Patent Licensing and Patent Litigation: an Empirical Study of Panel Data from Provinces of Mainland China

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Abstract. In recent years, patent litigation has evolved from simply being a traditional means of intellectual property protection to becoming a new tool used in competition. This transformation has had a profound impact on patent implementation and industrialization. In this study, the process of submission, trial and judgment of patent litigation is analysed; the characteristics involved in patent litigation are also extracted. Taking Chinese provincial panel data as the research sample, a regression model of litigation characteristics and patent licensing is constructed by analyzing the characteristic fields of patent litigation. The results show that the numbers of trials and compensation awards of patent litigations have a significant negative influence on patent licensing in China. Regional differences exist in the influence of patent litigation characteristics on patent licensing. Compared with China's western region, the above litigation characteristics have a more significant impact on patent licensing in eastern and central regions. This means that reducing the numbers of trials and decreasing compensation awards of patent litigations will help to promote patent licensing in China.

Keywords: Patent litigation; Patent licensing; Litigation characteristics; Panel data

1 Introduction

In recent years, patent litigation has shown a trend of rapid growth in major economies around the world. A large number of patent lawsuits have been deliberately initiated as a way to seek economic benefits, even without regard for questions of actual infringement [1]. At the same time, patent licensing, as an important way to apply inventions and realize patent industrialization, has been in a difficult situation that seriously restricts the improvement of product quality. China provides an illustrative example. Although China has risen to first place globally in patent applications in the last five years, the patent license implementation rate only accounted for 2% of the authorized patents [2]. The large number of patent lawsuits and infringement disputes have challenged the original intention of the patent system to promote innovation and seriously interfered with the patent licensing and industrialization of enterprises [3]. Faced with the rapid growth of patent litigation and the inefficiency of patent licensing, it is necessary to conduct in-depth research to reveal the impact of patent litigation on licensing, so as to provide theoretical support and a basis for decision-making to improve the efficiency of patent licensing in China.

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2 Literature review

In recent years, patent litigation has become not only a means of protecting intellectual property rights but also a strategic competitive tool and a means of making a profit. Blind et al. showed that enterprises regard patents as a tool of competition and profit. They continuously expand their patent portfolio through strategic patent application, so as to hinder competitors and increase their negotiating power [4]. Yuan Xiaodong et al. pointed out that in order to prevent others from using their patents without permission, the patentee obtains interests and competitive advantages through patent litigation [5]. Macdonald states that the excessive exploitation of patent value by enterprises is separating technology patents from technological innovation [6]. Shaver posits that enterprises actively carry out patent competition in order to obtain patents, and patent competition has gradually turned into patent litigation in recent years, hindering the subsequent innovation process [7]. Li Liming and Liu Haibo pointed out that in response to lawsuits, enterprises applied for a large number of patents, leading to the saturation of patents in some industries [8].

The emergence of patent litigation has occurred in the context of the explosive growth in the number of patents, and the overlapping and nesting of a large number of patents has increased the risk of patent infringement and litigation [9]. The rapid growth of patent applications began in the United States in the 1990s. The decline in the quality of patent examination and the expansion of patentable fields reduced the difficulty of applying for a patent [10]. With the enhancement of the implementation of "pro-patent" policy and the acceleration of the pace of technological integration, a large number of patent lawsuits have occurred in industries with the characteristics of a patent jungle [11]. It is possible for applicants to apply for a series of patents on the same principle through subtle changes in language [12]. A large number of peripheral patents will induce more patent applications, aggravate the pressure of patent examination, and bring troubles to patent management [13]. With the increase in the patent examination workload and the lack of time to retrieve existing technology, examiners tend to grant patents, leading to the generation of low-quality patents [14]. Patent litigation in the United States has increased dramatically in the past decade, as a large number of low-quality junk patents has led to malicious patent litigation [1].

With patent litigation's rapid growth, its impact on technological innovation has become increasingly prominent. Patent litigation increases the business cost of technology developers, reduces the technology investment income of enterprises, and weakens the incentive for innovation [15]. Smeets developed a model to predict the degree of innovation decline incurred by patent litigation, and studies have shown that patent litigation has a significant negative impact on a firm's R&D intensity [16]. Mezzanotti stated that patent litigation reduces innovation investment by reducing R&D returns, exacerbating financing constraints, and thus impeding enterprise technological innovation [17]. Cohen's research showed that patent litigation has a negative impact on the technological innovation of the target enterprise [18]. Once an enterprise is subjected to patent litigation, loss of the lawsuit not only means a high claim but also has a negative impact on the corporation's image and business development. Enterprises' innovation activities and normal operation will be seriously disturbed during this period [19].

The relationship between patent litigation, patent licensing, and subsequent industrialization has become a subject of research interest in recent years. Although patent litigation can be settled

out of court, the huge patent licensing fee also hinders the technological innovation of enterprises [20]. Siebert and Graevenitz showed that patent licensing is helpful for enterprises to solve the problem of patent blocking [9]. Shapiro believes that cross-licensing between patentees is an effective way to deal with the patent jungle [21]. Hargreaves proposed that patent litigation and disputes can be dealt with from the aspects of cross-licensing, patent pool, and disclosure of technical standards [22]. Tekic and Kukolj stated that unequal patent licensing prices in the patent pool will lead to patent litigation [23]. Vakili's research showed that the setting of restrictive clauses in patent pool licensing agreements is likely to lead to subsequent patent litigation problems [24].

Some scholars have tried to study the relationship between patent litigation and patent licensing for a single patent in a specific technology field. Qisu's research shows that the possibility of a patent infringement lawsuit is not only related to quality attributes such as claims and number of patents cited but also related to value attributes such as patent transactions and pledges [25]. Jeon integrated patent-related events based on the framework of real options and established a theoretical connection model of technological innovation, patent infringement, and patent litigation [26]. Fischer and Henkel took patents acquired as patent bait as research samples and identified the characteristic attributes of patents used to initiate lawsuits [27]. Zhang Kequn et al. took patent litigation as a proxy variable of patent value and studied its influencing factors in different technological development stages [28]. The research of Zhang Yurong and Yuan Chunsheng et al. on financial business method patents in the United States shows that patents with higher value or a higher degree of publicity are more likely to lead to patent lawsuits in the future [29].

In summary, patent litigation has shown a trend of rapid growth, and its influence on patent licensing and subsequent industrialization has become increasingly prominent. Relevant studies have begun to attract attention in business and academic circles, and positive research progress has been made. However, existing studies have not revealed which key patent litigation characteristics affect patent licensing and how they affect patent enforcement. Moreover, existing studies have mainly analyzed the litigation and licensing status of individual patents, and the relationship between the two has not been clarified at the national and regional levels. In addition, there is an obvious lack of relevant research based on the situation in China. Due to the regional nature of patents, there are differences in the scope of protection. For example, there are no utility model patents in the United States, but the number of utility model patents in China far exceeds that of invention patents, and some research conclusions from European and American countries are difficult to apply effectively to China. For this reason, this study taking advantage of China's accelerating technological catch-up to achieve independent innovation research opportunities, the characteristics in the process of the extraction of patent litigation proceedings are analyzed, using provincial panel data from mainland China. The licensing of the patent and patent litigation features are empirically tested, with the aim of helping to improve China's patent licensing and to provide theoretical support and a basis for decision-making.

3 Research Design

3.1 Research ideas

This study aims to explore the characteristics of patent litigation that affect patent licensing from national and regional perspectives, so as to provide decision support for policy optimization in the field of technological innovation. At present, existing studies have mainly analyzed the litigation and licensing status of individual patents, but the relationship between the two has not been fully clarified by using patent data at the national and regional levels. Therefore, in order to cope with the management challenges brought to patent licensing and industrialization by the surge in patent litigation, this paper analyzes the characteristic fields of patent litigation at the national and regional levels and uses this data as the basis to clarify the effect of patent litigation on patent licensing.

Some of the information involved in patent litigation cases is routine, such as case number, trial date, and address fields, and these will not affect the implementation of the patent license. Other contents describe the number of patent litigation cases, the amount of compensation awarded, and the duration of the trial, and these may be related to the implementation of patent licensing. For example, if there is a higher amount of damages obtained through patent litigation, the patentee may substantially increase the fee for licensing the patent, thus reducing the likelihood that the patent will be licensed. Therefore, the number of trials, the amount of compensation, and the trial time are taken as the characteristics of patent litigation.

In order to achieve the research objectives, first, based on the relevant information involved in patent litigation cases, the feature fields that may be related to patent licensing were analyzed and extracted. Then, descriptive statistics were made based on the panel data of provinces, and thermodynamic maps were drawn to intuitively analyze the differences in litigation characteristics among provinces and regions of the country. Finally, a panel data model of patent litigation characteristics and patent licensing was constructed to empirically analyze the correlation between patent litigation characteristics and patent licensing, and to reveal the key litigation characteristics closely related to patent licensing.

3.2 Research hypothesis

The number of trials, compensation amount, and trial time in patent litigation- all forms of information that may be related to patent licensing- were introduced into the regression model. The correlation between patent litigation features and patent licensing was empirically analyzed, in order to reveal the key litigation features closely related to patent licensing. In order to construct a regression model of patent litigation characteristics and patent licensing, the following hypotheses are proposed.

Hypothesis H1: The more patents are litigated, the fewer patents will be licensed.

As technology patents become an important competitive tool for enterprises, the patentee can obtain economic benefits or competitive advantages through patent litigation or patent licensing. In the process of patent management and operation, if an enterprise has a patent dispute and chooses to settle it through patent litigation, the number of patent licenses will be reduced accordingly. In addition, due to the highly uncertain outcome of patent litigation, litigants tend to

use limited resources to find favorable litigation conditions [30]. The higher the number of patent lawsuits, the higher the cost of silence and conversion, and this may also reduce the likelihood that either party will eventually license the patent.

Hypothesis H2: The longer a patent lawsuit is at trial, the fewer patents will be licensed.

Trial time refers to the period from the acceptance of a patent case to the end of the case. The trial of patent litigation is based on the scope of protection determined in the patent claims. Lemley's research shows that the applicant may apply for a patent with broad claims by constantly modifying or adding new claims or technical elements, so as to expand the scope of protection [31]. The longer the trial time, the more disputes the litigants will have about the scope of patent protection, which also increases the threshold and difficulty of out-of-court settlement through patent licensing and other means. Therefore, the more questions or objections a patent raises, the longer the trial will take and the more difficult it will be for the patentee to license the patent in the future.

Hypothesis H3: The more damages the patentee receives, the fewer patents will be licensed.

The higher the amount of compensation the patentee can obtain through patent litigation, the more likely it is that one of two effects will occur. On the one hand, the patentee may be encouraged to file more patent litigation in the future to seek more economic benefits and competitive advantages; this will reduce the possibility of patent licensing. On the other hand, although some patent lawsuits can be settled out of court through patent licensing, the higher the compensation the patentee obtains through patent litigation, the higher the patent licensing fee is likely to be. Faced with the uncertainty of patent litigation and huge patent licensing fees, the defendant may be forced to respond to litigation, which will reduce the possibility of patent licensing.

3.3 Model selection

In order to verify the above research hypotheses, it was necessary to select an appropriate regression model. A panel data model is a kind of econometric model that analyzes the relationship between variables and predicts changing trends in those variables by using mixed data. The model can reflect the variation law of the research object in two directions of time and section unit, as well as the characteristics of different time and different units. A panel data model makes comprehensive use of sample information to make the research more in-depth; such a model can also reduce the influence of multicollinearity. Mundlak was the first to establish the panel data model, which is generally expressed as follows [32]:

$$y_{it}=\alpha_i+x_{it}\beta_i+u_{it} \tag{1}$$

where x_{it} is a $1*K$ matrix representing the independent variables, β_i is a $K*1$ matrix representing the regression coefficient, K is the number of explanatory variables, and α_i is a constant term. According to the relationship between α_i and α_j, the model can be divided into a fixed intercept model and a variable intercept model. The variable intercept model is generally adopted. According to the relationship between β_i and β_j, the model can be further divided into a fixed coefficient model and a variable coefficient model. The panel data model can be further divided into a fixed-effect model and a random effect model. The criterion of differentiation lies in whether the inference is based on the individual characteristics of the sample. If the generation

of non-observed effects is an estimable parameter unique to each cross-section or individual, and the model does not change with time, it is a fixed-effect model. A random-effect model is one in which the non-observed effects are random variables, and the variables conform to a particular distribution. In summary, the following panel data model was constructed:

$$PC_{it}=\alpha_i+NJ_{it}\beta_1+DP_{it}\beta_2+WR_{it}\beta_3+CA_{it}\beta_4+u_{it} \quad (2)$$

where PC_{it} is the patent licensing of province i in year t, NJ_{it} is the number of patents litigated of province i in year t, DP_{it} is the trial time of province i in year t, CA_{it} is the compensation amount of province i in year t, α_i is a constant term, and $\beta 1$, $\beta 2$, and $\beta 3$ are the regression coefficients of independent variables NJ, DP, and CA, respectively. The above data were imported into the regression model. The constant terms and regression coefficients were obtained through statistical analysis, and significance tests were conducted to study the relationship between patent litigation characteristics and patent licensing. Thus, the impact of patent litigation on patent licensing could be revealed.

4 Empirical test and analysis

4.1 Research samples and data sources

When using a panel data model to study the impact of patent litigation characteristics on patent licensing, it is necessary to analyse the mixed data of time and cross-section. Therefore, the selection of research samples should meet the following three conditions: first, the complete time and cross-section data of patent litigation characteristics and patent licensing must be accumulated. Second, accurate and reliable patent litigation characteristics and patent licensing data can be obtained, preferably through open channels. This will improve the reliability and repeatability of the research work. Thirdly, due to the regional nature of the patent system, the selected research samples should be representative, in order to reflect the mainstream trend of the patent field. In view of the above conditions, the panel data of Chinese provinces were selected in this study as the research samples.

Chinese characteristics of patent litigation and patent license data have formed a complete time series. In recent years, the state intellectual property office, which contains the annual statistical reports of "China's Intellectual Property Rights Protection Situation", and the "Court Judicial Protection of the Intellectual Property Rights Situation in China", as well as relevant statistical data, has been closed to the public. This action has been taken on the basis of the accuracy and reliability of available data. In addition, patent databases, such as Big Data Retrieval and Analysis System of Intellectual Property (SOOIP) and China IP Litigation Analysis (CIELA), are increasingly available for research purposes. The annual number of patent applications accepted by SIPO has risen to the highest level globally. SIPO has also signed patent review highway (PPH) agreements with the United States, Germany, and the Republic of Korea to expedite the review of applications submitted in China and the above countries, which means that China's patent management can reflect the mainstream trend in this field.

Patent litigation data comes from CIELA database, which is a professional legal database website maintained by Rouse & Co. International. The case data published on the court's website were extracted, and corresponding keywords were extracted and summarized for different types

of intellectual property cases according to legal practice. Then, corresponding information was extracted from the judgments (through the legal judgments of the staff), and converted into basic data (CIELA). This study measured the number of trials of civil patent cases tried annually by courts at all levels, measured the trial time by the duration of the beginning and end of patent litigation cases, and measured the compensation amount by the annual average compensation amount of each patent litigation case.

The patent licensing data came from the Evaluation Report on China's Intellectual Property Development by the Intellectual Property Development Research Center of the State Intellectual Property Office. This report evaluates and analyzes the comprehensive development status and trends of intellectual property in China from the perspectives of creation, application, and protection of intellectual property, and grades and ranks the development status of intellectual property in all provinces, municipalities, and autonomous regions. The number of annual patent licensing contracts were selected to measure the patent licensing level. This report has been published since 2013, and reports after 2018 have not yet been made public. For this reason, this study extracts the inter-provincial panel data of patent licensing in 2017 for empirical analysis.

4.2 Descriptive statistics

In order to obtain panel data on patent litigation and licensing in China, first, CIELA's civil infringement database was selected and relevant litigation information was retrieved one-by-one, by province, based on the CIELA database. Then, the number of patent litigation trials, trial time, and compensation amount in each province were counted year by year. Due to the lack of patent litigation data in Xizang, Ningxia, and Hainan, these three regions were excluded from the research sample. Second, the number of patent licensing contracts recorded by provinces was retrieved and extracted year by year as the basic data for measuring inter-provincial patent licensing. Finally, panel data of patent litigation and patent licensing were generated and a descriptive statistical analysis was performed.

In this study, a descriptive statistical analysis of provincial patent litigation and licensing in China was conducted by drawing thermal maps. First, the function of regional map was selected based on the China map statistics graph generator. Then, the province name and the number of trials, trial time, compensation amount, and other basic data were input one by one, and the built-in program code was used to generate the thermal map of provincial patent litigation. Finally, the provincial name and relevant basic data of patent licensing were input one by one, and the built-in program code was used to generate the thermal map of provincial patent licensing.

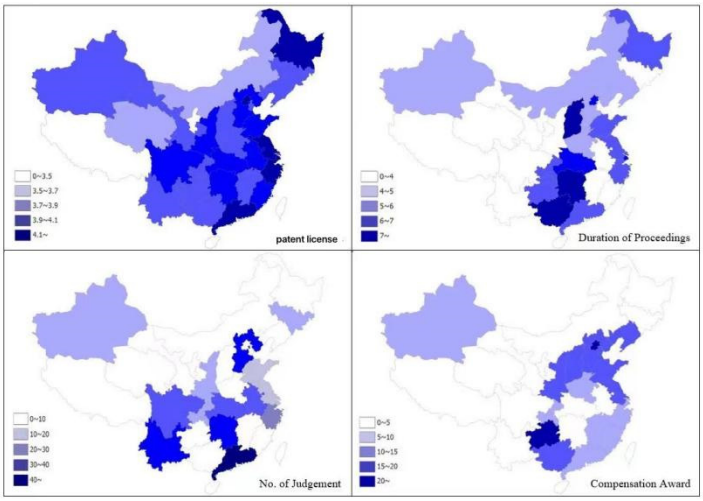

Figure 1 Thermal maps of patent licensing and patent litigation in China

Based on the above steps, this study draws Figure 1. Specifically, there were regional differences in patent licensing in China. In terms of the number of patent litigation trials, Guangdong, Zhejiang, Jiangsu, and Shanghai lead the way, followed by Beijing and Henan, while Qinghai, Inner Mongolia, Gansu, and Jiangxi lag behind. In terms of trial time, Hunan, Shanxi, Shanghai, Guangxi, and Beijing had relatively long trial times, while Shaanxi, Qinghai, Gansu, and Jilin had relatively short trial times. In terms of compensation, Beijing, Shanxi, Liaoning, Tianjin, and Shandong provinces had higher amounts, while Qinghai, Heilongjiang, Yunnan, and Hubei provinces had lower amounts.

4.3 Descriptive statistics

Taking the number of patent licenses as the dependent variable and the number of trials, trial time, and compensation amount as independent variables, the provincial panel data were imported into Eviews and pool estimation regression analysis was conducted to construct the regression model of patent litigation and patent licensing in China and its regions. Since taking the natural logarithm of variables does not change the nature and relationship of a time series and can eliminate possible heteroscedasticity, the natural logarithm was used for regression analysis of values.

The results of Table 1 show that the number of patent litigation trials and the amount of compensation have a significant negative impact on patent license in China; these relationships are significant at the confidence levels of 1% and 10%, respectively. Hypothesis H1 and H3 are thus verified. Although the regression coefficient of trial time was negative, that variable was not statistically significant and therefore failed to pass the significance test. H2 failed to pass the verification test. In addition, regional differences exist in the impact of related patent litigation characteristics on patent license. The number of cases has a significant negative impact on patent license in eastern and central China; the amount of compensation also has a significant negative impact on patent license in eastern China.

Table 1. Regression Analysis Results

	All	Eastern	Central	Western
C	4.208*** (16.701)	4.651*** (23.740)	3.479*** (13.909)	3.854*** (26.513)
Ln(NJ)	-0.054*** (-2.511)	-0.095** (-2.460)	-0.055* (-2.184)	-0.015 (-1.043)
Ln(DP)	-0.011 (-0.288)	-0.012 (-0.193)	-0.029 (-0.589)	-0.045 (-1.158)
Ln(CA)	-0.035* (-2.162)	-0.080* (-1.765)	0.019 (0.870)	-0.001 (-0.042)
R^2	0.811	0.720	0.959	0.780
Adjusted R^2	0.736	0.610	0.882	0.638
F	10.892***	6.513***	12.445***	5.468***
LR	7.574***	6.923***	9.465***	7.18***

*Note: * means significant at 10% confidence level, ** means significant at 5% confidence level, and *** means significant at 1% confidence level. The numbers in parentheses represent t values.*

On this basis, the goodness of fit of the model was tested. These findings indicate that the model estimates fit well with the observed data. The results show that the number of patent cases and the amount of compensation both have a significant negative impact on patent license in China, and again, regional differences exist. Compared with the western region, the above characteristics have a more significant impact on patent license in China's eastern and central regions.

5 Conclusion

By analyzing the process of the filing, hearing and adjudication of patent litigation in Mainland China, the characteristics of the litigation involved in the process can be extracted. Thus, the impact of patent litigation on patent license is empirically analyzed in this study. The results show that the number of patent litigation trials and the amount of compensation both have a negative impact on patent license. the number of patent litigation trials and the amount of compensation have a significant negative impact on patent license in China; these are also the key litigation features closely related to patent license. Regional differences exist in the influence of patent litigation characteristics on patent license. Compared with China's western region, the above litigation characteristics have a more significant impact on patent license in eastern and central regions.

The above research shows that patent litigation has a significant negative relationship with patent licensing. As patent litigation has become an important competitive tool and profit-making means for enterprises, patent litigation in China has increased dramatically in recent years, especially from foreign patent litigation. It can be predicted that the efficiency of patent licensing in China will be seriously disturbed in the future. For a long time, China's patent legislation has not considered the possible negative effects of patents. In the future, necessary adjustments should be made on the legal level and policy orientation In order to reduce the negative effect and potential harm of patent litigation on patent licensing, the patent examination and grant standards should be appropriately raised to curb the explosive growth of patent litigation.

This study has some limitations. For example, the research only focuses on patent litigation and patent license data in China. Although China's patent management can reflect the mainstream

trend in this field, it is necessary to include more national and regional data in future research. In addition, patent litigation features at the national and regional levels can be further expanded and refined. For example, with the improvement and upgrading of patent databases, more patent litigation features may be extracted in future research.

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