



Research on Patent Valuation Based on Social Network Analysis Method

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Abstract. In the era of rapid updating of patent technology, it is increasingly important to identify the value of patent. Through the study and selection of the previous patent valuation literature, this paper adopts the social network analysis method to select the patent valuation index, and uses Poisson regression method to analyze the impact of patent valuation index on patent value and determine the patent valuation model. The results show that the results of patent value obtained by the model in this paper are basically consistent with those obtained by Bateng patent database, indicating that the patent value evaluation model obtained by social network analysis method and Poisson regression in this paper can evaluate the value of invention patents more conveniently and accurately.

Keywords: social network analysis method · patent value evaluation · Poisson regression

1 Introduction

With the development of the information age, patent, as a representative product of intellectual property rights, is closely related to people's lives, and the study of patent value has become a hot topic. The value of patent is a complex phenomenon involving science and technology, law, market and other aspects, which cannot be judged by single or multiple indicators. Therefore, when the technical index of a certain level has problems, it may cause the wrong judgment of patent value. If this is not fully taken into account, assessment conclusions that deviate from objective reality may be drawn. How to select the evaluation index scientifically and how to select the correct evaluation model are decisive to the evaluation of patent value.

Researchers at home and abroad have made a comprehensive analysis of the main influencing factors of patent valuation. Professor Huabin Xu [1] analyzed relevant papers in recent 20 years by analyzing the field of patent value abroad, and proposed that international patent value includes technology price, legal value and economic value. Park [2] divided various factors that affect the value of intangible assets into two categories: fixed reasons of production technology and use reasons. The comprehensive classification method is investigated the existence of the patented technology and related business use, but as a result of this method is not the patent authorization and the transfer of the

process of the direct influence to the patent holder or the authorized person, also did not examine the company's main factors such as the direct impact of the patent strategy, therefore also has the researchers in a particular business transactions affect the price of technology perspective analyze the main factors of patent evaluation. With the further development of relevant research results, the evaluation index system of patent value is further refined and integrated, and the evaluation index system is gradually enriched. Professor Qinghai Li [3] summarized the technical cycle time, citation frequency, scientific and technological relevance, scientific and technological coverage, patent family size, right of Seven index systems, such as the number of claims, patent objection and litigation, have made an overall evaluation of the value of patent rights.

Researchers at home and abroad have put forward different methods and models for patent valuation. As early as in the 1970s, Black and Scholes [4] established the option pricing model, which was first applied in the financial field. Since then, Chungpeng Yang [5] tried to improve the real option method and apply it to patent valuation. Although good results were achieved, it was difficult in practical application due to its complicated calculation. Haiyun Xu [6] proposed that the text mining method is a method to evaluate the patent value based on the similarity of text content. The high value of a patent should be reflected in "significant progress compared with the technological frontier and the foundation of subsequent inventions and creations". Therefore, the similarity of the text content between the patent to be evaluated and the earlier patent and the later patent can be calculated respectively, and the lower the similarity with the earlier patent and the higher the similarity with the later patent, the higher the value of the patent. At present, the most widely used method of patent value evaluation is the econometric model method. The general process of the econometric model method is: firstly, several factors related to patent value are selected, and then the coefficients of each factor are determined by qualitative or quantitative methods, and finally the econometric model is formed. Rong Chao [7] and Chai [8] used Logistic regression model to regression the factors related to patent value and determine the coefficients of each factor. Fischer et al. [9] applied cox regression method to patent valuation; Lee et al. [10] established a negative binomial regression model for analysis. The econometric model method is very easy to understand and use, but the method itself implies a linear relationship between patent value and related factors, which has some limitations.

After analyzing the current situation of domestic and foreign academic in the field of patent value evaluation, although there are many patent value evaluation way, but since most patent value evaluation method is more complicated, can't make people clearly know the patent value evaluation method directly, so this article by using social network analysis method to extract the patent value evaluation index analysis, In order to select the patent value evaluation index objectively and effectively, and use Poisson regression model to construct a scientific and reasonable value evaluation model of patent data, and quickly and effectively evaluate the patent value.

2 Selection of Patent Valuation Index

This article takes the academic journals in the field of patent value evaluation in the CNKI database as the data source, the time span is nearly 20 years from 2002 to 2022,

Table 1. The point degree and center degree of patent value evaluation index

Serial number	Patent value index	Degree of centrality	Serial number	Patent value index	Degree of centrality
1	The IPC number	234.00	12	Patent type	86.00
2	Patent citations	201.00	13	Patent innovation	82.00
3	Duration of patent	199.00	14	market requirement	70.00
4	Number of patent families	198.00	15	applications	60.00
5	Number of claims	178.00	16	market size	57.00
6	Number of patents cited	165.00	17	Patent advancement	54.00
7	Patent validity	153.00	18	Patent independence	48.00
8	Number of inventors	118.00	19	Scientific correlation	30.00
9	Patent maturity	110.00	20	Number of family references	28.00
10	Patent fungibility	107.00		mean	113.75
11	Patent litigation	97.00			

and searches CSSCI and the core literature of Peking University with the theme “patent value evaluation”. A total of 126 literatures were retrieved, and these literatures were used as data sources for value indicators.

Extracting patent value evaluation indicators from the selected literature, and using social network analysis method to analyze the point-degree centrality of each indicator, it is helpful for this study to intuitively select the most influential patent value evaluation indicators. See Table 1 for the value of the point centrality of each patent value index.

It can be seen from Table 1 that each patent value evaluation index has a relatively large difference in centrality and distribution. The average centrality index of the whole network is 113.75, the centrality of IPC number (234.00), citations number (201.00), patent duration (199.00), patent kinks number (198.00), claims number (178.00), citations number (165.00) and patent validity (153.00) was higher than average centrality. We can conclude that the above seven indicators are important indicators in the evaluation of patent value. However, according to literature review, patent maturity refers

Table 2. Evaluation index of patent value

Serial number	Patent value index	Implication
1	The IPC number	Represents the scope of the technical field involved in the patent
2	Patent citations	The number of applied patents cited by current patents
3	Duration of patent	The actual time from the date of filing to the date of invalidity, termination, revocation or expiration of a patent
4	Number of patent families	A group of patents based on the same priority file that has been filed for multiple approvals in different countries
5	Number of claims	The size of the technical protection area
6	Number of patents cited	Number of times a patent is cited by other patents

to the application degree of patented technology in the market, which is a relative variable and difficult to quantify. Therefore, the patent maturity index is abandoned in this paper. Therefore, the patent value evaluation indexes selected in this paper are shown in Table 2.

3 Data Sources

The selection of patent data must be authoritative and official, so the invention patent data in this article comes from CNKI patent database, patent collection database and patent explorer database. The first two databases are currently the largest and most authoritative patent literature database system in China, with a time span from 2015 to 2022, retrieving the national authorized invention patent information in the field of new energy vehicles. Due to the two to three years review period from application to authorization of invention patents in China, and the lag time of data collection and update in the database, the invention patent literature collection in the last three years is not comprehensive, so the data of 2020, 2021 and 2022 are discarded in this paper. Only patent documents from 2015 to 2019 were retained as research data samples. A total of 4924 patents were obtained through retrieval, and 662 patent data were randomly sampled as sample data. According to the patent data information, the value score of web sites for patents was obtained from the patent Explorer database.

This chapter studies the influence of each patent value index on patent value. The dependent variable is patent value degree, and its value is non-negative integer. Through reading literature, it is found that generally, when the numerical type of dependent variable is discrete variable, Poisson regression or negative binomial regression can be used for data analysis, but only when the data is excessively discrete can negative binomial distribution be satisfied. This study calculated the mean value and variance of the selected patent value and found that they were similar, so this study chose Poisson

regression as the theoretical basis for building the model. Poisson regression model is a model built on the basis of Poisson distribution, and its dependent variable data meets the Poisson distribution. Based on the Poisson distribution, the event intensity λ is modelled. Where α is the intercept of Poisson's regression model, β is the regression coefficient of each index, and x is each index. The formula is:

$$\ln(\lambda) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n \quad (1)$$

4 The Establishment of Patent Valuation Model

First of all, SPSSAU software conducted discrete O test for the dependent variable, that is, the data of the dependent variable was levelled. The test results of mean and variance calculation are shown in Table 3.

Poisson regression requires equal dispersion of data, that is, the mean value and variance are consistent. In SPSSAU software, the O test can be used for overdispersion test. If the absolute value of the O value is greater than 1.96 and the p value is less than 0.05, it means that the data is overdispersed, and negative binomial regression can be considered for research. If the absolute value of the O value is less than 1.96 and the p value is greater than 0.05, it means that the data is discrete, and the data is suitable for Poisson regression.

As shown in Table 3, the mean value of patent value data in this paper is similar to the value of variance, and the absolute value of O value is $1.9 < 1.96$, and the P value is $0.057 > 0.05$, indicating that the patent data in this paper are discrete and Poisson regression is suitable for the theoretical model of patent data research.

In the second step, SPSSAU software analyzes the whole model, and the comprehensive analysis results of the model are used to analyze the effectiveness of the whole model. Analyze the overall p-value of the model. If the value is less than 0.05, it indicates that the model is valid; otherwise, it indicates that the model is invalid. The results are shown in Table 4.

In the overall analysis results of the regression model in Table 4, p value is $0 < 0.05$, indicating that the Poisson regression model constructed this time is meaningful.

Table 3. Over discrete O test results

Sample size	Mean	Variance	O values	P values
662	51.867	46.445	-1.900	0.057

Table 4. Results analysis of Poisson regression model

Model	P
Poisson	0.000

Table 5. Results of Poisson regression

Patent value index	Coef.	Std. Err.	z	P	OR
Duration of patent (x_1)	0.010	0.002	5.765	0	1.010
Number of patents cited (x_2)	0.013	0.004	3.485	0	1.013
Patent citations (x_3)	0.010	0.002	6.244	0	1.010
Number of claims (x_4)	0.132	0.013	9.953	0	1.414
Number of claims (x_5)	0.003	0.001	2.561	0	1.003
The IPC number (x_6)	0.018	0.003	5.293	0	1.018
Intercept	3.688	0.017	222.588	0	39.969

Table 6. Test Data of Patent Evaluation Model (partial)

	Patent Publication Number	Patent predictive value	Actual value of patent
1	CN110103761A	51.428	53
2	CN104734303A	57.729	59
3	CN110474988A	61.63	55
4	CN110266037A	58.48	55
5	CN110571842A	58.408	57

Thirdly, the regression coefficients of each patent value evaluation index on patent value were obtained by Poisson regression model, and the results were shown in Table 5.

Table 5 shows that the patent value evaluation model based on Poisson regression model is as follows:

$$\ln y = 3.688 + 0.01x_1 + 0.013x_2 + 0.01x_3 + 0.132x_4 + 0.003x_5 + 0.018x_6 \quad (2)$$

5 Validation of Patent Valuation Model

The value of randomly selected patents was evaluated by the patent value model, and the experimental evaluation results of patents were verified Check. The results are shown in Table 6.

In the patent Explorer database, patents are divided into low patent value (value degree 0–50), medium patent value (value degree 50–75) and high patent value (value degree 75–100) through the evaluation of patent value degree. Through the experimental study, the patent value evaluation based on Poisson regression model is basically consistent with the patent value evaluation given by Baiteng Patent Explorer database, indicating that the patent value evaluation model based on Poisson regression is effective and reliable.

6 Conclusion

Patent valuation has always been a hot issue in the field of patent valuation. In this paper, CNKI database is used to retrieve proprietary valuation literature, and evaluation indicators of each literature are extracted for word frequency statistics and co-occurrence matrix is generated. Eight indicators of patent valuation are obtained by social network analysis of patent valuation indicators. Then, the evaluation index data needed for new energy vehicle invention patents applied during 2015–2019 were collected through CNKI patent database and Patent Pool database. Based on Poisson regression model, the patent value evaluation model was established to evaluate the patent value. The main conclusions of this study are as follows:

(1) The theory of social network analysis is introduced to provide a new evaluation method for patent valuation. A patent value evaluation model based on social network analysis method is established to reduce the subjective bias in the selection of patent value evaluation indexes and avoid the deviation of patent value evaluation results caused by subjective factors.

(2) It enriches the theoretical research of social network analysis method in the field of patent valuation. From the theoretical point of view, the patent value evaluation system is established by using social network analysis method and Poisson regression, and the patent value evaluation system is comprehensively analyzed, which is applied to the automobile patent value evaluation.

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References

1. Xu HB, Cheng Q. (2014) Research on the Status and Trend of Patent Value Evaluation. *Journal of Modern Information*, 34(09): 75–79.
2. Park Y, Park G.A. (2004) New Method for Technology Valuation in Monetary Value: Procedure and Application. *Technovation*, 24 (5): 387–394.
3. Li QH, Liu Y, Wu SZ, Xu XB. (2007) Patent value indicators and their structure, (02):281–286.
4. Fischer Black, Myron Scholes. (1973) The Pricing of Options and Corporate Liabilities. *Journal of Political Economy*, 81 (3): 637–654.
5. Yang CP, Wu HH. (2002) Real Options Approach to the Value of Patents Right, (06):101–104.
6. Xu HY, Fang S. (2014) Technical Topics Association Analysis and Core Patents Mining Based on Patent Technology-Effect Matrix, 33(02):158–166.
7. Chao R, Xi HZ. (2019) Research on the Correlation Between the Main Characteristics of China Patent Gold Award and High-value Patents, (10):1–8.
8. Chai, KC, Yang, Y, Sui, ZY, Chang, KC (2020) Determinants of highly-cited green patents: The perspective of network characteristics. *PloS ONE*, 15(10):e0240679–e0240679.

9. 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.
10. Lee, C, Cho, Y , Seol, H ,Park, Y.(2011)A stochastic patent citation analysis approach to assessing future technological impacts. *Technological Forecasting & Social Change*, 79(1): 16–29

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