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Research on Quantitative Assessment of Patent Value in Electric Power Industry Based on Entropy Weight-Mutation Level Method

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Abstract: In order to accurately and efficiently assess the patent value and provide a solid data foundation for the subsequent patent management and operation strategy, this study closely focuses on the development orientation and objectives of the electric power industry, and constructs a comprehensive patent value assessment index system from the four core dimensions of technology, legal, market and strategy. On this basis, the entropy weight-mutation level method is adopted as an assessment tool to quantitatively analyze the patent value. In order to further verify the practicability and effectiveness of the system, this study selects the patents of State Grid Anhui Electric Power Co., Ltd as an empirical case for in-depth analysis, aiming to provide useful references and lessons for other enterprises in the electric power industry to carry out patent value assessment work. Through the introduction of quantitative indicators, the system developed in this study realizes the batch automated assessment of patent value, effectively breaks through the limitations of subjective and objective assignments in the traditional assessment method, and targets to solve the problems of excessive subjective judgments and weak applicability that generally exist in the current patent assessment system in the power industry. The system provides scientific and systematic methodological support for the company to efficiently screen high-value patents and implement refined patent classification and categorization management strategies.

1. Introduction

At present, the role of intellectual property rights as a strategic resource for national development and a core element of international competitiveness is becoming more and more prominent. As a basic industry of the national economy, the electric power industry occupies an important position in promoting the high-quality development of China's economy and safeguarding people's well-being. There are some qualitative factors in the patent value evaluation system currently prevailing in this industry, and the evaluation work needs to be carried out with the help of experts' personal experience, which can bring into play their professional skills and improve the accuracy of the appraisal results. However, with the sharp increase in the number of patents, it is increasingly difficult to manually

assess the value of patents, which is prone to problems such as declining appraisal quality and increasing management costs. To address the above problems, this paper adjusts and redesigns the assessment indexes, selects quantitative indexes from multiple dimensions, and takes the patents of State Grid Anhui Electric Power Co. as an example, and assesses each patent based on objective data. This is aimed at overcoming the limitations of the expert assessment method, such as strong subjectivity and high time cost, and realizing the batching and automation of patent value assessment.

2. Patent Value Related Research

The current definition of the connotation of patent value generally includes two dimensions: internal and external. The internal value mainly refers to the technical value of the patent itself, such as technical progress, novelty, inventiveness, etc.[1], and the legal value after authorization, such as the stability of the rights, the quality of the patent text, the difficulty of infringement, etc.[2] ; the extrinsic value mainly refers to the potential market application ability of the patent, which is related to the scope of patent protection, patent life, operation, etc.[3]. Patent value is gradually formed in the process of technology research and development, right application, technology transformation, technology application, etc., throughout the whole process of patent from research and development to application. Further, academic research on the construction of patent value evaluation index system can be summarized into two major perspectives: unidimensional and multidimensional perspective.

2.1. Unidimensional Perspective

The unidimensional perspective refers to the construction of a one-dimensional indicator system to assess the value of patents by comprehensively selecting multiple evaluation indicators without distinguishing the specific value dimensions of patents. CHI & NSF proposed the world's first patent value evaluation index system. Lanjouw et al[4] revealed the relationship between patent litigation and patent value, arguing that patents subject to litigation tend to have greater market value, emphasizing that attention should be paid to the market performance and legal status of patents in selecting evaluation indexes. Harhoff et al[5] went further by including factors such as patent scope, number of patents in the same family, and patent oppositions in the indicator system. However, the unidimensional perspective does not reflect the value dimension of patents well, and there are limitations such as one-sided assessment and missing dimensions, which make it difficult to assess the value of patents in a comprehensive and in-depth manner.

2.2. Multidimensional Perspective

The multidimensional perspective of building patent value evaluation index system aims to comprehensively reflect the real value of patents and provide accurate reference for decision makers. The multidimensional indicator system commonly used nowadays contains three major dimensions: technical, legal and market. The technical dimension focuses on the novelty, creativity and practicability of patents[6]. The legal dimension covers the patent's independence scope of protection, licensing status, patent family size, and the degree of solidity of legal status[7]. The market dimension takes into account the marketability, market demandand remaining economic life of the patented technology, which together affect the ability of the patented technology to be transformed into actual economic value[8]. This multidimensional index system provides a more comprehensive and scientific basis for patent value assessment, and has been widely used in practical research.

3. Construction of Patent Value Evaluation Indicator System

This paper combines the development orientation of electric power enterprises and chooses to reconstruct the evaluation indexes from the four dimensions of technology, legal, market and strategy.

3.1. Technical Dimension

The technical value of a patent refers to the comprehensive assessment of the technology contained in a patent in terms of key dimensions such as advancement, creativity and influence. Its definition not only covers the degree of novelty and originality of the technology itself, but also takes into account the technological innovation that may be triggered by the technology in the field to which it belongs, its potential for market application, and its role in promoting subsequent R&D activities.

3.1.1. Technological Advancement

Technological advancement means that a patent has a high technical value and is uniquely superior and innovative compared to other technologies. For example, through the introduction of cutting-edge design concepts, more efficient algorithms or the use of more advanced production processes, patents can achieve improved performance, reduced costs or optimized customer's experience.

①Number of inventors. The number of inventors can characterize the strength of the scientific forces brought together in the process of technology development and the commitment of R&D personnel. The more people involved, the more likely it is that high-value patents will be produced[9].

②Number of patent citations. The citation relationship between patents can reflect the inheritance and cumulative effect between new and old scientific and technological achievements[10].

Number of cited patents. This indicator emphasizes the technology transfer and knowledge flow of patents, and also reflects the origin and development trends of patented technologies.

Number of cited scientific literature. Patents show their technical sources and innovations more clearly by citing scientific literature, providing additional technical support for the patent.

3.1.2. Technological Impact

Technological impact is a key indicator of the extensive and far-reaching effect of a patented technology on subsequent patent research and development, scientific and technological progress, and market changes. High-impact patents are often able to lead the technological trend and promote technological innovation and industrial upgrading in related fields.

①Number of citations to patents. A patent being cited indicates that the technological innovation points contained in the patent have been recognized and applied by subsequent research or technological development, indicating that the higher its technological value and the greater its technological impact[11].

②Number of IPC subclass numbers. The more IPC classification numbers a patent contains, the more technical fields it involves, the more versatile and portable the technology is, and the more fields it can be applied to, so the patent is more likely to have a strong technological impact[12].

3.2. Legal Dimension

The legal value of a patent is reflected in the guarantee that the patentee enjoys exclusive rights and interests in accordance with the law throughout the life cycle and within the scope of claim protection, which is the core of the legal protection of patent rights.

3.2.1. Patent Text Quality

The quality of a patent text is a measure of whether the patent text meets the requirements in terms of accurate content, standardized language, detailed technical description, accurate claims, clear and complete accompanying drawings and so on.

①Number of pages in patent specification. The large number of pages in the patent specification indicates strong support for the patent right, thereby improving the quality of the patent text [13].

3.2.2. Scope of Legal Protection

The scope of patent protection determines the strength of legal protection for patents. The wide scope of patent protection can narrow the technological space for competitors to imitate, thereby protecting patents and increasing their value.

②Number of Claims. It not only reflects the applicant's grasp of the technical details of his invention, but also affects the strength and scope of the patent's right protection[14].

③Number of patents of the same family. This indicator reflects the importance that the applicant attaches to the adoption of legal protection for the patent, as well as the strength and coverage of the legal protection of the patent on a global scale[15].

3.3. Market Dimension

The market value of a patent lies in its ability to give the holder the ability to build unique competitive advantages and realize economic returns in the process of operation, which is the most direct driving force for companies in the process of acquiring and applying patent rights.

①Remaining validity period. The remaining validity period of a patent affects the economic benefits it brings to the patentee, which in turn affects its market value.

②Number of patent licenses. A high number of licenses indicates that the technology protected by the patent is more mature and has a high potential for market transformation[16].

③Number of patent transfers. Patent transfer not only makes the patent right obtain the circulation, but also creates the conditions for the operation of patent right assetization[17].

④Number of patent pledges. Secured credit obtained by the patentee can enhance the confidence of creditors in signing master claim agreements and broaden the debtor's access to finance[18].

3.4. Strategic Dimension

The patent achievements of the power industry are not only related to the leading and protection at the technical level, but also promote energy technology innovation and industrial upgrading through patent layout to ensure national energy security.

①Patent award. There are two types of award lists published in the market: the first is the China Patent Award, and the second is the provincial patent awards. Patents that receive patent awards often play an important role in promoting industry progress and social development.

②Number of strategic emerging industries classification. It not only reveals the technical field of the patent, but also indicates its potential market application and development direction.

4. Patent Value Evaluation Method Design

After comprehensively comparing the characteristics and applicability of various methods, this study chooses to use entropy weight-mutation series method to evaluate patent value, in order to overcome the inherent limitations of traditional transfer methods and measure patent value more

scientifically and comprehensively.

4.1. Entropy Weight Method

Entropy weight method is based on the concept of information entropy and numerical characteristics of indicators, and determines the weights by calculating the information entropy between indicators. It is not influenced by the subjective experience of experts, which makes the assessment results more scientific and reliable. The specific steps include: data normalization, calculation of variability indicators, information entropy, information entropy redundancy, and finally calculation of the weights of each indicator.

4.2. Mutation Series Method

The mutation series method is a comprehensive evaluation method, which decomposes the evaluation objectives through multi-level, combines the mutation theory and fuzzy mathematics to construct the mutation fuzzy affiliation function, and uses the normalization formula to carry out quantitative calculations. The specific steps are shown below:

① According to the purpose of the evaluation, the indicators in the evaluation system are decomposed at multiple levels and arranged into an inverted tree-like hierarchy of objectives.

②There are three types involved in this paper: if an indicator can be decomposed into two sub-indicators, the system can be regarded as a spike mutation; if three, the system can be regarded as a swallow-tailed mutation; if four, the system can be regarded as a butterfly mutation.

③Apply the normalization formula for evaluation. Based on the determined mutation system type, the normalization formula is derived from the corresponding divergence equation.

The specific content of the correspondence between the mutation model and the normalization formula is shown in Table 1.

Table 1: Correspondence between mutation models and normalization formulas

Mutation type	Spike mutation	Swallow-tailed mutation	Butterfly mutation
Potential function	$f(x)=x^4+Ax^2+Bx$	$f(x)=\frac{1}{5}x^5+\frac{1}{3}Ax^3+\frac{1}{2}Bx^2+Cx$	$f(x)=\frac{1}{6}x^6+\frac{1}{4}Ax^4+\frac{1}{3}Bx^3+\frac{1}{2}Cx^2+Dx$
Weight order	$W_A>W_B$	$W_A>W_B>W_C$	$W_A>W_B>W_C>W_D$
Normalization formula	$x_A=\sqrt{A}$ $x_B=\sqrt[3]{B}$	$x_A=\sqrt{A}$;$x_B=\sqrt[3]{B}$; $x_C=\sqrt[4]{C}$	$x_A=\sqrt{A}$;$x_B=\sqrt[3]{B}$; $x_C=\sqrt[4]{C}$;$x_D=\sqrt[5]{D}$

5. Empirical Application

5.1. Data Sources and Pre-processing

This study takes the invention patents of State Grid Anhui Electric Power Co. from 2013-2023 as a sample, and defines the application unit, IPC classification number, status and authorization time of the patents in the database. The classification numbers specifically include H01B, H01F, H01G, H01H, H02B, H02G, H02H, H02J, H02M, H02P, E02B, and G01R. This study excluded information lacking valid information and invalid patent types when exporting patents.

5.2. Evaluation Process

5.2.1. Entropy Weight Method for Assigning Weights

The evaluation indicators are weighted through the entropy weight method to determine the ranking of the indicators. For the indicator layer, the weights of the indicators are determined and ranked by the entropy weight method. For the dimension layer, the weights of the corresponding indicators are added together and sorted according to the size of the sum. The specific results are detailed in Table 2.

Table 2: Results of weight calculation by entropy weight method

Dimension layer	Indicator layer	Weight factor	Weight order
Technical dimension(28.06%)	inventors	2.90%	4
	patent citations	7.15%	2
	citations to patents	12.54%	1
	IPC classification numbers	5.47%	3
Legal dimension(24.78%)	pages of instructions	1.91%	3
	claims	2.59%	2
	patents in the same family	20.28%	1
Market dimension(20.05%)	remaining validity period	0.12%	2
	patent operations	19.93%	1
Strategic dimension(27.11%)	patent awards	13.51%	2
	strategic emerging industries	13.60%	1

5.2.2. Mutation Level Method for Evaluating Patents

During the evaluation process: ①Determine the corresponding mutation system according to the number of indicators in each dimension, rank and calculate the scores of each unit in the four sub-dimensions based on the weight of each indicator. ②Patent value is evaluated by selecting the corresponding quantitative indicators from the four dimensions, constituting the butterfly mutation system, and then calculated again using the mutation level method to arrive at the comprehensive value score of each patent. The table 3 shows the names and specific scores of the top 3 patents in terms of patent value score.

Table 3: Examples of Patent Value Evaluation Scores

Item	Patent title	Technical score	Legal score	Market score	Strategic score	Overall score
1	Intelligent substation secondary equipment configuration informati-on remote online control device	0.684	0.476	0.461	0.828	0.863
2	Fire extinguishing systems, fire extinguishing methods and extra-high voltage converter stations	0.576	0.764	0.775	0.519	0.862
3	An automatic test system and test method for intelligent substation protection devices	0.630	0.533	0.473	0.690	0.848

6. Conclusion

Based on the current patent value evaluation index system in the electric power industry, this study further refined the patent value, selected 11 quantifiable, accessible and representative patent indicators from four dimensions of technology, legal, market and strategy, constructed the index system, and quantitatively evaluated the patent value, realizing the transformation of the evaluation index system from qualitative to quantitative. In terms of evaluation method, this study chooses to adopt entropy weight - mutation level method method to carry out comprehensive evaluation of patent value, and do empirical application with the patents of State Grid Anhui Electric Power Co. in the past ten years. This method can effectively overcome the limitations of low evaluation efficiency and strong subjectivity of the current index system, and to a certain extent, it can circumvent the shortcomings of the traditional objective entropy weight method in terms of unreasonable weight setting and neglecting the relevance of the indexes, so as to improve the efficiency and effect of the evaluation of the patent value, and better promote the subsequent management and operation of the patents.

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