The Patent Policy Debate in the High–Tech World: A Literature Review

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Abstract

Patents have great public visibility these days; questions and opinions abound on the fairness of the patent system, the validity of large amount of patents, and the rights of the "haves" versus the "have nots". There are questions around the fundamental nature of the patent system – whether patents are protecting and fostering innovation, or whether they have begun to hurt innovation. In this atmosphere of intense debate, the rhetoric in the academic, regulatory, and policy circles often revolves around a handful of issues, namely: are there too many patents, do patents form non-navigable "thickets", do these thickets cause a "hold-up" problem for new innovators and implementers, do the royalties that need to be paid for several patents covering a single product stack together to form prohibitive royalty rates, how should reasonable licensing terms and damages for patents be defined, etc. However, several of these arguments are fraught with little or no empirical evidence. This review discusses an overview of the literature on the current patent policy debate with the goal of identifying gaps in existing arguments, and areas where further research may benefit this debate.

1 Introduction

The important role of Intellectual Property (IP) in today's knowledge economy has been acknowledged by an extensive theoretical and empirical literature. In essence, the idea behind intellectual property rights (IPR) laws is to provide incentives for creativity and innovation, which fuel the progress of humankind. This is achieved by granting protection to inventors in the form of exclusive rights to make, use, or sell their invention for a limited period of time. Patents are the most common form of IP[1] utilized by inventors for protecting their invention. However, there is a growing concern in the recent years that patents themselves may be becoming harmful for the innovative process.

An unprecedented rise in the number of patents applied for and granted by the U.S. Patent and Trademark Office (USPTO) has provided much fuel to recent concerns over the patent system. During the 1995–2008 period, the total number of patent applications grew at an average rate of 6.8%. This surge is patenting activity has coincided with what have been called pro-patent shifts in policy, e.g. the establishment of Court of Appeals for the Federal Circuit (CAFC) in 1982 is said to have strengthened patent rights (Gallini (2002)), and the new responsibility of USPTO for generating its own funds via the fee it collects, rather than operating as a federally funded agency (Jaffe and Lerner (2006)). Another reason for this surge in patenting activity is the increasing role of ideas, know-how, and innovation – in other words intangible assets – in today's knowledge economy. For the largest firms in the U.S., IP and other intangible assets have exploded as a percentage of S&P 500's market value from an average of 16.5% in 1975 to almost 80% in 2005 (Parr and Smith (2005)). The rate and pace of innovation in the high-tech industry is unprecedented in history.

Regardless of the underlying reasons, this pro-patent trend has raised concerns among scholars and public agencies. In particular, the role of patents is subject to significant scrutiny and skepticism in complex technologies, such as those in semiconductors, biotechnology, software, telecommunications, and the Internet, where one product is covered by hundreds of patents[2](Burk and Lemley (2002)). For example,

[1]Other forms of IP protection include copyrights, trademarks, trade secrets, and industrial design rights.

[2]In the more traditional drugs and pharmaceutical industry, one patent typically covers the entire product in the form of a formula for a molecule in a new pill or drug. In contrast, even one semiconductor chip in a smart phone is covered by hundreds of patents, and the smart phone itself – including software, display, user interface etc. – is covered by a even higher multiplicity of patents.

Heller and Eisenberg (1998) have suggested that the privatization of biomedical research has created highly fragmented patent rights, and termed this phenomenon as the "tragedy of the anticommons", for explaining that the existence of numerous rights holders may restrict access to new technological discoveries and thus undermine the development and commercialization of innovation. However, the extent of the anticommons problem is highly disputed in light of little empirical evidence (Epstein and Kuhlik (2004), Murray and Stern (2007)).

Similar to the anticommons theme, Shapiro (2000) uses the term patent thickets for the existence of overlapping and fragmented property rights in complex technology industries, that require firms to obtain extensive licenses of complementary patented inputs for commercializing new technology. These thickets are considered especially problematic when combined with the potential risk of hold up of downstream manufacturers, due to the threat imposed by a patent holder receiving injunctions after heavy investments into the production of an infringing feature have been made (Lemley and Shapiro (2007)). In addition, they argue that the royalty demands of multiple patentees stacked together may be prohibitively high for the downstream manufacturers. There are some known limitations to the hypotheses of thickets and hold-up, such as the presumption that the patent holder has all of the bargaining power in a negotiation (Sidak (2008)). Also, products covered by multiple patents consistently compete against each other in the marketplace, and the coordination mechanisms that allow for a competitive marketplace to occur despite multiple patent holders are yet to be explored in detail.

There have been some empirical studies that try to identify whether patents are creating thickets and hold up in the complex technology industries, providing mixed evidence. Focusing on semiconductors, computers and communications equipment, Cohen et al. (2000) suggest the existence of fragmentation of patent rights, but do not find an anticommons breakdown or hold up occurring in these industries due to extensive cross-licensing agreements across firms. A study by Hall and Ziedonis (2001) focused on the semiconductor industry finds similar cross-licensing evidence, but the authors argue that the use of patents as bargaining chips may stimulate strategic patent portfolio races among industry incumbents, acting as "barrier to entry" for newer firms. Notably, however, in another study Ziedonis (2003) finds that starting in the 1980's, there was a rapid entry by chip design firms in the semiconductor industry. The impact of patent thickets on R&D spending in the software industry has also been studied to provide mixed evidence. Some argue that stronger patent rights have induced a decline in R&D spending (Bessen and Maskin (2009), Bessen and Hunt (2007)), while others reject this claim based on empirical evidence (Mann (2005)).

The threat of patents causing hold up and prohibitively high royalty rates has been especially discussed in the context of standardized technologies. Standard setting organizations (SSOs) are industry groups that set common standards in a variety of technology areas, for allowing compatibility between products made by different manufacturers. Therefore, once a patented technology is selected to be included in an industry standard, all manufacturers must comply with the patent owner's licensing agreements. For this reason, most SSOs have adopted rules for obliging its members to publicly declare any IPR that becomes essential to implementation of the standard, and to license it to any interested parties on "fair, reasonable and non-discriminatory terms" (FRAND). Notwithstanding these policies, there have been many concerns about an increased threat of hold-up and excessive royalty demands in the context of SSOs, and call for scrutiny into the operation of SSOs (Shapiro (2000), Lemley (2002), Farrell et al. (2007)). A large literature has spawned for understanding whether FRAND commitments are working, and how they should be implemented by courts or regulators (for example: Lemley (2007), Geradin and Rato (2007), Layne-Farrar et al. (2007)). The methods for the determination of appropriate royalty rates and bases in the context of standards are of great interest and scrutiny.

Due to all of these concerns, the competition authorities have become greatly interested in the interface between the patent system and competition policy, and have touted incorporating careful consideration of the benefits patent rights into antitrust analysis (National Research Council (2004), Federal Trade Commission (2011), European Commission (2011)). The reliance of some of these proposals on terms that lack evidence is pointed out by some researchers (Epstein et al. (2012)).

In summary, there is an ongoing lively policy debate over the impact of patents in complex technologies and standards. Several parties have called for patent reform in light of potentially over-strengthened patent rights[3], while others have warned against a weakened patent system that will reduce the incentives to innovate and lead to dynamic loss of efficiency. However, there is little empirical evidence for many of the phenomena that are used in the ongoing debate. Some of the reasons are limited availability of data, for example, researchers often do not have access to licensing data in order to prove or disprove the evidence of alleged royalty stacking. However, other areas can greatly benefit from empirical research that is possible at the confluence of legal, economic, and technological disciplines.

In this literature review, I present an overview of some relevant topics currently being discussed in the patent policy debate, while reviewing the existing literature and identifying the potential gaps in it for further research. In Section 2, I discuss the literature around patent thickets and the alleged hold up problem in technology markets. Section 3 moves on to an overview of the issue of royalty stacking, i.e., whether multiple royalty demands lead to prohibitively high aggregate royalties on technology products. It is often argued that these issues of thickets, hold up, and royalty stacking are exacerbated in the standard setting context. Therefore, in Section 4, I focus specifically on these themes as they relate to the standards setting process. In order to address all of these concerns related to patents in technology markets, several proposals have been made for determining reasonable patent damages. Section 5 presents an overview of the related topic of determining reasonable royalty rates and bases for patents. Section 6 focusses specifically on the issues related to the licensing in the standard setting process. Section 7 concludes with a summary of the open research areas that have been identified in this literature review for further research.

[3]Whether the patent rights are too strong or too weak is not a new debate. Throughout the history of patent systems across the world, there have been periodic debates and changes made to the patent system making patent rights stronger or weaker, depending on the call of the day (See Machlup and Penrose (1950)).

2 Patent Thickets and Hold-up

The recent furore over patent thickets can be traced back to the introduction of the idea of "tragedy of the anti-commons" (Heller (1998)). The simple and powerful idea was introduced as an anti-thesis of the tragedy of the commons, where a common public good can be overused due to the problem of free-riders who do not have to pay for the shared resource. Instead, Heller posits that when multiple owners are each endowed with the right to exclude others from a scarce resource and no one has effective privilege of use, that resource remains under used, thus frustrating the socially optimal outcome and leading to the tragedy of the anti-commons. The argument was further made popular on the biomedical research by Heller and Eisenberg (1998), a key area where competing patent rights on a single product can theoretically prevent useful and affordable products from reaching the marketplace.

However, the extent of the anticommons problem is highly disputed in light of little empirical evidence. Epstein and Kuhlik (2004) point out that the number of patents filed have moved up sharply across the board, not just in the biomedical area. Moreover, patents are expensive options to acquire and are not analogous to "permits" as suggested by Heller et al, and their primary use is not for blocking other. They then move on to discuss the large sunk R&D investments, competition by generic brands, and pricing in the biomedical industry to illustrate the importance of patents. Cohen et al. (2000) also surveyed 70 attorneys, scientists, and managers, and find no evidence of a blockade due to patents that prevent the effective use of research tools. Murray and Stern (2007)) use empirical approaches to evaluate the impact of IPR on the diffusion of scientific knowledge by measuring effect of patent grants on scientific citations. Using a sample of 340 peer-reviewed scientific articles, they find quantitatively modest anticommons effect.

Shortly afterwards, Shapiro (2000) followed up with a related idea of patent thickets in the context of today's high-tech complex technologies, such as, semiconductors, biotechnology, computer software, and the Internet. Shapiro argues that complex technologies are fraught with hundreds of patents covering a product, thus creating a non-navigable thicket of patents. He cites the example of the Intel microprocessor, which is covered by no less than 5000 patents, representing a diverse set of patent owners. Furthermore, he argues that the existence of patent thickets – an overlapping set of fragmented IP rights – can lead to hold up of downstream manufacturing firms that must hack through the patent thicket in order to commercialize new technology due to two reasons:

- Threat of injunction due to potential infringement – Downstream manufacturing firms risk infringing upon someone's patent. Since patent holders can be granted a legal injunction for holding the infringer's product, the potential infringer risks a significant loss of investment
- Higher transaction costs – Downstream manufacturing firms may be required to reach licensing deals for multiple patents from multiple sources to reduce the risk of infringement

As is well known in economic theory, independent pricing of several complimentary inputs leads to a total price for the final product that is higher than if all the inputs were controlled by a single agent. This inefficiency is what had led Heller and Eisenberg (1998) to discuss the compliments problem in the biotechnology patents as the tragedy of the anticommons. It is the timing aspect, however, that causes potential hold up. This is because if a manufacturer has made a significant investment in implementing an input for a product in a certain way, which they later discover is infringing on someone else's patent, there may be a significant switching cost in designing around the patented input and changing the supply chain of the product. These switching costs can lower the bargaining power of the manufacturer and afford the patentee an opportunity to seek greater royalties, lest they seek an injunction shutting down the product from the market-place. This higher royalty based on switching costs is called the hold up value of a patent. It is argued that patent hold up can overcompensate patentees, raise prices for consumers, and stifle competition and innovation. It should be noted though that absent the threat of injunction, the bargaining power is shifted entirely towards downstream manufacturers, encouraging infringement and the lowering the reward of innovation for inventors.

While patent thickets have reached a prominent spot on the agenda of both researchers and policy makers, the natural questions posed by these works are: Do these patent thickets really arise, and if they do, to what extent do they arise? How does one measure their existence, or their impact on innovative activity? Some researchers have tried empirical analysis of some data that is available, providing mixed evidence. This empirical analysis can be divided in three broad themes: (i) efforts for measuring patent thickets, (ii) identifying if and where patent thickets exist, and (iii) analyzing the potential effects of patent thickets. The summary in the following sections suggests that much empirical research is yet to be performed to provide any conclusive evidence for answering these questions.

2.1 Measurement of Patent Thickets

Directly measuring the existence of patent thickets is a not a trivial task. In order to come up with a measurement index, it is important to first understand the features that define a thicket. The first feature is the overlap of patent rights. Different patent rights may cover different aspects of the technology required to produce a new product. In other words, a manufacturer of a product may require several complimentary inputs owned by different patent holders. By legal definition of the scope of patents, overlap of patent rights does *not* mean multiple patent holders potentially claiming necessary patents over the *same* input technology of a product, due to the uncertain nature of patent rights[4]. The second feature is the fragmentation of the ownership of patent rights. Different patent rights covering complementary inputs to a technology can be owned by several patent holders, potentially increasing complexity and transaction costs of licensing.

An ideal measure of patent thickets would involve linking patents to products, measuring how many patents are incorporated in each product and how many different

[4]This demarkation is important as it is sometimes confused in the economic literature. It is sometimes assumed that patent rights that are uncertain may be mutually blocking because a firm with a valid patent for aspect X of a technology may still fear infringement of another patent relating to the same aspect X of the technology, which may not be technically necessary (Regibeau and Rockett (2011)). However, there is no legal requirement for licensing non-necessary technology inputs.

patent owners these patents belong to. This measure would yield precise information about the overlap and fragmentation of patents covering a product. Linking this measure to the success or failure of products in the marketplace should provide direct evidence for whether hold up occurs due to patent thickets or not. No such measure for patent thickets exists in the literature, due to the empirical difficulties of using industry classification codes (Cohen et al. (2000)).

The measures of patent thickets that do exist are far from the ideal measure. They all rely on the power of backward citations – or citations made by a patent to other patents and scientific literature – as indicators of how much a given patent is building upon the complimentary inputs that it is citing. There are fundamental limitations of using backward citations as a proxy to identify complimentary inputs to a patent. First, not all citations made by a patent are truly necessary inputs upon which the given patented technology is built. Second, citations have two sources – patent applicants and examiners. There is enough evidence towards suspecting the relevance of examiner citations, since examiners are not the subject matter experts in the specific technological area covered by patents, and since the examiner search is limited by strict time deadlines made worse in the recent years (Thomas (2001), Cockburn and MacGarvie (2009)).

The earliest of such measures is the backward citation based fragmentation index introduced by Ziedonis (2004). This measure relies on the backward citations of a patent serving as a proxy to the inputs that it is advancing upon. Therefore, the fragmentation index aims to give an idea of the dispersion of the ownership of patent rights that a firm's patents may be infringing upon, in the same technology classes. Ziedonis bases this definition on the famous Herfindahl-Hirschman Index (HHI) to measure market concentration based on market shares, as follows:

$$\text{Fragmentation Index}_i = 1 - \sum_{j \in J} \left(\frac{\text{Number of Backward Cites}_{i,j}}{\text{Number of Backward Cites}_i} \right)^2$$

where j refers to each unique entity that is cited by patents issued to firm i, and J is the index set of the top four most cited firms. A large value of the index indicates that the ownership of patents is highly fragmented. However, it still does not imply whether fragmentation is causing any potential harm or not. In addition, the sample used for this fragmentation index consists of 72 publicly traded semiconductor U.S. firms, with almost 44% of the firms not patenting at all (and therefore they cannot be represented in the calculation of any fragmentation index), and with the median index being 0.79 (Ziedonis (2004)). This means that the median firm displays very high fragmentation, and indeed, the index is built in such a way that it will always be skewed towards high values if the number of patents generated by a firm are high. Therefore, it is not clear how to interpret the value of this index in terms of its relationship with thickets.

Siebert and von Graevenitz (2008) offer a variation of Ziedonis' approach for developing a measure of the strength of technological rivalry between patent holders (or likely "mutual blocking") and the potential for hold up. To capture these two dimensions, they construct a technology similarity index, along with a measure of backward citations, that is similar to Ziedonis's fragmentation index. The blocking measure is defined as:

$$\text{Blocking} = (C_{i,j} + C_{j,i})S,$$

where

$$S = \frac{\sum_c A_{i,c} A_{j,c}}{\sqrt{\sum_c A_{i,c}}\sqrt{\sum_c A_{j,c}}}$$

is the proposed technology similarity index. Here $C_{i,j}$ denotes the share of citations made by firm i's patents to firm j's patents, $C_{j,j}$ denotes the share of citations made by firm j's patents to firm i's patents, and $A_{l,c}$ is the number of patent applications by firm $l \in i, j$ in patent class c. The technology similarity index does serve in focusing the measure to a relevant industry area. However, the issues with backward citation based measures still apply. Also, two technologically similar firms citing each other may measure a technological overlap, but does not necessary imply a higher likelihood of the firms "blocking" each other, causing potential hold up. The data used by Siebert and von Graevenitz (2008) discusses the impact of this measure on licensing decisions prior to or after investment into patenting and R&D, however, only a small portion of licensing deals are publicly available and the time lag between patenting (used as a proxy for investment in R&D) and licensing decisions may not be only a year as assumed by the authors, since patentable ideas take a long time to be generated, then patents take a 3-5 years to grant on average, and then the technology diffusion of patented technology takes several more years (Jaffe and Trajtenberg (1996)), especially in the semiconductor industry. Therefore, the impact of this measure on an industry's innovation and success must be identified via outcomes other than licensing data, and by identifying a reasonable time gap between producing a patentable idea and generating any measurable monetary outcome from a patent.

von Graevenitz et al. (2011, 2012) utilize a specific feature of the European Patent Office (EPO) review process to develop a measure that may be more directly linked to overlapping patents, by addressing one of the weakness of the citations based indexes, i.e., reducing irrelevant citations. EPO examiners, when adding citations to patent applications they are reviewing, classify the references most likely to serve as prior-art (a legal phrase that covers everything known before the time of the patent application), as "X" and "Y" references. For any firm in a relevant technology area, they identify all firms that are cited by its patents as "X" and "Y" references. They then identify groups of three firms that are citing at least one of each others' patents under "X" and "Y" references. They then argue that technology areas with a high rate of such triplets are those where patent thickets are most likely to arise. One weakness of this measure is its reliance on triplets, as overlaps can be between pairs, quadruples, or any cluster of firms, and a larger cluster implies higher transaction costs. It is not clear that technology areas with higher triplets are necessarily the ones with a higher measure of thickets. In addition, this measure loses the intensity of overlap, that is captured in the other two measures.

In summary, most of the existing measures to identify whether patent thickets exist or not, and to what degree they exist, depend upon citations based analysis. None of these are close to the ideal of measuring how many patents are incorporated in each product and how many different patent owners these patents belong to. Practical limitations do not allow identifying specific industry classification codes that can be used for the ideal measure. However, case studies that rely on engineering knowledge of certain products can reach this ideal measurement. While such data may not suffice for a cross industry econometric study with several sample points, a focused case study on products that are alleged to be fraught with patent thickets and victims of hold up, would be able to identify the empirical evidence (or lack thereof) towards the extent of these problems.

2.2 Existence of Patent Thickets

While the potential of the existence of patent thickets has achieved prominence amongst policy makers and researchers, the question still remains as to whether such thickets arise, where do they arise, and how often do they arise. Given that the known measures of thickets are far from ideal, this is a difficult question to answer. Going back the definition of thickets, the existence of overlapping and fragmented patent rights covering a product would provide the requisite evidence. No known studies have addressed this question at the product level, while several have addressed it at a broad industry level.

In a study surveying U.S. manufacturing firms, Cohen et al. (2000) classify different industries according to whether they are complex – such that a product's value is derived from complimentary components, or discrete – such that there is a stronger link between single patents and products. While the study does not try to identify thickets, it suggests that firms in discrete product industries, such as chemicals, tend to use patents to block rivals from producing substitutes, while in complex product industries, such as telecommunications and semiconductors, firms are much more likely to strategically use patents for negotiations and cross licensing. This suggests no blocking of innovation in the complex technologies, however, the potential of a large strategic bargaining value associated with patents has led to a number of studies trying to find the evidence of thickets in complex technology industries.

Hall and Ziedonis (2001) study 110 publicly traded U.S. owned semiconductor firms during 1975–1996 and find an upsurge in their patenting activity. They also find that large scale manufacturers have invested far more aggressively in patenting, and propose this as a support for their hypothesis that firms in semiconductor industry may be engaged in strategic patent portfolio races, leading to thickets of patents. In a similar study, Ziedonis (2004) studies the semiconductor firms to try and identify a measure of fragmented patent rights (or an imperfect measure of thickets). She finds that firms patent more in the areas where fragmented patent rights exist, while controlling for other determinants of patenting (such as R&D spending and size of the firm). Using a similar measure, Schankerman and Noel (2013) also find a positive role of fragmented patent rights on patenting efforts in software firms in the U.S.. Notice that these observations are simply pointing out a higher amount of patenting by firms whose patents build upon prior art with more dispersed ownership. This may be because technology areas with rapid and fierce innovation will likely generate more patents and a more dispersed ownership.

von Graevenitz et al. (2012) capture the patenting behavior of over 2000 firms over 30 broad technology areas to identify where patent thickets may exist, based on their measure of triplets of firms that have (European) patents citing each others' patents as prior art. Based on this measure, they identify that thickets exist in 9 out of 30 technology areas, concentrated in the complex technologies, such as: telecommunications, semiconductors, and information technology. They also find that as technology areas become complex, firms' patenting activity increases. These technology areas are also identified as areas with large productivity increases in the recent past (although no lineage between increased productivity and increased patenting is made in this study), and no measurable effect of increased patenting on firms' productivity or R&D investments is investigated yet.

Overall, there is a consensus that fragmented and overlapping patent rights are more likely to exist in complex technology areas, where firms have recently witnessed increased productivity and patenting activity. This is unsurprising since complex technologies are more likely to have hundreds of patents covering a single product, the likelihood of the dispersion of ownership of those patents is also higher, as is the likelihood of higher cross-referencing across a higher quantity of patents. There is no measurable impact of the existence of thickets on increased productivity, nevertheless the increased patenting activity has been tied to defensive use or strategic use of patents.

2.3 Effects of Patent Thickets

Since no perfect measures exist for identifying the existence of patent thickets, the task to identify their effects on firms and industries where they manifest themselves is tricky. There are many anecdotes and hypotheses about the harm done by the fragmented ownership of patent rights, but there are few rigorous studies of their impact. From the studies that do exist, an ambiguous story regarding the overall welfare impact of thickets emerges.

The first effect of thickets is suggested to be an under use of the technologies due to multiple owners, and high transaction costs faced by downstream due to the requirement of acquiring licenses from multiple owners. Cohen et al. (2000) find in a survey that firms in the complex technologies, where the patent thickets are more likely to arise, display extensive cross-licensing and innovation does not stop. Hall and Ziedonis (2001) find such cross-licensing to be prolific in the U.S. semiconductor industry as well, while the industry grew at a rapid pace and saw entry of new firms. A study by Galasso and Schankerman (2010) analyzes how the fragmentation of patent rights affects the duration of patent disputes (that occur when licensing negotiations break down). Based on a model of patent litigation, they predict that settlement agreements are reached more quickly in the presence of fragmented patent rights, and confirm it in their empirical work. These two themes together imply that the presence of thickets may increase the number of licensing negotiations reducing the risk of hold up of innovation in the industry, and there is evidence of patent disputes being resolved more quickly.

As discussed Section 2.2, the firms or technology areas with fragmented patenting rights display higher amounts of patenting, with specific evidence from the semiconductor, software, and some other complex technology areas. This phenomenon has been termed as a strategic arms race towards hoarding patents, to be used for cross licensing negotiations or to arm up for potential litigation (Cohen et al. (2000), Hall and Ziedonis (2001), Ziedonis (2004), Schankerman and Noel (2013)). However, there are several alternate explanations for why this higher patenting activity is observed, and what are its effects. First, it is likely that firms may be patenting more in areas where innovation is more intense. Second, given that a patent is a temporary right to exclude others from making, using, or selling a product, it is not clear whether the use of patents as a tool for cross licensing negotiations in complex technologies is more harmful than their use to build fenced boundaries around a product in discrete technologies to suppress substitutes from entering the market place.

It has also been argued that thickets cause a barrier to entry for new firms due to prohibitively high royalty rates and risk of hold-up, contrary to the traditional focus of the literature on patents as indicators of innovation success and technological opportunity. The role of patents as a signal to the quality of startup firms to outside investors, or in facilitating contracting with venture capital or other financing sources as been highlighted by Hsu and Ziedonis (2013) and Mann (2005). In the software industry, it has been argued that the increased use of patents has lead to greater innovation and competition, via mechanisms such as incentive effect of increased appropriation of returns from R&D, as well as the increased disclosure of inventions facilitated by patents as opposed to a trade secret regime (Smith and Mann 2004). This traditional view of patents as a stimulus to innovation has been complicated in the recent years over the concerns of strategic use of patents by large firms, potentially causing a barrier to entry for newer ones. There is little empirical evidence for this phenomenon, due to the inherent endogeneity of firms' decision to enter a market. Cockburn and MacGarvie (2011) estimate the relationship between market entry and patents for 27 narrowly defined categories of software markets to find that an increase in number of patents reduces to rate of entry. However, potential entrants with patent applications relevant to a market are *more* likely to enter it. This result suggests that patents display a greater entry-deterring as well as an entry-prompting effect on new entrants. In the semiconductor industry, Hall and Ziedonis (2001) argue that the strategic use of patents may stimulate a patent race among incumbents, acting as a barrier to entry for newer firms. However, they find an increased entry of chip design firms during the same time period (see also Ziedonis (2003)). There have been no studies that have shown an absolute decline in innovation or a serious decline in the number of new entrants or competitors due to the existence of thickets.

Therefore, the evidence of an overall effect of patent thickets on the market place remains unclear. A negative effect of thickets has been touted via the mechanisms of increased licensing negotiations, a race towards acquiring more patents, and causing a barrier to entry for new firms. However, empirical data suggest ambiguous results. The presence of large number of fragmented patent rights seems to lend well to cross-licensing negotiations, which may be a more socially optimal strategic use of patents on the balance, than excluding competitors from making products. In addition, the duration of licensing negotiations seems to be shorter. Thus, the presence of thickets may be facilitating more and faster negotiations across firms. Finally, it is not clear whether the presence of these fragmented property rights is causing a barrier to entry for new firms from entering a marketplace, or whether patents are promoting overall competition and innovation.

Any empirical evidence on the effects of patent thickets should consider demonstrating their impact on the marketplace, via identifying lowering revenue growth in a particular technology area, or reduced number of entrants and competitors, or reduced number of products entering the marketplace. These are difficult empirical measures, and fall in a category where comparisons must be made with a hypothetical but-for world. It should be noted that albeit anecdotally, it is commonly understood that the industries that are targeted to be the victims of thickets – i.e., the complex technologies such as semiconductors, telecommunications, and software – are the ones that in the last few decades have displayed tremendous growth in revenues, great advances in innovation and number of new products being introduced, fierce competition with dynamic entry and exit of firms, and rapidly falling consumer prices. Smart phones, laptops, and other electronic devices are all examples originating from these technology areas. These are all potentially measurable outcomes, therefore perhaps there is evidence to be found towards measuring the effects of thickets, but in the direction opposite to what several theorists have claimed.

3 Royalty Stacking

As highlighted in Section 2, it is widely understood that the nature of complex technologies involves many patents owned by different parties reading on single product. A downstream manufacturer without its own patent portfolio must pay royalties to a number of separate patent owners. There is a concern that this may increase the transaction costs of the manufacturer due to the need for reaching multiple independent licensing negotiations. A greater threat that has been called out is that of royalty stacking, i.e., the royalty demands of multiple patent owners may add up to be prohibitively high for the manufacturer (Lemley and Shapiro (2005)).

Per economic theory, for a product sold at a positive margin by a downstream firm, potential stacking of running royalties combines two inefficiencies – double marginalization, which arises when input suppliers with market power sell to a downstream firm that can set product prices, and Cournot compliments, which arise when multiple suppliers with market power sell complimentary products. Together, the end price can be higher than set by an integrated monopolist. This hypothesis has not yet been tested empirically, while it can be. In the semiconductor industry, there are some firms that are both patent owners and manufacturers (i.e., they are close to integrated monopolists), while others are solely downstream manufacturers. If the price gap between the two competitors is reasonably high, then there is evidence of these inefficiencies playing out in the marketplace. If, on the other hand, market competition reduces the prices of both manufacturers, then royalty stacking is not causing these proclaimed inefficiencies.

Another related claim is that the total royalties may still require the manufacturers of products to pay "too much" royalty as a percentage of the product's value, reducing their margins. There is little empirical evidence of royalty stacking, since licensing agreements are typically not observed by researchers. Lemley and Shapiro (2005) raise concern over the total cost of stacked royalties on mobile phones due to the patents essential to second and third generation cellular technologies. However, they point out several mixed estimates available, ranging from 15% to 30% of the total price of the phone. They suggest that stacked royalties recouped by patentees drive up prices for manufacturers of a product, which eventually drive up the prices for the end customers of that product. Therefore, one evidence of the existence of prohibitively high stacked royalties would be that the prices of similar products do not drop sharply with competition, since the high royalty rates must be paid by all manufacturers. However, there exists contrary evidence of handset prices and royalty costs falling – with handset prices, upon which royalty fees are based, declining 77% on average since 1993 – despite the addition of many new technologies and increasing demand for advanced features and functionality[5]. Another evidence for royalty stacking would be that the margins of manufacturers should be lower than the total stacked royalties, if the manufacturers are "forced" to keep prices high for consumers solely due to the royalties they have to pay to multiple patentees. Again, existing evidence suggests reasonably high margins claimed by the leading mobile phone manufacturers, such as Apple's (40% margins), Samsung (37%) and Nokia (22%).

In general, simply listing the number of patents covering a product or a standard and citing these as potential evidence of royalty stacking is misleading. As an example, second and third generation wireless standards are large cross-firm efforts, with hundreds of specifications and fundamental and break-through technical contributions, that took several years to evolve. In order to find valid evidence for or against royalty stacking in a particular technology area, the right metric is to identify the pace of introduction of new products in that area, the trend of consumer prices, and what happens to the profit margins of product manufacturers.

4 Standard Setting Organizations

The perceived problems of patent thickets, hold up, and royalty stacking, potentially arising due to many patents owned by different parties reading on single product in complex technologies, are called out to be especially problematic in the context of standards setting. Standard setting organizations (SSOs) are industry groups that set

[5]See: http://ipfinance.blogspot.co.uk/2011/06/patent-licensing-fees-modest-in-total.html for source statistics

common industry standards in a variety of important technology areas. The compatibility of mobile phones communicating with each other, the operation of the internet, the operation of power cables for devices, are all possible because of inter-operability standards that allow compatibility across different products manufactured by different firms. Typically, firms collaborate together to form common standards. As an incentive to participate, the participants are allowed seek IP rights for their technical contributions and investments during the standardization process[6]. Because all manufacturers of a standard must comply with the licensing terms of patent owners holding patents essential to the implementation of a standard, there is a concern that standards essential patents confer significant market power on the patent owner.

If a standard becomes popular, the standard itself may be subject to holdup if these patent holders are not obligated to license their patents on reasonable terms (Shapiro (2000)). In order to address this issue, the IPR policies of several SSOs[7] require their members to publicly declare any IPR that becomes essential to implementation of the standard, and to license it to any interested parties on "fair, reasonable and non-discriminatory terms" (FRAND). However, there is much debate over whether FRAND commitments can effectively prevent patent owners from imposing excessive royalty obligations on licensees. Therefore, there have been several concerns raised about potential hold up caused by standards essential patents, along with potentially high royalties imposed by the patent holders, and varied calls for antitrust treatment of SSOs and regulatory intervention for determining the appropriate royalty rates for standards essential patents (Shapiro (2000), Lemley (2002), Farrell et al. (2007), Federal Trade Commission (2011)).

A fundamental concern raised in the literature on SSOs is the potential for hold up being particularly severe in the context of standardized technologies. Alternative technologies compete for inclusion in the standard. It is assumed that once a technology is incorporated into the standard, it generates a "hold up value" because of

[6]Some standards bodies produce open standards, i.e., participants forfeit their IP rights when contributing a technology into the standard, while others produce entirely proprietary standards, i.e., standards controlled by a single firm or a group of entities.

[7]The IP policies of SSOs vary widely, Bekkers and Updegrove (2012) provide a nice summary.

high switching costs once the industry is locked into the standardized technology. It is further assumed that the standards essential patent holder has the incentive and the capability to demand excessive royalties that are over and above the value of the patent's technical contribution. It is often argued that the there are too many patents declared essential to the standard, that some may be just be commercially valuable and others useless (Shapiro (2000)), and that high number of patents suggests "incremental" nature of the inventive value of these patents (Federal Trade Commission (2011)). For example Farrell et al. (2007) note that "Various technical alternatives exist ex-ante, before standard is chosen, and none ex-post. A patent covering a standard may confer market power ex-post, that was much weaker ex-ante." In other words, it is often argued that several standards essential patents derive their value primarily due to being included in the standard (called their hold up value) and would have none or little inventive value had they not been chosen to be included in the standard. Such a view of SEPs is overlooking the reality of how SSOs function. Most SSOs are organizations requiring voluntary participation, with hundreds of participating firms collaborating together to form the best technical standard. The delegates attending these standards are not IP savvy attorneys, but purely technical engineers tuned to arguing over technical merits of each others' contributions. In an empirical study covering four major SSOs, Rysman and Simcoe (2008) find that prior to disclosure to the standards, patents reading on standards receive roughly double the citation rate than an average patent, suggesting that SSOs perform well in selecting technologies with higher inherent merit. Taking the example of 3G cellular technology again, the most commonly used 3G standard – UMTS (Universal Mobile Telecommunications System) – formed under the 3GPP organization (a collaboration between a group of SSOs) contains hundred of specifications built over several releases and over a more than a decade[8]. Some of the technologies contained in the standard are breakthrough inventions without which the significant advances in wireless networks would not have been

[8] More information about 3GPP is available at: www.3gpp.org, and more information about the WCDMA based UMTS standard is available at: http://www.3gpp.org/Technologies/Keywords-Acronyms/article/umts. Nearly 200 specifications are listed solely for the radio part of the standard.

possible. Several of these fundamental features required investments of large communities of scientists and engineers, and millions of R&D dollars, over multiple years[9]. There exists data that can be exploited to identify the amount of investment and effort that goes into the building of a standard. For example, 3GPP maintains a roster list of all the specifications and their length. More importantly, the database maintains the list of participants and hours spent for each working group meeting, as well as the technical contributions discussed for each topic. For several features, a lot of research was developed alongside the standardization process in the scientific community in the form of IEEE and other conference and journal papers that can be identified. Therefore, caution should be exercised when arguing about the "incremental" nature of standardized technologies, and further work is needed between the intersection of technology and economic literature, to identify the true economic value of the inventive contribution of some of the core standardized technologies.

In order to mitigate the perceived potential risk of hold up when SSOs include patented technologies in standards, several academics have proposed a goal for the SSOs to find out the true cost of a standardized technology before it is adopted. Since various technical alternatives exist before standard is chosen, it is assumed that the standards essential patent covering the chosen alternative confers market power that was much weaker ex-ante. Lemley (2007) argues that SSOs should establish an internal arbitration procedure so that group members can figure out the cost of alternative standards prior to adopting one, while there are still competitive alternatives. The FTC endorses this view, and cites that "A definition of FRAND based on ex-ante value of the patented technology at the time the standard is chosen is necessary for consumers to benefit from competition among technologies to be incorporated in the standard." Choi (1996) argues that setting the standard prior to knowing the value of various technical alternatives ensures early benefits of compatibility, however the standard chosen could be a "wrong" one since the decision is made without precise information about

[9]In layman's terms, some examples of fundamental technologies are: innovative coding schemes for coding and decoding voice and data, methods for performing fast and efficient handoff avoiding dropped calls at high speeds, packing multiple antennas in mobile phones to increase the capacity, etc.

the actual values of potential technologies. These proposals, while theoretically sound, ignore the reality of the complex and technical nature of the standard setting process. Most standards include hundreds or thousands of technical elements. Each technical element corresponds to a technical contribution that is brought forward for consideration to be included in the standard. For each contribution, there are competing proposals, and their relative technical merit is decided prior to selecting one for inclusion in the standard. It is virtually impossible to tie one or multiple technical contributions to a precise economic value of the contribution ex-ante. As far as a technical or inventive value of the technology is concerned, that is already considered ex-ante, prior to inclusion in the standard, in this merit based selection. The understanding of how SSO processes work is starkly missing in the legal and economic literature. Another notable evidence can be derived from fourth generation cellular technology standard, LTE, for which licensing rates by several traditionally large patentees were announced ex-ante. Market evidence can determine whether this mattered in the adoption of this standardized technology.

A related argument raised in the literature on SSOs is the potential collusion in SSOs, as legitimately cooperating firms can cross the line and collude to form alliances. Shapiro (2001) argues that "Another pattern worthy of antitrust attention arises when a subset of firms in an industry adopt a standard that encompasses their IP rights and make it necessary for anyone producing the standard to make payments to those firms." It should be noted that most SSOs are consensus building organizations. Taking the example of 3G cellular technology again, 3GPP rules require the consensus of over 70% of the participants before accepting a technical contribution into the standard. With over 300 firms participating during the standardization process, inflating the risk of a few incumbents favorably pushing their technology consistently into the standard is impractical. In order to identify the risk of collusion, the rules governing the acceptance of contributions for inclusion into a standard must be surveyed carefully. It may also be possible to identify data for some of the SSOs that can definitively put the story of cooperation versus collusion to rest. Many standards bodies maintain a record of technical contributions made by author and firm name. In addition, the status of each contribution, whether accepted or rejected to be included into the standard is also made publicly available. Therefore, it may be possible to identify if some of the standards participants are consistently more successful in including their technical contribution into the standard compared to others.

Summarizing, the claims of patents essential to the standard exercising market power and causing hold up are based on the presumption that these patents derive their value primarily due to their inclusion in the standard. Various remedies have been proposed by researchers and competition authorities to mitigate the risk of such hold up, such as ex-ante valuation of standardized technologies prior to inclusion into the standard. In addition, there is a concern that there may be collusion in SSOs, exacerbating the market power conferred upon the essential patent owners. All of these claims lack any empirical evidence in their support. However, due empirical evidence should be readily extractable from the data recorded and made public by various standards bodies if used appropriately with some basic technical knowledge of the relevant standard. It is exceedingly important to further the knowledge of how SSOs really work in the legal and economic research community, so that the proposed remedies are rooted in practical reality.

5 Valuation Theories

The recent debate on patents has led to several proposals regarding how patentees should be appropriately compensated. The fundamental goal of the patent statute requires fully compensating the patentees for infringement of their inventions by requiring that the court award "adequate" damages. Courts have defined adequate damages as those that replicate the amount that the patentee would have earned in the absence of infringement by either selling or licensing the patented technology. The current law identifies two categories for patent damages – lost profits and reasonable royalties – providing legal rules for which category applies and how to calculate damages. In recent years, under the theme of avoiding any potential overcompensation of patentees, these calculations have been under much discussion and debate. In particular, some specific remedies are suggested by competition authorities and representatives of downstream manufacturers. However, both overcompensation and undercompensation of patentees can harm consumers, the former by reducing competition and the latter by reducing the incentives to innovate, and caution is warranted in considering any of these suggested remedies.

For the calculation of reasonable royalty damage awards, courts often make use of some or all of the *Georgia-Pacific* factors, a list of 15 factors identified by a district court in 1970 as relevant to the issue. The use of these factors has served as a standard framework for determining lost profits and reasonable royalties for over 30 years and have survived extensive economic analysis (Epstein and Marcus (2003)). Several economists have also provided a framework for extending the Georgia-Pacific factors to the standard setting context (Layne-Farrar et al. (2007)). However, the recent years have seen recommendations to use these factors as a non-exhaustive list of evidence categories, and Federal Trade Commission (2011) calls these as "not necessarily relevant to a specific (damages) calculation".

An important suggestion made by competition authorities is to highlight the role of alternative technologies in damages calculation. For example, the use of non infringing alternatives in lost profit calculation is touted as an important factor for determining what the infringer *might have done* absent infringement. In general, the U.S. case law restricts the considered non infringing alternatives to only include products sold in the market place. However, this proposal suggests that an infringer can claim that it could have developed and introduced some new non infringing product in the but-for world, and avoided infringement. Hansman et al. (2007) provide an economic analysis of such a calculation, and point out that it grants a free option to infringer (i.e., a firm can simply keep its options open by using infringing technology, and later point to an alternative technology it could have used) and this encourages infringement. This leads to potentially undercompensating the patentees and thus reducing their incentives to innovate.

The other role of alternative technologies is the use of the "incremental value test", that proposes only the incremental value of the patented invention over the next-best alternative to be aligned with a reasonable royalty calculation (Federal Trade Commission (2011)). Traditionally, the theory of incremental value has generally been discussed in terms of inventions that lead to cost savings for manufacturing. It suggests that a patent holder should receive the value of the incremental improvement that their patented technology offers compared to the closest rival. An early proposal that extends the theory of incremental value to patent licensing was made by Swanson and Baumol (2005), who argue that the licensing price of a patent in the standard setting context should be commensurate with the price it could have obtained during the standard setting process, if there had been an auction among competing technologies. Farrell et al. (2007) take the incremental value theory further to identify a cap (an upper bound) on reasonable royalties. Their interpretation considers entities competing in a R&D race, for example, one firm produces an invention valued at level X and another produces an invention valued at level Y, where $X - Y = \delta > 0$. Under Farrell et al. (2007) interpretation of the incremental value test, only the first firm receives a royalty payment of $\delta < X$ (i.e., strictly less than the full value of the technology it contributes). In other words, this interpretation of incremental value only relates to a comparison of alternatives in a patent race, not to the starting point of an innovation. That competition reduces prices, and should reduce the price of a patented technology, may be valid. However, for a competitive process or a race to begin, inventors must have an incentive to innovate new technologies. If they are systematically compensated strictly less than the full value of their contribution, this incentive is seriously reduced. Therefore, economic analysis that proposes an appropriate calculation between the strictly incremental delta and the total potential switching cost related to the use of a patented invention is sorely needed. Another challenge faced by this proposed incremental value test is a practical one. How can an "incremental value" of a particular patent be calculated, especially under the regime where an entire product or an entire standard is produced by thousands of patented technical components? More importantly, real world pricing is typically based on a portfolio of patents, and not on a single patent. There have been no suggestions as to how performing an incremental value analysis to a portfolio is possible. Finally, the traditional incremental value theory faces many challenges in the high-tech industry, where several disruptive technologies constantly emerge with no prior baseline product that can be used to measure the benefit due to reduced cost caused by a patented technology. Additionally, the value of such disruptive new technologies is often impossible to predict prior to their success and adoption in the marketplace.

Yet another suggestion made by the competition authorities is related to the choosing the royalty base on which the reasonable royalty rates are calculated. Courts have typically used the entire market value rule (EMVR) in the calculation of damages in order to allow the patentee to recover their losses due to infringement based on the entire market value of the product. Courts usually use the test of whether a patented feature formed the "basis for consumer demand" before choosing to implement this rule. Federal Trade Commission (2011) calls this test irrelevant, and proposes to identify the royalty base according to what the negotiating parties would have chosen in a hypothetical negotiation, and call this to usually be the "smallest priceable component containing the invention". There has been no economic analysis on what such a proposal would mean to some of the core and fundamental technologies that do indeed form the "basis for consumer demand" of certain products. In complex high-tech products, no single rule of thumb seems to be appropriate to apply. Some technical contributions only enhance a small component of a product, while others enhance the overall value of a product. In addition, some of the most successful technologies are valuable due to a combination of inputs, and not due to the contribution of a single input. For example, some of the successful smart-phones in the market place perform an "aggregation" function of various technical components, such as, a wireless chip-set providing the fundamental connectivity and high data rates, a memory processor, a software operating system, a plastic framework, a display screen, a camera, etc. Removing any one feature reduces the value of the entire product differentially, i.e., different technical components add a varying value to the product. Therefore, the royalty base cannot be determined simply on a smallest priceable component, but on the total value addition of a particular technology to the overall value of the product. Economic analysis on this topic must take tangible technology examples from the complex technology industry.

6 Licensing Negotiations and FRAND

The proposed remedies for determining how patentees should be appropriately compensated relates squarely to the IP policies in standards setting. IP rights, in particular patents, have become a customary feature of the standards setting process. As discussed in Section 4, standards essential patents are perceived to pose a significant threat due to the market power conferred on them once the standard is set. In order to address the goal of making a standard available to a relatively wide base of affected adopters, most SSOs have adopted *disclosure rules* requiring disclosure certain patents and patent applications, and *licensing rules* governing the terms and conditions for the licensing of these patents.

FRAND is a legal term, that stands for fair, reasonable, and non-discriminatory, used to describe the patent licensing obligation often required by SSOs for their members that participate in the standard setting process. It is normal for firms to have to agree to licensing their patents in FRAND terms before they will be accepted to become part of a SSO approved technical standard. Even though most SSOs are committed to FRAND licensing obligations (Lemley (2002), Bekkers and Updegrove (2012)), there is no universally agreed upon definition of this commitment. The general understanding is that the patent holder must make the licenses widely available to anyone who wishes to make a standards compliant product (and not "pick and choose" licensees, for e.g., by refusing to license to its rivals); the patent holder should make the license available on "reasonable" terms and conditions which may include other terms than royalty rates; and the patent holder should make the license available to different parties on a "non-discriminatory" basis. SSOs have refrained from giving exact explanations of these terms, and guidelines on how licensing disputes should be resolved, and have left the exact licensing terms for negotiations amongst the various parties involved. There are several reasons for this. The goal of the SSOs is to balance the interests of the licensees and the licensors, in order to provide the right incentives to participate in the standard setting process by all parties. Also, there is no one-size-fits-all mandatory licensing approach that is appropriate to enforce (Teece and Sherry (2003)). Finally, it should be noted that trying to determine exact licensing rates is not only outside the realm of the expertise of SSOs whose participants are technical experts that do not dealing with the legal, economic or business issues of licensing, but can also raise potential antitrust issues related to price fixing.

This lack of definition of what a FRAND commitment exactly implies has worried some economists and competition authorities. While not reaching similar conclusions, a number of authors have proposed various limitations on the freedom of parties negotiating a license to standards essential patents. Some of the proposed remedies require that in order to comply with a FRAND commitment, a patent holder:

- Is not entitled to seek injunctive relief against a standard implementer for its standards essential patents (Farrell et al. (2007), Federal Trade Commission (2011), Chien et al. (2012))
- Must not negotiate a royalty free cross-license or a cross-license including non-standards patents of the licensee[10]
- Must set royalty rates based on a mathematical proportion of all patents essential to the standard (Chappatte (2009)), and
- Must set royalty rates in such a way as to prevent cumulative royalties on the standardized product from exceeding a low percentile of the total sale price of that product (Lemley and Shapiro (2007)).

SSOs are considering these suggestions from the competition authorities, but have refrained from making changes to their existing IPR policies, several of which have been around much before the debate over patents and FRANDs started taking the center stage.

[10]The FTC decision and order released in January 2012 subsequent to the investigation of Google and Motorola Mobility notes that licensors of standards essential patents may not require the potential licensee to license any patent not essential to the standard, or another other patent, in a licensing offer made to the potential licensee.

We turn to the first proposal, of restricting the patent owner that has made a commitment to license on FRAND terms to seek injunctive relief against any implementer. The debate over restricting the patent owner from seeking injunctive relief has been rekindled since the Supreme Court's 2006 *eBay* ruling. Prior to 2006, there was a general belief that courts faced with patent infringement cases frequently granted injunctions as a matter of course (Lanjouw and Lerner (1996)). In its *eBay* decision, the Supreme Court called to stop automatic granting of injunctions, and called for lower courts to adhere to an equity test established in case law. However, raising concerns regarding the potential patent hold up caused by patent owners and their ability to derive higher royalties under the threat of an injunction (Shapiro (2000), Lemley and Shapiro (2007)), several researchers and have called for limiting injunctive relief further. Sidak (2008) points out that limiting injunctive relief for patent infringement is a method to reduce the royalty rate that will be negotiated between the owner of a valid patent and an infringing party. Others have also pointed out the lack of any evidence related to hold up caused by patent owners, and the error costs of weakening the presumption of injunctive relief (Denicolò et al. (2008)). In the recent years, these concerns have shifted from patent owners in general to standards essential patent owners in particular. Several patent and competition policy researchers have proposed a rule-of-thumb denying the standards essential patent holders their right to seek injunctive relief, as a part of their FRAND obligation. Surprisingly, amidst all this debate, there have been no studies that have identified the proportion of U.S. district court and/or ITC cases that involved standards essential patents, and whether an injunction was granted and/or seeked for such patent(s). Before acting upon the furore over standards essential patents, such a due diligence study rooted in case law appears to be in order.

The second proposal seeks to impose limitations on the private cross-licensing negotiations that occur between parties in the marketplace. Firms often license entire portfolio of patents and not just individual patents, and cross-licensing agreements of all types are common amongst vertically integrated firms in complex technologies. Indeed, there have been several arguments touting the benefits of extensive cross-licensing in navigating through the supposed problem of patent thickets (Cohen et al. (2000), Mann and Sager (2007)). The proposal for limiting the licensing of standards essential patents in exchange for the licensing of non standard essential patents is also highlighting an inherent presumption in this proposal, that standards essential patents are somehow less valuable than patents that do not relate to the standard. This is contrary to evidence found by Rysman and Simcoe (2008) that standards organizations perform well in selecting more valuable technologies for inclusion into the standard. More importantly, this proposal overlooks the fact that rational entities negotiating cross licensing terms are implicitly taking the price of the patent bundles that they are exchanging into account. In general, more studies that compare the average value of standards essential patents to a comparable group would go a long way in enlightening such proposals that are based on the premise of a lower inherent value of standards essential patents.

Third, the numeric proportionality proposal suggests that all patents essential to the standard should be regarded as equally valuable and treated symmetrically, since they all afford the same market power, or ex post hold up power (Chappatte (2009)). This premise leads to proposed royalties calculated to be proportional to the number of essential patents contributed to the standard. For example, a firm owning 100 standards essential patents out of a total of 1000 patents in that standard can claim 10% of the total royalty that the standard can command. First, this simple rule defies the well established empirical result in the patent literature that patents differ greatly in their inventive and economic significance, and that the distribution of patent values is known to be extremely skewed (Schankerman and Noel (1986)). Second, not all patents declared essential to the standard are truly technically or commercially essential (Goodman and Myers (2005)). Several SSOs require their members to declare essential patents, but do not act as enforcers or evaluate the disclosures reported by their members for essentiality. Therefore, it is exceedingly difficult to identify essential patents to implement such a rule. Finally, such a rule would create perverse incentives for members of SSOs to file and disclose as many patents as possible as essential to the standard, regardless of the technical contribution of those patents. Therefore, enough empirical evidence already exists to guide the sound methods for determining reasonable royalties away from such a proposal. Certain case studies that can highlight the significant difference across some specific standards technologies that are patented, could help in educating the policy makers that not all patents are created equal.

The fourth proposal relates to the presumption of the occurrence of royalty stacking in products that must comply with an industry standard. However, if a aggregate royalty rate is too high, then the license fee would result in downstream manufacturers producing at a loss leading to their exit from the marketplace. In Section 3, I discuss the existence of high margins maintained by downstream manufacturers of some of the standardized technologies. Empirical evidence proving the existence of royalty stacking would identify exiting downstream manufactures, or reduced entry by new ones, while evidence proving its non-existence lies in identifying entry of new and successful downstream manufacturers of standards compliant products *after* the standard has been set (or is close to being set), and researching their profit margins, as well as price drops of the standards compliant products in the marketplace.

7 Conclusion

In 1858 Abraham Lincoln stated that "the patent system has added the fuel of interest to the fire of genius, in the discovery of new and useful things". However, lately, the patent system is subject to much debate and scrutiny, in light of a surge in patenting activity witnessed in the United States since the 1980s that coincided with some policy shifts that may have been pro-patent. Several researchers and policy makers are paying attention to the patent system to understand whether the current system is working well, and reforms are being proposed for the most serious criticisms.

The controversy around the patent system is not new – most nations with a patent system enacted since the 19th century or earlier have periodically witnessed periods of intense debate, in particular around new and emerging technologies of the time. Today's patent controversy places the highly innovative complex technology industries at the heart of the patent debate. There are concerns that the growth of patenting may stifle further innovation. For example, the fragmentation of patent rights has raised the concern that the high transaction costs of gathering all the required licenses, as well as a risk of potential hold up of manufacturers by patent holders, may impede product development and undermine subsequent innovation. It is also argued that the high patenting activity in some industries may be explained by a strategic arms race towards hoarding patents for cross-licensing or defensive purposes, and that this may cause a barrier to entry for newer firms to enter the marketplace. A single product being covered by too many patents representing various patent holders also raises a concern for the royalty demands of each patent holder being stacked together to be a prohibitively high aggregate royalty for downstream manufacturers. These concerns are exacerbated in the standard-setting context, where in the industry is "locked in" to a single technology solution once the standard is set. Due to these concerns, there has been much interest by researchers and competition authorities in the interface between the patent system and competition policy, and several proposals towards the determination of reasonable patent damages as well as licensing terms for patents related to standards have been made.

The concern over whether the patent system is working well is healthy. The empirical basis for some of the specific concerns raised, however, is far from strong. Some existing evidence provides a mixed story. While patenting and cross-licensing activities do seem to be higher in the complex technology industries, it also appears that patenting does stimulate innovation in the incumbent firms in the semiconductor industry, and provides incentives as well as selection for entry in the marketplace in the software industry. It is not only feasible, but also imperative to raise the bar of this debate with facts, in order to facilitate informed policy making and to ensure that the proposed criticisms and proposals towards fixing the patent system and mired in hard empirical evidence.

This paper provides some guidelines for further empirical research. First, in order to prove or disprove the existence of patent thickets, the appropriate measures for identifying thickets must be introduced and the limitations of existing measures must be understood. Case studies that analyze individual products to measure the number of patent rights and diverse patent owners covering these products can provide a good measure for patent thickets. In order to then understand the effects of these thickets, such measures need to be related to the success or failure of products in the marketplace, and the innovation on these products in the industry. Even the existing measures of patent thickets have not yet been fully utilized to understand whether they facilitate or hinder entry of firms in the marketplace. Tying these measures to the start-up data can provide guidance regarding the potential barrier to entry that some argue these thickets cause. In general, any empirical evidence on the effects of patent thickets, such as potential hold up or barriers to entry, should consider demonstrating their impact on the marketplace via identifying the relationship of thickets with revenue growth, number of entrants or competitors, changes in prices of products, etc. Second, moving on to the topic of royalty stacking, merely identifying the number of patents covering a product and implying a risk of prohibitive royalty rates should not suffice as evidence to a problem. If royalty stacking exists, the effects should be demonstrated by reduced products in the marketplace, increase prices, and lowering margins of manufacturers. Any tangible evidence of a thriving product marketplace, dropping prices of products with comparable features, and high profit margins of manufacturers should be used against royalty stacking, according to the proposed theory of royalty stacking. Third, all of these problems are perceived to be particularly relevant to SSOs. However, there is very limited understanding of how SSOs work, and what typically constitutes standards essential patents. SSOs typically maintain and record a lot of public information that can be utilized for empirical work that facilitates the understanding of their processes, as well as provide conclusive evidence for or against the arguments of collusion in SSOs, selection process of standards essential patents, and the nature and value of standards essential patents. Once the complex and intricate nature of SSOs is understood, proposals such as ex-ante valuation of thousands of technological elements of a standard will hopefully change tone into more practical and feasible options. Fourth, there is much discussion on how reasonable royalty rate and royalty base should be determined. Economic analysis is needed to understand the role of the incremental value test in any pricing of highly innovative disruptive technologies. The typical pricing methods - of portfolios versus individual patents - in the real world should not be ignored. The proposals for the determination of royalty base must take the differential values of different technologies into account. Finally, the furore over licensing rates in standardized technologies lacks a due diligence study of understanding the proportion of disputes over standard essential patents in courts. In addition, studies that further illuminate the true value of standards essential patents, and identify the nature of skew in the value of these patents (like any patents), would lead to more informed proposals related to FRAND.

It may take sometime to collect relevant data and identify the concerns that surface and those that are dismissed based on empirical evidence. In the meantime, vigilance and prudence is warranted in policy recommendations. Aggressive empirical enquiry is the call of the hour in order to raise the bar for arguments based on conjectures and limited understanding of relevant technologies and organizations. Any proposal for or policy change must be based on balancing how it will affect the incentives of all parties involved - patentees as well as downstream manufacturers - and more importantly, must be rooted in practical realities of the industry and organizations that it is targeting.

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