Does patent litigation promote patent quality?

An empirical study on interprovincial panel data of China mainland

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Abstract. In recent years, patent litigation has evolved from a traditional means of intellectual property protection to a new tool of competition, which has a profound impact on the pattern of technological innovation and industrial competition. The process of submission, trial and judgment of patent litigation is analyzed, and characteristics of litigation trials are extracted. The interprovincial panel data from mainland China is employed to empirically analyzed the impact of patent litigation on patent quality. The results show that number of trials, win rates and compensation awards of patent litigations have significant positive influence on patent quality in China, and they are key litigation features closely related to patent quality. There are regional differences in the influence of patent litigation features on patent quality. Compared with the western region, the above litigation characteristics have a more significant impact on patent quality in eastern and central region.

Keywords: patent quality; patent litigation; litigation characteristic; panel data; patent protection

1 Introduction

As one of the world's largest manufacturers of patent, China is in urgent need to transform enterprise innovation from quantitative growth to quality improvement. As a means of intellectual property protection, patent litigation shows a rapid growth trend in recent years, and gradually evolves from a traditional means of intellectual property protection to a new competitive tool. Patent litigation is not only a competitive tool for leading enterprises to compete with each other, but also an important means to restrain catch-up enterprises [1]. Existing studies have shown that patent litigation is conducive to seeking economic interests or competitive advantages, which makes the patentee keen on obtaining patents and initiating lawsuits [2]. Whether patent litigation promotes the improvement of patent quality while promoting the number of patents has become an urgent research issue.

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For a long time, patent litigation has been regarded as a means of intellectual property protection. Many scholars believe that patent litigation aimed at protecting enterprises' intellectual property rights from infringement has a positive effect on technological innovation. The plaintiff enterprises are likely to obtain compensation through patent litigation, and have more capital, power and experience to carry out technological innovation activities, thus ensuring the establishment of a more complete patent system [3]. Even if the patent litigation activity is finally faced with failure, the plaintiff enterprises are still likely to adopt a catch-up strategy to increase the number of patents and enhance the quality of patents and improve the chances of winning in the future [4]. When an enterprise is not subject to the failure pressure of patent litigation, it is easy to ignore the investment and attention on technology research and development. However, the accused enterprise will adopt the patent application strategy, increase the investment in innovation, and build its own patent protection wall to deal with litigation and protection business [5]. For start-ups in the industry with frequent patent litigation, they are more motivated to carry out innovative activities and regard them as their core competitiveness [6].

In recent years, with the alienation of patent litigation function, the negative impact of strategic patent litigation on technological innovation has become prominent. It not only hinders the innovation activities of potential market entrants, but also goes against the innovation behaviors of patentees themselves [7].The speculation and abuse of patents by upstream innovators or patent concentrators will disturb the market order and push up transaction costs and innovation costs [8].As the outcome of the lawsuit may determine the future direction of the enterprise, the future of important products and huge compensation expenses, the management may devote more energy and time to patent litigation [9].The parties tend to use their limited resources to seek favorable litigation conditions, thus neglecting technology research and development, which hinders technological innovation [10]. Mezzanotti believed that patent litigation could reduce the return on research and development and aggravate financing constraints, indicating that patent litigation hindered enterprise innovation [11].

In order to make profit from strategic patent litigation, enterprises compete to develop intensive patent layout and breed a large number of low-quality patents. Chien's research believes that patent competition triggered by patent litigation not only consumes the company's resources and time, but also promotes the demand for low-quality patents, leading to the emergence of a large number of patent bubbles [12].Patentees strategically apply for a large number of peripheral patents around their core patents and surround the basic patents, among which there are a large number of low-quality patents [13].After the target enterprise suffers from patent litigation, it will significantly reduce innovation activities [14].Although patent litigation can be settled out of court, huge patent license fees will also hinder technological innovation of enterprises [15]. Smeets developed a model to predict the degree of corporate innovation decline after patent litigation, showing that patent litigation has a negative impact on corporate R&D intensity [16].

To sum up, although it has been agreed that patent litigation has an important impact on technological innovation, the existing studies have not revealed which key patent litigation characteristics will affect the quality of patents and how to influence them.

Moreover, the existing studies focus on the micro level of enterprises and fail to reveal the theoretical connection between them from the national and regional perspectives. In addition, there is an obvious lack of relevant studies based on the Chinese context. Due to the regional nature of patents and differences in the scope of protection, for example, the number of utility model patents in China far exceeds the number of invention patents in the United States without utility model patents. Some research conclusions aimed at European and American countries are difficult to be effective in the Chinese context. For this, using China to speed up technological catch-up, realize the independent innovation research opportunity, analysis of the characteristics in the process of the extraction of patent litigation proceedings, using the provincial panel data from China mainland, the empirical test on the quality of the patent, patent litigation features help for Chinese patent quality improvement to provide theoretical support and decision-making basis.

2 Theoretical Analysis and Hypothesis

In recent years, the number of patent litigation cases shows a rapid growth trend, and its influence on the quality of technology research and development and innovation is increasingly prominent. In the process of patent litigation, if the trial time is long, it indicates that the litigant objects to the scope of protection of claims, which is related to the level of patent and the quality of innovation. The high success rate of patent litigation indicates that the effectiveness, creativity and novelty of the patent involved can be tested, which also means that the patent quality is high. The amount of compensation in patent litigation can reflect the technical value and economic value of patent, which may be correlated with the quality of patent. Therefore, the number of lawsuits, trial time, victory ratio and compensation amount are selected as the key characteristics of patent litigation. In order to construct the regression model of patent litigation characteristics and patent quality, the following research hypotheses are proposed.

Hypothesis H1: The higher the number of patent litigation cases, the higher the patent quality.

Since technological progress is a process of cumulative innovation, each invention is inevitably built on the basis of previous research results [17]. When subsequent patents are applied to actual production, they must be licensed for the underlying patents. With the complexity of technology composition, patents cover a large number of technical fields, making it difficult for subsequent innovation to bypass these patents. Patent litigation, as an important means to protect innovation, can help the patentee to build a strong image [18]. Studies have shown that the quality of litigious patents is generally higher than that of non-litigious patents. Based on the above analysis, we believe that the higher the number of patent litigation cases, the higher the patent quality.

H2: The longer the trial time of patent litigation, the lower the patent quality.

Trial time refers to the time span from the acceptance of patent litigation to the conclusion of the case. In the trial process of patent litigation, technical contents such as patent claims are the main basis for determining whether there is infringement of a patent. If the subject of the lawsuit has doubts or objections to the relevant contents, the

examination and approval time will be extended accordingly. In order to in a strong position in the lawsuit, lawsuit main body behavior may be at risk for abuse of patent ambiguity, not only try to use less as far as possible the technical features and general language written claim, in order to broaden the scope of the claims, and the extension of the claim explanation to invention purposes, properties and specifications, etc., thus further blur and expand the scope of protection [19];A large number of patents with vague claims and broad authorization will have a significant negative impact on the quality of patent applications. Therefore, we believe that the longer the trial time of patent litigation, the lower the quality of patents.

Hypothesis H3: The higher the success rate of patent litigation, the higher the patent quality.

In the process of patent litigation, patent lawsuits, the effectiveness, creativity and novelty will be tested, for example, litigation-related were put forward the request for invalidation patent, patent litigation if the plaintiff can make successful, further illustrate litigation-related patent as to meet the requirements of the authorization of the patent law and standard, this means patent quality is relative taller. On the contrary, a large number of low-quality patents with vague patent rights or no novelty are declared invalid in the trial process, which leads to the loss of the plaintiff in patent litigation. Gibbs' research shows that the result of patent litigation will affect the patent value and prospect, and the patent litigation loss will greatly reduce the patent prospect and value [20]. Based on the above analysis, we believe that the higher the success rate of patent litigation cases, the higher the patent quality.

Hypothesis H4: The higher the compensation amount of patent litigation, the higher the patent quality.

Through patent litigation can not only seek economic benefits, but also help to obtain competitive advantage. The amount of compensation for patent litigation is determined according to the actual loss or patent license fee. Therefore, the amount of compensation can reflect the technical value and economic value of the patent. That is, the higher the compensation amount is, the greater the technical value and economic value of the patent is, which can further confirm the higher quality of the relevant patent. In addition, patent litigation will stimulate the innovation enthusiasm of the litigant subjects, and it is easy to ignore the investment and attention to technology research and development when they are not subject to the failure pressure of patent litigation [21]. Industries with frequent patent lawsuits are more motivated to carry out innovative activities [22]. Therefore, we believe that the higher the amount of compensation for patent litigation, the higher the quality of the patent.

3 Research Design

3.1 Research Method

In order to analyze the influence of patent litigation characteristics on patent quality and verify the above research hypothesis, it is necessary to select an appropriate regression model for analysis. Panel Data is used to study the influence of patent litigation characteristics on patent quality. Panel Data model is an econometric model that uses

mixed Data to analyze the relationship between variables and predict their changing trend. The model can reflect the change rule of the research object in the two directions of time and section unit and the characteristics of different time and units. The panel data model makes comprehensive use of sample information to further the research and reduce the impact of multicollinearity. Mundlak first created the panel data model[23]:

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

In formula (1), x_{it} is the 1*K matrix, representing the independent variable, β_i is the K*1 matrix, representing the regression coefficient, K is the number of explanatory variables, and α_i is the constant term. According to the relationship between α_i and α_j, it can be divided into fixed intercept model and variable intercept model. Variable intercept model is generally adopted. According to the relationship between β_i and β_j, it can be further divided into fixed coefficient model and variable coefficient model. The panel data model can be further divided into fixed effect model and random effect model. The standard of distinction 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 specific to each section or individual and does not change with time, then it is a fixed effect model. If the non-observed effects are random variables and conform to a specific distribution, it is a random effect model. To sum up, the following panel data model is constructed:

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

In formula (2), PC_{it} is quality of patent creation of province i in the t year, NJ is the number of judgements of province i in the t year, DP is duration of proceedings of province i in the t year, WR is win rate of province i in the t year, CA is compensation award of province i in the t year, α_i is a constant term, β_1, β_2, β_3, β_4 is respectively regression coefficient of independent variable NJ, DP, WR, CA. The above data are introduced into the regression model, obtain the constant term and regression coefficient through statistical analysis and conduct significance test, study the relationship between patent litigation characteristics and patent quality, and then reveal the impact of patent litigation on patent quality.

3.2 Sample Selection

Using panel data model to study the influence of patent litigation characteristics on patent quality requires time and cross-section mixed data to be analyzed. Therefore, the selection of research samples should meet the following three conditions: first, the patent litigation characteristics and patent quality have accumulated complete time and cross-section data; second, the patent litigation characteristics and patent quality have accumulated complete time and cross-section data. Secondly, accurate and reliable patent litigation characteristics and patent quality data can be obtained, and it is better to obtain research data through public channels, so as to 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 to reflect the mainstream trend of the patent field. According to the above conditions, the inter-provincial panel data of China is selected as the research sample.

Chinese characteristics of patent litigation and patent quality data has formed a complete time series, in recent years, the state intellectual property office of the annual "China's intellectual property rights protection situation", "the court judicial protection of intellectual property rights situation in China" such as statistical report, the relevant statistical data is closed to the public, on the basis of available data accurate and reliable information. In addition, SOOIP, CIELA and other patent databases are becoming more and more perfect to obtain relevant data needed for research. The National Intellectual Property Office (SIPO) ranks first in the number of annual patent applications and has signed patent examination Highway (PPH) agreements with the United States, Germany, South Korea and other countries to speed up the examination of applications filed in relevant countries, which means that China's patent administration can reflect the mainstream trend in this field.

3.3 Data Sources

Patent quality data from the state intellectual property office of the intellectual property development research center released the Chinese intellectual property development evaluation report, the report from the dimensions, such as creating, using and protection of intellectual property rights of Chinese provinces (municipalities and autonomous regions) comprehensive evaluation, the development status of intellectual property rights and the scoring and sorting [24];Text extraction of patent create quality data measure provinces of mainland China's patent quality, create quality including the related patent structural indicators, such as an application for a patent for invention, maintenance indicators, such as patent maintenance ratio, as well as other patent can reflect some measure of quality, such as PCT patent applications to accept the quantity, the application of Madrid international registration of trademarks, etc.. Since this report has been published since 2012, considering the time-lag of relevant data, the inter-provincial panel data from 2012 to 2016 are intercepted for analysis.

The patent Litigation data comes from the China IP Litigation Analysis (CIELA) database, which is an online tool for analyzing civil ipr infringement lawsuits in China. By integrating professional legal database websites such as Weike, Wanlv and Beidaichuan, the case data published by the court website was extracted. In addition, according to the legal work practice, relevant keywords are extracted for the summary of different types of intellectual property cases, and the corresponding information is extracted in the judgment through the legal judgment of the staff, which is then converted into basic data [25]. Due to the time lag of receipt collection, there is a lack of inter-provincial patent litigation data in this data after 2017. Therefore, this study intercepts the inter-provincial patent litigation data from 2012 to 2016 for research.

4 Empirical Analysis

4.1 Descriptive Statistics

In order to carry out descriptive statistical analysis of patent litigation characteristics and patent quality data, firstly, relying on CIELA database, province field was used to retrieve the number of patent litigation cases, trial time, victory ratio and compensation amount one by one. Then, by using the year field, the characteristics data of patent litigation among various provinces were counted year by year. Due to the lack of characteristic data of patent litigation in Xizang, Ningxia and Hainan, it was removed. Then, according to the Evaluation Report on the Development of Intellectual Property in China, patent quality data of each province over years were extracted and counted one by one. Finally, descriptive statistical and thermal map analysis were conducted on characteristics of patent litigation and patent quality data of each province.

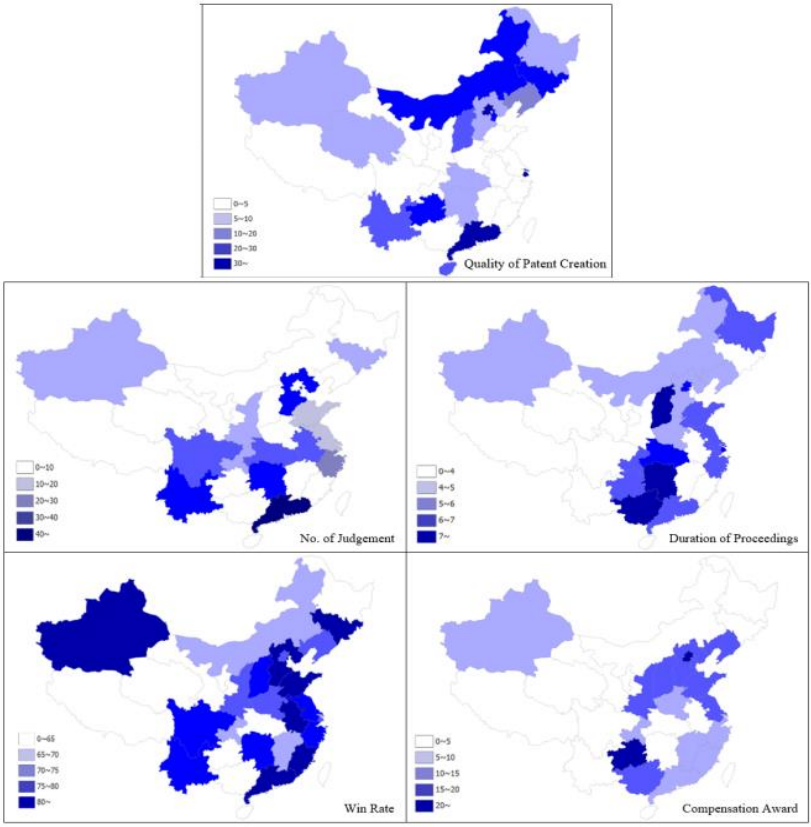

Fig. 1. Thermal map of patent litigation characteristics and patent quality

Based on the above steps, this study draws Figure 1. Specifically, China's inter-provincial patent quality shows significant regional differences, with Beijing, Shanghai and Guangdong leading the way and Jiangxi, Anhui and Xinjiang lagging behind. The

thermal map of patent litigation shows that the number of cases is higher in the southeast than in other regions, with more cases in Guangdong, Zhejiang and Jiangsu, and fewer in Qinghai, Inner Mongolia and Gansu. The trial time in the eastern region is higher than that in the central and western regions, hunan, Shanxi and Shanghai are longer, and Shaanxi, Qinghai and Gansu are shorter. In the eastern and central regions, the prevailing rates are higher than those in the western regions, higher in Shandong, Jilin and Anhui provinces, and lower in Heilongjiang, Tianjin and Guizhou provinces. The compensation in the southeast region is higher than that in other regions, with Beijing, Shanxi and Liaoning provinces receiving higher compensation and Qinghai, Heilongjiang and Yunnan provinces receiving lower compensation.

4.2 Regression Result

With patent quality as the dependent variable, the number of cases, the trial time, win ratio and the amount of compensation for the independent variable, the Chinese provincial panel data import Eviews software, 8 to Pool Estimation regression analysis, the construction characteristics of patent litigation and patent quality of fixed effects regression models, including the likelihood ratio test and its significance, F test model and its significance, R2 in the group of fixed effects model, the variable coefficient of regression coefficient, standard deviation and coefficient of the significance of the statistical indicator. Since taking the natural logarithm of a variable does not change the properties and interrelationships of time series, and it can also eliminate the heteroscasticity that may exist, therefore, the natural logarithm of the variable is used to establish the panel data model.

Table 1. Regression Analysis Results

	Country	Eastern	Central	Western
C	-3.073** (-2.247)	0.644 （0.255）	-0.333 （-0.091）	-1.372 （-0.509）
Ln(NJ)	0.250** (2.086)	0.283* （2.010）	0.629* （2.026）	0.320 （1.043）
Ln(DP)	-0.116 (-0.505)	-0.114 （-0.555）	-0.216 （-0.350）	-0.337 （-0.470）
Ln(WR)	0.862*** (2.700)	0.198 （0.356）	-0.157 （-0.159）	0.423 （0.663）
Ln(CA)	0.368*** (2.864)	0.066 （0.434）	0.503* （1.963）	0.440 （1.342）
R^2	0.843	0.923	0.859	0.775
F	12.314***	26.365***	6.763***	3.246**
LR	12.430***	33.204***	6.760***	3.263**
Model type	Fixed	Fixed	Fixed	Fixed

The results of Table 1 show that the number of patent litigation cases, success ratio and compensation amount have significant positive effects on patent quality in China, and they are significant at the confidence levels of 5%, 1% and 1%, respectively. The

research hypothesis H1, H3 and H4 are verified. Although the regression coefficient of trial time was negative, it did not pass the significance test and was not statistically significant. The research hypothesis H2 was not verified. In addition, there are regional differences in the impact of relevant patent litigation characteristics on patent quality. The number of cases has a significant positive impact on patent quality in the eastern region and the central region, and the amount of compensation has a significant positive impact on patent quality in the central region. On this basis, the goodness of fit of the model was tested, and the R2 values were 0.843, 0.923, 0.859 and 0.775, respectively, indicating that the model estimation fitted well with the observed data. The research shows that the number of patent litigation cases, the amount of compensation and the ratio of success have a significant positive impact on the patent quality in China, and there are regional differences. Compared with the western region, the above litigation characteristics have a more significant impact on the patent quality in the eastern and central regions. Therefore, improving the awareness of patent protection, increasing the cost of patent infringement and strengthening patent protection will help promote the improvement of patent quality.

5 Conclusion

Based on the inter-provincial panel data of Mainland China, this paper analyzes the process of filing, hearing and adjudication of patent litigation, extracts the litigation characteristics involved in this process, and empirically analyzes the impact of patent litigation on patent quality. The research shows that the number of patent litigation cases, the amount of compensation and the ratio of victory have a significant positive impact on the patent quality in China, and there are regional differences. Compared with the western region, the above litigation characteristics have a more significant impact on the patent quality in the eastern region and the central region. Therefore, improving the awareness of patent rights, increasing the cost of patent infringement and strengthening patent protection will help to promote the improvement of patent quality.

5.1 Theoretical Contribution

- Analyze the patent litigation submission, trial and judgment process, and extract the characteristics of patent litigation involved in this process. In recent years, patent litigation has evolved from a traditional means of protection to a new competitive tool. The characteristics of patent litigation may contain information related to patent quality. By exploring the process of patent litigation submission, trial and judgment, this study extracts the number of cases, trial time, victory ratio and compensation amount as the characteristics of patent litigation, providing a new analytical perspective for the quantitative research on patent quality.
- This study reveals the key litigation characteristics that affect patent quality and establishes the theoretical relationship between patent litigation and patent quality. Although it has been agreed that patent litigation has an important impact on technological innovation, the existing research has not revealed which key litigation

characteristics will affect the quality of patents and how to influence them. Therefore, this study reveals the key litigation characteristics closely related to patent quality by constructing the panel data model of patent litigation characteristics and patent quality, so as to provide theoretical support for accelerating the improvement of patent quality.

- Expand the theoretical research on patent litigation and patent quality to the national and regional levels, making up for the defects of existing researches focusing on the perspective of enterprises. Existing researches mainly analyze the relationship between patent litigation and patent quality from the perspective of enterprise, based on claims, maintenance time, innovation input, etc. In recent years, with the publication and improvement of national intellectual property statistical data, it is necessary and possible to analyze patent litigation and patent quality data at the national and regional levels, which is conducive to the improvement of national patent policies and the improvement of patent quality.

5.2 Policy Suggestions

- China's long-term prominent problem is the lack of necessary patent protection, and it is urgent to constantly improve patent legislation around the prominent problem of how to strengthen patent protection, so as to promote the improvement of patent quality in China. The results show that the number of patent litigation cases, the amount of compensation and the ratio of victory have a significant positive effect on the quality of Chinese patent. Therefore, in terms of the legal level and policy orientation, it is necessary to further enhance the awareness of patent rights protection, increase the cost of patent infringement and strengthen patent protection. China's current patent laws and regulations lack punitive provisions on compensation for patent infringement, and the current situation of difficult to obtain evidence for infringement and low compensation is not conducive to stimulating the enthusiasm of patent creation and promoting the improvement of patent quality in China.
- Due to regional differences in the impact of patent litigation on patent quality, it is necessary for each region to adopt more targeted regional patent strategies centering on national patent laws and regulations. The research shows that the number of patent litigation cases has a significant impact on the quality of patents in the eastern region. Therefore, the eastern region can take advantage of the opportunity of establishing intellectual property court to further optimize and standardize the judicial process and improve the trial efficiency of patent litigation cases. At the same time, the system construction also needs the support of judicial practice. Through the accumulation of typical cases and successful precedents, the relevant legislation for improving patent protection can further build consensus, so as to promote the rapid improvement of patent quality.

5.3 Research Limitations and Prospects

This research also has some shortcomings. For example, this research only focuses on patent litigation and patent quality data in China. Although China's patent management

can reflect the mainstream trend of this field, it is necessary to timely include more national and regional data in the future. In addition, the characteristics of patent litigation can be further expanded and refined. On the one hand, future research may excavate more characteristics of patent litigation. On the other hand, the research can be refined, such as with the improvement and upgrading of the patent database, the patent litigation can be subdivided into first instance and second instance, etc., and further discussed and optimized in the follow-up research.

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