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The Effect of Alliance Activity on Patent Litigation : In the Case of Printed Electronics†

기업의 제휴활동이 특허 소송 관계에 미치는 영향 : 인쇄전자 산업 중심으로

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목 차

국 문 요 약

특허 소송은 혁신 혹은 지적 재산권의 보호 수단으로서 알려져 있다. 그러나 특허 시장이 증대됨에 따라 경쟁사의 진입을 방해하기 위한 전략적 수단으로 특허 소송의 활용 범위가 증대되었다. 특허 소송에 연루될 가능성은 기업이 가지고 있는 특허의 양질이 증대할수록 높아진다고 밝혀져 왔다. 그러므로 혁신을 추구하는 기업의 입장에서는 특허 소송에 연루될 가능성을 최대한 낮출 수 있는 방안이 필요하다. 이에 본 연구는 인쇄 전자 산업 내 기업의 과거 제휴 활동이 특허품질과 특허 소송의 관계에 미칠 수 있는 영향력에 대해 분석하였다. 특허 품질과 특허 소송의 관계에 대한 기존 연구결과를 재 입증함과 더불어 피고인 관점의 특허 소송에 대한 연구를 진행하여 기업의 제휴 활동이 특허 소송을 낮춘다는 결과를 도출하였다. 예컨대, 평균치의 특허를 지닌 기업에 대해 과거 제휴 활동의 유무가 연간 특허 소송률을 약 33% 낮추는 것을 실증적으로 입증하였다. 본 연구가 특허 소송과 전략적 제휴에 관한 기존 문헌에 기여하는 바는 다음과 같다. 기업의 과거 전략적 제휴가 평판으로서의 역할을 하여 특허 소송을 감소시킴을 확인함으로써 기존 전략적 제휴 관련 문헌에 기여한다. 또한, 특허 품질이 특허 소송에 미치는 영향력에 대한 새로운 조절 변수를 밝혀냄으로써 기존 특허 소송 관련 문헌에 기여한다. 더불어, 본 연구는 특허 소송을 피고인 관점에서 분석한 최초의 연구라는 점에서 매우 의미가 있다.

핵심어 : 특허 소송, 전략적 제휴, 인쇄전자 산업

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ABSTRACT

Patent litigation has been considered as a tool to protect and facilitate innovation. Ironically, yet, the misguided uses of patent litigation as a strategic tool for vigilance against competitors are acting as a hindrance for innovation. Previous studies show that the better the quality of a patent, the higher the chance of the patent being litigated. Therefore, it is particularly important for the innovating firms to take strategic precautions to minimize the risk of patent litigation. This study investigates the moderating role of firms' past alliance experiences on the relationship between patent quality and patent litigation from the perspective of a defendant. A unique dataset on patents, infringement lawsuits, and firm performances in the printed electronics industry confirms that firms' previous alliance experiences mitigate the impact of patent quality on infringement litigation. For instance, the results confirm that the presence of past alliance experience reduces the litigation rate by 33% for firms with median-quality patents. This paper makes two major contributions. First, it contributes to the literature on alliance experience by confirming its role as a reputation in mitigating future litigations. Second, this paper contributes to the literature on patent litigation by identifying a unique moderator, i.e., alliance experience, on the linkage between patent quality and litigation. An innovating firm is likely to become an alleged infringer under a false accusation. Therefore, this paper focuses on firms that partake in infringement lawsuits unwillingly. Despite the importance, to the best of our knowledge, this is the first study to investigate patent litigations from the perspective of defendants.

Key Words : Patent litigation, Alliance experience, Printed electronics

I. Introduction

In 2016, Janssen Biotech filed a lawsuit against Celltrion. Janssen Biotech argues that their own patent about cell culture media was infringed but most experts interpret it as a strategic movement taken as a temporary blockage of Celltrion's entry into the U.S. market. In the same year, VoIP-Pal vigorously filed a lawsuit against Apple for a potential infringement on their internet communication technologies. VoIP-Pal argues that a number of their patents were infringed by Apple's Face Time and iMessage. However, most patent experts interpret this as a strategic attack initiated by a patent troll[1] to make a profit without manufacturing a product (Chien, 2012). Regardless of the complainants' genuine purposes, these two lawsuits showcase the possibility that the patent rights can be used as a legal weapon for the pursuit of profit.

Patent infringement lawsuits can burden firms with high costs; the expenses associated with patent litigation has risen approximately three times in just six years (i.e., from 20 billion USD in 2003 to 61 billion USD in 2009; Bessen et al., 2015). Along with the drastic increase in the cost of patent litigation, the number of patent infringement cases is on a steady incline. This growing number of patent litigation can be attributed to a number of different sources. First, both the number of patents filed and granted are relentlessly increasing. Recent statistics reported by the world intellectual property organization (WIPO) indicate that about 300,000 patents were granted in 2015 by the United States patent and trademark office (USPTO) alone (WIPO, 2016). The increase in the number of patents that are filed and granted renders higher possibility of infringement by nature. Second, the low and unclear standards at the patent office creates the "fuzzy" boundaries of patent and its systems which can cause the burden of litigation (Jaffe, 2000; Bessen and Meurer, 2008). Similarly, as the development and convergence of technologies take place at a rapid rate, the boundaries among technologies become blurry which can also result in higher occurrence of patent litigation. In this more competitive environment for firms, it is crucial to understand the moderators of patent litigation and undertake strategic countermeasures to minimize the cost.

Innovating firms that are bearing high R&D expenditures have a higher risk of

1) Also referred to as patent assertion entities.

infringing other firms. In line with this argument, previous studies have found that the patent system can act as a hinderance for innovation (Lanjouw, 1994; Lerner, 1995; Bessen and Meurer, 2008). On the contrary, previous literature on innovation often use patents as a measurement of innovation indicating that patents are the outcome of innovation (Scherer, 1965; Griliches, 1984; Trajtenberg, 1990). Pursuing innovation is considered as a vital method for survival and growth of firms. However, some studies suggest that the better the patent quality or the value of invention the higher the probability of litigation (Lanjouw and Schankerman, 2001; Allison et al., 2003; Cremers, 2004; Lemley and Allison, 2004).

Given these conflicting aspects, firms seek to minimize the cost associated with patent litigation and pursue innovation concurrently. Hence, it is important to understand the strategic breakthrough that can be used to avoid or reduce the cost of litigation. In order to unravel this issue, this study investigates how patent litigation occurrence of a firm with high patent quality (where the incurred cost will be the highest) can be reduced. An innovating firm is likely to become an alleged infringer under a false accusation. Therefore, this paper focuses on firms that are brought into patent litigations unwillingly. To the best of our knowledge, this is the first study to investigate infringement litigations with a primary focus on defendants[2]. Hence, this paper also contributes to the literature on patent infringement as a first study that investigates the issue from the perspective of the defendants.

II. Literature Review

The principal purpose of patent is to encourage innovation by protecting the rights of inventors. From inventors' perspective, patent right is an opportunity to receive sufficient rewards for their creations by pursuing innovation (Nordhaus, 1969; Reinganum, 1989). However, as pursuing innovation increases the probability of patent infringement and the consequential litigations, it is important to understand what factors mitigate the risk and the consequence of patent litigation.

2) Previous literature on patent litigation has all focused on inventors and plaintiffs.

1. Patent system and its effect on enforcement system

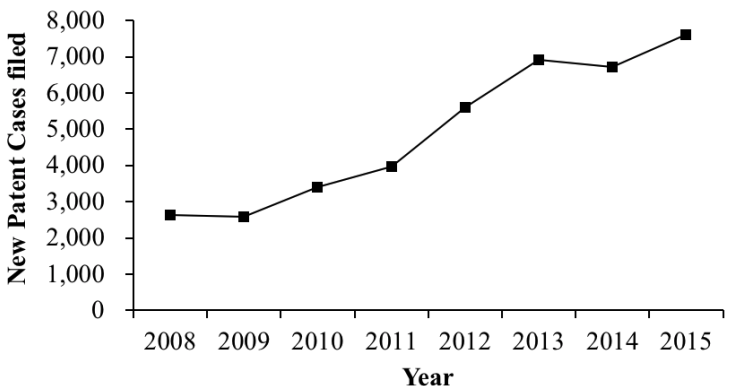
As patent "business" rapidly grows, vast research has been conducted on the effect of patent enforcement system (see, e.g., Nordhaus, 1969; Hall, 1999; Jaffe and Trajtenberg, 2002; Czarnitzki and Kraft, 2004; Scotchmer, 2004; Hall et al., 2005; Greenhalgh and Rogers, 2007). One of the main reasons for the significant increase in the number of patents and infringement lawsuits is the indistinct boundaries of patents (Lemley and Shapiro, 2005; Bessen and Meurer, 2008).

Filing, claiming, and granting a patent do not assure the success of patentees. After all procedures with filing and granting a patent, patentee should continue to pay maintenance fees from hundreds to a few thousand dollars in order to maintain patent's right in force. According to Moore(2005) and Lemley(2001), more than half of the issued patents in the U.S. are not sustained until the end of its term since patentees forget to pay the fees. This is interpreted as the patents that are forgotten having little to no significant value to the owners. According to a number of studies, the top one percent patents possess more than a thousand times greater value compared to the average patents (Pakes, 1984; Schankerman and Pakes, 1986; Lanjouw and Schankerman, 1999; Allison et al., 2003). Since patentees cannot predict the value of invention in advance, the uncertainty of patents regarding their commercial significance is described as winning a lottery ticket (Lemley and Shapiro, 2005).

Though holding a patent is like having a lottery ticket, the number of patent filings is continuously increasing every year. Many researchers in the field of economics and innovations have investigated what factors motivate firms to file patent applications. One of the possible explanations is that patent applicants are not able to distinguish the value of patents (Scherer, 2001; Denton and Heald, 2002). Even though inventors know many of the patents will turn out to be worthless, they continue to file patents with little hope for a big payoff. However, if we assume that inventors have enough knowledge to predict the value of patents, another possible reason for the gradual increase in the number of patent filings could be the failure to understand the value (Kline, 2000). Additionally a number of academic researchers argue that another reason for filing patents is its use as a tool to receive funds and increase the firms' market

valuation (Lemley, 2000; Hall et al., 2005), to signal information (Long, 2002), and to prevent others from filing a suit (Hall and Ziedonis, 2001; Lemley, 2001).

Along with the rapid growth in the number of patents granted, the number of filing a patent lawsuit has been gradually increasing. As illustrated in Figure 1, the number of patent infringement litigations had tripled in 2015 in comparison to 2008. According to the original purpose of a patent, the enforcement system simply operates to resolve "occasional errors of judgment" and to punish those who "ignore patentee's rights" (Weatherall and Webster, 2014). In the perspective of patent holders who was infringed, not acting a lawsuit is like abandoning their right and throwing away the investment on research, development, and commercialization of technology. Without proper enforcement system, inventors might not be motivated to promote innovation since they will not be able to receive sufficient rewards for their efforts. In this ideal scenario, filing a patent lawsuit has to have a role to protect and promote innovation.



(Figure 1) Number of Patent Cases Filed Reported in WIPO from 2008 to 2015

Yet most firms exploit an advantage of patentee-friendly-environment in the U.S. to capture patent premiums (Bessen and Meurer, 2005). In order to encourage innovation by providing right protection for inventor, the U.S. patent system has been operated with pro-patent strategy from the Reagan Administration in 1985 by establishing the U.S. Court of Appeal for the Federal Circuit (Dreyfuss, 1989; Kortum and Lerner, 1998; Hansen, 2013). This "pro-patent" policy in the U.S. could be ideal if a lawsuit functions only as a barrier to use intellectual property and to encourage innovation by excluding

competitors from practicing the patented invention or forcing competitors or non-competitors to take a license. However, some firms use patent enforcement system in order to: prevent patent suits by their competitors, threaten smaller actual or potential competitors, or earn settlement payment as strategic opportunity (Meurer and Bessen, 2005).

A number of researchers question about the impact of the patent litigation on a firm and show that patent litigation causes critical financial loss and hinders innovation for both plaintiffs and defendants. Financial losses are caused by the direct and indirect costs of patent enforcement. Direct costs for both parties ranged from 920,000 USD to 6 million USD in 2011 (AIPLA, 2011). However, direct costs may not be a huge burden compared to indirect costs (Bessen and Meurer, 2008).

The causes of indirect financial losses of patent litigation are as follows (Bessen and Meurer, 2008; Kingston, 2010). First, business is disturbed as a firm spends more time on handling a lawsuit instead of managing business and researching a new product. Secondly, litigation increases the risk of bankruptcy, sequentially costs of credit. Also, there is a chance of losing sales due to leaving customers who have doubt about firm's business management capability or injunctions issued, which prohibit any activity of a firm before a decision (Lanjouw and Lerner, 2001). Lastly, the process of a lawsuit may delay the launching of a new product.

A number of studies empirically show the detrimental impact of patent litigations on firms' financial performances; e.g., the decrease in the stock market value of a firm in the position of defendants when patent infringement suits were filed regardless of the types of plaintiffs such as a government entity, another firm, or a private citizen (Bhagat et al., 1994). Bhagat et al.(1998) measures economic wealth with the market value of the equity and found the average wealth loss is 0.97%. In addition to lawsuit itself, Lanjouw and Lerner(2001) investigated the effect of preliminary injunctions which is a part of lawsuit process to temporarily halt the business activity of involved firms. When large firms requests preliminary injunctions, it has a negative effect on R&D of small firms (Hall and Ziedonis, 2007).

These financial impacts on a firm from litigation lead to interruption on innovation since potential resources that are able to be afforded to research and development, are

expended to prepare a lawsuit. Bessen and Meurer(2008) study the negative effect of patent system to innovation theoretically. Innovating firms have a higher risk of infringing other firms and the benefits of owning a patent is smaller than the cost of defending the allegation of patent infringement (Bessen and Meurer, 2008). Also, they find that the filing of lawsuit has a negative effect on the stock market value for both patentee litigant and alleged infringers with -0.38% and -0.62%. Lerner(1995) shows the empirical result that innovation of biotech firms are hindered because of the litigation threat. Firms with higher litigation costs, the number of previous patent suit, are less likely to patent in classes where many rival firms exist and where firms with low litigation costs exist. Furthermore, the simulation from European data suggest that the value of average patent is reduced about 30% as legal costs are doubled (Lanjouw, 1994). Due to negative impact of litigation, it is better to avoid litigation regardless of whether a firm is a plaintiff or a defendant. In Section 2.2, the factors that potentially mitigate patent litigations are discussed.

1) Determinants of patent litigation and patent quality

Through empirical and theoretical studies, many researchers studied about determinants of patent litigation. Lanjouw and Schankerman(2001) concretize key factors of patent litigation rooting from theoretical study of Cooter and Rubinfeld(1989). In these theories, 'the size of the stakes' is one of the main reasons for patent litigation. There are other potential determinants of litigation; the possibility of a patent infringement occurring or being detected, "asymmetry of information or the divergence in parties' expectation about the outcome of a trial," and the cost of settlement relative to the cost of trial. A number of empirical studies found that the smaller size of a firm is more likely to be involved in a patent lawsuit (Lanjouw and Schankerman, 2001; Allison et al., 2003; Bessen and Meurer, 2005). Also, the better patent quality or the value of invention, the higher the probability of litigation (Harhoff et al., 1999; Lanjouw and Schankerman, 2001; Lemley and Allison, 2004; Chen and Chang, 2010).

Bessen and Meurer(2008) emphasize and define that 'fuzzy' boundaries of patents is one of the primary reasons for the rapid increase in the number of patent litigations. This indistinct boundaries of patent is caused by a number of actors. First, it is due

to the difficulty to understand the scope of patent rights partly due to the usage of vague language. The issue expands from the interpretation of the vague language in the patent legal system. Since the interpretation of the patent claims depends on judges, the results of the court often are reversed. Secondly, secret time for patent claims complicates other innovators. Even though patent applications are published after 18 months, patent claims can be hidden for many years. These hidden claims possibly mislead other innovators to invest in technology which a patent is pending. Next, unlike tangible property rights such as lands, cars are related to possession, patent rights are not always granted to the applicants who make or possess the invention. Hence, blurred boundaries of patents create unclear legal boundaries.

Unclear boundaries of patents stimulate a potential plaintiff's desire for greater stakes from a patent. A potential plaintiff can clarify indistinct boundaries of patents through litigation process. If a dispute proceeds to a trial and a potential plaintiff win in a case, part of indistinct boundaries could be clarified and more profit or stakes could be produced from its patent. In fact, only a few disputes proceed to the end of trial and most disputes are settled during a litigation process. The settlement is beneficial to a potential plaintiff especially when the value of alleged defendant's patents are greater due to the possibility of cross-licensing. In this case, whether or not the boundaries of patents are not overlapped, the potential plaintiff can gain a competitive advantage in negotiation for settlement. Therefore, the potential plaintiff has a higher chance to send a demand letter which warns and requests for a license to a potential defendant with higher patent quality. After the decision of a potential plaintiff to send a demand letter, the choice to proceed to litigation then depends on an alleged infringer. In the perspective of an alleged infringer, its patent quality may indicates its market power and competitive advantage for later competition in a market (Stefanadis, 1997; Teece et al., 1997; Somaya, 2003).

In sum, the greater the assets associated with a potential defendant's patent, the more likely litigation will occur. The benefits granted by the patent can confer competitive advantages and is an example of strategic stakes which is a key factors for patent litigation. If potential defendant's patent quality is high, procurable stakes that can be extracted from the patent is high in the perspective of a plaintiff. In other words, a

potential plaintiff can extract more benefits from negotiating with a potential target. Taken together, this paper hypothesized that the uncertainty of the boundaries and validity of patents create an odd situation that the more investing in technology, the more chance to become an alleged infringers (Bessen and Meurer, 2008).

Hypothesis 1. A firm with a higher quality patent is more likely to be litigated for alleged patent infringement compared to a firm with a lower quality patent.

2. Cumulative alliance experience and patent quality on litigation

A firm's action for filing a lawsuit is strategic decisions through weighing possible profits and losses (Somaya, 2003). The features that affect litigation is firm's size, uncertainty or asymmetric information, costs of litigation, the expected returns or stakes to the party. For instance, if stakes from litigation increase and costs of litigation fall, litigation are more likely to occur. As the alliance activity gives a firm to better reputation and capability to manage inter-organizational relationship, this section argues that repeated experiences in alliance of a potential defendant reduce the potential plaintiff's expected returns from litigation and increase uncertainty on the condition of high patent quality of a defendant.

1) Alliance and reputation

As a seminal paper, Gualti(1995) investigated the influence of previous alliances on the decisions for subsequent alliances thereby drawing a substantial attention to alliance experience as a research topic. He observed that more experienced firm in collaboration with others are more likely to develop trust and reputation (Gulati, 1995). Accordingly, repeated alliances engagement decreases risks from having alliance and enhances the potential benefit from subsequent partnerships by providing several information for collaboration activity (Gulati, 1995). Partnering with more experienced other firms contributes to information about alliance opportunities and expanding access to other firms (Gulati, 1995). In addition, repeated engagements in alliance suggest whether a

firm is trustworthy as a partner (Gulati, 1995; Oliver, 1997). Numerous partnering experience with other firms underlines their reputation as reliable collaborators. Gulati (1995) and Gulati(1999) showed that the existing relationships with other firms can provide information and reputation benefits that can further promote the formation of other alliances.

Established by alliance experience, reputation play an important role on subsequent alliance activity and its performance (Granovetter, 1985; Hill, 1990; Gulati, 1995; Dollinger et al., 1997). Saxton(1997) showed that partner reputation is positively related to alliance outcomes. Additionally, one study compared task-related parameters with partner-related parameters such as reputation, experience, personal knowledge of the partnering firms, characteristics of the chief executive officer (CEO) and found that the latter criteria are more significant on subsequent relationships, specifically about international joint ventures (Al-Khalifa and Eggert Peterson, 1999).

When a potential defendant's patent quality is desirable which indicates large stakes, a decision to file or not to file a lawsuit depends on whether investments on later alliances are worthy enough. Since firms are traditionally regarded as an economic entity that pursue for reasonable solutions, they search for the better and safer choice for achieving desirable stakes or expected returns. Consequently firms as an organization make a choice in order to avoid uncertainty (Cyert and March, 1963; Granovetter, 1985). Uncertainty can be avoided as focusing on more predictable conditions and short-run reaction or creating a negotiated condition (Cyert and March, 1963). The uncertainty about hazard for future partnership and its performance is reduced by the increase of alliance experience of other firms. Although a potential plaintiff pursues for dominant position in settlement or undoubtedly patent infringement occurs, the firm may deliver the demand letter informally without filing the case if the patent quality of a potential defendant is exceptionally valuable and has high reputation in alliance relationship. If a potential plaintiff decides act severely such as filing a lawsuit to a firm with quality patent, the firm may lose their valuable latent alliances and possibility for better performance. With latent possibility of losing subsequent partnering chances, the expected cost of litigation is increased. Eventually the decision not to file a lawsuit is an 'investment' for a further beneficial relationship. However, in the case with a potential

defendant with low patent quality, the potential stakes is not enough to aim at future friendly relationship due to low quality patent.

2) Alliance and relationship management

Alliance is for exchanging, sharing, and co-developing products, services, or technologies (Gulati, 1998) with several advantages such as cost sharing, risk reduction, and rapid response to unexpected situation (Lavie, 2007). Through repeated engagement in alliances, know-hows for codified routines, policies, procedures, and tacit knowledge of alliance management are accumulated as firm's asset (Rothaermel and Deeds, 2006). As well accumulated collaborative experiences 'facilitate interpretation and anticipation for subsequent activity', and allow firms to deal with unpredictable events during alliances (Anand and Khanna, 2000). Apart from facilitating decision-making, internal capabilities about strategic and network assets are developed by alliance experience (Powell et al., 1996). Generally competitive advantages of firms can be built over repeated alliance experiences (Dyer and Singh, 1998; Ireland et al., 2002).

Alliance management capability is developed by simultaneously managing a number of relationships and learning practical techniques from it (Powell et al., 1996). Firms learn proper procedures about how to handle with knowledge from alliance experiences (Simonin, 1997; Simonin, 2000; Rothaermel and Deeds, 2006). Apart from understanding knowledge flows, firms can learn how to position in more benefiting sites for capturing scientific and technological developments (Powell et al., 1996). Taken together, alliance experiences improve firms' capability for inter-organizational relationship management by learning about the effective management of alliances and collaboration capability is essential for managing tangible and intangible assets (Dyer and Singh, 1998; Ireland et al., 2002).

Alliance experience is not simply a resource in itself but also a means to establish a link with other prominent firms (Stearns and Mizruchi, 1986). Having a relationship with such firms which have greater alliance experience can enable partners to experience greater advantages (Stearns and Mizruchi, 1986). Besides, firms that are seeking collaboration partners for the development of new technology can consult their needs with their current and prior partners. Then, these partners can communicate about the needs of

seeking firms to current alliances or previous alliances. Hence a potential plaintiff may seek for a partner who had more experienced in alliances.

The more a firm forges alliance, the more friendly partners the firm has. Furthermore alliance experiences, in turn, contribute to build competitive advantage as improving alliance management capability (Dyer and Singh, 1998; Gulati, 1999; Lorenzoni and Lipparini, 1999; Ireland et al., 2002; Kale et al., 2002; Rothaermel and Deeds, 2006; Gulati, 2007), which in turn makes a firm to be equipped with more bonded relationship with its partners. This implies that a filing firm has a risk to build negative relationships with counterpart's allied partners. This also implies that there is a possibility that the firm might have forged an alliance with other companies which are friendly to the filing firm. Then the firm could utilized its alliance network to mitigate the negative relationship with the possible filing firms before they actually do so. Furthermore, the extensive technological knowledge available in the alliance networks could help to nullify the claims of the filing firm. Therefore, as a firm has more cumulative experience in alliances, the firm becomes the less attractive target to sue to litigate its patents.

Taken together, this paper hypothesizes that a potential defendant's cumulative alliance experience mitigates the link between quality of patent and patent litigation. When a potential defendant holds a high quality patent, having more alliance experiences will reduce patent litigation due to potential possibility of alliance.

Hypothesis 2. For firms with high quality patents, the occurrence of patent litigation decreases as the patent holders' past alliance experience increases.

III. Data and Methodology

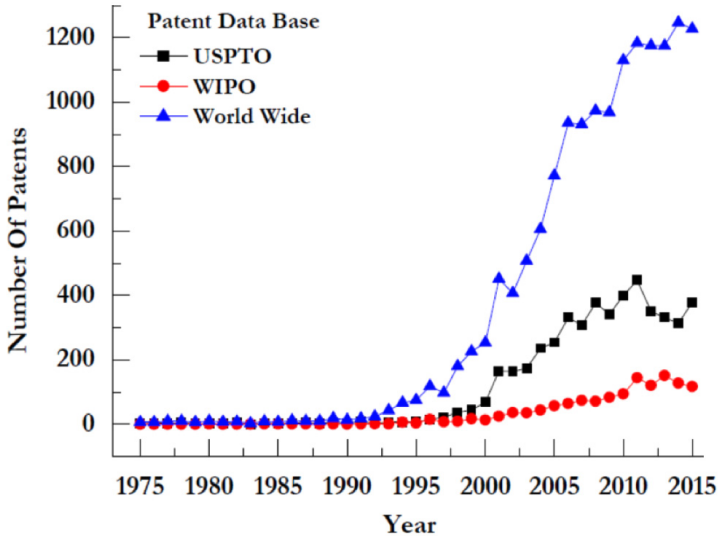
1. Data description

Since, in general, most firm level analyses are performed as selecting industry due to unique feature for each industry, this paper choose firms participating in printed electronics technology to examine the moderating role of alliance experience between

quality of patents and patent litigation. Printed Electronics allows for microchips to be manufactured in the same manner as printed objects such as newspapers or books. Specifically, this product can be substituted for photo lithography which produces electronic circuits and semiconductors. It produces electronic circuits and semiconductors via a printing process that utilizes inks that possess electrical properties. Since firms participating in this technology are diverse from traditional printing technology to electronic technology, participating firms had different functions, different industry fields, and different markets (Aistrup, 2009). Printed electronics are considered as one of representative cutting-edge technologies. The use of alliance in many industries, for example computer hardware, software, and electronics, has grown for a long time (Wassmer and Dussauge, 2012) and Powell et al.(1996) argued that innovation stems from alliance relationship when technology rapidly develops especially in high technology sectors. Hence, in this relatively new and high technology, learning and reputation built from previous alliance experience would be more important. In this context, firms involving in printed electronics would be tolerable to have certain degree of alliance activity that can be captured.

Increase of patent about printed electronics that can be depicted as cutting edge technology, may indicate the increase of litigation. Printed electronics were often selected in order to investigate merging trends of new technology using patent data (Kim et al., 2014; Patil et al., 2016). There are studies that showing considerable increase in filing and granting patent about printed electronics starting from 1975 and the growth of patents about printed electronics are significant from 2000 to 2015 (see Figure 2; Patil et al., 2016). Historically the number of filing a patent lawsuit has been significantly increased simultaneously with the number of filing and granting patents (Somaya, 2003; Bessen and Meurer, 2005). Hence, it is reasonable to assume patent lawsuit of firms participating in printed electronics has increased as growing market. Though the litigation rate may vary by technology area, it is higher in the field of high technology such as drugs, biotechnology and computers (Lanjouw and Schankerman, 2004; Bessen and Meurer, 2008; Weatherall and Webster, 2014). Bessen and Meurer(2008) showed that more litigation rate in instruments comparing to retail and wholesale. Bessen and Meurer(2005) found that the likelihood of litigation (both as a plaintiff and defendant)

in a patent infringement suit is particularly high in complex product industries such as electronics and instruments. Also, substantial percentage of patent suits took place between firms that neither are market competitors who share an industry segment (Bessen and Meurer, 2005). Since printed electronics is one of representative for high technology and substantial increase in patent, it is justifiable to select firms engaging in printed electronics in this study.



(Figure 2) Printed Electronics: The Trends of Patents Filed from 1975 to 2015

2. Data collection

This study examines the influence of alliance experiences on the link between value of patents and patent litigation. We collected information about patent litigation events from 2000 to 2015 using private data source name Docket Navigator. The source includes all electronically filed patents lawsuits from 2000; every patent infringement cases in the U.S. district courts, patent infringement investigations in the uniform traffic citation (UTC), every inter partes review (IPR) and covered business method (CBM) proceeding in the patent trial and appeal board (PTAB). In detail, litigation data includes case title, filing date, party, party role, issued patent number and patent's

industry code. In order to attain firm's financial information, Compustat[3] is utilized and patent data is collected from USPTO.

After manually collecting the entire patent litigation activity in the U.S. from 2000, the litigation events of the firms in printed electronics are selected. We identified the firms in the printed electronics industry using Cho et al.(2015)'s comprehensive list. The list consists of the firms with at least 10 patent registration related to printed electronics. Specifically, Cho et al.(2015) analyzed bibliographic data from the patents' abstracts that contain technological jargons related to printed electronics. Through keyword-based searching method, patents and firms in printed electronic industry are filtered and lastly 51 firms participating in printed electronics are remained. Then, we searched 51 firms using the global company key; i.e., gvkey[4], manually for the matching process. After cleaning process and manually selecting patent cases of 51 firms from litigation data, total 26 firms which gvkey code of Compustat was available and 2,469 patent suits were found. Then, numbers of litigation for each year and gvkey were counted and matched to Compustat data. In order to match Compustat and USPTO data, the NBER patent citations data by Hall and Ziedonis(2001) was utilized. The matched data from Compustat and NBER patent is until 2006. The strategic alliance database of the securities data company (SDC) was used to collect data on alliance activities. Although the database does not track all alliance activities—owing partially to the loose corporate reporting requirements—the SDC is one of the most comprehensive sources of information on firm alliance activities.

The patent information added to Compustat included with count of patent, forward citation. Since available period of litigation data was from 2000 to 2015 and of patent data was until 2006, the final available range was from 2000 to 2006.

A potential issue associated with using the patent citations is that firms could intentionally leave out some of their external knowledge sources from their competitors which could hamper the authenticity of the data. In fact, Narin et al.(1987) did not find a significant relationship between the patents and firms' financial performance but found that citations per patent did have a positive effect on firm performance.

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3) https://www.library.hbs.edu/Find/Databases/Compustat

4) A company identification code used in the Compustat database

1) Dependent variables

As the focal dependent variable of interest, the number of annual patent litigation was used. Docket Navigator derived data sources from those original raw data and transformed them into more structured data. Litigation data must be examined cautiously since low filing rates can be interpreted as low infringement rates, more pre-filing settlements, or simply an inaction from the patent owners. Therefore, it is imperative to first determine the amount of potential infringements, the proportion of them resulting in court proceedings, and the reasons why the rest of the infringement cases did not lead to court proceedings. Following the previous studies, the litigation rates are calculated as the number of litigations per year divided by the number of patents granted per year (Lanjouw and Schankerman, 2001; Somaya, 2003; Lanjouw and Schankerman, 2004; Bessen and Meurer, 2005). In order to apply the rate variable to the count model, logged exposure variables (i.e., offset variables) are implemented.

2) Independent variables

(1) Quality of Patent

Number of forward citations of a patent per 1000 patent is used. A number of previous studies support that, for patent characteristics, number of forward citations, backward patent citations, international patent classifications (IPCs) and inventors are mostly implemented (Wu et al., 2015).

Patent citations have a potential to represent firm's quality of patent and sometimes to further increase the inventions' value since firms build on their patents both technologically and commercially. To measure technological knowledge, Park and Park (2006) use patent citations. On the other hand, Lee et al.(2007) and Hu(2008) used patent citations as a representative for patent quality.

Previous studies showed that the relationship of invention's value and patent litigation. The number of claims is one of the determinants for the probability of litigation. More claims in a patent lead to higher risk of being litigated (Lanjouw and Schankerman, 2001; Lemley and Allison, 2004). In a recent study, the author finds that the patents with changing ownership, re-examining, and maintaining, are more likely to be litigated (Chien, 2011). Lanjouw and Schankerman(2001) examined the characteristics of patents

and its relationship with litigation. They found that patents with more forward citations have a higher probability of being involved in litigation and similar results showed in other research (Cremers, 2004; Lemley and Allison, 2004). Also, backward citation of a patent was presented as a factor for patent litigation (Harhoff et al., 2003).

In order to capture the effect on litigation, variable about quality of patent is lagged and dummy variable about it is created in order to distinguish the difference between absent in data and zero values of forward citation. A common issue with Compustat is that the data is implemented voluntarily is missing for many companies. To salvage as many observations as possible, we assign zero to all missing values and include a forward citation dummy as a control variable to determine which of the observations have forward citation value of zero (Hall et al., 2005).

(2) Alliance Experience

The cumulative number of previous alliance experience that a firm formed are used as a proxy for alliance experience with a year lagged effect. In order to test the moderating effect of alliance experience on the relationship between quality of patent and patent litigation, the sample is split in two sub-groups using the median of alliance experience as decision criterion similar to previous literature (Rothaermel and Deeds, 2006). T-tests and a variance ratio test are applied in order to examine the fulfillment of requirements for split sample approach and for creating binary variables. The alliance experience measure used in this study goes concordantly that of simple alliance counts generally used in prior research (Anand and Khanna, 2000; Rothaermel, 2001; Kale et al., 2002; Hoang and Rothaermel, 2005; Rothaermel and Deeds, 2006). Anand and Khanna(2000) used the number of partnering experiences to examine the learning effects through alliance experience.

A possible disadvantage to use alliance as level of analysis is that each alliance is treated as a single and independent business (Doz and Prahalad, 1991). As researchers have started to analyze knowledge transfer within firms, doubts arise whether an alliance or partner level of analysis is an appropriate level (Levinthal, 2000). However, in this paper, it is reasonable to employ the simple count number of previous alliances due to reputational perspective.

3) Control variables

In our baseline regressions, we control for a vector of firm-level characteristics that may affect patent litigation. All control variables are obtained from Compustat and Patent Data. Specifically, we control for firm size, number of patents, and R&D (research and development) expenditures. For the proxy of firm size, employment size in Compustat is used. According to Lanjouw and Schankerman(2004), individuals and firms with small patent portfolio is more likely to be involved in a lawsuit compared to firms with larger portfolio. Bessen and Meurer(2005) found that, compared to 1.1 suits per 100 patents for large firms, small firms are at a higher litigation risk with 4.3 suits per 100 patent. In consistent with previous results, Allison et al.(2003) showed that patents of individuals and small firms have a higher chance to be litigated than the patents of large firms. However, the results from using the data of other countries were diverse. The study about patent infringement in Germany and Australia presents a similar pattern (Cremers, 2004; Weatherall and Webster, 2010). Yet, according to Greenhalgh et al. (2010), large firms in the U.K. are at a higher litigation risks. Number of patents is controlled in order to capture the effect by the number of patents. R&D expenditure per year in unit s of millions. To avoid losing observations by data source, common practice in previous literature was followed and the missing values were set to zero. Then, additional control a dummy variable ("R&D dummy") that indicates whether R&D is zero is included (Hall et al., 2005).

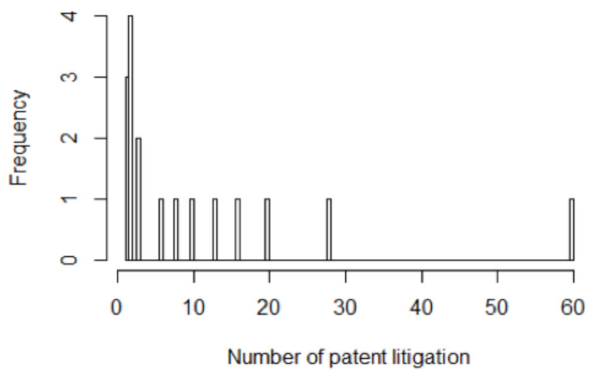
3. Research methodology

1) Descriptive statistics

Table 1 shows descriptive statistics on variables employed in this study. Each variable includes 157 observations and their distributions of dependent variable seemed right-skewed as shown in Table 1. The unconditional mean of patent litigation is much lower than its variance so as forward citation's mean. Therefore the histogram of patent litigation was plotted in Figure 3. Also, most variable have greater means than medians.

〈Table 1〉 Descriptive Analysis

	Patent Litigation	Forward Citation per thousand	Alliance Experience per thousand	Patent	Firm size	R&D
Min.	0.00	0.00	0.00	0.00	0.57	0.00
Max.	19.00	37.24	0.56	3,452.00	484.00	64.06
Median	2.00	1.22	0.07	580.00	88.50	15.67
Mean	2.99	3.18	0.11	864.47	127.72	16.63
SE. mean	0.29	0.39	0.01	65.80	8.60	0.91
CI. mean. 0.95	0.58	0.77	0.02	129.97	16.99	1.80
Variance	14.77	26.57	0.01	684,086.00	11,620.54	144.94
Std. dev.	3.84	5.15	0.12	827.09	107.80	12.04



(Figure 3) Distribution of Patent Litigation

T-tests and a variance ratio test are applied in order to examine the fulfillment of requirements for split sample approach.

2) Method

According to the positively skewed dependent variable and characteristics of the count data, this study chose to implement one of the Poisson family. In this study, both dependent and independent variables are counted numbers of occurrences, therefore the distribution is discrete, not continuous and is limited to non-negative values.

Additionally the data set of outcome variable includes significant amount of value. If an ordinary liner regression is applied, positively skewed data will result in the most distribution close to 0 which prevent the transformation into normal and there are the

possibility of negative predicted value which is nonsense to counting variable. Therefore, a Poisson regression model or its variants are considered as the appropriate model due to its advantages for skewed and discrete data. Furthermore, this model restricts the predicted value to non-negative numbers. A Poisson model assumes equality of the mean and variance of the errors. However, as shown in descriptive statistics, the variance of the errors is much larger than the mean. Also, zero-inflated Poisson is considered. Zero-inflated model should processed under the assumption that two distinctly different causes for zeros. Due to the lack of clear reason, zero-inflated Poisson was removed from the list (Gardner et al., 1995; Scott Long, 1997).

When the variance of the errors is larger than the mean, negative binomial model can be implemented as an alternative. In this study, significant difference between variance and the mean indicates negative binomial is clearly more appropriate than Poisson. Additionally this study examined using fixed effect, negative binomial is the most appropriate (Gardner et al., 1995; Scott Long, 1997).

Mainly in order to handle common proxy for litigation as rates in Poisson, exposure variables are applied by transforming the rate dependent variable into a count. The litigation rate is defined as the number of litigations per year divided by the number of patents granted per year (Lerner, 1995; Lanjouw and Schankerman, 2001, 2004; Prakash-Canjels, 2001; Bessen and Meurer, 2005; Razgaitis, 2006; Muller et al., 2010). In order to transform the rate into count, the number of patent grants per year was multiplied in both sides. Then, this exposure variable which was multiplied and moved is logged. This logged variable is called as an offset variable. In this paper, this offset variable is also utilized to account for the rate of litigation. This is processed under the assumption that the likelihood of litigation over a year does not change. For robustness check, different model that can be applied in counting variable is used; Poisson model (Gardner et al., 1995; Scott Long, 1997).

The empirical model used the estimate the coefficients of interest is as follows:

$$\begin{aligned} log(PatentLitigation_{it}+1) &= \beta_0+\beta_1\times PatentQuality_{it}+\beta_2\times AllianceExperience_{it} \\ &+\beta_3\times(PatentQuality_{it}\times AllianceExperience_{it})+offset(log(PatentGrants_t+1))+\gamma' X+\varepsilon_{it} \end{aligned} \quad (1)$$

where $log(PatentLitigation_{it}+1)$ denotes the logged number of patent litigations in which

firm i is involved at year t, $PatentQuality_{it}$ denotes the total number of forward citation on the patents which firm i owns at year t, $AllianceExperience_{it}$ is a binary variable that indicates whether or not firm i has an experience in establishing an alliance with other firms in year t, $log(PatentGrants_t+1)$ is the offset variable, X is a vector of covariates which includes firm size, number of patents, and R&D expenditures, and ε_{it} is the error term.

Interpreting the model of Poisson and negative binomial requires extremely cautious process, especially when interpreting the interaction effects. The method for interpreting count model is currently in the middle of an active discussion since the coefficients cannot be directly interpreted. In order to easily interpret the data, a ratio based on the rate, so called incidence rate ratio (IRR) is commonly used by researchers. Following Hilbe(2014), IRR for binary and continuous interaction is constructed. For instance, in order to interpret the effect of alliance experience, the following formula can be applied to calculate the IRR:

$$IRR_{B\times \overline{C}} = \frac{\exp[\beta_{AlliExp=1}]}{\exp[\beta_{AlliExp=0}]} = \frac{\exp[\beta_1 \times PatentQuality + \beta_2 + \beta_3 \times PatentQaulity]}{\exp[\beta_1]} \quad (2)$$

where $\beta_{AlliExp}$ is the total effect of alliance experience on the likelihood of patent litigation and $IRR_{B\times \overline{C}}$ is the incidence rate ratio in the presence and absence of alliance experience, ceteris paribus.

IV. Empirical Results and Discussion

1. Results

In Table 2, the results of negative binomial regression that employed count variable and exposure variable for rate are presented. Starting from checking individual effect of patent quality and alliance experience, the significance of the results are gradually illustrated up to the interaction of patent quality and alliance experience. Models 1, 2

and 3 showed gradual results with fixed effect, but without exposure variable and Models 4, 5 and 6 examined the results of negative binomial with both fixed effects and exposure variables. Across all models, patent quality is statistically significant and is positively associated with patent litigation. The interaction term of patent quality and alliance experience is negatively associated with the count of patent litigation.

Due to the log of the expected count, the results should be interpreted cautiously. Recalling that the proxy for patent quality, count of forward citation, is divided by 1,000, one unit of patent quality indicates per thousand of forward citation. The results indicate that an increase in the patent quality increases the number of litigations by a factor of 1.237[5] which means that a unit increase in patent quality leads to 23.7% more litigations (Column 3 in Table 2). Instead of implementing a simple count variable for patent litigation, model 6 utilizes the rate of litigation which is a more commonly used proxy for the risk of litigation. As the number of forward citation increases[6], the expected number of patent litigation increases by a factor of 1.241 or a 24.1% increase in the patent litigation (Column 6 in Table 2).

The values of the IRR for firms with past alliance experience at varying levels of patent quality are illustrated in Figure 4[7]. The results show that for firms with past alliance experiences, increase in the patent quality increases the likelihood of being litigated for patent infringement. For example, a unit increase in the $PatentQuality$ (i.e., from a thousand forward citation to two thousand forward citations) causes the litigation rate to increase by a factor of 1.03 which is equivalent to 3% increase in the litigation rate. This is likely due to the fact that higher quality patents are more likely to be litigated for infringement[8]. To interpret the effect of alliance experience, we fix $PatentQuality$ at its median (i.e., 7.136) and calculate the IRR. The results indicate that for firms with median-level patent quality, the presence of alliance experience decreases the litigation rate by a factor of 0.330 which is equivalent to 33% decrease in the litigation rate. Therefore, we confirm that both hypotheses 1 and 2 are supported.

5) exp(0.216) = 1.237, which indicates an increase of 23.7%.

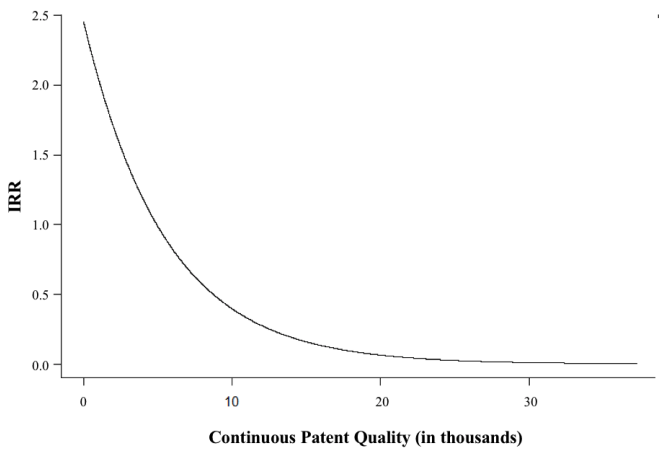
6) The unit of forward citation is 1,000.

7) The IRR values from model 6 (Column 6 of Table 2)

8) As discussed above, patent infringement litigation can be extensively costly for both plaintiffs and defendants. This means that the overall cost associated with litigations on low quality patents can outweigh the potential gain.

〈Table 2〉 Negative Binomial Regression Results

	Dependent variable:					
	Patent litigation					
	(1)	(2)	(3)	(4)	(5)	(6)
Patent quality	0.048**	0.047**	0.213***	0.048**	0.047**	0.216***
	(0.021)	(0.020)	(0.077)	(0.020)	(0.020)	(0.077)
Alliance experience		0.367	0.908*		0.350	0.899*
		(0.486)	(0.536)		(0.484)	(0.534)
Patent	-0.0002	-0.0002	-0.0003	-0.0002	-0.0002	-0.0003
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Firm size	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
R&D	0.029	0.023	0.020	0.031	0.025	0.023
	(0.020)	(0.022)	(0.022)	(0.020)	(0.022)	(0.022)
R&D dum	-3.372***	-3.405***	-3.150**	-3.329***	-3.360***	-3.103**
	(1.239)	(1.238)	(1.235)	(1.237)	(1.236)	(1.233)
Patent quality dum	-0.635	-0.645	-0.653	-0.629	-0.639	-0.645
	(0.629)	(0.626)	(0.608)	(0.626)	(0.623)	(0.605)
Patent quality * Alliance experience			-0.180**			-0.182**
			(0.080)			(0.080)
Constant	1.436**	1.468**	1.161	-10.714***	-10.684***	-10.993***
	(0.722)	(0.722)	(0.720)	(0.718)	(0.718)	(0.716)
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Exposure variable	No	No	No	Yes	Yes	Yes
Observations	157	157	157	157	157	157
Log Likelihood	-265.125	-264.868	-262.014	-264.477	-264.239	-261.288
Akaike Inf. Crit.	592.250	593.737	590.028	590.954	592.479	588.576
Note:						*p<0.1; **p<0.05; ***p<0.01



(Figure 4) IRR on High Alliance Experience of the Full Model (Column 6 of Table 2)

2. Robustness check

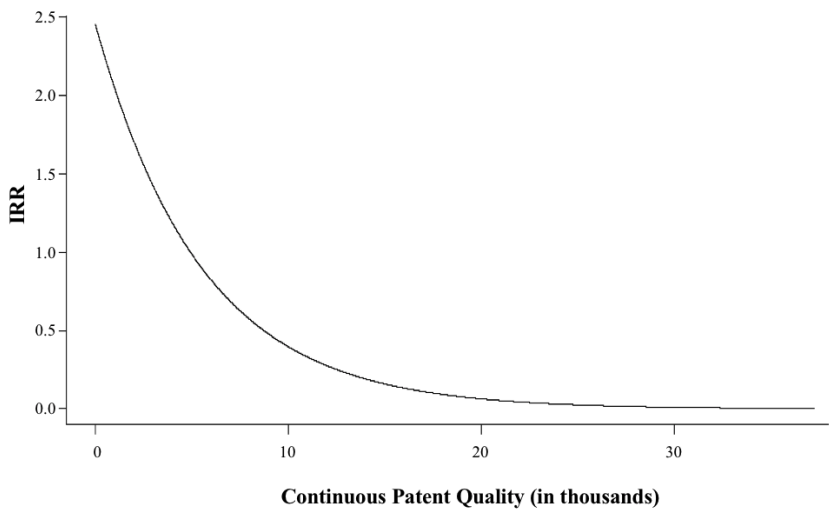
In order to check the robustness of the results a Poisson regression was employed. The results from the robustness check are similar to that of the negative binomial regression. That is, an increase in the patent quality increases the litigation rate by a factor of 1.259 which means that a unit increase in patent quality leads to 25.9% higher litigation rate (Column 3 in Table 3). Likewise, when using the litigation rate, we reaffirm that a unit increase in the patent quality increases the litigation rate by a factor of 1.259, a 25.9% increase in the litigation rate (Column 6 in Table 3).

The robustness check results also confirm that for firms with past alliance experiences,

〈Table 3〉 Poisson Regression Results for Robustness Check

	Dependent variable:					
	Patent litigation					
	(1)	(2)	(3)	(4)	(5)	(6)
Patent quality	0.045***	0.044***	0.228***	0.046***	0.045***	0.230***
	(0.015)	(0.015)	(0.064)	(0.015)	(0.015)	(0.064)
Alliance experience		0.481	1.069**		0.453	1.046**
		(0.382)	(0.442)		(0.382)	(0.443)
Patent	-0.0002	-0.0002	-0.0002	-0.0001	-0.0001	-0.0002
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Firm size	-0.005	-0.005	-0.004	-0.005	-0.005	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
R&D	0.033**	0.028*	0.026	0.036**	0.031*	0.029*
	(0.015)	(0.016)	(0.016)	(0.015)	(0.016)	(0.016)
R&D dum	-3.493***	-3.500***	-3.215***	-3.446***	-3.452***	-3.168***
	(1.109)	(1.110)	(1.116)	(1.109)	(1.111)	(1.116)
Patent quality dum	-0.713*	-0.740*	-0.748*	-0.681*	-0.706*	-0.714*
	(0.410)	(0.409)	(0.408)	(0.410)	(0.409)	(0.408)
Patent quality * Alliance experience			-0.195***			-0.196***
			(0.065)			(0.066)
Constant	1.563***	1.569***	1.229**	-10.592***	-10.587***	-10.926***
	(0.493)	(0.497)	(0.512)	(0.494)	(0.498)	(0.513)
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Exposure variable	No	No	No	Yes	Yes	Yes
Observations	157	157	157	157	157	157
Log Likelihood	-282.871	-282.019	-276.867	-281.277	-280.527	-275.362
Akaike Inf. Crit.	627.742	628.038	619.735	624.554	625.055	616.723
Note:						*p<0.1; **p<0.05; ***p<0.01

increase in the patent quality (i.e., from a thousand forward citation to two thousand forward citations) increases the likelihood of being litigated for patent infringement by a factor of 1.03 which is almost identical to the results presented in the results section. Again, we fix $PatentQuality_{it}$ at its median (i.e., 7.136) and calculate the IRR. The results reaffirm that for firms with median-level patent quality, the presence of alliance experience decreases the litigation rate by a factor of 0.300 which is equivalent to 30% decrease in the litigation rate.



(Figure 5) IRR of the Full Model (Column 6 of Table 3) for Robustness Check

V. Conclusion

This study investigated the moderating role of alliance experience on the relationship between patent quality and patent infringement litigation. Using count models, the results repeatedly confirm the hypotheses that high quality patent holders are litigated more often for infringement and that having a past alliance experience mitigates the likelihood of being litigated.

Along with the increasing number of patent lawsuits, myriad of research is being conducted on patent litigation. Studies have found that patent litigation leads to a

significant loss for both of the parties: plaintiff and defendant (e.g., Bhagat et al., 1994; Bhagat et al., 1998; Lanjouw and Lerner, 2001; Hall and Ziedonis, 2007; Bessen and Meurer, 2008). Also, a handful of studies have explored the determinants of patent litigation (see, for example, Allison et al., 2003; Lemley and Allison, 2004; Meurer and Bessen, 2005; Weatherall and Webster, 2014). However, most of the studies investigated the topic on the patent level. The studies that were conducted at the firm level investigated infringed patent rights in the perspective of inventors or plaintiffs. To the best of our knowledge, this is the first study that focuses on defendants of patent infringement lawsuits.

A unique dataset that combines information on patents, infringement lawsuits, and firm performance were used to investigate the role of alliance experience on the link between patent quality and infringement litigation. The results confirm that firms with past alliance experience are less likely to be litigated. For instance, for firms with median patent quality, the presence of past alliance experience reduces the litigation rate by 33%. This finding suggests that a firm's past alliance experience can act as a reputation that deters, to a certain degree, other firms to sue them for alleged patent infringement.

This paper makes two major contributions. First, the findings contribute to the literature on alliance experience by confirming its role as a reputation in mitigating the potential for future litigations. An innovating firm is likely to become an alleged infringer under a false accusation. Therefore, this paper focuses on firms that are brought into patent litigations unwillingly. To our knowledge, this is the first study to investigate infringement lawsuits with a primary focus on defendants. Hence, this paper also contributes to the literature on patent infringement as a first study that investigates the issue from the perspective of the defendants.

However, this paper is not completely free from limitations. One notible limitation is that the data used in this paper focuses on only one industry, i.e., the printed electronics. This limits the external validity of the results. Therefore, further studies could explore the influence of firms' past alliance experience on patent infringement lawsuits in other industries such as bio-pharmaceuticals to bolster the generalizability of the findings.

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강민정

미국 일리노이 대학교(Urbana Champaign)에서 화학공학을 전공하고 한국과학기술원(KAIST)에서 기술경영 석사학위를 취득하였다. 현재 삼성 바이오에피스에서 제약 관련 규제 업무 담당으로 근무 중이다. 관심 분야는 economics of innovation, intellectual property, regulatory policy 등이다.

유재원

미국 애리조나 대학교에서 경제학을 전공하고 한국과학기술원(KAIST)에서 경영과학 석사학위를 취득하였다. 이후 동 대학원에서 박사학위를 수학하고 있다. 주요 관심 분야는 IT platform innovation, management of technology, quantitative marketing, applied econometrics 등이다.

김원준

현재 한국과학기술원(KAIST) 기술경영학부 교수로 재직 중이다. 서울대학교에서 경제학 박사학위를 취득하고, 미국 예일 대학교 방문 연구원, 뉴욕 대학교 겸임 조교수, 매사추세츠 공과대학교에서 visiting scholar로 활동하였다. 주요 연구 분야는 innovation strategy and policy, empirical industrial organization, quantitative marketing 등이다.

김남일

캐나다 토론토 대학교에서 학사, 독일 본 대학교에서 석사, 한국과학기술원(KAIST)에서 기술경영학으로 박사학위를 취득하였다. 현재 한국과학기술원에서 연구원으로 재직 중이며 학술적으로 기술경영, 창업, 산업의 동태적 변화, 디지털 및 기술시장 등에 관련된 연구에 관심이 있다.