the licensees have no R&D capability. In such situations, as the counter-party has no threat on its own R&D efforts, the only mechanism left to the patent holder is to effectively license its own IP rights. In order to induce licensing, such rights should be certain, which can be undermined by the extensive interpretation of the patent misuse doctrine.

5.7. Standard-Setting Procedures and the IP-Competition Policy Interference

Interoperability between different technological systems has driven rapid progress in many technological fields. This property enables to understand the interfaces of a system or a product, and makes it compatible to work with other products or systems without any restricted access or implementation.[138] The objective of developing technical standards is to create such interoperability or compatibility that provides or intends to provide a common design for a product or a process (Soininen, 2007). In doing so, standard-setting organizations (SSOs) as well as participating companies establish standardized new technologies that can be used as widely as possible. However, the incorporation of the best technology that has the capacity for worldwide promulgation can often be embodied in proprietary technology (Soininen, 2005). Therefore, a number of problems can emerge during the incorporation of patents into standards. That is because while interoperability requires dismantling restrictions, patents grant firms the power to exclude others from using their technology.

Compatibility standardization can be achieved by several forms. One approach to achieve standardization is through private industry organizations inducing members to adopt a single

[138] Source: http://en.wikipedia.org/wiki/Interoperability

standard. These standards are usually first developed and later adapted by the members of the standard (Soininen, 2007). Some of these SSOs are formal bodies, which may have delegated authority. For instance, American National Standard Institute (ANSI) is a semi-governmental, non-profit organization that consists of hundreds of different special purpose SSOs (Teece and Sherry, 2002). Similarly, the European Telecommunications Standards Institute (ETSI) is an independent and non-profit standardization organization in the telecommunications industry, which has been successful in standardizing the GSM cell phone system. European Commission officially recognizes ETSI and has given this organization the responsibility of standardizing information and communication technologies (ICT) across Europe.[139] There might also be less structured SSOs often in the form of an industry consortia composed of interested parties (Teece and Sherry, 2002). For instance, World Wide Web Consortium (W3C) is formed this way, whose standards for HTML, CSS, and XML are used globally.[140] Standards can also be established through market driven forces by the widespread use and acceptance of a product or protocol by consumers. These are called *de facto* standards, which mean they were not officially adopted by a standard-setting body but the market forces decided on them to be the accepted standard. For example, Microsoft operating system is such a *de facto* standard as it was not adopted by an organization but demonstrated it dominance in the operating systems standards race (Lemley, 2002).

Most privately set standards are voluntary; firms may decide not to be a member and choose not to adopt a standard. However, this usually comes with a cost. Firms that do not have compatible products or protocols with others can be in a disadvantageous position, especially in the presence of network effects. As a result, in such cases, complying with a standard becomes a necessity to survive in the technology race (Teece and Sherry, 2002).

The remainder of this chapter focuses on standards set by private SSOs as this practice is currently shaping the technology development in complex product industries due to the advantages generated by interoperability between technological systems. Blocking patents are also usual cases in the standard-setting context. The objective of the standard-setting bodies is to facilitate participants to license essential patents to enable the production of compatible products. In high-tech industries, multiple firms often own patents that are essential to comply with the product standard, which gives each patent owner the power to block others from making compatible products. Cross-licensing and patent pools are often used to clear blocking

[139] Source: http://en.wikipedia.org/wiki/European_Telecommunications_Standards_Institute.
[140] Source : http://en.wikipedia.org/wiki/Standards_organization.

patents in the standard-setting context and enable firms to produce new products or processes (Shapiro, 2001b).

Despite these private solutions, potential conflicts may nevertheless arise when a patent holder attempts to incorporate the adoption of its own patented technology in the framework of the standard, which can provide huge commercial benefits in the existence of network effects and high switching costs for consumers. This generally occurs on the merits of refusing a license or claiming unreasonably high royalties that slows down or even blocks the implementation of the standard. An often given example for such cases is the so-called *patent ambush* in which participants may not fully disclose their intellectual property during the development of the standard, and wait until the standard is fully established which later enables them to claim higher royalties. A second problem is when SSO participants try to include too much of their intellectual property rights into a standard. This results in too high cumulative royalties to be paid for the standard and retards its implementation, which is a case mostly referred as *royalty stacking* (Sanders, 2010).

In order to prevent these adverse outcomes, the mainstream obligation that is set by a SSO is to license one's essential patents on "reasonable and non-discriminatory" (RAND) as in US or "fair, reasonable and non-discriminatory" (FRAND) as in EU terms. The SSOs generally apply relaxed and limited rules in the licensing of essential patents. Each company negotiates the licensing terms separately, which allows them to apply their own interpretations of what is considered as F/RAND (Sanders, 2010).

The anti-trust challenges related to patent ambush and royalty stacking cases primarily arise under Section 2 of the Sherman Act and Section 5 of the FTC Act in the US, and Article 102 of TFEU in the EU.[141] In the US, private parties challenge patent hold-up allegations under Section 2. In addition, FTC can bring claims under theories of liability predicated upon both Section 2 and Section 5 of the FTC Act. On the other, in the EU, Article 102 of TFEU has been the main enforcement mechanism for handling hold-up cases.[142] In particular patent-hold

[141] Sherman Act Section 2 violation has two elements: 1) the possession of monopoly power in the relevant market and (2) the willful acquisition or maintenance of that power as distinguished from growth or development as a consequence of a superior product, business acumen, or historic accident. In addition, Section 5 of the FTC Act prohibits ''unfair or deceptive acts or practices in or affecting commerce.'' The prohibition applies to all persons engaged in commerce, including banks.

[142] Article 102 of TFEU is aimed at "any abuse by one or more undertakings of a dominant position within the internal market or in a substantial part of it shall be prohibited as incompatible with the internal market in so far as it may affect trade between Member States."The prohibitions of Article 102 are triggered only after a firm's dominance within a relevant market is established. Article 102 proscribes two types of conduct by dominant firms, exploitative abuses and exclusionary abuses. While the two sometimes go hand in hand, exploitative

ups are examined under the claims of abusive behavior of Article 102 which are likely to involve cases such as excessive royalties, unfair licensing conditions, or refusals to license (Hockett and Lipscombs, 2008).

The recent antitrust complaints in the context of standard-setting process on both sides of the Atlantic has raised significant amount of discussion on policy changes regarding the modification the IP rights or the procedural rules applied by SSOs. After a description of the most common problems and related cases, the remainder of the chapter will elaborate on the proposed policy changes regarding SSO provisions and their regulation. The discussion will not particularly separate the US and EU rules (apart from the patent reform) as most of the issues discussed are yet only policy proposals that are in the agenda of both jurisdictions. Rather, these policy changes will be evaluated under the general benchmark of their possible effects on dynamic innovation incentives.

5.8. Emerging Antitrust Concerns in Standard-Setting Context

5.8.1. Patent Ambush

Any abuse on the standard-setting process in a way that harms competition may posit antitrust liability to the participants in standard-setting organizations. In this respect, a patent ambush occurs "when a member of a standard-setting organization withholds information, during participation in development and setting a standard, about a patent that the company owns, has pending, or intends to file which is relevant to the standard, and subsequently the company asserts that a patent is infringed by use of the standard as adopted which enables him to claim high royalties due to industry lock-in."[143] As a special form of ex-post hold-up, patent ambush cases have brought attention to the extent and enforcement of disclosure rules applied by standard-setting organizations.

The patent ambush matter started in a 1996 consent order for Dell Computer Corp., where the FTC accused Dell of violating antitrust laws when it participated in a standard-setting process.[144] Dell Corp. twice certified that it had no intellectual property rights to the proposed standard. Only after the standard had been adopted, Dell disclosed that it held a design patent related with the standard. As a relief, Dell agreed to refrain from enforcing the patents at

abuses may be deemed to violate Article 102 even in the absence of exclusionary conduct (e.g. excessive pricing).

[143] ZDNet (2005), "Telecom standards face patent ambush threat"

[144] *United States (filed at the request of the FTC) v. Dell Computer Corporation*, Civil Action No.: A-98-CA-02101996, Western District of Texas, FTC File No. 962 3105, 1996

issue. The matter was never litigated and the Commission's actions were criticized due to lack of clarity; however, the Dell consent was the first sign to bring antitrust principles in standard-reliant industries (Royall and Vincenzo 2008; Royall et al. 2009).[145] The key issue in the case was whether the requirement of disclosure expressed in Dell should apply to situations where the defendant did not have an actual patent, but only a pending patent application.

A second landmark case concerned a company called Rambus, which developed and licensed computer memory technologies. Between 1991 and 1996, the company participated in the Joint Electron Device Engineering Council (JEDEC), a semiconductor engineering SSO. In 1993 and 1999, respectively, the JEDEC approved a synchronous dynamic random access memory (SDRAM) standard and a double data rate (DDR) SDRAM standard that included technologies over which Rambus asserted patent rights. In 1999, Rambus informed DRAM and chipset manufacturers that it held patent rights over technologies included in the standards and that the continued manufacture, use, or sale of the products constituted an infringement (Royall et al., 2009). In 2002, the FTC filed a complaint asserting that Rambus violated Section 5 of the FTC Act by failing to disclose patent interests and made misleading disclosures, and that this deceptive conduct resulted in the monopolization of technology markets which adapted the standard.[146] One of the challenges in this case was the JEDEC's unclear disclosure policy, which the Federal Circuit in the related case of *Rambus v. Infineon Technologies*, found to suffer from "a staggering lack of defining details and left its members with vaguely defined expectations as to what they believed the policy had required" (Soininen, 2005).[147]

After an administrative law judge dismissed the complaint in 2004, two years later the FTC vacated this decision.[148] The Commission found that the JEDEC members were expected to disclose relevant patents, patent applications, planned amendments to pending applications, and any information which aimed to be protected by patents. Hence, it was decided that Rambus had mislead the JEDEC members and that this activity significantly contributed to its acquisition of monopoly power. FTC claimed that if the patents were known, the JEDEC

[145] Royall and Vincenzo (2008) discuss the Dell consent order. Royall et al. (2009) states that the FTC was careful to limit its discussion in the Dell decision to the facts of the case as it did not impose a general duty on participants to search for and disclose relevant patents in a standard-setting process, nor did it impose liability for an inadvertent failure to disclose patent rights.
[146] *In the Matter of Rambus Incorporated*., Docket No. 9302, 2009
[147] *Rambus v. Infineon Technologies AG*, 318 F.3 d 1081, 2003
[148] Chief Administrative Law Judge Stephen J. McGuire Dismissing the Complaint *In the matter of Rambus Inc*., (Docket No. 9302, Text of Initial Decision, February 24, 2004) FTC Order Reversing and Vacating Initial Decision and Accompanying Order, *In the matter of Rambus Inc*., (Docket No. 9302, Notice of Intent to Release, July 21, 2006)

would have either excluded Rambus's patented technologies from the JEDEC DRAM standards, or demanded RAND royalties with an opportunity for ex-ante licensing negotiations if Rambus appealed. In April 2008, the D.C. Circuit reversed the Commission's decision, not agreeing with the reasoning of the FTC's conclusion.[149] First, the Circuit concluded that there was insufficient evidence that the JEDEC would have standardized other technologies if it had known the full scope of Rambus's intellectual property. The second conclusion was that a lawful monopolist's intention to obtain higher prices did not necessarily incorporate the intention to exclude rivals and thus to diminish competition (Carrier, 2009).[150]

Despite these similarities, another case ended in a significantly different outcome.[151] In the *Qualcomm Corp.* v. *Broadcom Inc.* case, which are both chipset manufacturers and members of the *JVT*, (Joint Video Team- a SSO responsible for developing new industry standards for video compression technology), Broadcom accused Qualcomm of deceptively failing to disclose patents necessary to practice the JVT standard. The US District Court concluded that Qualcomm's conduct was inconsistent with the expectations of disclosure that existed among the JVT's members.[152] In addition, the Federal Circuit also concluded that Qualcomm failed to comply with a duty to disclose relevant patents written in the JVT's disclosure policy.[153] In the end, Qualcomm was banned from enforcing the relevant patents against any manufacturer or user of standard-compliant products (Royall et. al, 2009).

5.8.2. Royalty Stacking

Another potential difficulty in the standard-setting process arises when downstream companies using licenses of standardized technology from multiple gatekeepers have to acquire multiple licenses before a product can be commercialized. When each of those patent holders considers which royalty rate to charge for its IP rights independently, the cumulative

[149] *Rambus, Inc. v. Federal Trade Commission*, 552 F.3 d 456, 2008
[150] See Carrier (2009), who states that the court relied on *NYNEX Corp. v. Discon, Inc.* (525 US 128, 1998) in which the Supreme Court had found that a price increase from a fraudulent scheme by a monopoly provider of local telephone services did not harm competition since any injury flowed from "the exercise of market power that is lawfully in the hands of a monopolist." The D.C. Circuit stated Rambus's alleged charging of increased royalties resembles to the NYNEX case.
[151] Royall et al. (2009) states that this is possibly due to the fact that the two cases traveled distinct legal paths.
[152] *Qualcomm Inc. v. Broadcom Corp.*, 539 F.Supp.2 d 1214, 2007
[153] *Qualcomm Inc. v. Broadcom Corp.*, 548 F.3d 1004, 2008, p.1006. According to Royall et al. (2009) the basic question posed by the district court was whether Qualcomm engaged in conduct "so inconsistent with an intent to enforce its rights as to induce a reasonable belief that such right has been relinquished." This approach avoided some of the complexities of proof that the FTC was unable to overcome in Rambus, in particular the burden of proving what the SSO would have done in the "but for" world (if there was no allegation of patent ambush conduct). As the courts in Qualcomm applied the implied waiver doctrine, they claim Broadcom was not required to offer any proof of impact on the outcome of the standard-setting process.

royalty rate may be too high for the licensees. This is because each patent holder may ignore the negative externality caused by its own pricing policies and the aggregate royalty fee for licensing all of the required pieces of the standard may add up to a very large amount, which may be so large that it is no longer economical for the downstream company to implement and commercialize the standard. In such an event, licensees would be better off if all licenses were consolidated under the control of a single patent holder acting on behalf of the group as a whole, which is also known as the solution to the Cournot complements problem. This is the key motivation for cross-licensing and patent pools arrangements, as fragmented IP rights are aggregated into a single bundle (Geradin et al., 2008).

In 2007, the European Commission decided to open formal antitrust proceedings against Qualcomm Inc., concerning an alleged breach of EC Treaty rules on abuse of a dominant market position (Article 102). Qualcomm is a holder of IP rights in the CDMA (Code Division Multiple Access) and WCDMA (Wideband Code Division Multiple Access) standards for mobile telephones, which forms a part of the 3G (third generation) standard for European mobile phone technology (also referred to as UMTS-Universal Mobile Telecommunication System). The complaints were brought to the Commission by Ericsson, Nokia, Texas Instruments, Broadcom, NEC and Panasonic, all mobile phone and/or chipset manufacturers. The complaints allege that Qualcomm's licensing terms and conditions concerning its patents essential to the WCDMA standard are not consistent with FRAND licensing and, therefore, may breach EC competition rules.[154] Similarly in 2007, the Third Circuit, in *Broadcom Corp. v. Qualcomm Inc.* addressed deceptive behavior by Qualcomm relating to the WCDMA technology used in cell phones. The Court explained that a false promise of FRAND licensing could harm the competitive process by hiding the costs of including proprietary technology in a standard and increasing the likelihood that patent rights will confer monopoly power on the patent holder[155].

Probably also due to the wide use of wireless and 3G technologies, these landmark cases initiated a fierce theoretical discussion on royalty stacking and the definition of F/RAND licensing. Namely, Lemley and Shapiro (2007) extends the discussion of patent hold-up and injunctions to royalty stacking by the help of case studies in the 3G technology, which involves several standards and a large number of essential patents disclosed by their owners. Their main finding is that as of 2004, for the European version of 3G, WCDMA, 6,872

[154] Europa Press Release, Memo, MEMO/07/389, 01/10/2007
[155] *Broadcom Corp. v. Qualcomm Inc.*, 501 F.3d 297, 2007.

patents were declared as essential to the European Telecommunications Standards Institute (ETSI), which were held by over forty firms. However, their patent counts includes patents from all jurisdictions, such as the US, Europe and Asia, many of which are equivalent patents filed for global coverage of the same rights. In addition, it was acknowledged that three quarter of the essential patents are actually owned by four companies, which are Qualcomm, Eriksson, Nokia and Motorola. Based on these patent and firm counts, Lemley and Shapiro argue that a royalty stacking problem exists in the 3G standard, and provide an estimate of total royalties as high as 30% of the total price of each phone by summing up royalty demands. However, this estimation is based on summing royalty demands before any cross-licensing began. With cross-licensing, this rate is estimated to decrease to around 20%. Nevertheless, as Geradin et al. (2008) also points out it is not clear why this royalty rate is an indication of royalty stacking, as there is no benchmark for comparison. In addition, the 3G technology itself constitutes an important component of cellular phones, which can fairly deserve 30% royalty paid to its inventors who have devoted enormous amount of resources for the development of these technologies.

As their second case study, Lemley and Shapiro (2007) consider the Wi-Fi standard, where there is extensive patenting and a large number of rights holders, which can be a sign of the royalty stacking problem. They give the example of the patent lawsuit related to the standard between Symbol Technologies and Proxim, which ended with a 6% royalty rate award.[156] The implication they derive from this statistic is that if every patent holder charged a 6% royalty rate, there would have been a royalty stacking problem given the large number of patent holders. On the other hand, technological contributions vary substantially across patents. Knowing that one patent was awarded 6% by the courts does not provide enough information about the value of the remaining IP rights (Geradin et al., 2008). In addition, studies on patent lawsuits, such as Lanjouw and Schankerman (2001) suggest that the more valuable patents tend to be the ones which are litigated. Therefore, as in the case of 3G standard, the royalty rate decided by the court may reasonably deserve this amount.

[156] In September 2004, Symbol Technologies, Inc., announced that it had settled its patent litigation with Proxim Corporation relating to wireless local area network (WLAN) technology. According to the settlement, Proxim paid Symbol $22.75 million for previous sales of infringing products and also agreed to pay Symbol a royalty fee for future sales of WLAN products covered by Symbol patents, which was valued at a six percent royalty rate by the company (Source: http://www.symbol.com/news/pressreleases/settlement_with_proxim_.html).

5.9. Private Market Solutions used in Industries

Cross-licensing or patent pooling are the most common routes to overcome the complements problem, as they allow aggregating the complements under one entity's control. Under a pool, owners of patents deemed essential to a standard form a joint license in order to bundle at least some subset of the essential IP rights into a single package. The participating firms agree on an aggregate royalty rate for the package and then agree on the means to divide the royalty earnings among themselves. Private market solutions of this kind enable manufacturers to obtain the necessary complementary rights for implementing a standard at a lower cost as compared to purely bilateral licensing. This is because cooperation among pool members tends to hold royalty rates down as the aggregation of rights itself lowers transaction costs in negotiating licenses (Geradin et al., 2008).

Especially for vertically integrated firms, whose business models are focused more on downstream earnings compared to upstream royalty fees, cooperative licensing strategies are highly important due increasing reliance on complementary IP rights. As standards involve a number of complementary patents for different components, firms wishing to manufacture a product in line with a standard must obtain licenses for all of the necessary components. When participating manufacturing firms holding relevant patents agree to cross-license one another, at downstream level this increases interoperability or compatibility between products. Thus the standardization process increases cross-licensing incentives as the chances of success in the marketplace due to network advantages are higher (Shapiro, 2001b). As a result of market success and higher profits, incentives for innovation are also accelerated.

On the other hand, the most common concern in the failure of such private market solutions in resolving licensing disputes is the case where the licensor has no interest in the downstream market. In that respect, one problem that emerges is the refusal to deal with some licensees or asking unreasonably high royalty rates known as patent hold-up. However, there are significant disadvantages for firms which engage in this kind of conduct. Regarding refusal to deal with licensees, Epstein and Kuhlik (2004) underline that refusing to deal is a loss of opportunity. A patent is a depreciating asset as it is limited in time and prone to being replaced by better technologies. Therefore, the market power obtained by patents is not certain and this induces firms to license their relevant technology as much as and as soon as possible. The same arguments are valid with respect to concerns about non-practicing entities' ability to ask unreasonably high royalty rates. In addition, as far as royalty stacking is concerned, market collapse due to excessive aggregate royalties is not a desired outcome, especially in case of non-practicing patent holders with no downstream revenues. Patent hold-up examples are few in number and mostly involve firms that have no long-term plan in the industry such as patent trolls (Hall and Ziedonis, 2007).

In order to prove patent ambush and royalty stacking concerns one needs ideal data for analyzing licensing contracts and negotiated royalty rates before and after the conduct; which is not readily available to the public. Moreover, in general, the empirical literature provides weak evidence of significant and widespread licensing problems which cannot be resolved through private market solutions.[157] Although these are mostly based on indirect evidence, the commercial market growth or R&D expenditures in industries can be shown as an indicator of a lack significant market failure in high-tech sectors. The cross-industry analysis in Chapter 4, also contributed in providing such indirect evidence of an increase in R&D expenditures following cooperative agreements.

Lastly, the large number of agreements compared to the limited number of cases brought to court also raises concerns about the necessity of a policy change, just to catch these rare instances.[158] Therefore, any policy change that might undermine the already existing private market solutions on their own without policy intervention can mitigate the innovation incentives already at work. The following policy proposals are evaluated under this rule.

5.10. Policy Proposals

There are some policy proposals to overcome the antitrust concerns that have emerged in the standard-setting context. However, the relevant question for policy proposals aimed at overcoming the hold-up, anti-commons and patent thickets problem is whether any of the proposals offer lower costs and less competitive risk than the existing market solutions. If not, or if the proposals carry other risks, then they should not be pursued since their expected benefits will fall short of their expected costs. In the remainder of the chapter, several policy changes will be analyzed in terms of their effect to reduce the occurrence of certain market failures and their effect on firms' incentives to license or innovate.

[157] For semiconductors, see Ziedonis (2004), for software, see Noel and Schankerman (2006) and for biotechnology, see Epstein and Kuhlik (2004), Arora et al. (2003).

[158] For instance, Geradin et al. (2008) in their review of US court cases, found only seven cases that involved allegations of unfair, unreasonable, or excessive patent license prices within a standard-setting context. They also state that this figure is inflated since a particular dispute between firms frequently results in multiple lawsuits.

5.10.1. Patent Reform

For pharmaceutical and chemical industries the patent system seems to provide adequate incentives for innovation with least amount of distortions. This is probably due to the fact that essentially one patent covers a single marketable product, and the monopoly theory behind the patent law works well. On the other hand, currently most of the litigation and licensing problems have emerged in high-technology industries. This has naturally raised the question of whether the patent system can sufficiently address the necessities in these industries or whether a comprehensive patent reform is necessary.

Generally speaking, the US patent reform evolved by court decisions. For instance, in terms of patentability requirements, the *KSR v. Teleflex (2007)* ruling has increased the inventive step criteria, whereas the *Bilski v. Kappos (2010)* brought clearance on patentable subject matters and ruled that abstract ideas, natural phenomena, and products of nature are not patentable subject matters.[159]As of remedies are concerned, the land-mark *e-Bay ruling (2006)* has reduced the granting of injunctive relief from 95% to nearly 73%.[160] In terms of damage calculations, with *Lucent v. Gateway, Inc. (2009)*, it became more difficult for a patent holder to ask for high damages for components (Lemley, 2009).[161] Similarly in this respect, the Patent Reform Act of 2007 allowed judge's discretion in the method for calculating reasonable royalties.[162] This provision addressed concerns over the risk that damage awards may greatly exceed a patent's contribution to the product value when the product embodies complex technologies (Gilbert, 2010).[163]

However, the most significant change in the US patent system since 1952 has been the "America Invents Act", which has been passed by the Congress in September 2011. The Act switches the US patent system from a "first to invent" to a "first inventor to file" system, eliminates interference proceedings that determine the priority issues of multiple patent

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[159] *KSR v. Teleflex* (127 US 1727, 2007) and *Bilski v. Kappos* (130 US 3218, 2010)

[160] Given in Lim and Craven (2008) from an unpublished report of FTI Consulting that analyses relevant publicly available court cases (collecting cases between May 15, 2006, through Oct. 22, 2008, with 73% granted, 26% denied, 1% undecided for a total of 57 cases). Also see Lim and Niemeyer (2010), Foley & Larder Study (2007) and Isackson (2007).

[161]In *Lucent Technologies, Inc. v. Gateway, Inc.* (580 F.3d 1301, 2009, pp. 1338–1039); it was decided that unless a party satisfies the entire market value test, a patentee seeking damages for a component cannot use the entire market value of the larger product as a royalty base.

[162] As stated in Gilbert (2010), judges can follow an apportionment analysis (based on the incremental value contributed by the patented technology), entire market analysis (where the full end product is used as the basis for royalties), or other criteria, such as the *Georgia Pacific* 15 factors.

[163] For instance, the jury verdict against Microsoft in *Lucent Technologies, Inc. v. Gateway, Inc.* (470 F.Supp.2 d 1180, 2007) was originally set at $1.52 billion. Microsoft's Windows MediaPlayer was deemed to the infringe Alcatel-Lucent's software, but damages were calculated with respect to the average cost of the entire PC (a five-fold difference in price versus the software alone).

applications, develops a post-grant opposition system, expands the prior use defense and introduces the "joinder rules" to decrease the bargaining power of patent trolls as it will become more difficult to sue multiple defendants in one suit.[164] With these changes, most of the peculiarities of the US patent law are expected to disappear, and significantly get aligned with the European patent system, which is believed to produce better quality patents. Most studies highlight that the procedures, such as the post-grant opposition system, stricter examination rules, higher fees and taxing applications for numerous claims of the European patent system provide some sort of immunity from the patent trolls and hold-up problems.[165]

The most effective solution for the problems of the patent system is changing the rules and the internal operation procedures of the patent offices. As also indicated in the White Paper by the US Department of Commerce regarding the Patent Reform, one of the main problems of patent office's is that they are fee-based organizations and patent applicants usually do not pay the full cost of the services provided them by the patent offices (Dom et al., 2010). The white paper points out that under the current system in USPTO, a patent applicant whose application does not result in a patent grant, pays only about one-third of total search and examination costs. It is highlighted that this results in subsidizing the initial processing and review of a patent application procedures. Patent reform establishes a fee-setting authority that aims to provide the USPTO the right to flexibly adjust fees in a manner that will cover its costs. Currently, the fees require amendment by the Congress, which does not always possess the relevant information about the patent office's internal organization structure. The white paper states that with the fee-setting authority, the aim is to effectively reduce the backlog of pending applications at the USPTO and decrease the workload of patent examiners.

The most drastic increases in the fee schedule are applied to large entities. For instance, the proposed fee structure imposes a 47% total increase in basic filing, search and examination fees for utility patents in order to align the fee revenue with the cost of services provided. In addition, in order to induce compact and carefully devised applications, the new structure proposes an 84% fee increase for patent applications in excess of 3 independent claims. Moreover, the new structure imposes an 83% increase in the fees for requesting continued examination with the aim to achieve cost recovery and in order to reduce the scope of disputes

[164] Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284, 325, 2011) (to be codified at 35 USC. § 257).

[165] For a study assessing quality factor in patent systems, see Van Pottelsberghe de la Potterie (2011). For a tender study on EU patent system, see Scelletto et. al (2011). For studies on quality index of patent systems, see de Saint-Georges and Van Pottelsberghe de la Potterie (2011). For a report on strategic patenting, see Hall et al. (2007a).

in case of a final rejection when the applicant believes the examiner has made a mistake. The maintenance fees are also proposed to increase to better align front-end and back-end fees; early stage fees are lower than the later stage fees as there is more uncertainty regarding the value of an invention in the beginning of the patent life (Graham, 2012).[166]

Another welcomed reform is the establishment of a post-grant review system in the US, similar to the EPO post-grant opposition practice. In Europe, on average, about 5% of all granted patents were opposed between the years 2000-2008 and on average 75% of all the cases result in cancellation or at least amendment (Sceletto et al., 2011). The same ratio for the same time period for the US patents, which go through the current ex-partes and inter-partes reexamination system combined, is only 0.28%. If only inter-partes examination is taken into account, which is more similar to the EPO opposition system, the ratio falls to 0.03%.[167] The current reexamination practice in the US focuses on questions of novelty and obviousness based upon prior art in the form of printed publications and patents. The new post-grant review process extends the basis for challenges to patent validity (failure to disclose the best mode is not an acceptable base for request). Thus, apart from prior art patents and printed publications of prior art grounds, a post-grant review can also be requested on novelty and non-obviousness grounds based on evidence of public use, on-sale activity, or other public disclosures.[168] Moreover, post-grant review can be required based on an alleged lack of compliance with written description, enablement, or patent eligibility rules (Fish & Richardson, 2012).[169] On the other hand, the fees at $41,400 (the average of the fees charged depending on number of claims level) for filing for a post-grant review is radically high compared the EPO opposition procedure (745 euros).[170] This difference raises doubt about successful implementation of the post-grant review system.

There are some additional proposals, which have not yet been addresses by the patent reform. For instance, Bessen and Meurer (2008b) suggest that the inadequate search requirements in both jurisdictions imposed on firms in their patent application procedures is an important

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[166] Graham, S.J.H. (2012) "Patent Fees Proposal" February 12, 2012. USPTO America Invests Act implementation.
[167] Based on authors' own calculations.
[168] Source : RatnerPrestia, Guide to re-examination and post-grant review of US patents, available at: http://www.rppostgrant.com/ComparisonCharts/post-grant-review-comparison.html
[169] Source: Fish & Richardson, http://www.fr.com/reexam-services-post-grant-pgreview/
[170] Source: Federal Register, Changes to Implement Inter-partes Review Proceedings, Post-Grant Review Proceedings, and Transitional Program for Covered Business Method Patents; Final Rule, p.47, available at: http://www.gpo.gov/fdsys/pkg/FR-2012-08-14/pdf/2012-17906.pdf. Also see for EPO patents, Schedule of Fees and Expenses of the EPO, Supplement to OJ EPO 3/2012, available at: http://www.epo.org/applying/forms-fees.html

reason for the weak functioning of the patent system.[171] However, shifting the responsibility for patent search from examiners to patent applicant also has its downsides. Putting burden on firms, such as increasing the search requirements, can slow down the innovation process and should be carefully assessed before implementation. Especially in the context of complex product industries, when a product incorporates hundreds if not thousands of patents, it might be just too difficult and economically not viable for firms to search for all the relevant patents. This is another reason why firms hold extensive patent portfolios; to decrease the risk of inadvertent infringement.

In addition, strengthening definitiveness and enablement requirement (especially in respect to the source code in software patents) and restricting the doctrine of equivalents are some other policy changes Bessen and Meurer (2008b) suggest. Evidence presented in the previous chapter has shown that the difficulty in reverse engineering in software industry can lead to more cross-licensing agreements between firms, which have a positive impact on their innovation incentives; therefore, authorities should keep in mind that in some industries the limitation on enablement requirement is necessary to grant the patent strength required to induce firms to invest ex-ante. Moreover, in some industries, it might be better to have broad patents by applying low definitiveness standards (Burk and Lemley, 2003). Broad patents can induce firms to cooperate in resolving patent disputes and can lead to more socially efficient outcomes, which is one of the findings of Chapter 3.

To sum up, the overview of the patent reform suggests that improving the patent prosecution system is the most appropriate method to correct the inefficiencies in the system. In the US, the improvements of the fee structure in patent offices and the post-grant opposition system are right steps towards that direction, although more effort is necessary for the better functioning of these procedures. Nevertheless, it should be noted that increased levels of patent litigation, and problems associated with anti-commons and patent thickets are inherent complex product industries due to the cumulative and complementary nature of innovation. In that respect, even though the policies aiming at reducing weak patents will most likely improve the current situation, it cannot completely prevent it. This again highlights the importance of market mechanisms and bargaining in terms of overcoming the inefficiencies created by weak patents.

[171] The authors also suggest that simplifying the claim language can also provide some benefits in terms of reducing ambiguous patents and associated patent litigations.

5.10.2. Disclosure

Disclosure rules of existing patents aims to provide SSOs with information required to weigh the costs and benefits of the adoption of proprietary technology as a standard. However, in order to prevent the adverse outcomes similar to the Rambus case, current proposals aim to extend the obligation to future patent interests. In addition, due to lenient disclosure rules, it has been noted that many firms issue "generic" or "blanket" disclosures indicating that they hold essential patents, but without providing any publication numbers. These disclosures are claimed to provide little guidance to standard developers who are trying to understand which parts of a specification are actually covered by patents, or whether those patents are valid and enforceable (Simcoe, 2012). For these reasons, implementing stricter disclosure rules is among the policy proposals.

However, although applying stronger disclosure rules can significantly reduce the chances of ex-post hold-up, there are also essential reasons to apply lenient requirements. First of all, the concerns of patent hold-up have partly escalated due to the reason that a patent that belongs to a standard is litigated more often. In other words, infringement is easier to detect when a patent belongs to a standard (Simcoe, 2012). Second, for companies with large portfolios it might be difficult to assess whether a proposed standard incorporates a patent within its patent portfolio. Indeed, there are some strategies which firms can implement to avoid litigation. Investing in a systematic patent landscape monitoring system that enables firms to detect infringement in the early stages of the product-life-cycle or performing regular competitor analysis and due diligence with regards to other companies' patents are among these strategies (Soininen, 2007). However, even if these expenses are made, there is still the risk of infringement due to the complex patent landscape. Third, willful infringement claims, which mean that a infringer has to pay three times the normal damages, lead companies to intentionally refrain themselves from making such comprehensive patent searches. On the other hand, expecting the standard-setting bodies to conduct these searches is also not realistic due to the cumbersome efforts to find all relevant patents from many different patent portfolios and verifying the information provided by the participants. Due to these reasons, usually the disclosure requirement does not go beyond the personal knowledge of the discloser.

In addition, setting a standard takes a long time. Given long pendency lags of patent applications, and the widespread use of continuations and divisional applications to amend claims over time, it is often unclear whether a pending application will be essential at the time a standard is authorized (Simcoe, 2012). Such probabilistic nature of the information provided might be less likely to be useful for SSOs' decisions-making (Kolasky, 2006). Lastly, the scope of patents is actually unclear until it is confirmed by courts and the ambiguity is even higher when patents are not even granted. Therefore, in the existence of such uncertainties, setting ironclad disclosure rules may induce firms not to participate in the procedure to prevent significant patent liability in the form of being sued and paying high royalties to others or being prevented from using a particular technology. Since standards should encourage, rather than discourage, patent holders to participate into the procedure, it is believed that applying stricter disclosure rules would not go beyond putting extra burden on IP holders that aim to participate in a given standard.

5.10.3. Licensing Commitments

This proposal is based on the premise that regulatory agencies should mandate SSOs to provide well-defined licensing commitments that are introduced into the standard-setting process through ex-ante unilateral announcements of licensing terms by patent holders, so-called F/RAND commitments. For instance, in 2007 DOJ and FTC, in their joint report, provided a subsection to ex-ante licensing as a means to mitigate patent hold-up.[172] In addition, DOJ granted Business Letter clearance to two SSOs, VITA (VMEbus International Trade Association) and IEEE (Institute of Electrical and Electronics Engineers) to implement ex-ante licensing disclosure policies.[173] VITA's new policy mandates that each member must, among other things, declare the maximum royalty rate that it intends to seek for all of its patent claims that may become essential to implement the standard in question. VITA member companies must also disclose their most restrictive non-royalty terms, acting as a binding price cap on royalty rates.[174] IEEE's new policy is similar, although here members are simply encouraged (not required) to disclose their licensing terms when they disclose their IP rights to the SSO.

Implementing such a policy puts a burden on innovators as they have to bear the cost of negotiation at a point when revenues are not yet known and the details required for a license are not clear (Sanders, 2010). It may be the case that SSO members do not know the precise value of a proposed standard before it actually reaches the marketplace. As a result,

[172] Antitrust Enforcement and Intellectual Property Rights: Promoting Innovation and Competition, April 2007
[173] VMEbus International Trade Association (VITA) Patent Pool Business Review Letter (2006); Institute of Electrical and Electronics Engineers Inc. (IEEE) Patent Pool Business Review Letter (2007).
[174] VITA also permits patent holders to submit later declarations with less restrictive licensing terms.

information problems of this kind can only be resolved ex post. Voluntary disclosure regimes, on the other hand, take into account such information problems, and firms can disclose licensing terms ex-ante only if they wish to. Such a policy may increase firms' incentives to join SSOs, whereas policies that reduce incentives to participate in SSOs can cause lower quality standards (Geradin et al., 2008).

A related issue in particular, as studied in Chapter 3, is that firms that hold patents for defensive purposes typically do not actively enforce their IP rights, but instead use them as bargaining chips in negotiations with other firms. This is a case specially observed in semiconductors and biotechnology industries. Geradin et al., (2008) points out that if these firms are forced to ex-ante declare the licensing terms for such patents, the value of such chips would be substantially lessened. In addition, declaring a positive royalty rate for all patents may force right-holders to falsely signal higher aggregate licensing costs. Hence, depending on the number of firms following such a defensive strategy within a given SSO, mandatory disclosure terms could indicate a patent thicket that actually does not exist (Geradin et al., 2008). Interacting on patent portfolios has become a natural way of coping with the growing technological complexity followed by the patent landscape. Therefore, the effect of such a policy change could actually be limiting firms' bargaining power within their interactions, which can have adverse effects on how firms do business.

The empirical studies also provide evidence that the SSOs try to seek a balance between stronger disclosure rules and incentives to participate. For instance, Hussinger and Schwiebacher (2012) find positive significant contributions to firm value if the firm holds a patent that is relevant for a standard and licenses it under RAND or specific non-RAND terms.[175] On the other hand, they find evidence for a negative market valuation for royalty-free licensing announcements. Similarly, Chiao et al. (2007) find that the existence of royalty-free licensing is negatively correlated with the existence of a disclosure requirement. In other words, when firms are forced to disclose their patents, then the general trend is towards not requiring a royalty-free licensing scheme as well. In addition, they find that when there is more competition between SSOs in the same technological field, then the provisions of the standard-setting procedure is towards setting more lenient rules for technology sponsors. This means that the competition between SSOs to attract the best technologies available leads to

[175] Hussinger and Schwiebacher (2012) state that the acceptance of RAND terms is highly dependent on the value of the technology. If a technology is very valuable, licenses on RAND terms can be insufficient to induce participation of technology providers so that they may insist on their right on exclusivity and command licenses on specific, non-RAND terms. The reason why firms might, nevertheless, participate in the standard is to capture value from their technology contributions due to an increased standard adoption in the market.

provisions providing more concession toward the participants. This finding also supports a more market-based lenient legal approach towards firms participating in standard-setting development activities.

5.10.4. Ex-ante licensing

An alternative to RAND commitments are procedures to capture ex-ante competition as a means of restricting ex-post royalties. The rationale for instituting an ex-ante licensing policy within SSO is that after a standard is defined and a particular technology has been chosen for incorporation, competition usually lessens. Simcoe (2012) points out with ex-ante licensing, patented technologies that face competition during the development phase of a standard would have lower royalties if there are many substitute technologies. This is because ex-ante disclosure policies mimic the hypothetical negotiation between a willing licensor and a willing licensee that might take place before a standard is adopted, which is often the definition of a reasonable license. On the other hand, once a standard is adapted and firms have made technology specific investments to implement that standard, a patent holder can ask excessive royalties up to the difference in switching cost to alternative technologies, which is the economic reasoning behind hold-up. In ex-ante negotiations, a rational licensee would be unwilling to pay a high price as these investments are not made and switching costs cannot be incorporated into the analysis (Simcoe, 2012).

On the other hand, in reality it is not easy to institutionalize ex-ante negotiation between firms. First, in case of cumulative and complementary innovation, there are some difficulties in differentiating technologies from one another, and consequently in measuring the pure benefits of the isolated technology in question. In addition, there might also be some network effects, which can only be calculated once the products reach the marketplace. Hence, without knowing the exact total size of the pie, which is aimed to be shared among participants, it might be difficult to reach an agreement by means of ex-ante negotiations.

In addition, due to the vague interest of firms in certain industries, most licenses offered cover a firm’s entire patent portfolio, providing a licensee with the freedom to operate with respect to competitors. These firms rarely offer a narrow license that covers only the essential patents for a single standard and, as a result, the royalties may exceed the amount that emerges in RAND calculations (Simcoe, 2012). Once again, forcing firms to only accept certain licensing agreements or limit them in their drafting of their own royalty terms can discourage firm participation in SSOs.

5.10.5. Limiting Injunctive Relief

Supporters of this proposal suggest that a patent holder member of a SSO should not be empowered to bring actions for injunction since infringements cannot occur when a contract (the standardization activity) is in place (Lemley and Shapiro, 2007). In addition, others have recommended that injunctive relief be denied to certain classes of patent holders, specifically to non-competing innovators without manufacturing capabilities (Shapiro, 2010). The rationale is that with competing entities the threat of mutual plant shutdown induces patent holders to bargain, but such incentives are absent in case of firms with no manufacturing capabilities.

The most problematic issue regarding this proposal is that weakening bargaining power of firms by denying injunctive relief could seriously harm innovation. As it was seen in Chapter 3, symmetry is an important element that forces firms to settle disputes. It would be difficult to bring a potential infringer or licensee to the negotiation table without injunction threats. In addition, as far as the non-practicing patent holders are concerned, it should be noted that the revenues of these firms solely depend on licensing revenues; hence, they also have strong incentives to reach an agreement with the licensees to prevent lost income opportunities. Therefore, in either case, it is possible to argue that some negotiations are only possible when the bargaining takes place under the shadow of legal threat. Plus, there is no reason to believe similar outcomes would be achieved if these market solutions are not in place. At the end of the day, licensing is a good thing and one would like more of this practice rather than less. As currently there is little doubt that the patent system encourages innovation, it is also believed that the certainty in the property rules increases licensing activities. Moreover, licensing disseminates knowledge providing grounds for future innovations. If private market solutions which firms rely on are at work, it means that a certain policy proposal can actually be Pareto irrelevant.

5.11. Final Remarks

Private market solutions to overcome transaction costs and inefficiencies in complex product industries consist of coordination and collaboration through the transaction or exchange of patents between market participants. As a result, competition policy and patent law often interact in the matter of IP licensing. The costly and increased litigation in complex product industries that has been observed in the last couple of years has generated discussions about implementing a stricter approach towards such agreements. However, such restrictions should only be justified if there are insufficient efficiency gains and no potential cost generated.

The analysis of Chapter 3 has investigated the problems associated with increased intellectual property rights and has noted that there might be market failures in the form of deterred innovation incentives due to problems inherited in the nature of innovation, complexity of products, and fragmentation of IP rights. As Hunt (2006) also suggests, these problems may result in firms allocating resources to patenting, which could instead have been used in more R&D. However, as it has been shown, market mechanisms, such as cross-licensing and patent pools, can solve these problems if firms have credible threats that can be used in bargaining. Furthermore, the empirical analysis of Chapter 4 has shown that in industries, where vertical relations are common, there is significant evidence of increased R&D efforts after collaborations and no evidence to the contrary. The general implication of these findings is that, the policy environment should induce firms to reach optimal solutions. On the other hand, policies ignoring market responses and only focusing on some limited static gains can mitigate the dynamic efficiency gains as designed by the IP system.

This chapter focused on the potential costs of the current regulatory framework concerning IP licensing and some policy proposals regarding the standard-setting procedures. The economic findings in this research support the US approach to IP licensing already in place. On the other hand, even though mostly aligned with the US rules, some rules in the EU regulations have been identified as being too restrictive. In terms of cross-licensing, in case of vertical agreements, the provisions restricting the territorial and field of use of the licensed technology could be relaxed as there are proven efficiency gains regarding these agreements. In case of patent pools, the strict application of not allowing non-essential technologies into the pool could be troublesome if there is technology overlapping rather than full substitution between patents. The exclusion of these patents causes the risk of litigation to remain in the market and hinders the purpose of patent pooling. Lastly, the doctrines such as patent misuse applied to the context of portfolio licensing could potentially ignore various benefits of portfolio licensing if it is applied through a solely static perspective.

Moreover, in the context of standard-setting procedures, the patent reform is likely to improve the dubious quality of patents in the US, which can be problematic in the context of complex product industries. The increase in the fees applied and the establishment of a post-grant review procedure, similar to the ones already in practice in the EU, is expected to align the patent quality in the US with the EU. On the other hand, applying stricter disclosure rules is difficult to implement due the costs and the willful infringement doctrine. Licensing commitments are likely to induce inefficient bargaining since the negotiation takes place at a point when revenues are not yet known and details are not yet clear. Due to the uncertainty of the innovation process, this information is only available ex-post. In addition, such a policy could seriously prevent patents to be used as bargaining chips in negotiations. Ex-ante licensing is difficult to institutionalize as certain information problems regarding bargaining can only be resolved ex-post and thus discourage firm participation in SSOs. Finally, limiting injunctive relief could adversely affect the incentives to engage in negotiations.

In conclusion, due to the limited evidence on patent ambush or royalty staking cases, and the likelihood of these policy changes hampering the current market mechanisms, these policy proposals are predicted to impose extra burden on firms in the already complex technological and market settings. This is why apart from the patent reform their likelihood to be beneficial for the society is low.

CHAPTER 6. CONCLUSIONS

6.1. Aim of the Research

The main objective of the research is to provide a more quantitative understanding of the contemporary patenting behavior of firms and its consequences. An initial observation is that firms in complex product industries are interacting over patent portfolios. Secondly, it is observed that such patent portfolio races are especially taking place in industries that previously relied on other mechanisms such as secrecy or lead-time advantages rather than patent production to appropriate returns from their investments. The conventional wisdom is that the patent portfolio races are mainly derived for strategic reasons with the aim of negatively affecting the competition in the markets and creating some transaction costs for other firms operating in the same or similar technological areas. As a result, some scholars suggest that policy should target at preventing large volumes of patent applications. This research underlines that the main facilitators behind portfolio races are inherent in the complexity of modern day technology and are partly inevitable. Due to the fact that the production of many new high-technology products often requires numerous complementary innovative components, each of which may be protected by one or more patents, complex product industries are unavoidably associated with fragmentation of IP rights.

The study aimed at providing a framework conceptualizing patenting activities in the existence of IP fragmentation. Such a framework has to deal with interrelated problems of technological complexity and modern patent landscape. In that respect, ex-post licensing agreements between firms that are heavily resorted in certain sectors have been incorporated into the analysis. More precisely, by consolidating the right to use patents required for commercialization of a product, private market solutions, such as cross-licensing and patent pools, have been widely used to overcome problems triggered by IP rights fragmentation, Thereby, private bargaining between parties as such cannot be isolated from the legal framework. A result of this analysis is that policies ignoring market solutions and only focusing on static gains can mitigate the dynamic efficiency gains as induced by the patent system. The evidence found in this thesis supports the opinion that legal reforms that aim to decrease the degree of patent protection or to lift it all together can hamper the functioning of the current system.

A second policy layer, apart from the optimal design of patent protection in complex product industries, can be found in the competition rules governing cross-licensing, patent pools or standard-setting arrangements. The costly litigation in complex product industries that has been observed in the last couple of years has generated discussions about implementing a stricter approach toward these market solutions. However, such restrictions should only be justified if there are not enough efficiency gains from these private agreements. The empirical research presented in Chapter 4 provides evidence that at least in certain industries, there are benefits involved in these practices especially increased R&D incentives. Therefore, together with the findings of Chapter 3, the research provides evidence which can justify a more lenient approach towards these arrangements.

The methods used in this research have the objective of filling the gap in the literature regarding the functioning of the patent system in complex product industries in the light of fragmented IP rights and cooperative market solutions. The starting point of analysis was not an identified market failure as it is done in the classical law and economic literature but investigating whether there is actually one as often claimed in the literature. The reason to follow this approach is that the regulation - without knowing the real dynamics of a system - holds the risk of creating additional externalities. This risk is potentially higher in complex product industries compared to simple product industries, as there are private market solutions to overcome transaction costs in the market. Firm behavior is shaped in a given institutional setting; hence, it would not necessarily mean that the same efficient outcomes will be achieved when there are some changes in the policy environment. This study gives insights into the direction of this behavior in certain circumstances. Economic methods are used to explain the effects of some rules on firm behavior. The results derived from this analysis enable to assess whether related regulations currently in effect are economically efficient, or to foresee the effect of some potential policy changes. As a result, as previously mentioned, the efficiency criterion used in this dissertation is based on the following rule: *if firms can efficiently organize their operations under private regulation, do not change the current rule if it is likely to generate additional transaction costs within the system.*

6.2. Summary of Economic Analysis

The findings of this research contribute to the discussions evolving around the patent policy in complex product industries. After Chapter 1, which defines the scope of the research and methodology, the following chapters gradually contribute to answer the research questions and, hence, provide the necessary input for the subsequent chapters.

Chapter 2 presents the developments of economic analysis of IP rights starting from the initial models of its economic justifications following the current considerations in the literature. The intention is to show the differences and also similarities between the contemporary use of patents and the traditional economic view. In addition, theories are presented regarding the interconnection of patent portfolio races and the modern patent landscape and how this relation influences firm behavior. The summarized potential benefits of patent portfolio races illustrate that the term often used as strategic patenting is mostly a necessity of the current technological and market order. For that reason, the conclusion derived from this part is that it is highly difficult to identify which patenting activities should be prevented from a policy perspective as these patenting strategies are also a part of firms' innovation decisions. The review of the empirical literature provides supporting evidence on this finding, in particular about how fragmentation affects patenting strategies and how this influences firm behavior. Lastly, the chapter focuses on the main concerns related with the modern patent landscape, namely the dubious quality of patents and the deterred follow-on innovation incentives. The section points out the proper policy layers to solve these problems and underlines the potential costs of using wrong mechanisms. In both cases, the improvement of the patent granting system is likely to decrease the potential transaction costs and inefficiencies in the system. However, despite this benefit, such a policy change will not eliminate the complementarities between patented technologies and hence fragmentation of property rights. Therefore, there is still need for market mechanisms to overcome the problems of mutually blocking patents. Often these mechanisms are negotiated under the shadow of IP protection. As a result, it is argued that reducing the level of IP protection without knowing its actual effect, can lead to inefficient market outcomes.

In Chapter 3, a formal theoretical model is developed to understand the private market solutions, namely cross-licensing deals, emerged to overcome the problems, which are a result of fragmented property rights. Following the setting used in Hunt (2006), it is assumed that firms devote separate resources and hence develop separate strategies for organizing their R&D and patenting activities. The analysis focuses on the bargaining outcomes of firms under the threat of litigation. The contribution of this model is the introduction of a new variable that enables to disentangle the effectiveness of patent protection and the effect of technological overlaps between firms' portfolios. The model shows that the option of cross-licensing increases firms' R&D investment levels, especially when the degree of technology overlap is high. In addition, firms obtain more patents as the risk of infringement increases and even more so when the degree of technology overlap is high. This suggests that a prisoners' dilemma in patenting does take place when the technology is fragmented. The consequence of this problem is that incremental reductions in the cost of obtaining patents can result in less R&D than would otherwise occur. However, the model shows that when firms are allowed to cross-license, implementing a patent policy that is more in favor of infringement can solve the negative externality of less R&D when the cost of obtaining patents is low. This means lowering the strength of patent enforcement tools would not probably produce efficient outcomes. In addition, patent granting rules can also directly affect the outcome through the degree of technological overlapping. The comparative statics exercise points out that the R&D incentives of firms increase as the degree of overlap decreases. This can be attained through increasing the inventive step. In addition, applying a high level of such non-obviousness standard can lead to broader protection for granted patents. This can indirectly increase the infringement probabilities, hence strengthening patent enforcement.

Chapter 4 presents an empirical application that tests the relevance of the model, and the analysis is further extended by conducting a cross-industrial analysis. In this way it is possible to disentangle the different innovation and market mechanisms inherent in various complex product sectors. Through the construction of a novel dataset, the study focuses on the impact of ex-post cooperative agreements on further R&D incentives and investigates whether there are differences in the nature of the impact depending on the characteristics of the industries. Previous economics and strategic management literature do not consider ex-post cooperation mechanisms as a significant source of technology transfer but more as a tool for parties that are interested in each other's technologies to have access to patents without the risk of infringement. However, it is found that, on average, firms which are engaged in an ex-post cooperative agreement invest more in R&D than those that are not. In addition, the analysis of the consolidated data reveals that, on average the R&D spending of firms increases following an ex-post cooperative agreement. Moreover, the evidence indicated that these ex-post cooperation agreements can serve different purposes in different industries, an issue which has not received the deserved consideration in terms of its implication in the literature. This distinction emerges from the finding that in industries where the aim of the cooperative agreement is to attain freedom to operate, there is no significant effect of ex-post cooperation on firms' R&D incentives. This is the case for instance in semiconductors and biotechnology sectors, as in both industries firms are competing to produce similar end products, and therewith most of the time are capable of developing their own technologies. At the time of ex-post cooperation, technologies are already developed but firms need guarantee not to be blocked from competitors' patents. On the other hand, if the aim is to attain freedom to design as is the case for electronics/communication equipment, computer manufacturing and software industries, then there is significant evidence that the R&D expenditures are increased following an ex-post cooperative agreement. When the aim of the agreement is design freedom, even though the firm already has developed the main technologies by itself, the final product may still require the assembly of different components. Interestingly, software industry also falls under this category, due to the restrictions posed on reverse engineering of software codes. As a result, ex-post cooperative agreements enable further technology development. However, this result should not undermine the usefulness of these practices in which operational freedom serves as the objective of cooperation. When the patent landscape is highly fragmented and it has direct effects on how firms do business, private market solutions such as cross-licensing and patent pools provide protection against inadvertent infringement and consequently create efficiencies in terms of saved litigation costs. The study has some implications for the antitrust analysis of cross-licensing and patent pools. In some instances, portfolio licensing can be considered as tying arrangements and may be subject to the patent misuse doctrine. However, it should be noted that, in multi-component industries the transaction costs to license individual patents for specific products are too high; therefore, licensing occurs on a portfolio basis. In addition, antitrust limitations regarding agreements between non-competitors can sometimes ignore the fact that the efficiency gains generated by these arrangements can exceed the potential loss due to the restrictive provisions. These limitations can particularly come to light in industries with broad interests such as electronics/ communication equipment and computer manufacturing.

6.3. Is the Legal Innovation Aligned with the Technological Innovation?

Chapter 5 specifically explores the regulatory framework affecting the private market solutions, with the aim to answer the research question: *"Do current and proposed rules regarding IP licensing adequately address the innovation dynamics in complex product industries?"* In other words, it investigates whether legal innovation is aligned with the innovation observed in many technology areas. Based on the theoretical and empirical findings of the previous chapters, the chapter analyzes and compares the US and EU rules regarding IP licensing. In addition, due to the intensive standardization activities in complex product industries, some predictions have been generated regarding certain policy proposals that are suggested in terms of regulating the use of patent portfolios and market mechanisms in the standard-setting context. Based on this analysis, the answer to the question above to a large extent is found to be "*yes*", but the comparison between the licensing rules has pointed out that the US approach is more lenient towards IP licensing than the EU rules. The assessment of rules and proposals can be summarized as follows:

Cross-licensing

1. The EU Commission gives extra scrutiny to determine whether a blocking relationship between patents in fact exists, relying on objective factors and independent experts, whereas this is not explicitly stated in the US Guidelines. The Commission takes a strict approach to cross-licensing, which is a beneficial mechanism in order to clear blocking relationships.
2. In the EU Guidelines, hard-core restrictions also apply to non-competitors that include standard vertical restraints, such as territorial and field-of-use limitations, even in the existence of mutual blocking relationships. Industries, where vertical relations are quite important, rely on extensive cross-licensing of technologies to achieve design freedom without infringing others intellectual property rights. These cross-licenses often limit where and how technologies may be used. Such limitations do not necessarily imply that firms have divided customers or markets in ways that increase the prices of the products they produce. It should also be noted that, prices clearly would be higher in many industries if firms were prohibited from entering into these broad cross-licensing agreements.
3. In case of significant market shares, the EU Commission does not allow fixing two-way royalties to clear blocking relationships, which means the Commission assumes that only royalty-free or one-way royalty cross-licensing can settle patent disputes related to blocking patents. However, in case of vertical relationships, such anti-competitive concerns are at minimum, and a two-way royalty may be preferred by parties to maximize the value and use of technology, which can prompt them to invest in further technology development.
4. The approach of the EU Commission to vertical licensing is considered to be too strict as these arrangements usually enable a product or process innovation, which would have not been realized in the absence of an agreement.

Patent Pools

1. The divergence in essentiality rules used by agencies in the EU and the US can result in differences in the competitive relationship among patents or potential patents that aim to be integrated into similar pools. For pool members that have operations on both sides of the Atlantic, this creates uncertainty.
2. In US, even if a patent is deemed to be substitute or non-essential, a more lenient approach is followed by authorities towards letting the inclusions of such patents into the pool. The EU applies stricter rules that prevent the inclusion of non-essential patents into the pool. However, as pointed by some experts, in case of overlapping between some substitute technologies rather than full substitution, inclusion of such patents in the pool may be welfare enhancing. If policy by default prohibits overlapping technologies to be pooled, the transaction costs can be higher for licensees to individually obtain these licenses. Exclusion of these patents can undermine the purpose to engage in patent pooling in the first place as the risk of infringement to certain patents will persist. This can discourage firms from investing in follow-on technologies. Efficiency arguments of such, which can be successfully used in enforcement actions in the US, can be rejected by the EU Agencies.

Package Licensing

1. The analysis focuses on the economic arguments presented in the recent case law of the US as so far there has not been a similar case in the EU to make a comparison between the two approaches.
2. Recently, the Federal Circuit in the US has emphasized the need for portfolio licensing in complex product industries. Package licensing of portfolios serves as a guarantee to the licensee that it will not be sued for engaging in any conduct covered by the entire group of patents in the pool. In this way, patent-to-patent tying arrangement should be considered differently from the patent-to-product tying arrangements.
3. At least in the US, this decision has reduced the scope of the patent misuse doctrine and thus has implications on licensing efforts. The economic reasoning of the Court has similarities with the economic findings of this research. The Court has underlined the importance of fully compensating the innovators ex-post in order to provide adequate innovation incentives ex-ante. Antitrust rules that are applied to IP matters

can sometimes create ambiguity due to their ignorance of dynamic incentives involved in certain licensing arrangements.

Policy Proposals to Improve Standard-Setting Procedures

1. *Patent Reform:* The "America Invests Act" is predicted to alleviate the low quality problem of the US patents compared to their European counterparts. In that respect, the change in the fee structure and the establishment of a post-grant review system are promising developments. On the other hand, proposals regarding the increase of search requirements in both jurisdictions can slow down the innovation process, especially in the context of complex product industries, when a product incorporates hundreds if not thousands of patents. In addition, in some industries the limitation on the enablement requirement is necessary to provide patent protection that adequately compensates the innovators from an ex-ante perspective. Moreover, in some industries it might be better to produce broad patents through the application of low description standards. It should be noted that certain externalities are solved via bargaining between market participants; therefore, tailored policies should aim to enable firms to reach cooperative outcomes.
2. *Disclosure Rules:* It is predicted that applying stricter disclosure rules would put extra burden on IP holders that aim to participate in a given standard and hence may discourage firms from participating in the standard. The justifications for applying lenient disclosure rules are numerous, but the main reason is that patent search is a costly and time consuming activity and willful infringement doctrine can withhold firms from investing in this process. In addition, the probabilistic nature of information provided in case of patent applications might be less likely to be useful for SSOs' decisions making.
3. *Ex-ante Disclosure Policies*: Such policies can result in inefficient negotiations as the value of innovation and the terms to allocate rents are only certain from an ex-post perspective. These policies can reduce the incentives to participate in SSOs and even result in lower quality standards. In addition, this policy can undermine the value of patents that are held for bargaining chips in negotiations, which is a necessary business strategy for firms in certain industries. To implement such a policy should only be justified if ex-post mechanisms fail to overcome market failures. Yet so far,

there has been no empirical proof (neither in the previous literature nor in this analysis) of such a widespread problem.

4. *Ex-ante Negotiation*s: Imposing ex-ante negotiations also leads to problems based on uncertainty of information regarding the ex-post value of innovation. Requiring firms to only accept certain licensing agreements or limit them in drafting their own royalty terms can discourage firms participating in SSOs. This can be especially problematic in industries where firms' interests are vague and portfolio licensing is common.
5. *Limiting Injunctive Relief:* Denying injunctive relief to patent owners whose patent is a part of a standard could also harm innovation incentives. Weakening bargaining power of firms could obstruct firms to settle potential patent disputes. There is convincing evidence that both in case of practicing and non-practicing entities, settlements are only reached when the bargaining takes place under the shadow of litigation.

6.4. Limitations and Suggestions for Further Research

As previously mentioned, the economic analysis presented in this dissertation focuses on certain aspects of the phenomenon of patent proliferation and fragmentation; therefore it discusses a simplified version of reality. As the world is too complex, economic analysis makes use of certain assumptions in order to illuminate specific research questions. Therefore, one should still be aware of the limitations inherent in the analysis and the extent of its implications. For instance, as mentioned before, one shortcoming of the model presented in Chapter 3 is that in terms of social welfare, all that matters is the number of innovations while the pricing policies are excluded. The absence of pricing policies rules out the possibility to investigate parallel pricing above the competitive level and, hence, does not measure the extent of deadweight loss as done in the traditional monopoly view of patents. However, the aim of the chapter is to focus on the dynamic innovation incentives of firms when multi-patents are needed to appropriate returns. In order to capture this effect, it is assumed that firms devote separate resources to R&D and patenting. Even under this setting, patents' ability to appropriate returns from investments is not undermined. Nevertheless, it will be fruitful to explore possibilities that incorporate pricing decision into this setting in future research.

In addition, more formal analysis is possible in cases where manufacturing firms that hold patents on key technologies, cross-license one another but refuse to license newcomers, or license outsiders only at very high rates (Jaffe and Lerner, 2004). A similar entry deterrence strategy can be in the form of not suing oligopolistic competitors but instead suing new entrants to drive them out of the market. These are possible extensions that can be incorporated in the model by changing the setting as a well-established oligopoly competing against potential entrants. Another asymmetric environment that was not formerly analyzed is when firms with no manufacturing possibilities negotiate with firms having manufacturing capabilities. However, the particular focus of the thesis is competition in the technology markets. In addition, the legal analysis focuses on aspects that can be attributable to the findings of the model, and special consideration was given not to stretch the implications beyond the results of the analysis. Furthermore, regarding the concerns about non-practicing entities, normative reasons were provided on why they also have interests in settlements; hence, they should not be an immediate suspect of strategic behavior.

The empirical study also relies on some simplifying assumptions to be able to answer the research questions. One of them is that the analysis only uses US data rather than other EU or Japanese sources. However, this was necessary in order to maintain consistency, reliability, and comparability among different datasets used. For instance, the fact that the application of patentability standards and patent granting procedures can differ among the different national systems could have posed comparability problems. The US represents one of the largest markets for complex product industries, so foreign firms which commercialize their inventions in the US also patent there. Including these firms' patents under other jurisdictions can therefore lead to double counting of some patents and hence create consistency problems. Nevertheless, in order to reflect the full picture, foreign firms that are publicly available in the US stock market were also included in the sample. As noted before, previous studies have shown that US patent data provide a good measure for the innovative activities of foreign firms.[176]

Furthermore, even though SDC Platinum, the dataset used to identify licensing contracts, covers the period between 1986 to 2008, after 1999, there is a sudden close to 50% decrease in the number of deals per year which continues throughout the following years. For that reason the data after 1999 is not included in the analysis. Due to inadequate corporate reporting requirements or a change in the database system, it might be possible that the database does not cover all the deals executed in the relevant time period (although it is certainly much more comprehensive than any available alternative data set). Missing data on deals can cause false negatives (identifying firms which have engaged in a cross-licensing

[176] See Basberg (1983), Dosi et al. (1990).

deal in the relevant time period when they actually have not) that can undermine the validity of the findings. To alleviate this potential problem, the time frame for the analysis is between the years 1990-1999, for which the coverage of the database seems reasonably good. Given the rapid technological change in these industries, this can raise some concerns about the timeliness of the analysis. However, this was essentially necessary for the proper identification of cross-licensing firms and the comparison group.

Lastly, as a proxy that measures technological overlapping, the study uses non-self backward citations. As mentioned in Chapter 2, there is yet no widely accepted method to measure the degree of overlapping between different patent portfolios. This is also true for patent thickets where obtaining a good measure is highly difficult. Besides providing information about overlapping patent portfolios and the potential for hold-up, an ideal measure of patent thickets should show how many patents are incorporated in each product and how frequently products incorporate patents of rival firms. At the same time, it should also provide information about products that do not reach the market due to hold-up (Von Graevenitz et al., 2011a). To incorporate all this information in a single measure is challenging; hence, there are different approaches generated in the empirical literature of patent thickets. The analysis of Chapter 4 uses citations to other patents (non-self citations) as evidence of spillovers or knowledge flows between patented inventions, which can also be interpreted as technology overlapping. Even though there are studies using the same interpretation, future research could also consider other measures of technology overlapping that exist in the literature.[177]

[177] See Sørensen and Stuart (2000); Lanjouw and Schankerman (2001)

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About the author

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English Summary

This thesis has the objective of filling a gap in the literature. It is concerned with the law and economics analysis of the functioning of the patent system in complex product industries given the fragmentation of intellectual property rights and cooperative market solutions. The starting point of the analysis is not an identified market failure, as it is done in the classical law and economics approach, but investigating whether there is actually one as often claimed in the literature. The reason to follow this approach is that regulation - without knowing the real dynamics of a system - holds the risk of creating additional externalities. This risk is potentially higher in complex product industries compared to simple products industries.

While investigating the possible inefficiencies of the patent system, the thesis provides a quantitative understanding of the contemporary patenting behavior of firms and its consequences. An initial observation is that firms in complex product industries are interacting over patent portfolios. Secondly, it is observed that such patent portfolio races are especially taking place in industries that previously relied on other mechanisms such as trade secrets or lead time advantages rather than patent production to appropriate returns from their investments. The conventional wisdom is that these patent portfolio races are mainly derived for strategic reasons with the aim of negatively affecting the competition in the markets and creating transaction costs for other firms operating in the same or similar technological areas. As a result, some scholars suggest that policy should target at preventing large volumes of patent applications. The thesis underlines that the main facilitators behind these portfolio races are inherent in the complexity of modern day technology and are partly inevitable. Due to the fact that the production of many new high-technology products often requires numerous complementary innovative components, each of which may be protected by one or more patents, complex product industries are unavoidably associated with fragmentation of intellectual property rights.

The study aims at providing a framework conceptualizing patenting activities under the condition of intellectual property rights fragmentation. Such a framework has to deal with the interrelated problems of technological complexity in the modern patent landscape. In that respect, ex-post licensing agreements have been incorporated into the analysis. More precisely, by consolidating the right to use patents required for commercialization of a product, private market solutions, such as cross-licensing agreements and patent pools help firms to overcome problems triggered by the intellectual property rights fragmentation. Thereby, private bargaining between parties as such cannot be isolated from the legal

framework. A result of this analysis is that policies ignoring market solutions and only focusing on static gains can mitigate the dynamic efficiency gains as induced by the patent system. The evidence found in this thesis supports the opinion that legal reforms that aim to decrease the degree of patent protection or to lift it all together can hamper the functioning of the current system.

A second policy layer, apart from the optimal design of patent protection in complex product industries, can be found in the competition rules governing private market solutions of cross-licensing agreements, patent pools or standard-settings. The costly litigation in complex product industries that has been observed in the last couple of years has generated discussions about implementing a stricter approach towards these market solutions. However, such restrictions should only be justified if there are not enough efficiency gains from these private agreements. The empirical research presented in this thesis shows that at least in certain industries, there are benefits associated with these practices, especially increased R&D incentives, which can justify a more lenient approach towards these arrangements.

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