博士論文

An empirical study of innovators' risk assessment: how innovators gain benefits and are affected from enforcement of patents in litigations?

（イノベーターが原告として特許訴訟に巻き込まれるリスクのアセスメントに関する実証研究）

胡　章

Abstract

With the advent of the knowledge economy, patents play an increasingly important role in protecting innovators' inventions. The number of granted patents has been constantly increasing since 2000 in most of the major economies of the world. On the other hand, more and more patentees are willing to enforce their patents in litigations. The number of patent litigations doubled in the US from 2009 to 2015 and increased to over seven times in China from 2000 to 2015. With an increasing number of patents being granted and the increase of patentees' propensity to litigate their patents, innovators face an increasing patent litigation risk either as a patent litigant or as an alleged infringer. As patent litigation is usually costly, it is important for innovators to manage their patent litigation risk. This dissertation provides an empirical study of some issues regarding patent litigation risk assessment. I design the research from the perspective of innovators and focus on their risk of being involved in patent litigation as a patent litigant. Chapters 3 and 4 are the main body of this dissertation and make some comparative studies between the US, Japan, and China at the patent level, while Chapters 5 and 6 provide supplement studies using samples in Japan at the firm level.

In Chapter 3, I make a comparative study of the effects of different aspects of patent value on patent damage awards between the US, Japan, and China. I examine the effects of three most well-established patent value indicators and find that the number of forward citations positively impacts the patent damage awards ruled by Japanese judges. In contrast, family size positively impacts patent damage awards ruled by Chinese judges and US judges. In addition, none of the indicators of patent value has a significant effect on patent damage awards ruled by US juries. As these indicators reflect different aspects of patent value, these findings suggest that judges in the US, Japan, and China attach weight to different aspects of patent value when determining patent damages. The findings in this chapter will enable patentees to have a clearer

understanding of the determinants of patent damage awards and to make a more precise prediction of the stakes of litigating a patent in the US, Japan, and China.

In Chapter 4, I provide a comparative study of the characteristics of patent litigation at the patent level between the US, Japan, and China. Although most of the characteristics tested in this chapter are those previously tested in the US or Germany, three of them are introduced for the first time in this study. I find that although common characteristics of litigated patents exist between the litigated patents in the US, Japan, and China, some differences also identified in this study. For example, the number of International Patent Classification (IPC) subclasses has a significantly negative effect on the probability of litigation in the US, but no significant effect is found in Japan and China. These findings enable patentees to identify patent litigation risk more precisely.

In Chapter 5, I further examine the characteristics of patent litigation at the firm level using a sample in Japan. I find that the characteristics of patent litigation at the firm level are greatly consistent with those at the patent level identified in Chapter 4. For instance, like their counterparts at the patent level, the ratio of patents whose family size is more than one, the average number of forward citations, and the average number of backward citations also have a significantly positive effect on the probability of litigation at the firm level. However, unlike their counterparts at the patent level, no significant effect on the probability of litigation is found at the firm level for the average number of words in the first independent claims, the ratio of patents asserting domestic priority, the average number of inventors.

In Chapter 6, I study the impact of patent litigation on the subsequent patenting behavior of the plaintiff small and medium enterprises (SMEs) in Japan. I find that the number of patent applications filed by the plaintiff SMEs significantly decreases in the second and third year after patent litigation. This negative effect is more significant for the litigations with extremely high costs. I argue that this is most probably caused by SMEs' regular R&D activities being negatively affected by the high costs of patent litigation. Moreover, I also find that the quality (strength and enforceability) of patents filed by the plaintiff SMEs increases subsequently after patent litigation. This indicates

that patent litigation provides a good chance for SMEs to learn to apply for stronger patents. These findings will enable SME patentees to evaluate patent litigation risk more comprehensively.

To summarize, this dissertation contributes to the literature on patent litigation risk management. It contributes to the literature on patent valuation which is seldom conducted in Japan and China. It is also the first academic attempt to study patent litigation comparatively between China and other countries and greatly contributes to the future research on patent litigation in China.

Key words: patent litigation; risk assessment; patent damages; litigated patents; patent litigants; the effect of patent litigation

JEL codes: K41; K42; O31; O32; O34; D81

List of Abbreviations

AIPA	American Intellectual Property Association
CAFC	Court of Appeals for the Federal Circuit
CIP	Continuation-in-part
CPI	Consumer Price Index
EPO	Europe Patent Office
ICTCLAS	Institute of Computing Technology, Chinese Lexical Analysis System
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
IP	Intellectual property
IPC	International Patent Classification
JPO	Japan Patent Office
NPE	Non-Practicing Entity
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
PPP	Purchasing Power Parity
PTO	Patent and Trademark Office
R&D	Research and Development
SME	Small and Medium Enterprises
TLO	Technology Licensing Offices

Contents

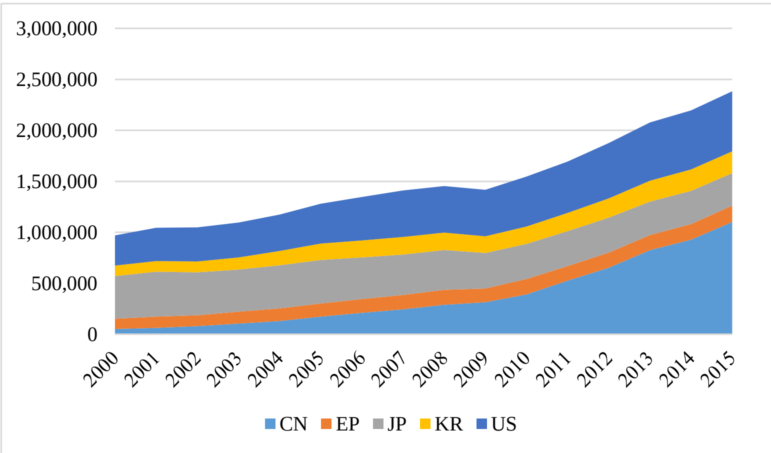
Chapter 1 Introduction

1.1 Increasing Patent Litigation Risk

In the era of the knowledge economy, intellectual property (IP) assets, such as patents, trademarks, copyrights, trade secrets, play an increasingly important role in firms' business activities. Two facts evidence this. First, intellectual property has become one of the most important sources of competitive advantage for many firms (Watanabe and Yoneyama, 2004). Second, the value of intellectual property assets has exceeded that of tangible assets such as buildings, machinery, and fixed assets in most firms in modern times (Simensky and Osterberg, 1999).

Recognition of the value of intellectual properties has motivated firms to compete to create intellectual properties and apply for IP rights. In this dissertation, I will focus on patent right, a key component of IP rights. Figures 1-1 and 1-2 show the growth of the number of patent applications and the growth of the number of granted patents respectively in China (CN), Europe (EP), Japan (JP), Korea (KR), and the US. The number of patent applications and the number of granted patents in these countries or areas increased by up to 2.5 and 2.8 times respectively from 2000 to 2015.

Figure 1-1. The growth of the number of patent applications



(Data source: WIPO statistics database)

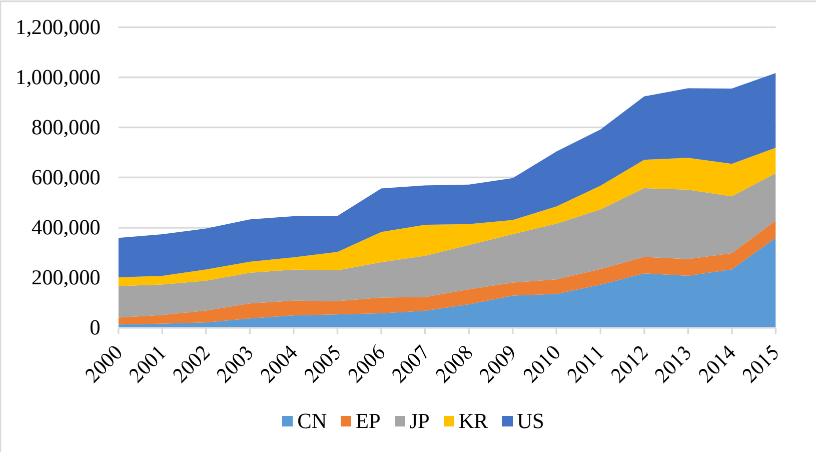


Figure 1-2. The growth of the number of granted patents

Data source: WIPO statistics database

On the other hand, firms are facing increasingly intense competition in the knowledge economy. To gain competitive advantage, more and more patentees tend to enforce their patent rights in litigation. Figures 1-3 and 1-4 show the changes in the number of patent cases filed in the US and in China respectively during the period of 2000 to 2015. It can be seen that the number of patent infringement suits doubled from 2009 to 2015 in the US. The growth tendency is even sharper in China. Figure 1-4 shows that the number of patent infringement suits in China increased by seven times from 2000 to 2015.

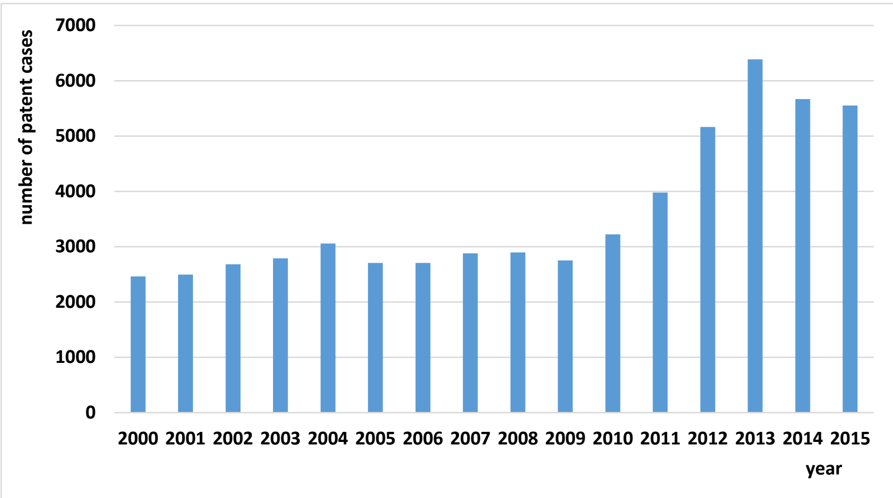


Figure 1-3. The growth of the number of patent cases filed in the US

Data source: Judicial Facts and Figures (US Courts)

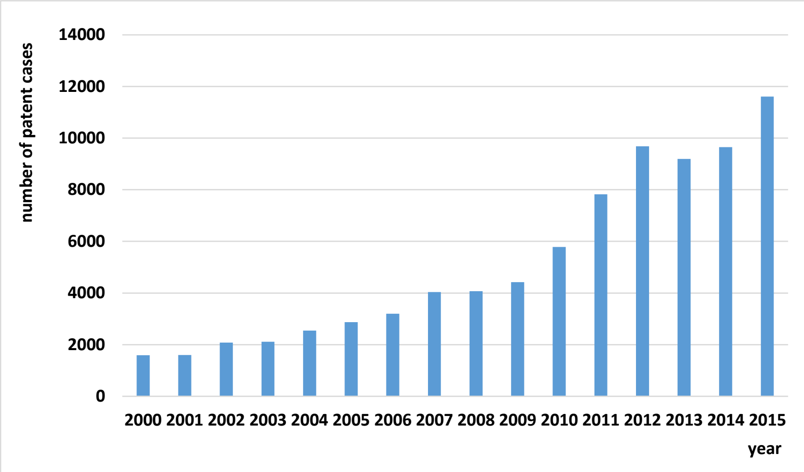


Figure 1-4. The growth of the number of patent cases filed in China

(Sum of invention patent, utility model patent, and design patent cases)

Data Source: Intellectual Property Protection by Chinese Courts;

Annual Report of the Supreme People's Court on Intellectual Property Cases.

With an increasing number of patent rights being granted and the increase of patentees' litigation propensity, firms are facing the growing risk of being involved in patent litigation, either as a patent litigant or as an alleged infringer. In some cases, firms infringe others' patent rights deliberately because the stakes are high. In other cases, though firms innovate by themselves, they may infringe on others' patent rights innocently due to a lack of extensive patent clearance search. Moreover, firms may also be involved in patent litigation because the components or machines purchased from other firms infringe others' patent rights. This phenomenon typically occurs in the smartphone industry. Besides, patent cases filed by non-practicing entities (NPEs), which is a new threat for innovators, have increased significantly in the US since 2010.

Moreover, patent litigation risk is also reflected in the high costs of patent litigation. According to a survey conducted by the American Intellectual Property Association (AIPA) in 2015, for a claim less than $1 million, the average cost of patent litigation is $873, 000; for a claim between $1 million and $25 million, it is $ 2.2 million; for a claim between $10 million and $25 million, it is $3.5 million; and for a claim over $25 million, the figure is $ 6.3 million. In addition to these direct costs, there are also various indirect costs, which take many forms (Bessen and Meurer, 2008). First, a great deal of time that managers and researchers spend in litigation might disrupt a firm's regular business activities. Second, patent litigation might destroy the cooperative relationship between two parties. Third, for firms with weak fiscal capacities, patent litigation may decrease their credits because of a possible bankruptcy risk.

1.2 Key Issues Regarding Patent Litigation Risk Assessment

Considering the increasing risk of being involved in patent litigation and the high costs of patent litigation, it is important for firms to manage their patent litigation risk in their daily routines. Figure 1-5 reproduces the general risk management process defined in ISO 31000:2009, an international standard of risk management codified by the International Organization for Standardization (ISO).

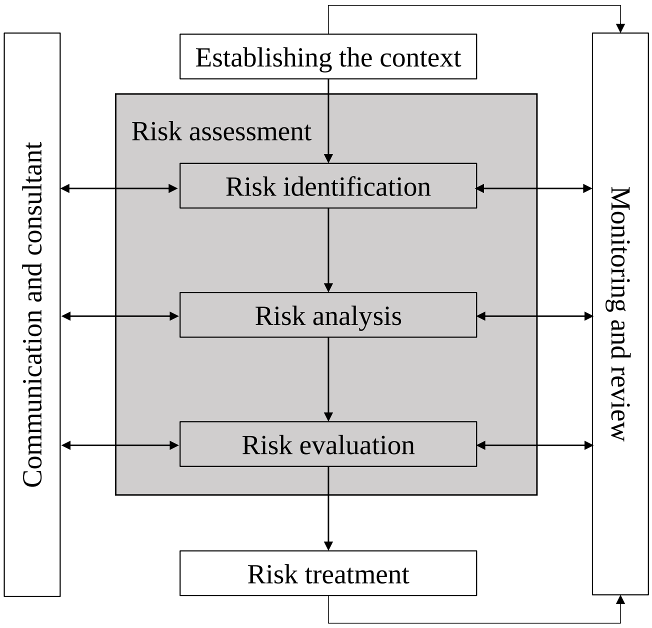


Figure 1-5. Risk management process from ISO 31000: 2009

According to this standard, a sound risk management process consists of five elements: communication and consultation, establishing the context, risk assessment, risk treatment, and monitoring and review. Among these elements, risk assessment plays a key role in risk management. In fact, in view of the importance of risk assessment in risk management, the ISO and the International Electrotechnical Commission (IEC) codified another standard called ISO/IEC 31010: 2009 to provide guidance on risk assessment techniques.

In the case of patent litigation risk management, the precise assessment of the magnitude of patent litigation risk is an essential step for firms to take effective measures to treat it. Based on the framework of risk management above, I summarized some key issues regarding patent litigation risk assessment in Figure 1-6. From this figure, patent litigation risk assessment needs at least three aspects of information.

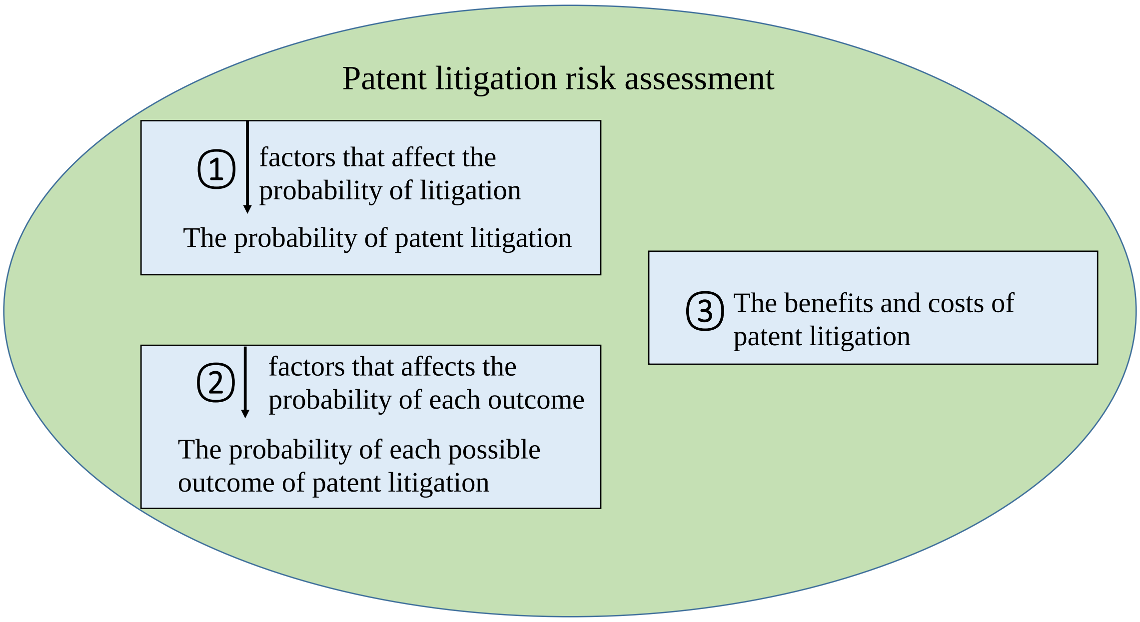


Figure 1-6. Key issues regarding patent litigation risk assessment

(1) Predicting the possibility of litigation

Patent litigation risk assessment first involves the prediction of patent litigation. Two kinds of patent litigation risks exist for an innovator. On the one hand, an innovator is always confronted with the risk of being a patent litigant if it owns patents in force because it is impossible for them to control others' infringement acts. On the other hand, as noted above, an innovate is always confronted the risk of being sued as a patent infringer because he may infringe others' patent rights deliberately or innocently, or just be deemed as infringed. Since the probability of litigation for different patents varies greatly, it is essential for innovators to manage to distinguish the patents of a higher probability of litigation from those of lower probability of litigation. This helps them make a better resource allocation for monitoring infringement, preparing for litigation, or doing extensive clearance search.

(2) Predicting the possibility of each outcome

The second information necessary for patent litigation is that the possibility of each outcome of patent litigation. The possible outcomes of patent litigation are settlement, winning and losing. In addition, in the case of winning, the prediction of patent damage awards will be a further issue. Predicting the possibility of each outcome will be very helpful in the evaluation of the magnitude of patent litigation risk. This is true both for a potential patent litigant and for a potential alleged patent infringer.

(3) Predicting the benefits and costs of patent litigation

Winning and losing a patent litigation will surely benefit or cause losses to the parties. Furthermore, regardless of its outcome, patent litigation itself has both positive and negative effects on the parties. For instance, patent litigation has an announcement effect to deter potential infringement because filing an infringement lawsuit reflects a patentee's willingness to assert its patent rights. On the other hand, the high costs of patent litigation may negatively impact its regular business activities. Grasping these benefits and costs of patent litigation will help the parties evaluate the risk more comprehensively.

1.3 Previous Literature

1.3.1 The Determinants of Patent Damage Awards

Although patent litigants can benefit from patent litigation in various ways, patent damage awards are one of the key beneficial outcomes. However, patent damage awards involve so many uncertainties that they are commonly thought to be systematically unpredictable. Recently, several prior studies have attempted to solve this puzzle by constructing prediction models to identify the determinants of patent damage awards. Lai and Che (2009) attempted to model US patent damage awards with two neural network methods, Extension Neural Network and Back-Propagation Neural Network, with 17 indicators of patent property (Lai and Che, 2009a; 2009b). Mazzero et al. (2013) constructed a series of econometric models explaining over 75% of the variation in the US patent damage awards. In addition, Li (2015) studied patent damage awards in

China and found that the courts in China determine statutory compensation by different principles according to the infringers' industry attributes. For the traditional fast moving consumer goods, the scale of sales and the sale price of the infringing product have a significant effect on patent infringement damages. For durable customer goods, the court also considers sales coverage and the infringement extent of the infringing product. For a knowledge-based new product, the court further refers to the plaintiff's claims.

1.3.2 The Characteristics of Patent Litigation

Lanjouw and Schankerman (2001) summarized four key determinants of patent litigation: the likelihood that a litigious situation or event, which could be considered an infringement of patent rights occurs and is detected by the patentees or exclusive licensees, a divergence in the parties' expectation of the outcome of a trial, a divergence in the parties' expectation of the damages to be awarded, and the cost of trial relative to the cost of settlement. Although theoretically, these determinants will be very useful in predicting patent litigation, as they are always unobservable, it is difficult to make use of them directly and thus it is necessary to find some observable indicators to identify patent litigation. In view of the fact that patent characteristics usually correlate with some of these determinants, Lanjouw and Schankerman (2001) made a first attempt to predict the probability of litigation for a given patent by identifying the characteristics of US litigated patents. After that, the characteristics of litigated patents have been extensively studied in several later studies. Table 1-1 summarizes the prior findings.

Technology fields

Using a sample of US patent cases between 1980 and 1984, Lanjouw and Schankerman (2001) found that the litigation rate is highest for patents in the technology field (classified by IPC codes) of drugs and health (2.01%), and lowest for patents in the technology field of chemical (0.54%). They updated their findings (2004) by showing that during the period from 1978 to 1995, the litigation rate is lowest for patents in the technology fields (classified by USPC codes) of chemicals (1.18%), electronics (1.54%), and mechanics (1.69%); modest for patents in the pharmaceutical

Table 4-1. The Effects of Patent Characteristics on the Probability of Litigation

Intrinsic characteristics	Effect	Sample
Technology field	Highest for biotechnology Lowest for chemicals	US and German patent cases
Number of claims	+	US and German patent cases
Number of IPC codes	−	US patent cases
Family size	+	US and German patent cases
Number of backward citations	No consensus	US and German patent cases
Domestic family size	+	US patent cases
Opposition	+	German patent cases
Prosecution length	+	US patent cases
Patent Age	+	US patent cases
Acquired characteristics	**Effect**	**Sample**
Number of forward citations	+	US patent cases
Change of ownership	+	US patent cases
Change of owner size	+	US patent cases
Number of reassignments	+	US patent cases
Maintenance fees	+	US patent cases
Ex Parte Reexamined	+	US patent cases
Patent collateralization	+	US patent cases
Characteristics of patentees	**Effect**	**Sample**
Patent portfolio size	−	US and German patent cases
Firm size	No consensus	US and German patent cases
Nationality	Domestic > Foreign	US and German patent cases

field (2.22%); and highest for patents in the other health fields (3.46%), miscellaneous group (3.42%), biotechnology (2.79%), and computers (2.56%). Allison (2003) classified US patents into six industries and found that patents in the industries of drugs and medicine and computer and communications are more likely to be litigated than those in the mechanical, chemical, electrical, and electronic industries are. Moreover, Lerner (2010) found that the litigation rate is significantly higher for financial patents than that for patents as a whole in the US.

Meanwhile, Cremers (2004) found that in Germany, the litigation rate of patents in the pharmaceutical and mechanical fields is significantly higher than that in the technology fields of chemicals and electronics. Cremers argued that the lower litigation rate for patents in the chemical field is due to the easy detection of imitation of patents, which makes it easier for the parties to reach a similar expectation of the outcome of patent litigation and thus reach a settlement. This logic is theoretically applicable to patents in the electronic, mechanical, and drugs fields. However, Cremers found that patents in the pharmaceutical field are more likely to be litigated than those in other technology fields are. This may be because the pharmaceutical field defined in Cremers' study includes not only drugs but also biotechnology. Moreover, Cremers also argued that the highest litigation rate for patents in the mechanical field in Germany is due to the high percentage of mechanical patents owned by SMEs, which are more likely to be litigated than those owned by large firms in Germany are.

Although prior studies have reached no agreement on the litigation rate across different technology fields, it can be concluded that patents in the chemical technology field are less likely to be litigated and patents in the biotechnology and computer technology fields have a higher probability of litigation. The former is probably due to the easy detection of imitation or infringement in the chemical technology field, which results in a lower infringement rate or higher probability of settlement. The latter is probably due to high uncertainty in these new technology fields which results in a divergence in the parties' expectations regarding the outcome of the litigation, and thus hinders them from reaching a settlement.

The number of claims

Empirical evidence shows that litigated patents on average have more claims than issued patents (Lanjouw and Schankerman, 2001; 2004; Allison et al., 2003; Cremers, 2004; Chien, 2011). There are two possible interpretations for this phenomenon. First, as it is costly to draft, file, and prosecute a patent application with more claims, more claims in a patent indicate the applicant's higher expectation of benefits from this patent. Thereby, a large number of claims in a patent indicate its higher value and thus make it more likely to be imitated and infringed. Second, the existence of more claims also indicates a broader patent scope, which will trap the infringement more easily. Both of these interpretations indicate that the existence of more claims in a patent leads to a higher probability of litigation for it.

The number of 4-digit IPC subclasses

Patents are assigned 9-digit International Patent Classification (IPC) codes by patent examiners according to their technology fields. As a patent may belong to multiple technology fields, it could have more than one IPC code. Prior studies found that patents with more IPC codes are less likely to be litigated (Lanjouw and Schankerman, 2001; 2004). Two possible interpretations explain this phenomenon. First, it is more difficult for patent holders to detect the imitation or infringement of patents of broader utility because most of the imitation or infringement may occur in some industries, which are beyond the patent holders' detection (Lanjouw and Schankerman, 2001). Second, patents with more IPC codes are more general and thus less immediately relevant for the market outcomes (Harhoff and Reitzig 2004). Therefore, it takes more time for these kinds of patents to be imitated and infringed. Many of them might expire before they are imitated and infringed.

Family size

Family size refers to the number of countries in which the patent right for the same invention has been applied for. Cremers (2004) found that family size has a positive effect on the probability of litigation for a given patent in Germany. Meanwhile, Chien (2011) also found that the number of foreign family members (foreign applications for the same invention) positively impacts the probability of litigation for a given patent in the US. As family size is well validated as a patent value indicator, patents with a larger family size are theoretically more likely to be infringed and litigated.

The number of backward citations

Backward citations are citations made to prior patents by patent examiners and/or inventors in the patent applications. Lanjouw and Schankerman (2004) found a significant and negative effect of the number of backward citations per claim on the probability of litigation for a given patent. They argued that a small number of backward citations indicates the patent belongs to a relatively new technology field and is full of uncertainty. This leads to the parties' divergence in the outcome of the litigation and thus a higher probability of litigation. However, contrary to this finding, Allison et al. (2003) found that litigated patents in the US tend to have more backward citations. This finding is further confirmed in Cremers' study, which uses Germany patent cases. One possible interpretation for this is that as backward citations are usually similar to the citing patent, more backward citations indicate more competitors in the same technology field, which makes the patent more likely to be infringed, and thus have a higher probability of litigation.

The number of domestic family members

Patent applicants can file a continuing patent application based on a previously filed patent application (parent application) before it is abandoned or issued. In the US, three types of continuing patent applications (child application) are available for an applicant to cover new claims or even add new subject matter not disclosed in the parent application: a continuation application, a continuation-in-part application, and a divisional application. All these "parent" and "child" patent applications are called domestic family. Allison et al. (2003) found that the average number of domestic family members of the litigated patents is significantly more than that of a non-litigated patent. They argued that a continuation application and a continuation-in-part application may indicate the applicator's desire to build a platform of related patents. Chien (2011) also found that the number of domestic family members for a given patent has a positive impact on its probability of being litigated. Chien argued that as filing a continuing application is costly, the larger number of domestic family members indicates the applicant's higher expectation of the value of the patent. As valuable patents are more likely to be infringed, patents belonging to larger domestic family have a higher probability of litigation.

Opposition

The validity of a patent granted by some patent offices, such as the Europe Patent Office (EPO), the patent office in Germany, and the Japan Patent Office (JPO) can be challenged by any third party under the mechanism of opposition. Cremers (2004) analyzed a sample of German patent cases and found that patents that have ever been opposed are more likely to be litigated in their later lifetime. Cremers argued that opposition to the grant of a patent indicates that the opposing party has the interest to use the invention, which may be because they have made a similar invention or the patented invention is so valuable that it is worthy to oppose and even infringe the patent. For this reason, patents that underwent opposition are more likely to be litigated.

Prosecution length

Allison et al. (2003) found that the time spent in prosecution is on average significantly longer for litigated patents than for issued patents. There are two possible interpretations for this. First, a long prosecution time indicates that the patent belongs to a crowded technology field and thus takes longer for the patent examiner to investigate prior arts (Osenga, 2012). This indicates that the patented inventions are mature and more relevant for the market outcomes. These kinds of patents are more likely to be litigated than general technologies. Second, a longer time in prosecution indicates the applicant's greater effort on the quality of the patent right. This will make the patentee more confident in its enforceability and thus they will tend to litigate it instead of accepting a pretrial settlement.

Patent age

Allison et al. (2003) found that patents are more likely to be litigated when they are young. They argued that this is because the potential value of a patent is always found early in its lifetime. This explanation is supported by the fact that forward citations for a patent are usually made in its early lifetime.

The number of forward citations

Forward citations are citations received by a patent from later patent applications. The number of forward citations has been found to positively impact the probability of litigation for a given patent in many studies (Lanjouw and Schankerman, 2001; 2004; Allison et al., 2003; Cremers, 2004; Chien, 2010). As the number of forward citations has been well verified and widely used as a patent value indicator (Trajtenberg, 1990; Albert et al., 1991; Harhoff et al., 1999; 2003; Yamada, 2010), one plausible interpretation for this is that patents with more forward citations have a higher probability of infringement and thus are more likely to be involved in patent litigation.

Other acquired characteristics of litigated patents

Chien (2011) divided the characteristics of litigated patents into two categories: intrinsic characteristics and acquired characteristics. The former includes the characteristics that are acquired when or before the patent right is granted. Except for forward citations, all the characteristics noted above are intrinsic characteristics. After a patent right is granted, it will undergo many post-issuance "events," such as change of ownership by patent transfer, post-issuance investment, patent collateralization, citation by later patent applications, and patent enforcement. Chien (2011) called these post-issuance events acquired characteristics. She constructed three variables relating to change of ownership (number of recorded assignments, recorded transfer, and change of owner size), two variables related to post-issuance investment (maintenance fees and ex parte reexamination), and two other variables (adjusted forward citations and patent collateralization). She found that all these variables positively impact the probability of litigation for a given patent.

Patent portfolio size

Lanjouw and Schankerman (2004) found that patents in a large patent portfolio are less likely to be litigated and this effect is even more significant for non-drug patents because being a part of a large patent portfolio is less important for drug patents than non-drug patents. Cremers (2004) confirmed this argument in Germany and found that with the increase of patent portfolio size, the negative effect becomes increasingly significant. One plausible interpretation is that a large patent portfolio is a good bargain chip for a patentee to negotiate with infringers. Therefore, firms with a large patent portfolio are more likely to reach a settlement than those with a small patent portfolio.

Firm size

Allison et al. (2003) found that the probability of litigation for patents originally issued to individuals and small businesses is significantly higher than that for those originally issued to large firms is. Lanjouw and Schankerman (2004) demonstrated that patents owned by domestic individuals, unlisted companies, and small listed companies are more likely to be litigated than those owned by their large counterparts in the US. Bessen and Meurer (2005) affirmed that patent litigation rates for small firms are significantly higher than those for large firms are (42.5 suits per 1000 patents for small firms versus 10.7 suits per 1000 patents for large firms). There are two possible interpretations for these findings (Allison et al., 2003). First, patents issued to individuals or small firms may be more valuable than those issued to large firms are. As valuable patents have a higher probability of being infringed, patents issued to individuals or small firms are more likely to be litigated than those issued to large firms are. Second, individuals or small firms are less conservative about litigation because they usually have little to lose while large firms face a high risk of being countersued by defendants. Cremers (2004) also found that small firms are more likely to litigate their patent rights than larger firms in Germany. However, patents owned by firms are found to be more likely to be litigated than those owned by individuals in this study, which is contrary to the finding in the US. Cremers argued that this is because individuals in Germany are more pessimistic about the financial burden of patent litigation.

Nationality

Nationalities of patentees are found also to be an important factor that affects the probability of patent litigation. Domestic entities are found to be significantly more likely to litigate their patents than their foreign counterparts are (Lanjouw and Schankerman, 2001; 2004; Cremers, 2004; Allison, 2003). There are several possible interpretations for this finding. First, as it is more difficult for a foreign entity to detect infringement, foreign entities are less likely to be involved in patent disputes. Second, as it is costlier for foreign entities to file a patent infringement suit abroad than for their domestic counterparts, foreign entities preferably choose to resolve patent disputes by settlement instead of litigation. Third, as foreign entities may expect a lower probability of winning because of their disadvantage in evaluating the information, they have a lower propensity to litigate (Cremers, 2004).

Non-practicing entity

A number of studies have demonstrated that NPEs have higher litigation rates than ordinary firms. Chien (2009) found that 17% of patent lawsuits in hardware, software, and financial inventions filed in the US between January 1st, 2000 and March 21st, 2008 were sued by NPEs. Actually, the ratio of patent cases filed by NPEs in all the US patent cases has increased from 26% in 2008 to 69% in the US in 2015 (NPE Activity Highlights, 2012; 2015).

1.3.3 The Benefits and Costs of patent litigation

(1) The benefits of patent litigation

Patent litigation has many benefits for patentees. First, patentees have the right to claim injunctions and damages if they win a patent infringement suit. Second, patent litigation can be used to deter potential infringement because launching an infringement lawsuit reflects a patentee's willingness to assert its patent rights. Third, patent litigation can be strategically used to license patent rights. This has been widely used in the United States (US) by the so-called "patent trolls," who aim to earn licensing fees rather than to get injunctions and damages through patent litigation. Fourth, patent litigation can be used to enhance the plaintiff's reputation, especially for large public firms. Several previous studies have affirmed this argument. Marco (2005) analyzed stock market reactions to patent litigation decisions in the US and found that patent litigation leads to positive excess returns for patent holders if the litigated patent is ruled valid. Henry (2013) also found that patent litigation in the US leads to an increase in the plaintiff's market value when its litigated patents are ruled valid and have been infringed upon. Raghu et al. (2008) examined market reactions to patent litigation using 65 patent cases in the IT industry and found that patent litigation increases abnormal returns for plaintiff firms at both the announcement date and the settlement/termination date of patent litigation indicating that patent litigation enhances shareholder confidence in the future profits of the plaintiff firms. Schliessler (2015) found that, regardless of the outcome of patent litigation, being a plaintiff in patent litigation in Germany has a significantly positive impact on a firm's credit rating.

(2) The costs of patent litigation

One of the most important parts of risk assessment is to assess the costs of the risk. As patent litigation usually lasts for several years, plaintiffs must be able to afford a large amount of direct and indirect costs of patent litigation. The direct costs include legal fees to the court and attorney fees to lawyers and patent attorneys. In addition, the plaintiff patentee faces the risk of the litigated being invalidated during patent litigation.

On the other hand, the indirect costs of patent litigation include the significant time and manpower required for the lawsuit. Bessen and Meurer (2008) argued that business activities could be interrupted because managers and researchers must commit a considerable amount of time preparing for litigation and appearing in court. Moreover, Shane and Somaya (2007) found that patent litigation has an adverse effect on university licensing activities. They argued that this is because patent litigation disrupts the overall activities of technology licensing offices (TLOs) and reduces the time and resources available for TLO to market technologies and establish licenses. Moreover, cooperative relations between the two parties are destroyed by litigation. Some firms with weak fiscal capacities even face the danger of bankruptcy.

1.4 Remaining Issues

There are at least three limitations in the previous literature above. First, most of the prior literature studies patent litigation in the US. Empirical studies of patent litigation in the countries other than the US are just exceptions. As the patent and litigation systems, people’s attitudes toward litigation differ across countries, it is necessary to study and compare these issues between different countries. Second, patent litigation risk assessment should be evaluated not only at the patent level but also at the firm level. However, to the best of my knowledge, up until now, no empirical literature has studied the characteristics of patent litigation at the firm level. Third, up until now, the monetary benefits and costs of patent litigation have attracted most scholars’ attention and the impact of patent litigation on the parties’ business activities has not been studied extensively.

1.5 Research Questions

1.5.1 The Effect of Patent Value on Patent Damage Awards

First, although it is logical to expect that patent value has a significant effect on patent damage awards, up until now, no prior literature has systematically demonstrated this argument. Second, most of the prior literature studied patent damage awards in the US and to the best of my knowledge, only one of them studied the determinants of patent damage awards in China. In this dissertation, I compare the effect of patent value on patent damage awards between the US, Japan, and China from three perspectives: the technological importance, the private economic value for the patentee and the scope of a patent. In other words, I will answer the following two questions in Chapter 3:

Q1: How do different aspects of patent value impact the patent damage award?

Q2: Do these effects vary between the US, Japan, and China?

1.5.2 The Characteristics of Patent Litigation

Although the characteristics of litigated patents have been studied extensively in the US, they are seldom studied in other countries. The only exception studied a sample of German litigated patents. In this dissertation, I attempt to examine the applicability of the findings in the US in Japan and China. I will answer this question in Chapter 3:

Q3: How do the characteristics of litigated patents vary across countries?

In addition to the previously examined patent characteristics in the prior literature, I examine the effects of three new patent characteristics—the number of words or nouns in the first claim, asserting domestic priority, and the number of inventors—on the probability of litigation. I will mention this in detail in Section 4.1. In other words, in Chapter 4, I also attempt to answer the following three questions:

Q4. Are patents with a shorter first independent claim more likely to be litigated?

Q5. Are patents asserting domestic priority more likely to be litigated?

Q6. Are patents with more inventors more likely to be litigated?

Furthermore, all the literature above studied the characteristics of patent litigation at the patent level. Compared with the characteristics of litigated patents, there are very few studies on the characteristics of patent litigants. Evidence on the characteristics of patent litigant (Characteristics 12-15 noted above) is mainly from descriptive statistics and the analysis results at the patent level. As predicting patent litigation at the firm level is also an important part of patent litigation risk assessment, I provide a direct study of the characteristics of patent litigation at the patent level. I will answer the following question in Chapter 5:

Q7: Can the characteristics of the patent portfolio be used to predict the probability of patent litigation at the firm level?

1.5.3 The Impact of Patent Litigation on the Plaintiff SMEs

Although, as noted above, patentees can theoretically benefit from patent litigation in various ways, SMEs usually faces certain difficulties in acquiring these benefits. First, SMEs usually have little internal expertise to apply for strong patent rights, which have a broad scope to trap infringement and can stand validity challenges by others. Second, SMEs usually lack resources to detect and collect proof of infringement, which is important for successful litigation and for calculating patent damages. Third, unlike large firms, SMEs usually have limited financial capacities, so the high costs of patent litigation may be a heavy burden for them. For such firms, patent litigation may even adversely affect their reputation rather than enhance it because of possible bankruptcy risks (Bessen and Meurer, 2008). In brief, all these factors put SMEs at a disadvantage when trying to benefit from patent litigation. Even so, I still argue that patent litigation benefits plaintiff SMEs in some ways. As a patent litigant, plaintiff SMEs interact frequently with patent attorneys, patent lawyers, the judge, and the defendant during the period of patent litigation. They can learn plenty of explicit and tacit knowledge on how to use the patent system more effectively. Therefore, I examine whether patent litigation provides a chance for plaintiff SMEs to learn to apply for strong patents in Chapter 6.

To summarize, I attempt to answer the following questions in Chapter 6:

Q8: Do the high costs of patent litigation negatively impact plaintiff SMEs' patenting activities?

Q9: Does patent litigation provide a good chance for plaintiff SMEs to learn to apply for strong patent rights?

1.6 Some Relevant Facts

Figure 2-1 displays some important events related to this research. I will discuss these in detail in the remainder of this section.

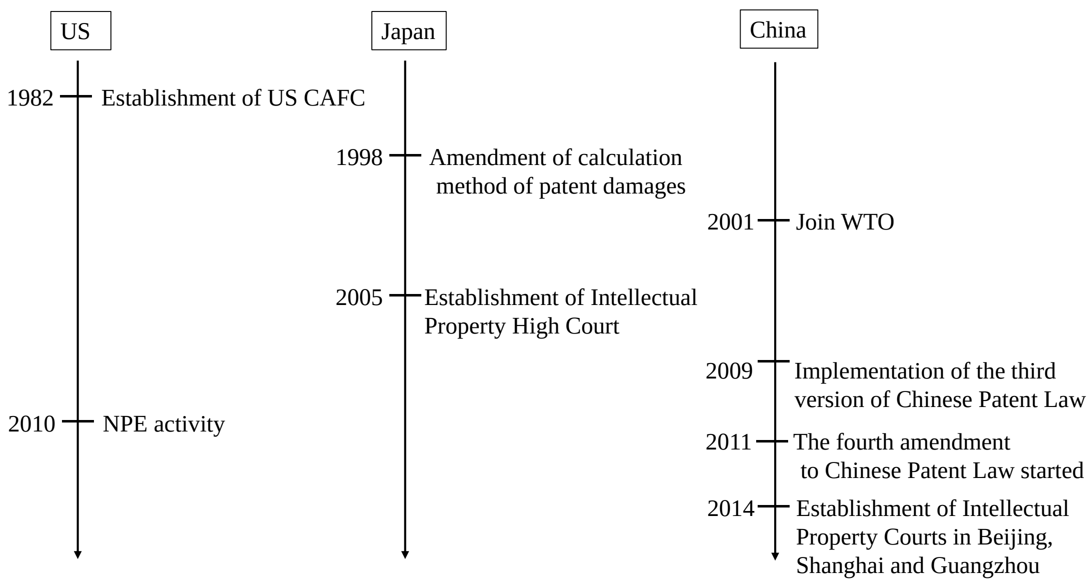


Figure 2-1. Some important events relating to this research

1.6.1 Patent Litigation in the US

(1) The definition of patent rights in the US

In the US, patent rights include the utility patent, plant patent, and design patent. The utility patent right in the US is the counterpart of the invention patent right and utility model (patent) right in China and Japan.

(2) Continuing patent application

Patent applicants can file a continuing patent application based on a previously filed application (parent application) before it is abandoned or issued. In the US, three types of continuing patent applications are available to cover new claims or even add new subject matter not disclosed in the parent application. They are the continuation application, the continuation-in-part application, and the divisional application. A continuation application is usually filed by an applicant to pursue additional claims to the inventions disclosed in the parent application. Continuation-in-part applications are those allowing an applicant to add new subject matter not disclosed in the prior parent application. Divisional applications are usually filed if the patent applicant has required by the patent examiner to split the parent application into one or more divisional applications each claiming only a single invention. The former two only exist in the US, and the third is also available in Japan and China.

(3) Methods of calculating patent damages in the US

Section 284 of the Patent Act in the US provides the following framework for awarding patent damages: *Upon finding for the claimant, the court shall award the claimant damages adequate to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by the infringer, together with interest and costs as fixed by the court. When the damages are not found by a jury, the court shall assess them. In either event, the court may increase the damages up to three times the amount found or assessed.* (Section 284 of the US Patent Act)

This statute does not provide any specific methods for calculating patent damages, but in practice, the court uses the following two options: lost profits and a reasonable royalty. In some cases, a combination of the two methods is used in the same litigation (Love, 2009). If the infringement act is found willful, the court can enhance damages up to three times the amount found or assessed (treble damages).

To recover lost profits, one must establish causation between the infringement acts and the damages. In the US, the *Panduit* test was established by the 6th Circuit to determine "but for" causation (Frank and DeFranco, 2000). To pass the *Panduit* "but for" test, a patentee must establish the following four requirements: the market demand for the product covered by the litigated patent; the absence of non-infringement substitutes satisfying the demand in the market; the patentee's manufacturing and marketing capacity to exploit the demand; and the amount of profits that the patentee would have made had infringement not occurred (Frank and DeFranco, 2000; Love, 2009).

If a patentee cannot establish all the four requirements, a reasonable royalty will be awarded by the court. A reasonable royalty is an amount that the patentee would have earned if both the patentee and the infringer been willing and had tried to negotiate to license the patent at the beginning of the infringement (Love, 2009). In *Georgia-Pacific Corp. v. United States Plywood Corp*, the US District Court for the Southern District of New York summarized 15 factors that should be taken into consideration in a hypothetical negotiation analysis (Frank and DeFranco, 2000). These 15 factors are called the *Georgia-Pacific* test and are now the most commonly used standard for US courts to calculate a reasonable royalty. An alternative method of calculating a reasonable royalty is a method called the "analytical approach," under which the infringer's profits relating to the infringing product or process are apportioned between the patentee and the infringer (Opderbeck, 2009).

(4) Jury system

The jury system is a special system in the US that does not exist in Japan and China. In a jury trial of patent litigation, juries play an important role in deciding questions of fact, especially in deciding the issues on infringement and damages (Signore, 2001). An increasing number of patent suits have been decided by juries in the US since 2010 (NPE Activity Highlights, 2012, 2015).

(5) The establishment of US Court of Appeals for the Federal Circuit (CAFC)

In the US, the U.S. CAFC was established early in 1982 as the only appellate-level court with the jurisdiction to hear patent appeals. Although it also has other jurisdictions, such as appeals from the United States International Trade Commission and appeals from Patent and Trademark Office (PTO), CAFC is most well-known for its unique jurisdiction of appeals from all of the U.S. District Courts. It plays an important role in strengthening patent protection and promoting uniformity in the jurisdiction of patent litigation across all the states in the US.

(6) NPE activities

A significant characteristic of recent patent litigation in the US is that the number of patent cases filed by NPEs has drastically increased since 2010. NPE is a corporate patent enforcement entity that neither practices nor seeks to commercialize its patents (Chien, 2009). According to the 2015 NPE Activity Highlights, the ratio of patent cases filed by NPEs in all the patent cases in the US has increased from 35% in 2010 to 69% in 2015. However, it should be noted that NPEs are more widespread in the US than in other countries because of the special features of patent and litigation systems in the US, such as the high cost of litigation, cost allocation rules, high damage awards and treble damage system, the courts' pro-patentee posture, low examination quality, and broad patentable subject matter (Harhoff, 2009).

1.6.2 Patent Litigation in Japan

(1) The definition of patent rights in Japan

In Japan, patent rights, utility model rights, and design rights are three interdependent intellectual property rights. The patent right in Japan is the counterpart of the invention patent right in China.

(2) Methods of calculating patent damages in Japan

Before 1998, the Patent Act in Japan provided only two options for calculating patent damages: defendant's profits and a reasonable royalty. To recover lost profits, one had to claim damages under Article 709 of the Japanese Civil Code, which required stringent proof of causation between lost profits and the infringement act. However, because patent rights are intangible property, it is extremely difficult for one to do so. Therefore, to reduce the plaintiff party's burden of proof, Japanese lawmakers revised

Article 102 of the Japanese Patent Act in 1998 by adding a new provision for calculating lost profits. This provision shifted the burden of proof largely to the defendant. Before 1998, the court usually determined reasonable royalties by referring to either of the patentee's prior royalty rate for the litigated patent, the license royalty rates for government-owned patents, or industry-standard royalty rates (Takenaka, 2000). In such cases, the infringer could simply afford the same or a smaller amount of money to the patentee even if it lost the litigation. This had no deterrent force to the alleged infringer or to other potential infringers. In other words, it gave them incentives not to apply for a license before infringing on others' patent rights. Therefore, Japanese lawmakers amended Article 102-2 of the pre-1998 Patent Act in Japan by eliminating the word "normally" (*tsujo*) in 1998 and allowing the courts to consider the value of the litigated patent, the commercial relationship between two parties, defendant's profits, and other related matters when determining a reasonable royalty.

Article 102 of the current Patent Act in Japan provides three options for calculating patent damages: lost profits, defendant's profits, and a reasonable royalty. Unlike in China which will be noted below, lost profits in Japan are calculated by multiplying a patentee's own profit from a single product and the defendant's quantity of sales of the infringing product instead of the plaintiff's reduction in the patentee's quantity of sales for the infringement. However, lost profits should never exceed the amount that can be attained by the patentee or exclusive licensee's own capacity. Article 102 also provides that a patentee or exclusive licensee can claim more than a reasonable royalty but if the infringement is unintentional or not grossly negligent, the court may take these circumstances into consideration when determining patent damages. In practice, this provision confers the court discretion to limit damages to a reasonable royalty (Cotter, 2013). Moreover, Article 105-3 provides that if "*it is difficult for the court, due to the nature of the facts, to prove the facts necessary to determine the amount of damage, the court may determine a reasonable amount of damage based on the entire import of oral argument and the result of the examination of evidence*."

(3) The establishment of the Intellectual Property High court

Before 2005, the first instances of patent litigations were mainly heard in the Tokyo District Court and Osaka District Court, and the second instances of patent litigations were heard in the Tokyo High Court and Osaka High Court. In 2005, the IP High Court was established to accelerate and reduce the costs of patent litigation in Japanese courts. Currently, the IP High Court is the only appellate-level court with the jurisdiction to hear appeals from district courts in Japan. As a part of Japan's pro-patent policy, the establishment of the IP High Court played an important role in strengthening patent protection in Japan.

(4) The technical investigation officer

Unlike courts in other countries, Japanese courts attach great importance to determining questions of facts relating to technology. For this reason, technical experts have long been used to assist in hearing patent litigation in Japan (Matsuda, 2005). Technical experts are divided into two types: full-time technical investigation officers and part-time technical advisors. The former is those with both technical knowledge and the knowledge of the patent act, while the latter is those with specialized knowledge in some high technology fields. In principle, full-time technical investigation officers are indispensable for patent litigation while part-time advisors attend patent litigation when necessary.

1.6.3 Patent Litigation in China

(1) The definition of patent rights in China

In China, patent rights include invention patent rights, utility model patent rights, and design patent rights.

(2) Methods of calculating patent damages in China

Since being enacted in 1984, the Patent Law in China has been amended three times, in 1992, in 2000, and 2008, respectively. The pre-2000 Patent Law did not provide any specific method of calculating patent damages, and most of the patent disputes at that time were resolved by administrative enforcement instead of patent litigation.

The post-2000 Patent Law provided three options for calculating patent damages: lost profits, defendant's profits, and a reasonable royalty. While it provided that lost profits and defendant's profits were the preferred methods for calculating patent damages, no preference was given. A reasonable royalty was an appropriate multiple, usually one to three times the prior royalty rate of the litigated patent. The Patent Law was amended in 2008 and went into effect on October, 1st, 2009. It provides four options for determining patent damages: lost profits, defendant's profits, a reasonable royalty, and statutory compensation. In principle, the court should select a method in the following descending order of preference: lost profits, defendant's profits, a reasonable royalty and statutory compensation. In other words, statutory compensation should function as an alternative method when patent damages cannot be calculated with any of the other three methods. However, in practice, more than 90% of patent litigations in China has been awarded statutory damages. Actually, although statutory compensation is not provided in the post-2000 Patent Law, courts in China had awarded statutory damages on their own authority and later, pursuant to Article 21 of Patent Trial Guidelines for several years before the post-2008 Patent Act went into effect in 2009 (Cotter, 2013). At that time, statutory compensation was restricted to the range of RMB 5, 000 *yuan* to RMB 30, 000 *yuan* and should never exceed RMB 500, 000 *yuan.* Currently, statutory compensation has been stipulated in the current Patent Law, and its upper and lower limits have doubled to 1, 000, 000 *yuan* and 10, 000 *yuan*, respectively. As mentioned below, the lower limits of statutory compensation will be furtherly increased in the fourth amendment of the Patent Law in China.

(3) The establishment of the intellectual property courts

In China, three IP courts were established in the three most developed cities in China (Beijing, Shanghai, and Guangzhou) in 2014. Unlike those in the US and Japan, IP courts in China are for the first instance of patent litigation and have no jurisdiction to hear appeals of patent litigation. Like courts in Japan, technical investigation officers must attend patent litigation in IP courts. The establishment of IP courts also suggests that the Chinese government is attempting to strengthen patent protection in China.

(4) The fourth amendments to the Chinese Patent Law

Since 2011, the Chinese Patent Law has been undergoing the fourth amendment. The main aim of this amendment is to strengthen patent protection in China. The lower limits of statutory compensation will be greatly increased and punitive compensation will also be introduced.

1.7 Thesis Structure

The remainder of this dissertation is organized as follows. The following chapter describes the research design. Chapter 3 provides a comparative study of the effects of different aspects of patent value on patent damage awards between the US, Japan, and China and answers questions 1 and 2. Chapter 4 provides a comparative study of the characteristics of litigated patents between the US, Japan, and China and answers questions 3-6. Chapter 5 studies the characteristics of Japanese patent litigation at the firm level and answers question 7. Chapter 6 presents an empirical study of the effect of patent litigation on subsequent patenting behaviors of the plaintiff SMEs in Japan and answers questions 8 and 9. Finally, Chapter 7 presents the conclusions, implications, and future research.

Chapter 2 Research Design

2.1 Research Objectives

2.1.1 The Definition of Patent Litigation

Two things should be noted about patent litigation in this dissertation. First, as noted above, the definition of patent rights differs across countries. As invention patents are usually of higher value than other types of patent rights, invention patent litigation in China, patent litigation in Japan, and utility patent litigation in the US are used in this dissertation. Second, unlike in Japan and China, where the validity of a patent right is decided by the patent office, any third party can file a suit to challenge the validity of other patentees' patent rights in court in the US. To ensure the same definition of patent litigation for samples from the US, Japan, and China, I excluded patent challenge suits from the analysis and only used patent infringement suits for the analyses. In other words, the plaintiffs in the sample of this study are patent holders or exclusive licensees and the defendants are alleged infringers.

2.1.2 The Definition of Patent Litigation Risk

Patent litigation risk can be defined from two different perspectives. From the perspective of a patentee, patent litigation risk is the risk of being involved in patent litigation as a plaintiff (patent litigant). From the perspective of a potential infringer, patent litigation risk is the risk of being involved in patent litigation as a defendant (alleged infringer). Because research design will differ greatly by the definition assumed for patent litigation risk, I have designed the research and interpreted the findings from the perspective of a patentee in this dissertation, though the findings in Chapter 3 and 4 are also useful in the assessment of the risk of being sued as an alleged infringer.

As noted above, NPE is a special type of patent litigants that neither practice nor seek to commercialize its patents. As NPEs usually file patent litigation with the intention of licensing their patents, patent litigation serves more as an opportunity for profit than a risk for them. On the other hand, it is also logical to believe that patent litigation filed by NPEs may have different characteristics from that filed by innovators. Therefore, patent litigation filed by NPEs should be studied separately from that filed by innovators. Therefore, in the dissertation, I focus on the innovators' patent litigation and exclude patent litigation filed by NPEs from the analyses to the extent possible.

2.2 Data Collection

2.2.1 Data Sources

The US patent litigation data were collected from the database WestlawNext. The Japanese litigation data were collected from the IP litigation database provided by the Supreme Court of Japan. The Chinese litigation data were collected mainly from the database Pkulaw provided by Beijing Beidayinghua Technology Co., Ltd and partly from the website of the China Supreme People's Court (http://ipr.court.gov.cn/zgrmfy/).

Patent data are mainly collected from the patent database PatentSQUARE provided by Panasonic Solution Technologies Co., Ltd. Exceptionally, the number of claims for Chinese patents were manually investigated in Google Patent Search.

2.2.2 Data Extraction Intervals

Because the patent system and patentees' propensity for patenting and litigating their patent rights change over time, recent data are more appropriate for this study. Therefore, I planned to extract patent cases whose rulings were decided between 2000 and 2014. However, the data extraction intervals for some of the analyses in this dissertation actually differ from this setting for various reasons.

As patent cases filed by NPEs has begun to increase drastically in the US since 2010 (NPE activity highlights, 2012, 2015), I tried to use patent cases filed before 2010 for the analyses in the US. However, in Chapter 3, to ensure a sufficient sample size, I extended the decision year of extracted patent cases to 2012 and excluded those filed after 2010 from the extracted sample. In addition, in Chapter 4, although patent cases ruled after 2009 also contain patent cases filed before 2010, patent cases decided during the period from 2000 to 2009 were sufficient for the study. Therefore, I only extracted patent cases decided from 2000 to 2009 for the analysis in Chapter 4.

For Chinese samples, since only a few patent litigation decisions in the earlier years were available in the Beidafabao Database, I only managed to collect patent cases decided from 2003 and 2014 for the analysis in Chapter 3. And only one patent case decided in 2000 and no patent case decided in 2001 for the analysis in Chapter 4. In any case, in view of the drastic change in patent protection strength in China, a sample with more patent cases decided in recent years may be more appropriate for this study.

For Japanese samples, the patents used for the analyses were those filed before 2011 to ensure relatively stable forward citation data, since it takes time for patents to be cited. For this reason, in chapters 3 and 4, I used all the patent cases decided from 2000 and 2014 in which the patents involved were mainly filed before 2011, while patent cases used in Chapter 5 were those with rulings between 2000 and 2010, and the patent cases used in Chapter 5 were those with rulings from between 2000 and 2008.

Chapter 3 The Effect of Patent Value on Patent Damage Awards

3.1 Research Questions

Patent damage awards are commonly regarded as a monetary manifestation of patent value. Therefore, it is logical to expect that patents of higher value will be awarded higher patent damages. However, as noted in Section 1.5.1, up until now, the effect of patent value on patent damage awards has not been extensively investigated, especially in Japan and China. Therefore, I examine the effects of the most commonly examined three patent value indicators－the number of forward citations, patent family size, and patent scope－on patent damage awards in the US, Japan, and China. In other words, I attempt to answer the first two research questions noted in Section 1.5.1:

Q1: *How do different aspects of patent value impact patent damage awards?*

Q2: *Do these effects vary among the US, Japan, and China?*

3.1.1 Forward Citations

The value of a patent should depend on its technological importance. In this chapter, I use the number of forward citations as the indicator for the technological importance of a patent. The correlation between the number of forward citations and patent value has also been extensively demonstrated in prior literature (Trajtenberg, 1990; Harhoff et al. (1999, 2003; Yamada 2010; Fischer and Leidinger, 2014). Theoretically, a large number of forward citations indicate that the patented invention contributes greatly to the development of later innovations. Albert et al. (1990) validated this argument directly by showing a strong positive correlation between the citation rate of a patent and its technological importance evaluated by knowledgeable researchers and inventors. Trajtenberg et al. (1997) found that university patents, which are usually basic inventions, are cited more than corporate patents. Czarnitzki et al. (2011) found that "wacky" patents, which do not involve a high inventive step or only marginally satisfy the "non-obviousness" criterion, have fewer forward citations than ordinary patents. All these findings suggest that the number of forward citations could function as a good predictor of the technological importance of a patented invention.

3.1.2 Patent Family Size

Unlike the number of forward citations, patent family size indicates the private economic value of a patent for the patentees. Generally, it is significantly costlier in terms of time, effort, and money to file a patent application in foreign countries. Hence, patentees file an international patent application only when they expect that the returns from the patent in that country is higher than the filing costs (Martínez, 2011). As a result, a larger patent family size indicates the applicant's expectation of a return from the patented technology (Nagaoka et al., 2010). Prior literature has found some compelling empirical evidence to support this argument. Harhoff et al. (2003) found that patent family size is significantly associated with the private economic value of a patent as estimated by the patent holder. Fischer and Leidinger (2014) also demonstrated the validity of patent family size as an indicator of the private economic value of a patent by showing the correlation between the family size of a patent and its patent auction price.

3.1.3 Patent Scope

A third aspect of patent value is the scope of a patent. Theoretically, a patent with a broader scope could be used in many products or processes and hence has higher value. Furthermore, it is more difficult for a competitor to invent around a broader patent, which enhances the exclusive value of patent rights for the potent holder (Fischer and Leidinger, 2014). In this chapter, I use the number of 4-digit IPC subclasses as an indicator of patent scope put forth this approach by Lerner (1994). Lerner (1994) found that the number of 4-digit IPC subclasses positively affects the value of startup firms in the biotechnology industry. Since that, the number of 4-digit IPC subclasses has been widely used in many later studies (Lanjouw and Schankerman, 1998; Harhoff and Reitzig, 2004). However, it should be admitted that many recent studies fail to found a significant correlation between the number of 4-digit IPC subclasses and the patent value (Harhoff et al., 2003; Yamada, 2010; Fischer and Leidinger, 2014). Therefore, I also use the number of 9-digit IPC codes to check the robustness of the findings based on IPC codes in this chapter.

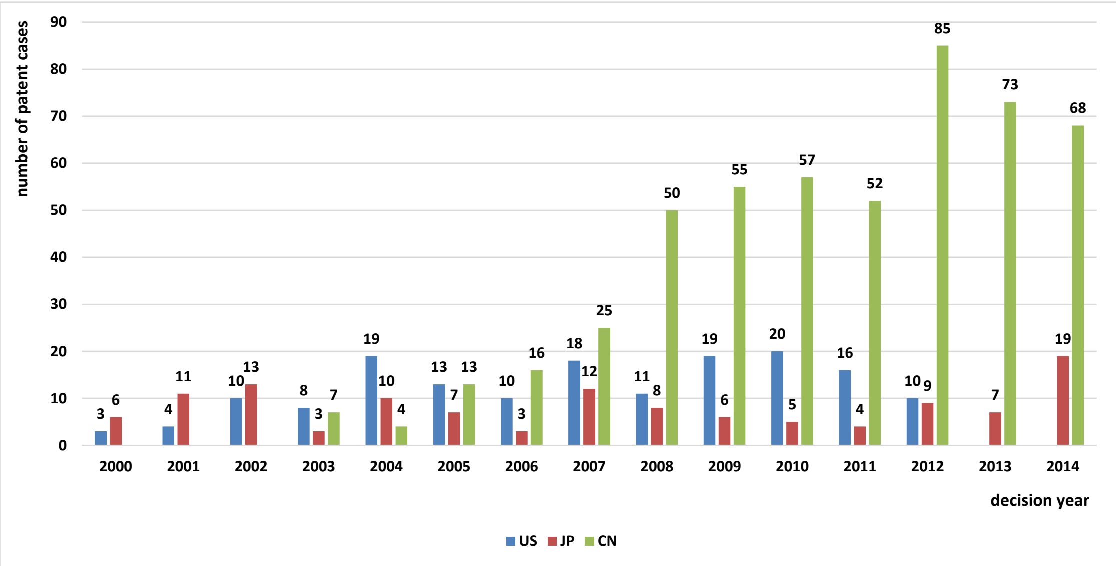
3.2 Datasets and Variables

3.2.1 Data Description

Based on a careful reading of the decisions of patent infringement suits, I identified 161 damage-awarding patent cases that were filed before 2010 and decided by US courts between 2000 and 2012. From them, I collected 242 damage-awarded patents, of which 145 were ruled by judges and 97 were ruled by juries. In addition, I extracted 123 damage-awarding patent cases decided by Japanese courts between 2000 and 2014. From them, I collected 131 damage-awarded patents. Furthermore, I extracted 505 damage-awarding patent cases decided by Chinese courts between 2000 and 2014. I identified 507 damage-awarded patents in these patent cases.

Figure 3-1 displays the distributions of these patent cases by decision year. The most notable thing is that most of the patent cases in China are those decided in recent years after 2008. As noted in Section 2.2.2, in view of the drastic change in patent protection strength in China, a sample with more patent cases decided in recent years may be more appropriate for this study.

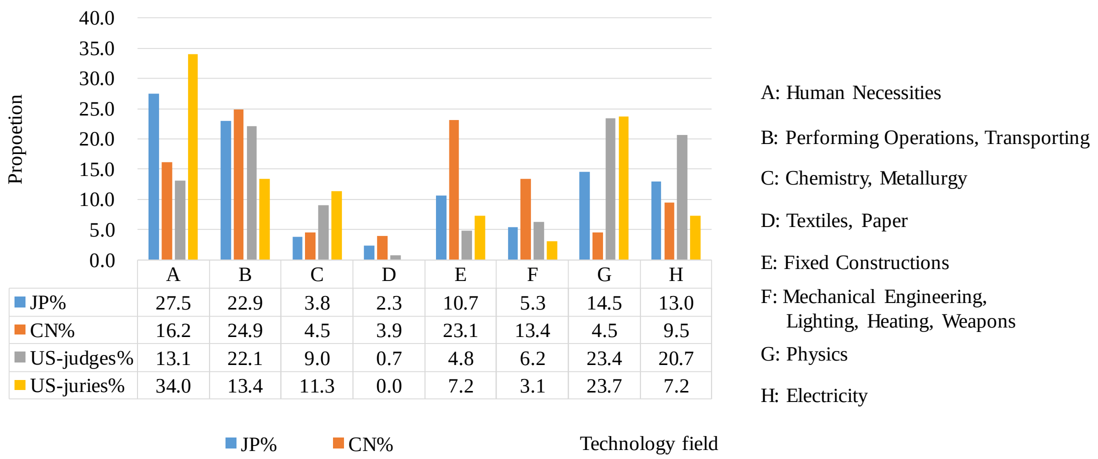
Figure 3-1. The Distributions of Patent Cases by Decision Year.



In addition, patent litigations in the US lasted significantly longer than those in Japan and China do. In the US, patent cases lasted for 4.1 years on average, and 47.8% lasted for more than 4 years. In Japan, patent cases lasted for 2.5 years on average, and 56.5 % of them were decided before the end of the second year after the filing year. In China, patent cases last for 1.0 year on average, and 84.0% of them were decided before the end of the first year after the filing year. Furthermore, although about 30% of the patent cases in all the three countries are appealed to a higher court (28% in the US, 32.1% in Japan, and 33.7% in China), patent damage awards are amended by the higher court at the highest rate in Japan (66.7% in Japan, 29.4% in the US, 18.8% in China).

Figure 3-2 shows the distributions of technology fields of the litigated patents by the first letter of the principal IPC code assigned by patent examiner when issued. In the US, 45.5% of the litigated patents ruled by US judges are from Technology Fields B and G, and 57.7% of those ruled by US juries are from Technology Fields A and G. In Japan, 50.4% of the litigated patents are from Technology Fields A and B. In China, 48% of the litigated patents are from Technology Fields B and E.

Figure 3-2. The Distributions of Technology Fields of the Litigated Patents



	A	B	C	D	E	F	G	H
JP%	27.5	22.9	3.8	2.3	10.7	5.3	14.5	13.0
CN%	16.2	24.9	4.5	3.9	23.1	13.4	4.5	9.5
US-judges%	13.1	22.1	9.0	0.7	4.8	6.2	23.4	20.7
US-juries%	34.0	13.4	11.3	0.0	7.2	3.1	23.7	7.2

3.2.2 Dependent Variable

Patent damage awards are the dependent variable in this study. I conducted several data-refining processes on patent damage awards. First, I removed lawyer and attorney costs from patent damage awards if they are awarded and written clearly in the decision because they are not directly related to the damages resulting from infringement. Second, this study is based on each litigated patent instead of each patent case. So, I ascertain patent damages for each litigated patent by reading the decision carefully if the patent case involves more than one patent. In cases where the patent damage award for each patent is not written clearly, I calculated them simply by dividing the total patent damages by the number of the litigated patents that were judged to be infringements. Third, according to the Japanese Code of Civil Procedure, the court in Japan does not award the plaintiff party more than the amount claimed. Therefore, I use the calculated damages as patent damages instead of the actual awards if the calculated damages are over the plaintiff's claims. Fourth, for patent cases that were appealed to higher courts, if patent damage awards are amended in the higher courts, the amended patent damage awards are used in the analyses. Fifth, to eliminate the effect of inflation on patent damage awards, I converted all patent damages to 2010 US dollars (for the US cases), 2010 Japanese *yen* (for Japanese cases), and 2010 Chinese *yuan* (for Chinese cases) with the Consumer Price Index (CPI). Finally, as patent damage awards in the US, Japan, and China all obay a lognormal distribution, I use the natural logarithm of patent damage awards as the dependent variables.

To make a comparison of patent damage awards among the US, Japan, and China, I adjusted Japanese and Chinese patent damage awards to US dollars with purchasing power parity (PPP) and later to 2010 US dollars with the CPI of the US dollar. Table 3-1 shows some detailed statistical quantities of patent damage awards in the three countries. Differences in patent damage awards among the US, Japan, and China increase from the first quartile to the third quartile. The first quartile of US patent damage awards is more than those of Japanese and Chinese patent damage awards by only one digit. When it comes to the third quartile, US patent damage awards is more than Japanese patent damage awards by two digits and more than Chinese patent damage award by three digits. It can be inferred that compared with US courts, Japanese and especially Chinese courts tend not to award high patent damages.

Table 3-1. Comparison of Patent Damage Awards (2010 US dollars).

Nation	Minimum	First quartile	Median	Third quartile	Maximum	Mean	S.D.	Obs.
US	1, 873	500, 000	3, 196, 139	13, 608, 450	575, 283, 461	18, 879,257	58, 361, 793	242
Japan	44	27, 201	170, 429	806, 029	22, 068, 481	1, 282, 778	3, 266, 108	131
China	1, 292	15, 838	31, 515	65, 425	1, 500, 150	67, 825	128, 387	507

3.2.3 Independent Variables

The number of forward citations. The number of forward citations is the number of citations that a patent received. It should be noted that there are two problems with the use of the raw number of forward citations. First, forward citations face a truncation problem. In other words, older patents are more likely to receive more citations than younger patents. Second, patent application counts and citation rates may change greatly across years and technology fields. Therefore, Hall et al. (2001) proposed a fixed-effect approach to eliminate these issues. With this approach, the number of forward citations is normalized by dividing the raw number of forward citations by the average number of forward citations received by patents applied for in the same year and technology field (based on 4-digit IPC code). This variable is not used for Chinese patent damage awards because forward citation data are unavailable for Chinese patents.

Patent family size. Patent family size refers to the number of jurisdictions in which patent protection for the same invention has been sought.

The number of IPC codes. Both the number of 4-digit IPC subclasses and the number of 9-digit IPC codes assigned when issued are used in the regression models.

3.2.4 Control Variables

Age of litigated patent. Older patents may have been infringed for a longer time. In this study, patent age is calculated in years by subtracting the year of patent application from the filing year of the lawsuit.

Willfulness dummy. If an act of infringement is considered to be willful, the court in the US can enhance damages up to three times of the actual amount found or assessed.

Therefore, I add a willfulness dummy in the regression models of US patent damage awards. If enhanced damages are awarded in a patent case, the willfulness dummy takes the value of 1, and otherwise, it takes 0.

The number of claims. Patents with more claims are usually costlier in both the patent application and patent renewal stages. Theoretically, the number of claims can be an indicator of patent value, but this argument lacks adequate empirical evidence (Reitzig, 2004). On the other hand, the larger the number of claims, the better the patent is protected. Therefore, the number of claims is probably more appropriate as an indicator of patent quality.

The number of lawyers and the number of patent attorneys. Efforts of the plaintiff and the defendant may influence patent damage awards. I use the number of the plaintiff's lawyers, the number of the plaintiff's patent attorneys, the number of the defendant's lawyers, and the number of the defendant's patent attorneys to control these effects in the analyses of Japanese and Chinese patent damage awards. For the US patent cases, I cannot make a distinction between lawyers and patent attorneys according to the decision, so I use the total number of lawyers and patent attorneys.

Year dummies. The court's propensity to award high patent damages may vary across different years. Therefore, I use year dummies to control for this effect. Year dummies are defined by the decision year.

Technology dummies. Innovations in different technology fields may differ greatly in market size. Technology dummies are also used to control for this effect. Technology dummies are defined by the section symbol of the first IPC code assigned when granted.

Court dummies. Court dummies are also added in the models to control the effect of court. In the regression of Chinese patent damage awards, I define court dummies by administrative area because the courts in the same administrative area probably take the same approach when awarding patent damages.

3.2.5 Analytical method

As patent damage awards in this study obey a lognormal distribution, I use an ordinary least square (OLS) model to do the regression.

3.3 Empirical results

I examine correlations between variables before doing regression analyses and find that the number of plaintiff's lawyers and attorneys is highly correlated with the number of the defendant's lawyers and attorneys in the datasets of US patent damage awards (Appendices 1-2). To avoid the multicollinearity problem, I remove the number of the plaintiff's lawyers and attorneys from the analyses of US patent damage awards. Correlations between variables in Japan and China are either insignificant or significant but quite low. Descriptive statistics of the variables are displayed in Appendices 4-6.

As noted above, both the number of 9-digit IPC codes and the number of 4-digit IPC codes are tested in this study. In all the analyses, Models 1 and 2 use the number of 9-digit IPC codes and the number of 4-digit IPC subclasses respectively.

Table 3-2. OLS Regression Results for the Log_Japanese Patent Damage Awards

	Model 1		Model 2	
Intercept	12.903***	(1.719)	12.805***	(1.743)
Number of forward citations	0.207***	(0.075)	0.206***	(0.075)
Family size	0.041	(0.075)	0.048	(0.073)
Number of IPC codes	0.061	(0.129)	0.150	(0.305)
Age of the litigated patent	0.081**	(0.040)	0.081**	(0.040)
Number of claims	0.009	(0.056)	0.006	(0.058)
Number of plaintiff's lawyers	0.001	(0.134)	−0.005	(0.132)
Number of plaintiff's attorneys	0.206	(0.197)	0.204	(0.196)
Number of defendant's lawyers	−0.067	(0.109)	−0.061	(0.109)
Number of defendant's attorneys	0.781***	(0.203)	0.790***	(0.205)
Court dummies	Yes		Yes	
Technological dummies	Yes		Yes	
Year dummies	Yes		Yes	
R^2	0.469		0.469	
Adjusted R^2	0.273		0.273	
Observations	131		131	

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

Table 3-2 shows the regression results of Japanese patent damage awards. The number of forward citations significantly positively impacts patent damage awards. However, the coefficients for family size and the number of IPC codes are insignificant in both models. Moreover, the age of the litigated patent significantly positively impacts patent damage awards. The coefficients for the number of the defendant's patent attorneys is significant and positive. However, this is probably due to selection bias. Patent litigations with higher stakes will encourage the defendant to make more efforts to defend themselves, such as to employ a greater number of patent attorneys.

Table 3-3 shows the regression results of Chinese patent damage awards. The coefficients for family size is significant and positive in both models, and the coefficient for and the number of IPC codes is also significant and positive in Model 1, which uses 9-digit IPC codes, but is insignificant in Model 2, which uses 4-digit IPC subclasses. Moreover, as in Japan, the coefficient for the number of the defendant's attorneys is also significant and positive, which is probably due to selection bias.

Table 3-3. OLS Regression Results for Log_Chinese Patent Damage Awards

	Model 1		Model 2	
Intercept	11.519***	(0.281)	11.961***	(0.291)
Family size	0.022**	(0.009)	0.020**	(0.009)
Number of IPC codes	0.070**	(0.034)	−0.106	(0.066)
Age of the litigated patent	−0.008	(0.013)	−0.010	(0.013)
Number of claims	0.003	(0.004)	0.002	(0.004)
Number of plaintiff's lawyers	0.032	(0.063)	0.042	(0.064)
Number of plaintiff's attorneys	−0.046	(0.124)	−0.039	(0.124)
Number of defendant's lawyers	0.084	(0.056)	0.091	(0.056)
Number of defendant's attorneys	0.326**	(0.163)	0.324**	(0.163)
Court dummies	Yes		Yes	
Technological dummies	Yes		Yes	
Year dummies	Yes		Yes	
R^2	0.224		0.220	
Adjusted R^2	0.173		0.170	
Observations	507		507	

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

Table 3-4 displays the regression results of US patent damage awards ruled by court judges. Contrary to the regression results of Japanese patent damage awards, the coefficients for both family size and the number of IPC codes (either 9-digit or 4-digit) is significant and positive, but the coefficient for the number of forward citations is insignificant. Moreover, as in Japan, the coefficient for the age of the litigated patent is significant and positive. The coefficient for the number of the defendant's lawyers and patent attorneys is significant and positive in both models, which is probably due to selection bias. In fact, the coefficient is also significant and positive if the coefficient for the plaintiff's lawyers and patent attorneys is used in the models.

Table 3-4. OLS Regression Results for Log_US Patent Damage Awards Ruled by Court Judges

	Model 1		Model 2	
Intercept	9.375***	(1.075)	9.063***	(1.073)
Forward citations	−0.061	(0.039)	−0.046	(0.038)
Family size	0.067**	(0.028)	0.060**	(0.027)
Number of IPC codes	0.444**	(0.181)	0.897***	(0.300)
Age of the litigated patent	0.119***	(0.033)	0.110***	(0.033)
Number of claims	0.004	(0.007)	0.002	(0.007)
Defendant's lawyers and attorneys	0.252***	(0.055)	0.244***	(0.054)
Willfulness dummy	0.448	(0.333)	0.536	(0.327)
Court dummies	Yes		Yes	
Technological dummies	Yes		Yes	
Year dummies	Yes		Yes	
R^2	0.585		0.595	
Adjusted R^2	0.475		0.488	
Observations	145		145	

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

Table 3-5 displays the regression results of US patent damage awards ruled by juries. None of the three patent value indicators are significantly associated with patent damage awards ruled by juries. The adjusted coefficient of determination is significantly lower than that of the regression of US patent damage awards ruled by court judges. Moreover, like the regression of patent damage awards ruled by court judges, the coefficient for the defendant's lawyers and patent attorneys is also significant and positive, which is probably due to selection bias. The coefficient for the willfulness dummy is significant and positive in both models.

Table 3-5. OLS Regression Results for Log_US Patent Damage Awards Ruled by Juries

	Model 1		Model 2	
Intercept	14.181***	(1.504)	14.238***	(1.541)
Forward citations	0.084	(0.063)	0.085	(0.064)
Family size	0.016	(0.037)	0.017	(0.037)
Number of IPC codes	0.051	(0.050)	0.051	(0.050)
Age of the litigated patent	−0.125	(0.410)	−0.205	(0.668)
Number of claims	−0.002	(0.013)	−0.002	(0.013)
Defendant's lawyers and attorneys	0.169**	(0.063)	0.169***	(0.063)
Willfulness dummy	1.290**	(0.545)	1.307**	(0.544)
Court dummies	Yes		Yes	
Technological dummies	Yes		Yes	
Year dummies	Yes		Yes	
R^2	0.503		0.503	
Adjusted R^2	0.288		0.288	
Observations	97		97	

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

3.4 Discussion

(1) The Different Effect Patterns of Patent Value across Countries

As a well-established indicator of the technological importance of a patent, the correlation between the number of forward citations and the patent value has been extensively demonstrated in precious literature. Therefore, patents with more forward citations are expected to be awarded higher patent damages in court. However, the regression results show that it is true only in Japan and no significant effect is found in the US. One plausible interpretation is that in comparison with the courts in the US, the courts in Japan attach more weight to the technological quality of the litigated patent. This interpretation has sound foundations. In the US, patent litigation is heard by court judges and/or juries. The former are generalists but usually lack technological knowledge and the latter are even less knowledgeable with respect to both the US Patent Act and technologies. In contrast, in Japan, court judges of patent litigation are usually generalists and knowledgeable in a specific technology field. In addition, as noted in Section 1.6.2, technical experts have long been used in Japanese patent cases. Each patent case involves full–time technical investigation officers and some cases may further involve technology advisors who are knowledgeable in high technology fields. In contrast, in the US, although based on case law, technology advisors could also be used to support a patent trial, they are seldom employed in practice. Even if technology advisors are employed, the court in the US does not attach enough weight to their technological advice. These differences in the judicial systems will probably lead to a situation where the courts in Japan attach great weight to the technological importance of the patent while the courts in the US do not do so. For this reason, a significant correlation between the number of forward citations and patent damage awards is found in Japan, but not in the US.

On the other hand, as noted in Section 3.1.1, patent family size is a well-established indicator of the private economic value of a patent for the patent holder and the number of IPC codes is an indicator of patent scope, which is related to the utility breadth and the excludability of a patent. Compared with technological importance of a patented invention, both these two aspects of patent value are relatively easy for court judges to understand. Therefore, in the US and China, where court judges are generalists and technology experts are not or seldom employed in patent litigation, the courts attach weight to them since court judges can sufficiently understand them. For this reason, patent family size and the number of IPC codes have a significant effect on patent damage awards in the US and China. In contrast, due to the participation of technological experts, the courts in Japan attach too much weight toward the technological importance of a patent and neglect the aspects of patent value indicated by patent family size and the number of IPC codes.

(2) The Different Effect Patterns of Patent Value between US judges and US juries

Although no significant effect is found for the number of forward citations, patent family size and the number of IPC codes have a significant effect on patent damage awards ruled by court judges in the US. In contrast, none of the three aspects of patent value have a significant effect on patent damage awards ruled by juries. One plausible interpretation for this difference is that juries do not have the competencies to hear complex patent litigations. Modern patent cases are so complex that juries struggle to understand them and accurately apply the law (Wilson, 1997). Some commentators even suggest that the Seventh Amendment should be invoked to eliminate juries from patent cases in which the complexity of facts or the underlying issues are too difficult for juries to understand (Miller, 2004). This argument is further supported by the fact that the coefficient of determination (0.288) in Table 3-5 is significantly lower than that in Table 3-4 (0.475/0.488), which indicates that patent damage awards by juries are significantly less predictable than those ruled by court judges.

Chapter 4 The Characteristics of Litigated Patents

4.1 Research Questions

Predicting the probability of litigation for a given patent is important for patent litigation risk assessment. Incapable of distinguishing patents of a high probability of litigation from those of a low probability of litigation, patent holders will find it difficult to make sound resource allocations for detecting infringements and preparing for patent litigation. However, as noted in Section 1.4, up until now, as prior studies on the characteristics of litigated patents mainly used the US patent cases, it is necessary to examine the characteristics of the litigated patents in other countries. Up until now, the characteristics of litigated patents in Japan and China have never been empirically studied. Therefore, I attempt to examine whether the prior findings in the US are applicable in Japan and China. The first research question in this chapter is:

Q3: Are the findings on the characteristics of patent litigations in the US applicable in Japan and China ?

In addition to the previously examined patent characteristics in the prior literature, I examine the effects of three new patent characteristics on the probability of litigation.

First, theoretically, patents with a broader scope can trap infringement more easily and thus are more likely to be litigated. In this dissertation, I use the number of words or nouns in the first independent claim in a patent as the indicator of patent scope which was well established and used in several prior studies (Malackowski and Barney, 2008; Meeks and Eldering, 2010; Dang and Motohashi, 2015). The theory for this indicator is that the length of a claim in a patent indicates the number of limitations in the claim and thus can serve as a measurement of its scope. The second research questions in this chapter is:

Q4. Are patents with a shorter first independent claim more likely to be litigated?

Second, although patent systems are different across countries, mechanisms for patent applicants to add new subject matters to a previously filed patent application exists in either of the US, Japan, and China. In Japan and China, a patent applicant can add new subject matters by filing a new patent application claiming domestic priority to one or several previously filed patent applications. In the US, a patent applicant can add new subject matters to a previously filed patent application by filing a continuation-in-part application. All these mechanisms can be strategically used by patent applicants to make the patent application easier to trap competitors' newly launched products and/or newly developed technologies. Even if they are not strategically used by patent applicants, the more efforts devoted to these patents also indicate that they are more valuable than ordinary patents. Therefore, patents applied for in these forms are expected to have a higher probability of litigation. The third research questions in this chapter is:

Q5. Are patents asserting domestic priority more likely to be litigated?

Third, theoretically, patents with more inventors are more likely to be valuable patents. First, a large number of inventors indicate that large resources have been invested in the development of the patented technology (OECD Patent Statistics Manual, 2009). Second, a large number of inventors indicate that the patented invention is a result of diverse knowledge. Nagaoka and Owan (2011) demonstrated this argument by finding that the size of an inventor team is significantly positively correlated with patent value. As valuable patents usually involve higher stakes, patents with more inventors are expected to be more likely to be litigated. Therefore, the fourth research question in this chapter is:

Q6. Are patents with more inventors more likely to be litigated?

4.2 Research Method

4.2.1 Data Description

I extracted US patent cases decided during the period from 2000 to 2009 to exclude patent cases filed by NPE as much as I could. After screening the patent infringement suits decided between 2000 and 2009, I found 2,825 US patent infringement cases with

3,850 individual patents involved. However, five of the litigated patents are so old that they are not collected in the PatentSQUARE patent database. Besides, five other patents are in technology fields where only one granted patent applied in the same year exists. For these five patents, I cannot assign non-litigated control patents to them. Therefore, I removed these 10 patents and finally obtained 3,840 litigated patents in the US.

I collected 671 patent infringement suits decided between 2000 and 2014, with 703 individual patents involved. I further removed five litigated patents with only inadequate patent data and finally obtained 698 litigated patents in Japan.

In addition, I collected 970 Chinese patent cases decided between 2000 and 2014, which involved 602 individual patents in total. Four of them were applied in technology fields where only one granted patent applied in the same year exists. For the same reason noted above, I cannot assign non-litigated control patents to them. Therefore, I removed them from the analysis and obtained 598 Chinese litigated patents.

Figure 4-1 shows the distributions of technology fields of the litigated patents in Japan, China, and the US. More than half of the litigated patents in Japan are from the technology fields A, B, and G. More than half of the litigated patents in China are from the technology fields B, A, and E. More than half of the litigated patents in the US are from the technology fields A and G.

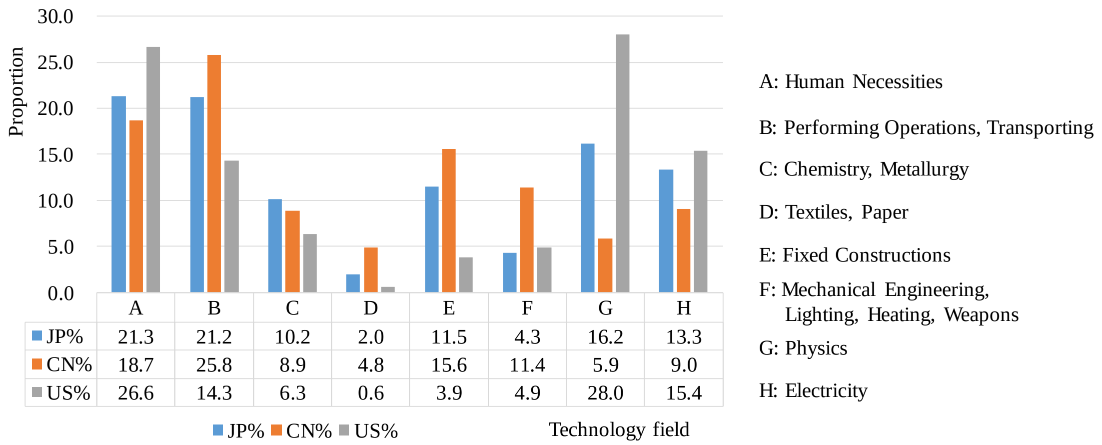


Figure 4-1. The Distributions of Technology Fields of the Litigated Patents in this chapter

4.2.2 Control Group Sampling

To identify the characteristics of litigated patents, I assigned a non-litigated control patent to each litigated patent randomly from the set of granted patents applied for in the same year and technology field (4-digit IPC codes). With this method, the effect of the application year and technology field are controlled for. I also did my best to make sure that the matched patents in the control group are non-litigated patents by checking if a matched patent is also in the group of litigated patents. If a matched patent is also in the litigated group, I removed it and performed a new matching process for this litigated patent. To check the robustness, I constructed three control groups for each dataset.

4.2.3 Dependent Variable

The dependent variable, *litigated*, is a dummy variable. If a patent is a litigated patent, it takes the value 1, and otherwise 0.

4.2.4 Independent Variables

Table 4-1 summarizes the definitions of the independent variables in this study. Among them, the number of words/nouns in the first independent claim and the ownership of a patent is determined by the following:

The number of words/nouns in the first independent claim. Generally, the first independent claim of a patent contains the broadest patent scope. As such. I use the natural logarithm of the number of words or nouns in the first independent claim as the indicator of the claim breadth of a patent. For US patents, as words in the sentence are separated by spaces, words in the first independent claims can be simply calculated by counting the space between words and adding 1. As no space exists between words in the sentence in Japanese and Chinese, I use open source software to count the words in the first independent claims. For Japanese patents, a piece of software called KH Coder is used, and for Chinese patents, a Chinese word segmentation system program called ICTCLAS is used. It should be noted that following prior literature conducted by Dang and Motohashi (2015), the inverse of the number of nouns was used as an indicator of claim breadth instead of the inverse of the number of words for Chinese patents.

Table 4-1. Tested Characteristics of Litigated Patents in this Study

Characteristics	Definition
Previously Tested Characteristics in the US or Germany	
Family size	The number of countries in which patent rights have been applied for with the same invention.
The number of claims	The number of patent claims
The number of forward citations	The normalized number of citations received from later patent applications.
The number of backward citations	The number of citations made by the patent in question
The number of 4-digit IPC codes	The number of 4-digit IPC subclasses assigned by patent examiners when issued
Ownership	Dummy variables. Patent owners are divided into domestic individual, foreign individual, domestic firm and foreign firm. Foreign firm is baseline group in the analyses.
Newly Tested Patent Characteristics Put forth in this Study	
Log_number of words/nouns	Natural logarithm of the number of words or nouns in the primary independent claim
Assertion of domestic priority	Dummy variable. If a patent has ever asserted a domestic priority, the value equals 1, and otherwise 0.
Number of inventors	The number of inventors written in the front page

Ownership. According to their types (i.e., individual or corporate) and nationalities, I divide patent owners into four categories: domestic individuals, domestic corporations, foreign individuals, and foreign corporations Firm types are determined by the name of the patent owners when the patents were issued. Nationality data of patent owners in the US and China are available in the PatentSQAURE database. Nationalities of patent owners in Japan are determined by their addresses. In the regression analysis, the foreign corporate category is used as the baseline category.

4.2.5 Analytical Method

As the dependent variable is a dummy variable (0/1), I use a probit model to do the regression analysis.

4.3 Empirical Results

In all the analyses, I use three samples which are the combinations of the litigated groups and the three respective control groups.

Table 4-2 displays regression results of the probability of litigation for a given patent in the US. The coefficients for all the variables are highly consistent in the three models. All the coefficients for the newly tested patent characteristics are significant. The coefficient for the number of words in the independent claim is significantly negative. This indicates that patents with more words in the first independent claim are more likely to be litigated. Though insignificant in Model 2, the coefficient for assertion of domestic priority (i.e., continuation-in-part patent application in the US) is significantly positive in Models 1 and 3. Patents which are filed in the form of continuation-in-part patent application are more likely to be litigated than others. However, the coefficient for the number of inventors is significantly negative. This indicates that patents with more inventors are less likely to be litigated.

Moreover, most of the coefficients for the previously tested patent characteristics are consistent with the findings in the prior literature. The coefficients for some variables related to patent value, that is, family size, the number of claims, and the number of forward citations, are significantly positive. The coefficient for the number of IPC subclasses is significantly negative. Moreover, patents originally issued to domestic entities are more likely to be litigated than those issued to their foreign counterparts. In addition, it is true for both domestic entities and foreign entities that patents owned by individuals are more likely to be litigated than those owned by firms. However, the coefficient for the number of backward citations are also significantly positive in all models, which is consistent with the finding in Germany by Cremers (2004) but not with the finding in the US by Lanjouw and Schankerman (2004).

Table 4-2. Probit Regression of the Probability of Litigation for a Given Patent in the US

	Sample 1		Sample 2		Sample 3	
Intercept	−0.741***	(0.149)	−0.597***	(0.149)	-0.811***	(0.150)
Log_number of words	−0.089***	(0.027)	−0.108***	(0.027)	-0.059**	(0.027)
Assertion of domestic priority	0.156***	(0.053)	0.081	(0.053)	0.218***	(0.054)
Number of inventors	−0.029***	(0.010)	−0.026***	(0.010)	-0.042***	(0.010)
Family size	0.039***	(0.003)	0.037***	(0.003)	0.007***	(0.001)
Number of claims	0.010***	(0.001)	0.008***	(0.001)	0.043***	(0.003)
Number of forward citations	0.228***	(0.010)	0.231***	(0.010)	0.229***	(0.010)
Number of backward citations	0.003***	(0.001)	0.004***	(0.001)	0.004***	(0.001)
Number of IPC subclasses	−0.124***	(0.032)	−0.142***	(0.032)	-0.137***	(0.032)
Domestic individual	0.902***	(0.054)	0.932***	(0.054)	0.882***	(0.054)
Domestic firms	0.650***	(0.041)	0.642***	(0.041)	0.620***	(0.041)
Foreign individual	0.407***	(0.106)	0.299***	(0.102)	0.331***	(0.106)
Observations	7680		7680		7680	
Pseudo R-squared	0.206		0.205		0.206	
Log-likelihood	−4224.8		−4230.0		−4225.2	
AIC	8473.5		8484.0		8474.5	

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

Table 4-3. Probit Regression of the Probability of Litigation for a Given Patent in Japan

	Sample 1		Sample 2		Sample 3	
Intercept	−0.674*	(0.373)	0.048	(0.379)	−0.377	(0.380)
Log_number of words	−0.074	(0.059)	−0.120**	(0.061)	−0.133**	(0.061)
Assertion of domestic priority	0.136	(0.132)	0.328**	(0.137)	0.264*	(0.138)
Number of inventors	−0.040*	(0.021)	−0.066**	(0.021)	−0.037*	(0.021)
Number of claims	−0.013*	(0.008)	−0.015*	(0.008)	−0.010	(0.009)
Family size	0.064***	(0.014)	0.042***	(0.012)	0.071***	(0.015)
Number of forward citations	0.225***	(0.024)	0.196***	(0.022)	0.222***	(0.024)
Number of backward citations	0.083***	(0.010)	0.103***	(0.011)	0.073***	(0.010)
Number of IPC subclasses	−0.028	(0.041)	−0.083**	(0.041)	0.017	(0.041)
Domestic individuals	1.291***	(0.205)	1.066***	(0.215)	1.290***	(0.216)
Domestic firms	0.332**	(0.165)	0.001	(0.171)	0.256	(0.175)
Foreign individuals	5.221	(78.766)	−0.176	(0.365)	−0.254	(0.364)
Observations	1396		1396		1396	
Pseudo R-squared	0.180		0.185		0.177	
Log-likelihood	−793.5		−788.2		−796.5	
AIC	1611.0		1600.4		1617.0	

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

Table 4-3 shows the regression results of the probability of litigation for a given patent in Japan. The coefficients for all the variables are highly consistent in the three models. Although two of them are insignificant in Model 1, significant coefficients are found for all the three newly tested patent characteristics. The coefficient for the number of words in the first independent claim is negative in all the models and significantly negative in Models 2 and 3. The coefficient for assertion of domestic priority is positive in all models and significantly positive in Models 2 and 3. The coefficient for the number of inventors is significantly positive in all models. These results are consistent with the regression results in the US.

Moreover, the coefficients for family size, the number of forward citations and the number of backward citations are significantly positive. The coefficient for domestic individuals is significantly positive in all models and the coefficient for domestic firms is significantly positive in Model 1 though insignificant in Models 2 and 3. Furthermore, the coefficient for domestic individuals is 3 times larger than that for domestic firms in Model 1, which supports the argument that patents issued to domestic individuals have a significantly higher probability of litigation than those issued to domestic firms. These results are also consistent with the findings in the US. However, the coefficient for the number of claims is negative in all models and significantly negative in Models 1 and 2. These results are contrary to the regression results in the US and prior findings in the US. Although the coefficient for the number of IPC subclasses is significantly negative in Model 2, this finding is unstable in Model 1 and 3. These results are inconsistent with the regression results in the US.

Table 4-4 displays the regression results of the probability of litigation for a given patent in China. The coefficients for the newly tested patent characteristics are all significant. The coefficient for the number of nouns in the independent claim is significantly negative in all models. The coefficient for assertion of domestic priority is significantly positive in Models 1 and 2 and positive though insignificant in Model 3. The coefficient for the number of inventors is significantly negative in all models. These results are consistent with the findings in the US and Japan.

Moreover, the coefficient for family size is significantly positive in all models, which indicates that patents of higher value are more likely to be litigated. The coefficient for domestic entities is significantly positive, which indicates that patents issued to domestic entities are more likely to be litigated than their foreign counterparts. Furthermore, the coefficient for domestic individuals is bigger than that for domestic firms, which indicates that patents issued to domestic individuals are more likely to be litigated. These results are also consistent with the regression results in the US and Japan. However, the coefficients for the number of claims and the number of IPC subclasses are insignificant though they are consistently positive and negative, respectively, in all models.

Table 4-4. Probit Regression of the Probability of Litigation for a Given Patent in China

	Sample 1		Sample 2		Sample 3	
Intercept	−0.196	(0.256)	0.106	(0.263)	−0.158	(0.250)
Log_number of nouns	−0.105*	(0.060)	−0.164***	(0.061)	−0.109*	(0.057)
Assertion of domestic priority	1.356***	(0.467)	0.689**	(0.312)	0.405	(0.255)
Number of inventors	−0.078***	(0.022)	−0.069***	(0.024)	−0.043*	(0.024)
Number of claims	0.004	(0.004)	0.002	(0.004)	0.003	(0.004)
Family size	0.042***	(0.008)	0.038***	(0.008)	0.039***	(0.008)
Number of IPC subclasses	−0.061	(0.050)	−0.080	(0.051)	−0.080	(0.050)
Domestic individual	1.230***	(0.112)	1.212***	(0.115)	1.169***	(0.112)
Domestic firms	0.844***	(0.122)	0.759***	(0.121)	0.728***	(0.118)
Foreign individual	0.097	(0.230)	−0.020	(0.240)	0.188	(0.232)
Observations	1196		1196		1196	
Pseudo R-squared	0.114		0.109		0.091	
Log-likelihood	−734.5		−738.5		−753.4	
AIC	1489.1		1496.9		1526.9	

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

4.4 Discussion

In this chapter, I investigate the effect of some previously tested and three previously untested patent characteristics on the probability of litigation for a given patent in the US, Japan, and China. Table 4-5 summarizes the findings. Most of the characteristics of litigated patents found in the US could also be used to predict the probability of litigation for a patent in Japan or China.

Table 4-5. Summary of the Findings in the US, Japan, and China.

	The US	Japan	China
Log_number of words/nouns	－/***	－/**	－/**
Assertion of domestic priority	＋/***	＋/**	＋/**
Number of inventors	－/***	－/**	－/***
Number of claims	＋/***	－/*	＋/
Family size	＋/***	＋/***	＋/***
Number of forward citations	＋/***	＋/***	
Number of backward citations	＋/**	＋/***	
Number of IPC subclasses	－/***	－/	－/
Domestic individual	＋/***	＋/***	＋/***
Domestic firms	＋/***	＋/**	＋/***
Foreign individual	＋/***	＋/	＋/

+/－: symbols of the coefficients *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

(1) The effect of patent scope on the probability of patent litigation

Three of the variables in this chapter are presented as patent scope indicators: the number of words or nouns in the first independent claims, the number of claims, and the number of IPC subclasses. Theoretically, patents with broader patent scopes are more likely to be infringed upon, and this kind of infringements are usually more likely to be detected. Therefore, patents with broader patent scopes are theoretically more likely to be litigated. The finding that patents with more words or nouns in the first independent claim are less likely to be litigated validated this argument. More words or nouns in the first independent claim indicate that there are more limitations in the claim, which results in a narrower patent scope.

However, the effect of the number of claims on the probability of litigation differs across countries. Although, as expected, patents with more claims are more likely to be litigated in the US, they are less likely to be litigated in Japan, and no significant effect on the probability of litigation is found in China. One possible interpretation is that people's attitudes toward patent litigation differ between across countries As patents with more claims usually have more dependent claims, which define specific inventions, they are less likely to be invalidated and more enforceable in court. In other words, patent with more claims are usually stronger patents. Yamaguchi and Nagano (2015) argued that one of the main reasons why the number of patent litigation in Japan are significantly fewer in Japan than those in the US and China is that the Japanese are more pessimistic toward litigation. This might lead to a consequence that both the infringed infringer and Japanese patent holders are more likely to resolve a patent disputes involving strong patent rights by other approaches, such as a pretrial settlement. The Chinese take an approach somewhere between the Japanese and the Americans and thus the effect in China is insignificant though positive.

Additionally, it was unexpected that patents assigned more IPC subclasses are less likely to be litigated in the US. There are two possible interpretations for this result. First, although the number of IPC subclasses has long been argued as an indicator of patent scope, unlike the number of words or nouns in the first independent claim, the scope indicated by the number of IPC subclasses is more related to the utility breadth of the patented invention. Because of this, patents with more IPC subclasses are theoretically more likely to be infringed. However, as patent holders usually can only detect the infringement acts relating to their own business, most of the infringement acts to this kind of patents will be out of the detection capacity of their patent holders. From this perspective, the number of IPC subclasses will not increase the probability of litigation for a given patent. On the other hand, patents with more IPC subclasses also indicate that they are more basic and thus less immediately relevant to market outcomes. In other words, patents assigned fewer IPC subclasses are more likely to be incremental inventions which are more related to market outcomes. Therefore, it takes longer time for this kind of patents to be used in practice, then to be infringed, and finally to be litigated. Most patents with many IPC subclasses may expire before it is infringed upon. From this perspective. The number of IPC subclasses are expected to decrease the probability of litigation for a given patent. Furthermore, it should be noted that the number of IPC subclasses does not have explanatory power in Japan and China though the coefficients for it are also negative. This is probably because the number of IPC subclasses is not a good approximation of market relevance of a patent in Japan and China, which results from different ways of assigning IPC codes. This should be further studied in the future research.

(2) The effect of patent value on the probability of patent litigation

Infringement of a valuable patent usually involves higher stakes than infringement of an ordinary patent. As patent litigation is costly in terms of time and money, both parties will choose to resolve a patent dispute through litigation only when the stakes are big enough. Therefore, theoretically, valuable patents are more likely to be litigated.

Two of the most well-established patent value indicators are used in the models: family size and the number of forward citations. The coefficients for them are significantly positive in all models. This affirms the prior argument that valuable patents are more likely to be litigated. In addition, as noted in Section 4.1, patents with more inventors are also argued to be more valuable. However, the coefficient for the number of inventors, which is argued to be positively associated with patent value, are significantly negative in all the three countries. One possible explanation is that potential infringers avoid infringing patents with many inventors. The number of inventors of a patent might indicate that the patented invention is a result of a big R&D project which is extremely important for the patent holder. It is logic to believe that the patent holder will devote more efforts to protect this invention. Therefore, infringement of a patent with many inventors is more likely to be detected and sued by its patent holder. This makes potential infringers avoid infringing this kind of patents.

(3) The effect of ownership on the probability of patent litigation

Patent ownership is divided into four categories: domestic individuals, domestic firms, foreign individuals, and foreign firms. On the one hand, the regression results show that patents issued to domestic individuals and firms are significantly more likely to be litigated. One plausible interpretation for this finding is that domestic patent owners have an advantage in detecting patent infringement, and it is less costly for them to file a patent infringement suit than their foreign counterpart. On the other hand, the regression result confirms the prior findings that patents issued to individuals are found to be significantly more likely to be litigated than those issued to firms. This is probably because individual patent owners have less bargaining chips to reach a settlement instead of filing a patent suit. However, this effect is insignificant between patents issued to foreign individuals and foreign firms in Japan and China. This is probably because the number of patents issued to foreign individuals in the dataset are so small (33-35 for Chinese datasets, 7-17 for Japanese datasets) that the regression results for foreign individuals in Japan and China are temporary and without merit.

(4) The effect of patenting strategies on the probability of litigation

As noted in Section 4.1, the domestic priority system in Japan and China and the continuation-in-part (CIP) patent application in the US allows patent applicants to add new subject matters to a previously filed patent application. As an experienced patent applicant will adjust its patent strategies according to its competitors' innovation tendency, the domestic priority system and CIP patent application are probably used by patent applicants strategically to trap their competitor's innovations. Therefore, theoretically, patents asserting domestic priority in Japan and China or applied for in the form of CIP patent application are more likely to be litigated than ordinary patents. The regression results support this argument.

(5) The effect of the number of backward citations on the probability of litigation

As noted in Section 1.3.2, prior studies have not reached a consensus on the effect of the number of backward citations and the probability of litigation for a given patent. Lanjouw and Schankerman (2001, 2004) argued that a small number of backward citations indicates that the patent belongs to a relatively new technology field which is more uncertain. This makes it difficult for the parties of a patent dispute to make similar expectations of the outcome of the litigation. As a result, they are more likely to resolve the dispute by litigation rather than settlement.

On the other hand, the number of backward citations can also be interpreted in another way. As backward cited patents are usually technologically similar to the citing patent, more backward citations indicate that many innovators are interested in the same technology field. This makes patents with many backward citations more likely to be infringed by other innovators and thus more likely to be involved in patent litigation. This argument is supported by prior studies by Allison et al. (2003) and Cremers (2004). In this chapter, the significant and positive coefficient for the number of backward citations in the US and Japan provides new evidence to this argument.

Chapter 5 The Characteristics of Patent Litigants

5.1 Research Question

In Chapter 4, the characteristics of patent litigation are examined at the patent level. However, to the best of my knowledge, no empirical analysis has been conducted upon the characteristics of patent litigation at the firm level. It is logical to believe that firms have different propensity to enforce their patents by litigation. This can be reflected in the characteristics of their patent portfolios, and are affected by their firm sizes and their patent portfolio size. Therefore, in this chapter, I provide an empirical analysis of the characteristics of patent litigants in Japan. As noted in Section 1.5.2, I attempt to answer the following question:

Q7: Can the characteristics of a patent portfolio be used to predict the probability of patent litigation at the firm level?

5.2 Datasets and Variables

5.2.1 Data Description

From the IP litigation database provided by the Supreme Court of Japan, I collect 671 patent cases decided during the period from 2000 to 2014. Among them, those filed during the period from 2001 to 2010 are used in this chapter. I have refined the data as follows. First, as the names of individual plaintiffs are not written in the decisions of Japanese patent litigation, I only analyzed plaintiff firms in this chapter. Second, as firms registered in different districts can be registered under same name in Japan, tracing the records of patent application by firm names will be misleading. Therefore, I use identification numbers which are unique to each firm to trace the records of patent applications by the plaintiff firms. As the identification number system was introduced into the Japanese patent system in the December of 1990, firms that have never filed a patent application since then were not assigned an identification number. Therefore, I removed these firms from the sample. Third, some plaintiff firms are not original assignees of the litigated patents. The characteristics of the patent portfolio of these plaintiff firms probably do not explain why they were involved in patent litigation because these characteristics probably differ from those of the litigated patent transferred from others. Therefore, I removed these firms from the study.

5.2.2 Control Group Sampling

Control firms are matched for plaintiff firms with the ratio of 1:1. To control the effect of technology fields, I selected control firms from the corporate applicants of backward citations of the litigated patents because they apply for patents in similar technology fields with plaintiff firms. Among them, the applicants of corporate-filed applications whose application date is nearest to that of the litigated patent is extracted as the control firm of the litigated patent. I attempt to ensure that the control firms did not file a patent lawsuit in the same year with their litigating firms. However, some litigating firms cannot be matched to a control firm with this method. I exclude these litigating firms from the study. With this method, I finally get 154 pairs of litigating firms and control firms.

5.2.3 Dependent Variables

The dependent variable, *litigated*, is a dummy variable. The value equals 1 for the firms in the litigated group and equals 0 for the firms in the control group.

5.2.4 Independent Variables

Table 5-1 summarizes the independent variables used in this chapter. Except the firm type variable, all the variables are calculated according to the characteristics of the firms' patent portfolio, which is defined as the granted patents applied for in the past 10 years before the filing year of a patent case in question. I set the extraction interval to 10 years because, as the identification number started to be used in December 1990 and patent cases used in this study were filed during the period from 2001 to 2010, I will lose most of the sample firms if I attempt to trace the 20-year patent application history.

Firm size is defined according to the number of employees in 2015. According to the standard by Small and Medium Enterprise Agency in Japan, firms with fewer than 300 employees are classified as SMEs and those with more than 300 employees are classified as big firms. I mainly investigate the number of employees in a commercial firm information database provided by Tokyo Shoko Research, LTD and partly from firms' websites. For firms that I cannot get employee number with these two methods for, I simply classify them as SMEs because big firms usually have their own websites.

Table 5-1. Tested Characteristics of Litigating Patentees in this Study

Characteristics	Definition
Log_patent portfolio size	Natural logarithm of a firm's patent portfolio size (the number of granted patents which are filed over previous 10 years before the filling year of the patent case).
Log_average number of words	Natural logarithm of the average number of words in the primary independent claims of the patent portfolio.
Ratio_domestic priority patents	The ratio of patents which have ever asserted domestic priority to the patent portfolio size.
Average number of inventors	The average number of inventors of all the patents in the patent portfolio.
Average number of claims	The average number of claims of all the patents in the patent portfolio.
Ratio_foreign priority patents	The ratio of patents the family size of which is more than 1 to the patent portfolio size.
Average number of forward citations	The average number of forward citations of all the patents in the patent portfolio.
Average number of backward citations	The average number of backward citations of all the patents in the patent portfolio.
Average number of IPC codes	The average number of assigned 4-digit IPC codes of all the patents in the patent portfolio.
Types of firms	The firms are divided into three categories: Japanese SMEs, Japanese big firms and foreign firms

5.2.5 Analytical Method

As the dependent variable is a dummy variable (0/1), I use a probit model to do the regression analysis.

5.3 Empirical Results and Discussions

Table 5-2 displays the regression results of the probability of litigation for a given firm in Japan. Model 1 uses the entire sample and Model 2 excludes foreign firms from the sample. The rightmost column shows the corresponding regression results at the patent level.

Table 5-2. Probit Regression Results of the Probability of Litigation for a Given Firm in Japan

	Model 1		Model 2		
Intercept	0.861	(1.406)	1.171	(1.494)	
Log_patent portfolio size	−0.050	(0.043)	−0.057	(0.045)	
Log_average number of words	−0.310	(0.234)	−0.298	(0.265)	−/**
Ratio_domestic priority patents	−0.156	(0.677)	0.494	(0.760)	+/**
Average number of inventors	0.028	(0.061)	−0.058	(0.086)	−/**
Average number of claims	−0.069*	(0.038)	−0.086*	(0.046)	−/*
Ratio_foreign priority patents	0.898**	(0.414)	0.929**	(0.450)	+/***
Average number of forward citations	0.392**	(0.173)	0.571***	(0.217)	+/***
Average number of backward citations	0.092*	(0.048)	0.052	(0.053)	+/***
Average number of IPC subclasses	−0.047	(0.157)	0.021	(0.189)	−/
Domestic SMEs	0.885*	(0.494)	0.641**	(0.267)	
Domestic big firms	0.242	(0.506)			
Observations	308		270		
Pseudo R-squared	0.097		0.107		
Log-likelihood	−192.9		−167.1		
AIC	409.8		356.2		

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

As at the patent level, several characteristics of patent portfolio are found to have the same effect on the probability of litigation at the firm level. First, the coefficient for the average number of claims is significantly negative. This indicates that firms which tend to apply for more dependent claims in a patent application are less likely to be litigated. As noted in Section 4.4, the Japanese are generally pessimistic toward litigation. Therefore, it is easier for Japanese patent holders and alleged infringers to reach a settlement in disputes involving patents with more dependent claims, which are less likely to be invalidated and are more enforceable in court. Second, the coefficients for patent value indicators, namely the ratio of patents asserting foreign priority and the average number of forward citations, are significantly positive in both models. This indicates that firms owning many valuable patents are more likely to be involved in patent litigation as a patent litigant. Third, the coefficient for the average number of backward citations is significantly positive in Model 1 and positive though insignificant in Model 2. This indicates that firms applying for patents in more crowded technology fields are more likely to be involved in patent litigation as a patent litigant. In addition, the coefficient for domestic SMEs is significantly positive in both models. This indicates that domestic SME firms are more likely to litigate their patents than foreign firms (the baseline in Model 1) and domestic big firms (the baseline Model 2).

However, not all the variables tested in this chapter are significant. First, as noted in Section 1.3.2, patent portfolio size has a significantly negative effect on the probability of litigation for a given patent at the patent level. However, the coefficient for patent portfolio size is insignificant at the firm level. This is probably because the positive and negative effects of patent portfolio size on the probability of litigation counteract each other at the firm level. On the one hand, a large patent portfolio provides a strong bargaining chip for the patent holder to reach a settlement so that the probability of litigation will be reduced at the patent level. On the other hand, a large number of patents will also increase the probability of a patent holder being infringed upon and thus being involved in litigation as a patent litigant. The result observed in this chapter might be the comprehensive outcome of the relative strengths of these two opposite effects. Second, as at the patent level, the coefficient for the average number of IPC subclasses is still insignificant at the firm level. As noted in Section 4.4, this is probably because the number of IPC subclasses has less market relevance in Japan. Third, unlike at the patent level, all the coefficients for the three newly tested patent characteristics are insignificant at the firm level. A possible interpretation for the insignificant coefficient for the average number of words in the first independent claims, and the ratio of the patents asserting domestic priority, is that their effects on the probability of patent litigation might depend on the technology fields of the patented inventions. The number of words in the first independent claims might vary greatly across technology fields and domestic priority might be strategically used in some technology fields but not in others. In Chapter 4, as control groups are constructed by random sampling of a non-litigated patent that was applied for in the same year and technology field as the litigated patent, the effect of technology fields is controlled for. Even so, one of the three models in Table 4-4 is still insignificant. In this chapter, because of the limitations of sampling methods for control group, the effect of technology fields is not well controlled for at the firm level. For this reason, the effects of the average number of words in the first independent claim and the ratio of the patents asserting domestic priority for some specific technology fields are not observed. In addition, a possible interpretation for the insignificant coefficient for the average number of inventors is that unlike its counterpart at the patent level, the average number of inventors at the firm level might just indicate the distinct organization form of R&D teams in a firm instead of the importance of the patented invention. Larger average numbers of inventors might indicate R&D projects in these firms are always conducted in a big team while a smaller number of inventors might indicate R&D projects in these firms are always subdivided into smaller subprojects so that each subproject can be conducted by a small number of individuals. If this is true, the threatening effect identified at the patent level might not be identified for the average number of inventors at the firm level.

Chapter 6 The Effects of Patent Litigation on Plaintiff SMEs

6.1 Research Questions

As patent litigation is usually costly, patent holders should weigh advantages and disadvantages before filing a patent infringement suit. This is especially important for SMEs because they usually face more difficulties in benefiting from patent litigation than their larger counterparts. In this study, I examine the effects of patent litigation on plaintiff SMEs from two perspectives. First, from an organizational learning perspective, patent litigation may present a good opportunity for innovators to learn to use the patent system more effectively. This is particularly important for SMEs which usually have little experience or expertise in this area. Second, high costs of patent litigation may place such a heavy burden on SMEs that their regular R&D activities may be adversely affected. I expect that these effects will be reflected in SMEs' subsequent patenting behaviors. To put it in another way, I attempt to answer the following two questions:

Q8: Do the high costs of patent litigation negatively impact plaintiff SMEs' patenting activities?

Q9: Does patent litigation provide a good chance for plaintiff SMEs to learn to apply for strong patent rights?

6.2 Datasets and Variables

6.2.1 Data Description

Litigation data used in this chapter are collected from the intellectual property case history database provided by the Supreme Court of Japan. To make the impact of patent litigation consistent in the sample, I refined the plaintiff firms by the following steps. First, I collected all the plaintiff firms for the patent cases decided in Japan during the period from 2000 to 2008. Second, as it is logical to expect that SMEs are more likely to be influenced by litigation than large firms, I focused on SMEs in this chapter. SMEs are defined here as the firms with fewer than 300 employees, which is the standard used by the Small and Medium Enterprise Agency in Japan. Third, because manufacturing firms are the central sources of technological innovation, I excluded non-manufacturing SMEs, such as sales companies and construction firms, from the analysis. Fourth, as most foreign SMEs do not locate their R&D centers in Japan, I excluded them from the analysis. Fifth, as firms registered in different districts can have the same name, it would be misleading for us to trace patenting history by firm name. Therefore, I used identification numbers, which are unique to each patentee, to trace its patent application history. However, I failed to find identification numbers of some SMEs because some firms have never applied for a patent right since the identification number system was introduced in 1990. Therefore, I removed these firms from the sample. In this way, I collected a total of 142 patent cases, which involved 121 domestic plaintiff SMEs.

6.2.2 Dependent Variables

To examine the effect of patent litigation on the patenting behavior of plaintiff SMEs, the number of patent applications and the number of forward citations are used as quantitative and qualitative indicators, respectively. Both the maximum number of forward citations which were received by the most-cited patent among the granted patents applied for by a plaintiff SME in a cohort and the average number of forward citations which were received by the granted patents filed by a plaintiff SME in a cohort are used to examine the learning effects of patent litigation.

It should be noted that, although the number of forward citations is always used as an indicator of patent value, it is used as an indicator of the strength of patent rights in this chapter. For a given patent, the number of forward citations could be influenced by the writing style of the patent specifications and patent claims. First, generic terms could be used to apply for a broader patent. Second, patent rights could also be strengthened by writing more claims. Both these strategies result in patent rights with broader scopes and are more likely to be cited by patent examiners as prior art to restrict the claims of later patent applications. Therefore, I argue that the number of forward citations can also be used as an indicator of the strength of patent rights.

6.2.3 Independent Variables

As the impact of patent litigation may last for several years, I use a distributed lag model, which has been used in two prior studies (Ahuja and Katila, 2001; Ernst, 2001). I use five lagged litigation variables (litigation_{t-1}-litigation_{t-5}), five lagged ExtremeCost litigation variables (ExtremeCost_{t-1}-ExtremeCost_{t-5}), five lagged winning variables (win_{t-1}-win_{t-5}) if the plaintiff SME won the litigation, and five lagged losing variables (lose_{t-1}-lose_{t-5}) if the plaintiff SME lost the litigation. Litigation_{t-x} is the number of patent cases decided by the courts for the plaintiff SMEs *x* years before the observation year. Other lagged variables are defined in a similar way.

Among the sample, approximately 57 cases were appealed to higher courts. For these cases, it is difficult to determine whether the impact of patent litigation occurred after the first decision or final decision. Therefore, I examine both possibilities. For the former, I used the decision year of the first instance as the benchmark to define the lagged variables. For the latter, I used the final decision year of the litigation as the benchmark to define the lagged variables. This means that, if a lawsuit was appealed to a higher court, litigation_{t-x} is the number of patent cases decided by the courts for the plaintiff SMEs *x* years before the decision year of the second instance.

6.2.4 Control Variables

Year dummies. Year dummies are used to control for the time trends.

Knowledge stock. As knowledge stock is an important element that influences innovation output, and I control for it in the regression of the number of patent applications. It is defined as the sum of patent applications over the previous five years.

The number of granted patents. I control for the number of granted patents applied for by the plaintiff SMEs in the same year in the regression of the maximum number of forward citations and the average number of forward citations.

6.2.5 Analytical model

As noted above, I collected a total of 142 patent cases involving 121 domestic plaintiff SMEs for further cleaning. I traced the patenting behavior of these SMEs in Japan Patent Office over a consecutive ten-year period from 2000 to 2009. As one of the SMEs was established in 2002, I only obtained eight observations for it.

As both the number of patent applications and the number of forward citations obey a Poisson distribution and the data are panel data, I used the fixed-effect Poisson model for the analyses. I used the *pglm* package for the regressions using R software. However, it should be noted that, as the *pglm* package automatically excludes firms whose dependent variables are constant during the observation period, I was forced to omit these samples in the regressions. Among the 121 firms, five had never applied for a patent and another 17 were never granted a patent during the observation period. For the reasons mentioned above, the former is excluded from the regressions of the number of patent applications and both the former and the latter are excluded from the regressions of the number of forward citations. Furthermore, the number of forward citations will certainly be zero for the observations with no patents granted. As these observations do not provide any information on the strength of patent applications, I excluded them from the regression analysis of the number of forward citations. After this refining process, 13 firms only had one observation in the dataset. As panel data require that the number of observations for each firm is greater than one, I excluded these 13 firms from the sample.

Table 6-1 displays the distribution of patent cases for each regression analysis. The total numbers of patent cases in columns 3 and 5 are smaller than those in columns 2 and 4, respectively. This is because six patent cases that were appealed to higher courts were decided by the courts after 2008. Although the plaintiff SMEs involved in these patent cases are also included in the analysis of the effect of patent litigation after the final instance, they actually function as a control group because their corresponding lagged variables defined by the final decision year are outside the 2000 to 2009 observation period. The same thing happens in the analysis of the effect of the litigation with extremely high costs, where the plaintiff SMEs claiming damages of less than 100 billion Japanese yen function as a control group.

Table 6-1. The Distribution of Patent Cases for Each Regression Analysis by Decision Year.

	For the analysis of patent applications		For the analysis of forward citations	
Decision year	after the first instance	after the final instance	after the first instance	after the final instance
2000	18(7)	9(4)	16	7
2001	24(7)	23(5)	16	16
2002	25(10)	24(10)	22	20
2003	9(1)	18(6)	4	11
2004	18(6)	15(5)	11	8
2005	14(3)	17(3)	9	11
2006	8(3)	6(3)	2	1
2007	11(4)	7(3)	7	4
2008	7(3)	9(2)	3	6
Total	134(44)	128(41)	90	84

Numbers in parentheses are the number of patent cases with extremely high costs.

6.3 Empirical Results

In all the following analyses, Model 1 uses the lagged variables defined by the decision year of the first instance, and Model 2 uses the lagged variables defined by the final decision year.

Table 2 displays the regression results for the effects of patent litigation on the number of subsequent patent applications. In Model 1, the coefficients for all the lagged litigation variables are negative. Among them, the coefficients for the second-year and third-year lagged litigation variables are significantly negative. This indicates that patent litigation leads to a significant decrease in the number of patent applications in the second and third years after litigation. Similar results can be seen in Model 2. However, the coefficient for the first-year lagged variable is significant in comparison to the significant coefficient for the second-year lagged variable after the final decision year. This difference is probably because the effect of the 51 patent cases that appealed to higher courts on subsequent patent applications started with the decision of the first instance and disappeared before the second year after the final decision.

Table 6-2. The Effect of Patent Litigation on the Number of Subsequent Patent Applications.

	Model 1		Model 2	
Knowledge Stock	0.002***	(0.0003)	0.002***	(0.0003)
Litigation_{t-1}	−0.031	(0.041)	−0.124***	(0.044)
Litigation_{t-2}	−0.087**	(0.044)	−0.057	(0.047)
Litigation_{t-3}	−0.203***	(0.055)	−0.231***	(0.057)
Litigation_{t-4}	−0.074	(0.055)	−0.094*	(0.056)
Litigation_{t-5}	−0.050	(0.061)	−0.088	(0.062)
Year Dummy	Yes		Yes	
Observations	1158		1158	
Log-Likelihood	−2228.0		−2231.1	
AIC	4486.0		4492.3	

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

One concern is that the effects of patent litigation on subsequent patent applications may differ according to the different outcomes of patent litigation. Therefore, I separately examine the effects of patent litigation by the outcome in terms of winning and losing. Table 6-3 displays the regression results. In Model 1, the coefficients for all lagged winning dummies are significantly negative, except in the fourth year. On the other hand, the coefficients for the lagged losing dummies in Model 1 turn from significantly positive in the first year to significantly negative in the fourth year. One plausible interpretation is that, although patent litigation negatively affects subsequent patent applications, losing a patent lawsuit enhances the crisis awareness of the plaintiff SME and thus stimulates it to strengthen its patent portfolio for several years after patent litigation. The positive effect is significantly larger than the negative effect in the first year after patent litigation. However, as the crisis awareness gradually weakens, the negative effect exceeds the positive effect in the fourth year after litigation. Similar results can be seen in Model 2, which uses the lagged winning variables and lagged losing variables, as defined according to the final decision year.

Table 6-3. The Effect of Patent Litigation on Subsequent Patent Applications by Outcome.

	Model 1		Model 2	
Knowledge Stock	0.002***	(0.0003)	0.002***	(0.0003)
Win_{t-1}	−0.367***	(0.083)	−0.332***	(0.083)
Win_{t-2}	−0.297***	(0.087)	−0.296***	(0.089)
Win_{t-3}	−0.483***	(0.109)	−0.494***	(0.111)
Win_{t-4}	0.067	(0.088)	0.103	(0.086)
Win_{t-5}	−0.221**	(0.103)	−0.244**	(0.104)
$Lose_{t-1}$	0.102**	(0.047)	−0.032	(0.052)
$Lose_{t-2}$	−0.009	(0.051)	0.049	(0.055)
$Lose_{t-3}$	−0.093	(0.063)	−0.119*	(0.065)
$Lose_{t-4}$	−0.137**	(0.067)	−0.187***	(0.069)
$Lose_{t-5}$	0.051	(0.072)	0.002	(0.074)
Year Dummies	Yes		Yes	
Observations	1158		1158	
Log-Likelihood	−2204.0		−2210.8	
AIC	4448.1		4461.6	

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

Table 6-4 displays the regression results for the effect of patent litigation with extremely high costs, where the claimed damages are at least 100 million Japanese yen, on subsequent patent applications. In Model 1, the coefficients for the lagged ExtremeCost variables are significantly negative from the second year to the fifth year after patent litigation. Compared with the results of Model 1 in Table 2, the negative effect of patent litigation with extremely high costs lasts significantly longer than the average effect of all patent litigation. Furthermore, the absolute value of these significant coefficients is greater than that of Model 1 in Table 2. This suggests that the higher the costs of patent litigation, the more significant the negative effect. Model 2 shows similar results and the negative effect is significant, beginning with the first year after the final decision. As noted above, this is probably because the effects of the patent cases that appealed to a higher court on subsequent patent applications started from the decision year of the first instance.

Table 6-4. The Effect of Patent Litigations with Extremely High Costs on Subsequent Patent Applications.

	Model 1		Model 2	
Knowledge Stock	0.002***	(0.0002)	0.002***	(0.0002)
$ExtremeCost_{t-1}$	0.088	(0.066)	−0.169**	(0.078)
$ExtremeCost_{t-2}$	−0.162**	(0.080)	−0.288***	(0.089)
$ExtremeCost_{t-3}$	−0.460***	(0.108)	−0.522***	(0.113)
$ExtremeCost_{t-4}$	−0.268***	(0.104)	−0.301***	(0.103)
$ExtremeCost_{t-5}$	−0.625***	(0.129)	−0.580***	(0.124)
Year Dummies	Yes		Yes	
Observations	1158		1158	
Log-Likelihood	−2207.2		−2213.7	
AIC	4444.4		4457.5	

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

Tables 6-5 and 6-6 display the effects of patent litigation on the strength of subsequent patent applications. The models in Table 6-5 use the maximum number of forward citations as the dependent variable. The models in Table 6-6 use the average number of forward citations as the dependent variable. In Table 6-5, the coefficients for the first four lagged litigation variables of Model 1 are all significantly positive. This indicates that patent litigation motivates the plaintiff SMEs to improve the strength of their patent applications in the following four years after patent litigation. Similar results can be seen in Model 2. However, this effect only lasts until the fourth year after patent litigation. The coefficient for the fifth-year lagged litigation variable is insignificant in Model 1 and significantly negative in Model 2. This is probably because the plaintiff SMEs have forgotten about the importance of the strength and enforceability of patent rights, and the knowledge about how to apply for stronger patent rights beginning with the fifth year after patent litigation. The significantly negative coefficient for the fifth-year lagged litigation variable in Model 2 indicates that the plaintiff SMEs tend to return to their original patenting strategy, which attaches more weight to the probability of passing the patent examinations than to the strength and enforceability of their patent rights. Similar results are seen in Table 6-6.

Table 6-5. The Effect of Patent Litigation on the Strength of Subsequent Patent Applications (Using the Maximum Number of Forward Citations as the Dependent Variable).

	Model 1		Model 2	
Granted Patents	0.019***	(0.001)	0.021***	(0.001)
$Litigation_{t-1}$	0.154***	(0.029)	0.213***	(0.030)
$Litigation_{t-2}$	0.219***	(0.030)	0.192***	(0.032)
$Litigation_{t-3}$	0.284***	(0.031)	0.354***	(0.031)
$Litigation_{t-4}$	0.132***	(0.036)	0.126***	(0.037)
$Litigation_{t-5}$	0.053	(0.041)	−0.180***	(0.046)
Year Dummies	Yes		Yes	
Observations	534		534	
Log-Likelihood	−4145.4		−4098.9	
AIC	8320.8		8227.8	

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

Table 6-6. The Effect of Patent Litigation on the Strength of Subsequent Patent Applications (Using the Average Number of Forward Citations as the Dependent Variable).

	Model 1		Model 2	
Granted Patents	−0.007**	(0.003)	−0.006**	(0.003)
$Litigation_{t-1}$	0.024	(0.045)	0.075	(0.047)
$Litigation_{t-2}$	0.159***	(0.046)	0.232***	(0.046)
$Litigation_{t-3}$	0.091*	(0.048)	0.082*	(0.050)
$Litigation_{t-4}$	0.095*	(0.056)	0.163***	(0.056)
$Litigation_{t-5}$	0.119**	(0.060)	−0.186***	(0.070)
Year Dummies	Yes		Yes	
Observations	534		534	
Log-Likelihood	−2452.4		−2436.5	
AIC	4934.7		4903.1	

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

I also attempt to examine whether the effect of patent litigation on the strength of subsequent patent applications varies by the outcomes of patent litigation. Tables 6-7 and 6-8 display the regression results of the maximum number of forward citations and the average number of forward citations, respectively. Columns 4 and 7 in Tables 6-7 and 6-8 show the number of non-zero values for each lagged variable. There are only a few observations for the lagged winning variables, and the regression results for the lagged winning variables are unstable. These results are probably temporary and without merit. Therefore, I do not attempt to provide any further interpretation. On the other hand, like the regression results in Table 6, the coefficients for the lagged losing variables from the first year to the fourth year are significantly positive for both models in Table 6-7. The coefficient for the fifth-year lagged losing variable is insignificant in Model 1 and significantly negative in Model 2. Similar results are also seen in Table 6-8.

Table 6-7. The Effect of Patent Litigation on the Strength of Subsequent Patent Applications by Outcome (Using the Maximum Number of Forward Citations as the Indicator).

	Model 1			Model 2		
Granted Patents	0.020***	(0.001)		0.022***	(0.001)	
Win_{t-1}	−0.166***	(0.058)	15	−0.263***	(0.060)	15
Win_{t-2}	0.347***	(0.046)	17	0.325***	(0.047)	14
Win_{t-3}	0.182***	(0.061)	11	0.269***	(0.058)	11
Win_{t-4}	−0.221***	(0.072)	11	−0.137**	(0.067)	12
Win_{t-5}	0.063	(0.064)	11	−0.045	(0.068)	10
$Lose_{t-1}$	0.264***	(0.033)	45	0.416***	(0.035)	42
$Lose_{t-2}$	0.129***	(0.038)	34	0.117***	(0.041)	33
$Lose_{t-3}$	0.329***	(0.036)	31	0.395***	(0.037)	32
$Lose_{t-4}$	0.265***	(0.041)	30	0.261***	(0.043)	29
$Lose_{t-5}$	0.030	(0.051)	22	−0.261***	(0.059)	19
Year Dummies	Yes			Yes		
Observations	534			534		
Log-Likelihood	−4088.2			−4013.8		
AIC	8216.5			8067.6		

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

Table 6-8. The Effect of Patent Litigation on the Strength of Subsequent Patent Applications by Outcome (Using the Average Number of Forward Citations as the Indicator).

	Model 1			Model 2		
Granted Patents	−0.007	(0.003)		−0.005*	(0.003)	
Win_{t-1}	−0.204**	(0.092)	15	−0.323***	(0.097)	15
Win_{t-2}	0.285***	(0.071)	17	0.262***	(0.073)	14
Win_{t-3}	−0.027	(0.105)	11	0.207**	(0.091)	11
Win_{t-4}	0.012	(0.100)	11	−0.006	(0.096)	12
Win_{t-5}	0.192**	(0.091)	11	0.083	(0.100)	10
$Lose_{t-1}$	0.094*	(0.052)	45	0.242***	(0.055)	42
$Lose_{t-2}$	0.063	(0.060)	34	0.219***	(0.058)	33
$Lose_{t-3}$	0.123***	(0.053)	31	0.043	(0.058)	32
$Lose_{t-4}$	0.120**	(0.065)	30	0.252***	(0.066)	29
$Lose_{t-5}$	0.055	(0.074)	22	−0.368***	(0.093)	19
Year Dummies	Yes			Yes		
Observations	534			534		
Log-Likelihood	−4088.2			−4013.8		
AIC	8216.5			8067.6		

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

6.4 Discussion

There are two concerns about the interpretation of the regression results:

(1) Can the decrease in subsequent patent applications be interpreted as the negative effect of patent litigation on R&D activities?

A lag period of two or three years usually exists between R&D activities and patent applications. And a total of 82% of the first instances of patent cases in the sample lasts for two to three years. The time lag between the R&D activity and patent application is about three years. Therefore, if the decrease in subsequent patent applications is due to the negative effect of patent litigation on R&D activities, it will occur beginning with the first or second year after patent litigation. This is consistent with the results in Tables 2 and 4, which show that the decrease in subsequent applications begins with the second year after patent litigation. On the other hand, if the decrease in subsequent applications is mainly due to the negative effect of patent litigation on the patenting propensity of the plaintiff SMEs, it should begin with the first year after patent litigation, which is inconsistent with the regression results. I admit that this kind of effect does exist. In fact, a firm manager in the sample said that, after experiencing patent litigation, they tended to be cautious toward patenting inventions for a process for producing a product. However, the regression results support the notion that this may not be the main reason for the decrease in subsequent patent applications. On the other hand, the fact that the effect of patent litigation with extremely high costs is more significant, both in terms of length and magnitude, also supports the argument that the decrease in subsequent patent applications is mainly due to the negative effect of patent litigation on the plaintiff SMEs' R&D activities.

(2) Is the number of forward citations an effective indicator of the strength of patent rights?

Although I have discussed the rationality of the usage of the number of forward citations as an indicator of the strength of patent rights in Section 6.2.2, one concern about the increase in the number of forward citations is that forward citations may increase according to the announcement effect of patent litigation. Patent litigation may draw the attention of the firms in the same industry, which will also lead to an increase of the number of forward citations received by patents of the plaintiff SMEs. However, it should be noted that this announcement effect will not only lead to an increase in the number of forward citations of patents applied for by the plaintiff SMEs after patent litigation, but it will also lead to an increase in the number of forward citations of patents applied for before patent litigation. This effect can be controlled for by the fixed-effect model used in this study and will not be reflected in the regression results. Therefore, I argue that the significant increase in the number of forward citations identified in this study is due to the learning effect of patent litigation instead of the announcement effect.

Chapter 7 Conclusion, implication and future research

7.1 Conclusion

I empirically analyze some issues on firms' patent litigation risk assessment from the perspective of patentees in this dissertation. I focus on the probability of patent litigation and the stakes of patent litigation in this dissertation. The findings will help patentees to evaluate the magnitude of their patent litigation risks. Chapters 3 and 4 comparatively study patent infringement suits among the US, Japan, and China at the patent level. Chapters 5 and 6 study Japanese patent infringement suits at the firm level.

Chapters 3 makes a comparative study of the effects of different aspects of the value of a litigated patent on its patent damage award in the US, Japan, and China. The regression results show that court judges in the three countries and juries in the US attach importance to different aspects of patent value when deciding patent infringement awards. The technological importance of a litigated patent positively impacts its patent damage award in Japan but not in the US and China. In contrast, the private economic value for the patentee and patent scope of a litigated patent positively impacts its patent damage award in China and those ruled on by US judges. In addition, none of the three aspects of patent value has a significant impact on patent damage awards ruled by US juries.

Chapter 4 compares the characteristics of patent litigation among the US, Japan, and China at the patent level. The effects of three new characteristics of patents on the probability of litigation are examined in this study for the first time. I find that the number of words or nouns in the independent claim and assertion of domestic priority impact the probability of litigation for a given patent negatively and positively, respectively. This happens in all the three countries, though the robustness of the results is not so good in the US and Japan. Besides, the number of inventors negatively impacts the probability of litigation for a given patent, and this finding has good robustness in all the three countries. Moreover, I examine whether some previously examined patent characteristics have the same effects on the probability of litigation in Japan and China.

Several common characteristics of litigated patents are found across the three countries. First, patents of higher value (i.e., family size and/or forward citations) are significantly more likely to be litigated than those of lower value. Second, patents issued to domestic individuals have a higher probability to be litigated than those issued to domestic firms. Third, patents issued to domestic business entities are more likely to be litigated than those issued to foreign business entities. However, the effect of the number of claims on the probability of litigation is complex across countries: it is significantly positive in the US, significantly negative in Japan, and insignificant in China. The effect of the number of 4-digit IPC subclasses is significantly negative in the US but insignificant though still negative in Japan and China.

Chapter 5 takes Japan as an example to examine whether the characteristics of patent portfolios can be used to predict patent litigation at the firm level. High consistency is found between the characteristics of patent litigation at the firm level and those at the patent level. First, the number of claims has a significantly negative impact on the probability of litigation both at the patent level and at the firm level. Second, firms with valuable patents are more likely to litigate their patents. Third, the number of backward citations has a significantly positive impact on the probability of litigation both at the patent level and at the firm level, though the latter does not have a good robustness. Fourth, domestic small business entities are more likely to be involved in patent litigation than domestic big entities and foreign business entities. However, unlike their correspondent variables at the patent level, the three newly tested characteristics－the average number of words in the first independent claim, the ratio of patents asserting domestic priority, and the average number of inventors－are not found to have a significant effect on the probability of litigation at the firm level.

Chapter 6 examines the effect of patent litigation on plaintiff SMEs' subsequent patenting behaviors. I find that number of patent applications of plaintiff SMEs decreases significantly from the first or second year to the third year after litigation. This negative effect is even more significant for patent litigation with extremely high costs. The most plausible explanation for this phenomenon is that the high costs of patent litigation have a significantly negative effect on the plaintiff SME's regular R&D investment in terms of both money and labor. In addition, the number of forward citations received by the patents applied for subsequently after litigation increases significantly from the first year to the fourth year after litigation. One plausible explanation is that plaintiff SMEs realized the importance of patent quality and learned to apply for strong patents during the period of patent litigation. However, this learning effect does not last long and plaintiff SMEs tend to return to their original patenting strategy in the fifth year after patent litigation.

7.2 Academic contribution

This dissertation is the first academic challenge of making an empirical comparison between patent litigation in China and those in other countries. Chapter 3 analyzes the correlation between patent damage awards and three most well established patent indicators. The findings contribute to the literature on patent valuation. To the best of my knowledge, this is the first attempt in Japan and China. Chapter 4 firstly examines the applicability of the effect of patent characteristics on the probability of litigation in Japan and China and identifies three new determinants of patent litigation. Furthermore, Chapter 5 provides a first attempt to identify characteristics of patent litigation at the firm level. The findings contribute to the theories on prediction models of patent litigation. Chapter 6 provides the first attempt to study the externality (i.e., learning effect) of patent litigation.

7.3 Practical Implications

7.3.1 Implication for Industries

As noted above, patent litigation risk management is becoming an increasingly important issue for business entities. The findings in this dissertation help patentees to assess the magnitude of their patent litigation risks and decide measures to treat them.

Considering the high costs of patent litigation, a pretrial settlement is usually a better choice for two parties involved in patent disputes. However, in many cases, a pretrial settlement is not reached because of two parties' divergence in the expectation of outcomes of litigation. Therefore, identification of the determinants of patent damage awards in Chapter 3 will help the parties of a patent dispute have a similar expectation of the stakes of a patent litigation and make them more likely to reach a pretrial settlement.

Identification of the characteristics of patent litigation in Chapters 4 and 5 will help patentees to distinguish the patents of a higher probability of litigation from those of lower probability of litigation and evaluate their patent litigation risks more precisely. This will help patentees make a better budget and resource allocation for patent litigation risk management. For example, knowing patents of a higher probability of litigation, patentees can allocate more labor and budget to the detection of infringement for these patents and even purchase patent litigation insurance for them if necessary.

Moreover, the identification of characteristics of litigated patents and patent litigants will also promote the development of the patent insurance industry. Although patent litigation insurance has been available as an alternative solution to patent litigation risk since the early 1980s in the US, Japan, and Europe, very few patentees choose to purchase this kind of insurance (Chien, 2011; Duchêne, 2015). One of the most important reasons is the problem of adverse selection. Unable to assess patent litigation risk of a given patent or a given patentee, insurance companies must increase premiums and limit coverage. This hinders most of the patentees, especially individuals and small and medium enterprises, from taking advantage of patent litigation insurance. Without enough users of patent litigation insurance, insurance companies cannot spread the risk. This prevents insurance companies from decreasing the premiums and providing broader coverage. The findings on the characteristics of litigated patents and litigating patentees help insurance companies to overcome the problem of adverse selection that has stunted the development of the patent insurance industry.

Besides, in view of their weak financial capacity, patent litigation is riskier for SMEs than their larger counterparts. Therefore, it is important for SMEs to know the effects of patent litigation on their business activities. The findings in this study show that patent litigation negatively affects SMEs' R&D activities during the trial period, but there is a learning effect for SMEs to learn to apply for patents with more enforceability. However, the learning effect does not last long due to lack of in-house IP experts. Therefore, this study warns that if SMEs want to protect their invention by patent right, it is important for them to cultivate internal IP experts or even to establish an IP department if the financial condition permits.

7.3.2 Implication for Policy Making

This dissertation reveals that judges in different countries in the US attach weight to different aspects of the value of the litigated patents when deciding patent damages. From the perspective of patentees, patent damage awards should always reflect the private economic value of the litigated patent for the patentee. Since the technological importance of a patent does not always correlate with its private economic value, the courts in Japan should attach more weight toward the private economic value of a litigated patent for its patentee rather than merely toward its technological importance.

Moreover, this study finds that patent damage awards ruled by US juries reflected none of the three aspects of the value of litigated patents in question and are significantly unpredictable compared with those ruled by US judges. This result recalls the question about whether patent juries are qualified to hear patent cases, especially complex ones. This finding provides empirical evidence of juries' incompetence to hear patent cases.

Furthermore, this study confirms the prior finding that that SMEs are at a greater risk of being involved in patent litigation as a patent litigant than their large counterparts (Lanjouw and Schankerman, 2004; Cremers, 2004). Besides, patent litigation is also found to impose such a major burden on plaintiff SMEs that their R&D activities are negatively affected. All these findings warn that the patent system does not function well for SMEs (Kingston, 2004). As SMEs play an important role in the development of any economy in the world, it is essential for policymakers to improve the circumstances for SMEs to appropriate their innovations through patent rights.

7.4 Limitations and Future Research

Although the analyses in Chapter 3 find the evidence that courts in the US, Japan, and China attach different weights to the three aspects of patent value when deciding patent damage awards, the effects of these differences are not analyzed. Future research should be conducted to clarify whether the effects of these different patent damage award systems affects firms' R&D investment and patentees' confidence in patent systems.

As noted in Section 1.6.3, three IP courts were established in China in 2014, and Chinese Patent Law is also undergoing the fourth amendment. All these institutional reforms indicate that patent protection is being strengthened in China recently. It will be interesting to further analyze the impact of these reforms in China.

References

Ahuja, G., & Katila, R. (2001). Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. *Strategic management journal, 22*(3), 197-220.

Albert, M. B., Avery, D., Narin, F., & McAllister, P. (1991). Direct validation of citation counts as indicators of industrially important patents. *Research policy, 20*(3), 251-259.

Allison, J. R., Lemley, M. A., Moore, K. A., & Trunkey, R. D. (2003). Valuable patents. *Geo. Lj, 92*, 435.

Allison, J. R., Lemley, M. A., & Walker, J. H. (2009). Extreme Value or Trolls on Top? The Characteristics of the Most Litigated Patents.

Bai, J. B., Wang, P. J., & Cheng, H. (2006). What multinational companies need to know about patent invalidation and patent litigation in China. *Nw. J. Tech. & Intell. Prop., 5*, 449.

Bender, G. A. (2000). Uncertainty and Unpredictability in Patent Litigation: The Time Is Ripe for a Consistent Claim Construction Methodology. *J. Intell. Prop. L., 8*, 175.

Bessen, J. E., & Meurer, M. J. (2005). The patent litigation explosion.

Bessen, J. E., & Meurer, M. J. (2008). The private costs of patent litigation.

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

Buzzacchi, L., & Scellato, G. (2008). Patent litigation insurance and R&D incentives. *International Review of Law and Economics, 28*(4), 272-286.

Burrone, E. (2005). Intellectual property rights and innovation in SMEs in OECD countries.

Czarnitzki, D., Hussinger, K., & Schneider, C. (2011). “Wacky” patents meet economic indicators. *Economics Letters*, 113(2), 131-134.

Chien, C. V. (2009). Of Trolls, Davids, Goliaths, and Kings: narratives and evidence in the litigation of high-tech patents.

Chien, C. V. (2011). Predicting patent litigation. *Tex. L. Rev., 90*, 283.

Choi, J. P. (2010). Patent pools and cross-licensing in the shadow of patent litigation. *International Economic Review, 51*(2), 441-460.

Choi, J. P. (1998). Patent litigation as an information-transmission mechanism. *American Economic Review*, 1249-1263.

Cotter, T. F. (2008). Patent holdup, patent remedies, and antitrust responses.

Cotter, T. F. (2010). Four Principles for Calculating Reasonable Royalties in Patent Infringement Litigation. *Santa Clara Computer & High Tech. LJ, 27*, 725.

Cox, A. J., & Sepetys, K. (2009). Intellectual property rights protection in China: Trends in litigation and economic damages.

Cotter, T. F. (2013). *Comparative Patent Remedies: A Legal and Economic Analysis*. Oxford University Press.

Cremers, K. (2004). Determinants of patent litigation in Germany.

Dang, J., & Motohashi, K. (2015). Patent statistics: A good indicator for innovation in China? Patent subsidy program impacts on patent quality. *China Economic Review, 35*, 137-155.

Duchêne, A. (2015). Patent Litigation Insurance. *Journal of Risk and Insurance*.

Durie, D. J., & Lemley, M. A. (2010). A Structured Approach to Calculating Reasonable Royalties. *Lewis & Clark L. Rev., 14*, 627.

Elhauge, E. (2008). Do patent holdup and royalty stacking lead to systematically excessive royalties?. *Journal of Competition Law and Economics, 4*(3), 535-570.

Ernst, H. (2001). Patent applications and subsequent changes of performance: evidence from time-series cross-section analyses on the firm level. *Research Policy, 30*(1), 143-157.

Frank Jr, R. S., & DeFranco, D. W. (2000). Patent infringement damages: a brief summary. *Fed. Cir. BJ, 10*, 281.

Golden, J. M. (2006). Patent trolls and patent remedies. *Tex. L. Rev., 85*, 2111.

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

Hall, B. H., Jaffe, A. B., & Trajtenberg, M. (2000). *Market value and patent citations: A first look* (No. w7741). National bureau of economic research.

Hall, B. H., Jaffe, A. B., & Trajtenberg, M. (2001). *The NBER patent citation data file: Lessons, insights and methodological tools* (No. w8498). National Bureau of Economic Research.

Hall, B. H., Graham, S., Harhoff, D., & Mowery, D. C. (2004). Prospects for improving US patent quality via post-grant opposition. *Innovation policy and the economy, 4*, 115-143.

Hall, B. H., Jaffe, A., & Trajtenberg, M. (2005). Market value and patent citations. *RAND Journal of economics*, 16-38.

Harhoff, D., Narin, F., Scherer, F. M., & Vopel, K. (1999). Citation frequency and the value of patented inventions. *Review of Economics and statistics, 81*(3), 511-515.

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

Harhoff, D., & Reitzig, M. (2004). Determinants of opposition against EPO patent grants-the case of biotechnology and pharmaceuticals. *International journal of industrial organization, 22*(4), 443-480.

Harhoff, D. (2009). Challenges affecting the use and enforcement of intellectual property rights. *The Economic Value of Intellectual Property: An Agenda for Policy-Relevant Research.*

Henry, M. D. (2013). The Market Effects of Patent Litigation. *Technology and Investment,* *4,* 57-68

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

Hu, J. (2016). Determining Damages for Patent Infringement in China. *IIC-International Review of Intellectual Property and Competition Law*, 47(1), 5-27.

Keeley, M. C. (1999). *Estimating damages in patent infringement cases: an economic perspective*. Cornerstone Research.

Lai, Y. H., & Che, H. C. (2009a). Evaluating patents using damage awards of infringement lawsuits: A case study. *Journal of engineering and technology management, 26*(3), 167-180.

Lai, Y. H., & Che, H. C. (2009b). Modeling patent legal value by Extension Neural Network. *Expert Systems with Applications, 36*(7), 10520-10528.

Lanjouw, J. O., Pakes, A., & Putnam, J. (1998). How to count patents and value intellectual property: The uses of patent renewal and application data. *The Journal of Industrial Economics, 46*(4), 405-432.

Lanjouw, J. O. (1998). Patent protection in the shadow of infringement: Simulation estimations of patent value. *The Review of Economic Studies, 65*(4), 671-710.

Lanjouw, J. O., & Schankerman, M. (1999). *The quality of ideas: measuring innovation with multiple indicators* (No. w7345). National bureau of economic research.

Lanjouw, J. O., & Lerner, J. (2000). The enforcement of intellectual property rights: a survey of the empirical literature. In *The Economics and Econometrics of Innovation* (pp. 201-224). Springer US.

Lanjouw, J. O., & Schankerman, M. (2001). Characteristics of patent litigation: a window on competition. *RAND journal of economics*, 129-151.

Lanjouw, J. O., & Schankerman, M. (2004). Patent quality and research productivity:

Measuring innovation with multiple indicators. *The Economic Journal, 114*(495), 441-465.

Lerner, J. (1994). The importance of patent scope: an empirical analysis. *The RAND Journal of Economics*, 319-333.

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

Lemley, M. A. (2009). Distinguishing Lost Profits from Reasonable Royalties. *Wm. & Mary L. Rev., 51*, 655.

Lemley, M. A., & Shapiro, C. (2006). Patent holdup and royalty stacking. *Tex. L. Rev., 85*, 1991.

Levitt, B., & March, J. G. (1988). Organizational learning. *Annual review of sociology, 14*(1), 319-338.

Li, L. M. (2015). Research on the subject nature and industrial characteristics of statutory compensation in patent infringement. *Modern Law Science, 37*(4), 170-183

Li, X. (2012). Behind the recent surge of Chinese patenting: An institutional view. *Research Policy, 41*(1), 236-249.

Love, B. J. (2007). Patentee overcompensation and the entire market value rule. *Stanford Law Review*, 263-294.

Love, B. J. (2009). The Misuse of Reasonable Royalty Damages as a Patent Infringement Deterrent. *Mo. L. Rev., 74*, 909.

Love, B. J., Helmers, C., & Eberhardt, M. (2015). Patent litigation in china: Protecting rights or the local economy. *Vand. J. Ent. & Tech. L., 18*, 713.

Malackowski, J. E., & Barney, J. A. (2008). What Is Patent Quality--A Merchant Banc's Perspective. *Nouvelles-Journal of the Licensing Executives Society, 43*(2), 123.

Martínez, C. (2011). Patent families: when do different definitions really matter?. *Scientometrics*, 86(1), 39-63.

Marco, A. C. (2005a). The Value of Certainty in Intellectual Property Rights: Stock Market Reactions to Patent Litigation.

Marco, A. C. (2005b). The option value of patent litigation: Theory and evidence. *Review of Financial Economics*, 14(3), 323-351.

Matsuda K.. (2005). The Handing of Technical Issues by Courts in Patent Litigation. *Patent Studies, (40)*, 9-35.

Mazzeo, M. J., Hillel, J., & Zyontz, S. (2013). Explaining the "unpredictable": An empirical analysis of US patent damage awards. *International Review of Law and Economics, 35*, 58-72.

Moore, K. A. (2002). Juries, Patent Cases & a Lack of Transparency. *Hous. L. Rev., 39*, 779.

Moore, K. A. (2000). Judges, Juries, and Patent Cases: An Empirical Peek Inside the Black Box. *Michigan Law Review, 99*(2), 365-409.

Miller, J. F. (2004). Should Juries Hear Complex Patent Cases?. *Duke L. & Tech. Rev., 2004*, 4-15.

Meeks, M. T., & Eldering, C. A. (2010). Patent Valuation: Aren't I Forgetting Something-Making the Case for Claims Analysis in Patent Valuation by Proposing a Patent Valuation Method and a Patent-Specific Discount Rate Using the CAPM. *Nw. J. Tech. & Intell. Prop.*, 9, 194.

Nagaoka, S., Motohashi, K., & Goto, A. (2010). Patent statistics as an innovation indicator. *Handbook of the Economics of Innovation, 2*, 1083-1127.

Nagaoka, S., & Owan, H. (2011). *Exploring the Sources of Firm-level Scale Economies in R&D: Complementary assets, internal and external knowledge inflows, and inventor team size* (No. 11-E, p. 038). RIETI Discussion Paper Series.

Nam, S., Nam, C., & Kim, S. (2015). The impact of patent litigation on shareholder value in the smartphone industry. *Technological Forecasting and Social Change, 95*, 182-190.

OECD. 2006. Triadic patent families dataset. OECD, January 2006

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

Opderbeck, D. W. (2009). Patent Damages Reform and the Shape of Patent Law. *BUL Rev., 89*, 127.

Osenga, K. (2012). Get the Balance Right: Squaring Access with Patent Protection. *Pac. McGeorge Global Bus. & Dev. LJ, 25*, 309.

Raghu, T. S., Woo, W., Mohan, S. B., & Rao, H. R. (2008). Market reaction to patent infringement litigations in the information technology industry. *Information Systems Frontiers, 10*(1), 61-75.

Reitzig, M. (2003). What determines patent value?: Insights from the semiconductor industry. *Research Policy, 32*(1), 13-26.

Reitzig, M. (2003). What do patent indicators really measure? A structural test of 'novelty'and 'inventive step'as determinants of patent profitability. *Research Policy, 33*(6-7), 939-957.

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

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

Pakes, A., Simpson, M., Judd, K., & Mansfield, E. (1989). Patent renewal data. Brookings papers on economic activity. *Microeconomics, 1989*, 331-410.

Putnam, J. D. (1996). *The value of international patent rights.* Yale: Yale University.

Schliessler, P. M. (2015). Patent litigation and firm performance The role of the enforcement system. *Industrial and Corporate Change*, dtv001.

Shane, S., & Somaya, D. (2007). The effects of patent litigation on university licensing efforts. *Journal of Economic Behavior & Organization, 63*(4), 739-755.

Simensky, M., & Osterberg, E. C. (1999). Insurance and Management of Intellectual Property Risks, THe. *Cardozo Arts & Ent. LJ*, *17*, 321.

Sidak, J. G. (2007). Holdup, royalty stacking, and the presumption of injunctive relief for patent infringement: A reply to Lemley and Shapiro. *Minn. L. Rev., 92*, 714.

Signore, P. (2001). On the Role of Juries in Patent Litigation (Part 1). *J. Pat. & Trademark Off. Soc'y, 83*, 791.

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

Takenaka, T. (2000). Patent infringement damages in Japan and the United States: Will increased patent infringement damage awards revive the Japanese economy. *Wash. UJL & Pol'y*, *2*, 309.

Taylor, D. O. (2014). Using Reasonable Royalties to Value Patented Technology. *Ga. L. Rev., 49*, 79.

Trajtenberg, M., Henderson, R., & Jaffe, A. (1997). University versus corporate patents: A window on the basicness of invention. *Economics of Innovation and new technology, 5*(1), 19-50.

Trajtenberg, M. (1990). *A penny for ythe quotes: patent citations and the value of innovations*. The Rand Journal of Economics, 172-187.

Tucker, C. E. (2014). The effect of patent litigation and patent assertion entities on entrepreneurial activity.

Watanabe. T., Yoneyama, S. (2004). "Chizai Manegement Nyumon" (Introduction of Intellectual Property Management). Nikkei Business Publications

Weatherall, K., & Webster, E. (2014). Patent enforcement: a review of the literature. *Journal of Economic Surveys, 28*(2), 312-343.

Wilson, B. S. (1997). Patent Invalidity and the Seventh Amendment: Is the Jury Out. S*an Diego L. Rev., 34*, 1787.

Xiaowu, L. I. (2015). On Abolishment of Statutory Damages in Chinese Patent Law.

Yamada,S. (2010). “Shinsa kan inyou ha jyuuyou ka”(Is citations by patent examiners important).“*Keizai Kenkyu*”(Economics Study),61(3), 203-213.

Yamaguchi. W. and Nagano E. (2015). “Data kara miru nihon niokeru tokkyo singai sosyou no genjyou”(Observation of the reality of patent infringement litigation in Japan from data).“Soei-Voice”

Yang, D., & Clarke, P. (2005). Globalisation and intellectual property in China. *Technovation, 25*(5), 545-555.

Appendices

Appendix 1. Correlations between variables in the dataset ruled by US judges in Chapter 3

	1	2	3	4	5	6	7	8	9
1.Log_patent damages	1								
2.Forward citations	0.149	1							
3.Family size	0.131	0.455^{**}	1						
4.4-digit IPC codes	0.117	0.123	-0.023	1					
5.9-digit IPC codes	0.006	0.175^{*}	-0.130	0.644^{**}	1				
6.Age of litigated patent	0.191^{*}	0.109	-0.070	0.081	0.093	1			
7.Number of claims	0.151	0.284^{**}	0.209^{*}	0.023	-0.020	-0.140	1		
8.Plaintiff's lawyers etc.	0.457^{**}	0.271^{**}	0.269^{**}	-0.025	-0.130	-0.135	0.286^{**}	1	
9.Defendant's lawyers etc.	0.388^{**}	0.359^{**}	0.368^{**}	-0.099	-0.170^{*}	-0.235^{**}	0.267^{**}	0.644^{**}	1

** $p < 0.01$, * $p < 0.05$

Appendix 2. Correlations between variables in the dataset ruled by US juries in Chapter 3

	1	2	3	4	5	6	7	8	9
1.Log_patent damages	1								
2.Forward citations	0.198	1							
3.Family size	0.214^{*}	0.156	1						
4.4-digit IPC codes	-0.035	0.088	0.263^{**}	1					
5.9-digit IPC codes	-0.072	0.107	0.227^{*}	0.840^{**}	1				
6.Age of litigated patent	0.114	0.045	-0.052	-0.092	-0.096	1			
7.Number of claims	0.126	0.221^{*}	0.111	0.179	0.174	-0.201^{*}	1		
8.Plaintiff's lawyers etc.	0.293^{**}	0.110	0.040	-0.176	-0.091	0.002	0.041	1	
9.Defendant's lawyers etc.	0.281^{**}	0.012	0.233*	-0.058	-0.016	-0.081	0.018	0.596^{**}	1

** $p < 0.01$, * $p < 0.05$

Appendix 3. Descriptive statistics of variables in the dataset in Japan in Chapter 3

	Minimum	Mean	Maximum	STD.	Observations
Forward citations	0	20.569	2.596	3.404	131
Family size	1	19	3.115	3.737	131
4-digit IPC codes	1	6	1.557	0.824	131
9-digit IPC codes	1	12	2.359	1.954	131
Age of the litigated patent	0	26	11.069	6.079	131
Number of claims	1	33	4.359	4.975	131
Plaintiff's lawyers	0	11	2.771	1.987	131
Plaintiff's patent attorneys	0	7	1.313	1.259	131
Defendant 's lawyers	0	12	2.733	2.176	131
Defendant's patent attorneys	0	5	1.290	1.154	131

Appendix 4. Descriptive statistics of variables in the dataset in China in Chapter 3

	Minimum	Mean	Maximum	STD.	Observations
Forward citations	1	40	4.929	6.479	507
Family size	1	4	1.489	0.794	507
4-digit IPC codes	1	14	2.108	1.529	507
9-digit IPC codes	2	22	8.093	4.102	507
Age of the litigated patent	1	117	12.154	14.260	507
Number of claims	0	3	0.968	0.848	507
Plaintiff's lawyers	0	3	0.138	0.436	507
Plaintiff's patent attorneys	0	4	0.874	0.904	507
Defendant 's lawyers	0	2	0.089	0.311	507
Defendant's patent attorneys	1	40	4.929	6.479	507

Appendix 5. Descriptive statistics of variables in the dataset ruled by US judges in Chapter 3

	Minimum	Mean	Maximum	STD.	Observations
Forward citations	0	32.267	3.882	4.896	145
Family size	1	36	6.648	6.719	145
4-digit IPC codes	1	4	1.255	0.537	145
9-digit IPC codes	1	6	1.648	1.004	145
Age of litigated patent	0	22	8.372	4.975	145
Number of claims	1	176	23.655	24.442	145
Plaintiff's lawyers&attorneys	0	18	5.166	3.757	145
Defendant's lawyers&attorneys	0	17	5.407	4.166	145

Appendix 6. Descriptive statistics of variables in the dataset ruled by US juries in Chapter 3

	Minimum	Mean	Maximum	STD.	Observations
Forward citations	0.069	18.823	3.006	3.647	97
Family size	1	38	6.258	7.121	97
4-digit IPC codes	1	3	1.124	0.361	97
9-digit IPC codes	1	4	1.216	0.563	97
Age of litigated patent	1	20	8.887	4.566	97
Number of claims	3	89	22.072	17.298	97
Plaintiff's lawyers&attorneys	0	20	5.309	3.551	97
Defendant's lawyers&attorneys	0	18	6.258	4.050	97

Acknowledgement

I gratefully acknowledge the guidance of my instructor, Prof. Toshiya Watanabe. During the period of my doctoral course, Prof. Watanabe not only gave me many valuable instructions and suggestions on my research but also supported my life greatly.

I am grateful for the financial support provided by the Japan Society for the Promotion of Science (JSPS). Owing to this financial support, I managed to concentrate on my research and minimize external stresses.

I would express my gratefulness to my senior, Tohru Yoshioka-Kobayashi, for his valuable advice on the research design and insightful comments on the interpretation of the regression results. Besides, he also told me so much about Japanese culture to help me adapt to Japanese society. Moreover, I also want to thank Maho Furuya, who gave me much encouragement during my doctoral course and helped me to understand the differences in patent systems across countries. I also would like to thank other members in Watanabe Laboratory for their comments and encouragement during lab seminars and daily life.

I am also grateful to Toshifumi Futamata and Nobuaki Kimura for their precious comments based on their practical experience. Moreover, I would like to thank Liming Li for his helpful comments about data and model specification. I also want to say thanks to Jianwei Dang and Haiyu Mao for their helpful advice and comments.

I appreciate the valuable comments from many scholars from all over the world when I presented an earlier version of my studies in several international conferences. Among them, I would like to thank Prof. Masafumi Suzuki, Prof. Alan C. Marco, and Prof. Yann Ménière for their precious comments in Asia Pacific Innovation Conference 2016.

Finally, I would express my gratefulness to the committee examiners of this dissertation, Prof.Toshiya Watanabe, Prof. Ichiro Sakata, Prof. Kazuro Kageyama, Prof. Masahiro Hashimoto, and Prof. Haibo Liu, for their precious comments in the committee examination. These comments helped me refine this dissertation greatly.