Patent Value Analysis Based on the EPTV Model Investigation of Building Energy-Saving Industry

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Building energy efficiency technology is hoped to play an important role in climate change. Taking the building energy-saving industry as the research sample, this paper aims to investigate the patent competition situation with an intelligence analysis of EPTV model. This study explored the patent competition situation among the major applicants according to the high-value patent layouts. The results of intelligence analysis indicate that the EPTV model provides a panoramic overview of patent value for the building energy-saving industry, which also provides a new perspective for patent competition situation investigation and some implication suggestions for the industry development.

Keywords: patent value orientation, EPTV model, competitive intelligence investigation, patent competition situation, building energy-saving

INTRODUCTION

The energy consumed in the construction and operation of buildings is the most important energy consumption in each country (Yang, Liu, & Zhao,2004). China has become the world's third largest energy producer and the second largest energy consumer (Zheng, Yu, Wang, & Tao, 2019), the total area of buildings built each year has surpassed the sum area of which all developed countries (Sher, Kawai, Güleç, & Sadiq, 2019). Buildings consume 50% of the total energy in the process of production and use, of which building energy consumption accounts for about 47.24% (Dodoo, Gustavsson, & Tettey, 2017; Olivieri, Caamaño-Martín, Moralejo-Vázquez, Martín-Chivelet, Olivieri, & Neila-Gonzalez,2014). So, it is necessary to carry out policies for saving energy in building construction to achieve the sustainable development of building in China.

The patent literature integrates technology, law and economic information, and it is an important information resource for promoting industrial technology innovation and industrial development. According to the statistics from the World Intellectual Property Organization, more than 90% of the world's technical information was first recorded in the patent literature. Therefore, being good at using specialized analysis to obtain industrial competitive intelligence information can play a guiding role in the industrial development and provide data support for the development of the industry. At the same time, the pace of innovation in developed countries has become faster and faster, and the quality of patents and their level of protection have been raising constantly, which brings new challenges to developing countries (Ma & Zhao,2018). For enterprises, high-quality patents can fully protect the innovation of enterprises, meanwhile protect the innovative products of enterprises in the market, win the market advantages and bring high profits. In addition, Chinese enterprises continue to go to overseas markets, intellectual property rights, as an international prevailing law, will inevitably encounter a large number of intellectual property barriers, hindering the internationalization of enterprises without the support of high-value patents (Han & Lei,2017).Therefore, with the patent value orientation, and using the patent analysis model to explore the technical competition situation of the rare building energy-saving industry has important theoretical and practical significance.

LITERATURE REVIEW

Competitive Intelligence Method

Competitive intelligence is an important method to investigate the competition situation of an industry. Most commonly, the process on patent documents is the key way to achieve the investigation, such as patent intelligence mining and patent information appreciation. Byungun and Yongtae (2007) proposed a patent analysis method that combined text mining technology with joint analysis and morphological analysis to discover the new and potential technological opportunities using patent information. With the continuous development and improvement of the information technologies, the network technologies and patent databases after the 1990s, patent analysis methods began to be applied gradually, especially in corporate strategy and competition analysis (Zhang & Lan,2003). Through the comprehensive analysis of domestic and foreign related research, there are two different research directions. Some patent mining methods were proposed in the prior research based on PTCM and PSALM models respectively to help companies develop appropriate businesses strategies (Shih, Liu, & Hsu, 2010; Tekić, Dražić, Kukolj, Nikolić, Kukolj, & Vitas, 2015). Wang, Liu, Ding, Liu and Xu (2014) used a three-layer Bayesian Probability Model to explore hotspots and directions in the research subclasses. Subsequently, Miao, Song and Huang (2015) proposed a four-dimensional analysis method including market, capability, time and opportunities, which made up for the lack of analyzing the competition opportunities in the CMT three-dimensional analysis method and increased the information volume of competitive intelligence analysis. Huang, Chang, & Miao (2016) used the modified ESTP-Chain four-dimensional analysis method to reveal the international competition pattern in the field of welfare technology from the four dimensions of environmental chain, main chain, technology chain and status chain. Yu and Zhang (2019) propose a patent roadmap model, including a road mapping method and application directions.

Analysis for Different Technology Industries

The other research focuses on the application of patent analysis in the competitive situation of different technology industries. Deng, Yu and Cui (2014) based on patent information to study the competition situation of China's cloud computing industry. Shen and Zhang (2014) based on patent analysis methods, studied the competitive situation of Chinese dye battery automotive technology. Huang, Gao and Wu (2014) divided the technology of solar cell technology from different points, and analyzed the technical compositions and the development status of solar cells. Li, Liu and Lu (2015) applied the patent analysis method to comprehensively scan the technical competition situation of China's big data industry from two perspectives of the layout at home and abroad. Through the patent perspective, Jin

(2015) carried out researches on the technical competition situation of China's mining fan industry. Yang, Yu and Liu (2017) analyzed the competitive situation of graphene industry based on the ECIRM (E stands for entrepreneur, C stands for capital, I stands for industry, R stands for resource, M stands for management) model, and provided countermeasures and suggestions for graphene technology innovation and industrial development in China. Qiu and Yang (2018) compared the competition situation between China and the United States in the Carbon Capture and Storage field from the perspectives of patent life, the number of claims, the number of forward references, and the patent strength. Yang, Yu and Liu (2018) aimed to develop an approach to identify SCA in the target technological area by conducting a patent review from the comprehensive perspectives of the macro landscape, the meso socio-technical system, and the micro niches, and then integrate patent analysis with technology life cycle (TLC) theory to examine patents involving global technological competition, based on a patent-based multi-level perspective (MLP).

Literature Summary

In summary, although many researches have been carried out on the patent analysis methods and their applications in various industrial fields at home and abroad, and many research results have been obtained, few scholars have conducted competitive intelligence research from the perspective of patent value. This paper analyzed the GREP model, introduces the V-dimension (Patent Value), discards the R-dimension (Resource) which is not related to the patent value, and improves the design of the subordinate indicators of the G-dimension (Governance) and E-dimension (Entrepreneur). A patent intelligence analysis model based on EPTV is proposed.

ANALYTICAL MODEL and DATA

Analytical Model

The GREP model was used to analyze the internal environment of the organization and is an endogenous rule for analyzing the competitive advantage of enterprises. The GREP model analyzes its strategic structure from the G-dimension, R-dimension, E-dimension and P-dimension of the enterprise, of which each dimension subdivides multiple elements and constructs a competitive advantage analysis model. Because it has been proved that its various factors were deeply influenced by subject, it is only suitable for qualitative analysis. The existing research proposed the GREP model and introduced the patent analysis indicators. Lou, Wang and Huang (2015,2016) analyzed the situations of the aging industry in Beijing and the low-carbon clothing industry in China from the G-dimension, R-dimension, E-dimension and P-dimension. The research showed that the improved GREP model overcomes the subjective influence and can comprehensively analyze the industrial status from the micro-quantitative perspective, but the model cannot clearly reflect the value of patents, and cannot analyze the number of high-value patents that the innovation subjects have in the industrial competition, so that it can't generally analyze the competition and threat in the market. The V-dimension analysis is based on the patent value model independently developed by Beijing IncoShare Technology Co., Ltd. The patent value model integrates the most common and important technical indicators in the patent analysis industry, such as patent types, the number of cited times, the number of the same family, the number of countries in the same family, the number of claims, the number of inventors, the number of IPC large groups, and the remaining patent validity period, etc., more than 20 technical indicators, by setting index weights, calculation order and other parameters. The patent is divided into 1-10 points. The higher the score, the higher the patent value. Patent value is obtained from the sum of the comprehensive values, the three dimensions are patent technology, law, and market values (Beijing IncoShare Technology Co., Ltd. 2018)

$$V = W_1{}' \sum_{i=1}^{n1} W_i V_i + W_2{}' \sum_{i=n1+1}^{n2} W_i V_i + W_3{}' \sum_{i=n2+1}^{n} W_i V_i \quad (1)$$

where V_i means when i ranges from *[1,n1]*、*[n1+1,n2]*、*[n2+1,n]* contribution of patent parameters in the three dimensions of technology, law, and market to the patent value system, W_i mean the corresponding weight coefficient of V_i, W_1'、W_2'、W_3' respectively weighting factors for technology, law, and market value . V_i is equal to:

$$V_i = 2 * M * \left(\frac{1}{1+e^{\frac{-5*p}{K}}} - 0.5 \right) \quad (2)$$

where *M* represents the maximum value of V_i, p represents the parameter value, and *K* represents the p value of V_i flattening.

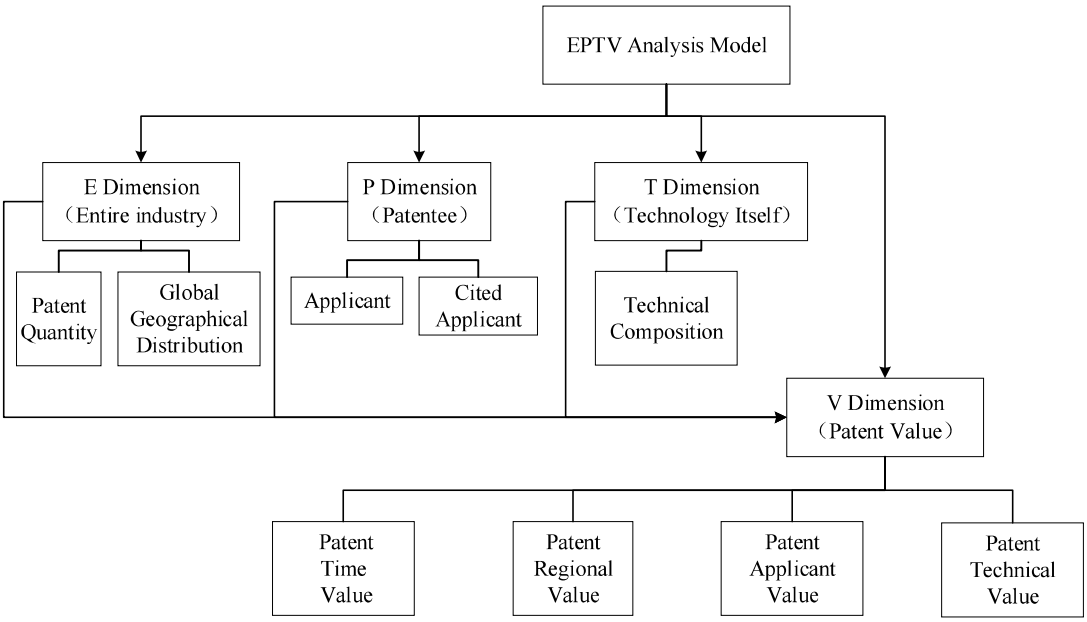
Based on the above two analytical models, this paper explores a new method of the industrial patent competitive intelligence analysis based on the patent value, which is called the patent analysis method based on EPTV model. Based on the GREP model, this study improved the prior GREP dimensions, which the G-dimension, R-dimension, E-dimension and P-dimension are converted into E-dimension (Entire industry), P-dimension (Patentee), T-dimension (Technology) and V-dimension (Value). Each dimension is designed with specific patent analysis indicators. Among them, the E-dimension subordinate indicators are creatively divided into two analytical indicators which include the number of patent applications and the global geographical distribution of patents. As an important means of protecting technological innovations, the annual trend of the patent reflects the development process of R&D innovation in specific technology fields (Zhang, Shen & Ding, 2015). Different technology development stages have different impacts on the creation, protection and application of high-value patents. Therefore, from the perspective of patent analysis, by analyzing the trend of patent applications, the life cycle of the specific industry can be discovered. At the same time, the global innovation layout of the industry can be obtained through the distribution of patents in different countries or regions, which can provide strategic guidance for the development and the layout of the industry.

The P-dimension means a patent applicant, at the same time, introducing the index of the cited applicants can reflect the importance of the patent. The patent applicants of the technological innovation, by analyzing the industry's top global rankings of the patent applicants, and their patent applications amounts, it's useful for the in-depth understanding of the industry's major global competitors and their patent layout, which provides navigation for the development of the industry. The number of patents cited directly reflects the importance of the patent. Therefore, by analyzing the cited applicants and its cited frequency, the patent can be directly informed of the importance of the patent in the industry, thereby researches can identify the potential competitors and formulate technological innovations and patent layout strategies in advance. The P-dimension constitutes of one indicator. The technical field involved in the building energy-saving industry is very extensive, and the technology is complex. By analyzing the technical fields of its patents, it helps to further understand the global technology research and development direction of the building energy-saving industry.

In addition, in order to further reflect the countries in which the high-value patents of the building energy-saving industry are distributed or the competitors who own the high-value patents of the building energy-saving industry, this paper introduces the patent value V-dimension, through associative analysis of the E-dimension, P-dimension, T-dimension and V-dimension four sub-indicators of time patent value, regional patent value, applicant value and technical patent value are formed. Meanwhile, by analyzing the degree of patent regional value and its proportion within different development stages of ranking in the specific range of the industry, it is possible to confirm the distribution and layout of innovative entities with high-value patents in a certain industry in different development stages. By further analyzing the applicants and the degree of the value of technology patents, researchers can grasp the in-depth understanding of which applicants have the most high-value patents, and which sub-technical areas they are. So as to accurately find the strong competitors of the industry, and do a good job in technical

innovation direction planning and industrial development countermeasures. Figure 1 shows the patent analysis model based on EPTV proposed in this paper.

FIGURE 1
PATENT INTELLIGENCE ANALYSIS MODEL BASED ON EPTV



Data Resources and Processing

This paper uses the intellectual incoPat patent database as the main data source for the global patent search analysis, and uses the Derwent patent database as an auxiliary tool to verify the search results. Through the technical research and consulting expert opinions on the building energy-saving industry, the technical decomposition table is constructed. We finally determined to perform the retrieval for the research with ((FULL=((construct* OR build* OR architecture* OR roof* OR wall* OR window* OR house*) AND ('energy consumption*' OR 'consume* energy' OR 'energy sav*' OR 'calorific value' OR 'energy efficiency ratio' OR 'load* factor*' OR 'thermal load*' OR 'solar energy utilization*' OR 'solar roof*' OR 'air infiltrate*' OR 'rain infiltrate*' OR 'air insulate*' OR 'fan* unit*' OR 'coil air condition*' OR 'cold storage*' OR 'fluorescent*' OR 'canteen*' OR 'socket' OR 'special power' OR 'cold stat*' OR 'indoor routine' OR 'office equipment*' OR 'kitchen equipment*' OR 'informat* center*' OR 'electric water boil*' OR 'mechanical ventilate*' OR 'water suppl*' OR 'drainage pump*' OR 'refrigerator* pump*' OR 'cool* pump*' OR 'cool* tower*'))) AND (IPC=((E04B1/00 OR E04B2/00 OR E04H6 /00 OR F24F13/00 OR F24F11/00 OR F24F7/00 OR F21V23/00 OR F21S9/00 OR E06B3/00 OR E04D13/00 OR E04G21/00 OR F24F5/00 OR F24H1/00 OR F21V29/00)))) AND (AD=[19600101 to 20171231]), and then denoised by IPC classification number and indexing, and finally obtained 52316 analysis sample data. Due to the lag in patent disclosure, the number of patent families in 2016 and 2017 may not be complete, but it does not affect the analysis of building energy-saving technologies.

CASE STUDY

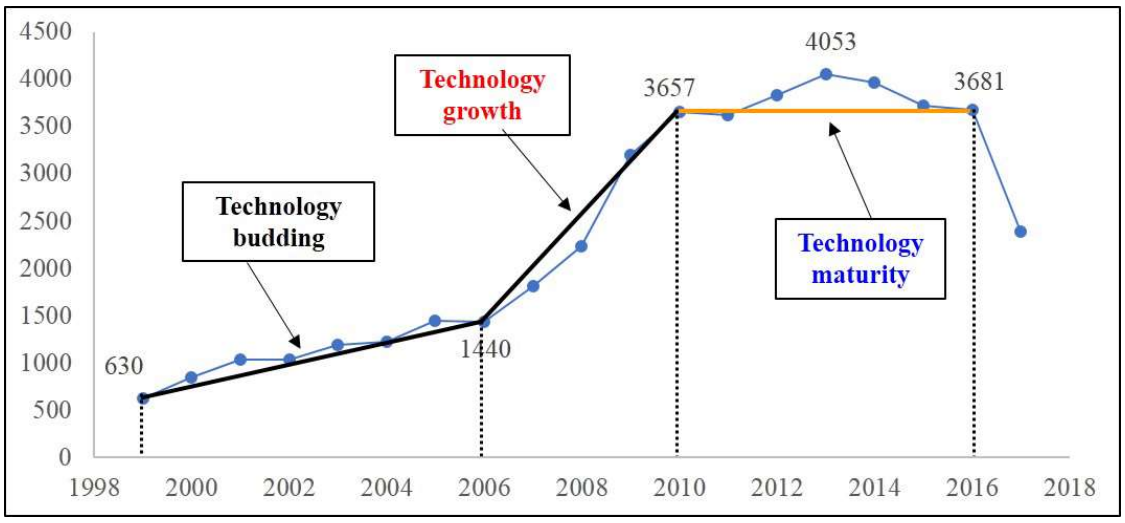
E-Dimension Analysis

Patent Development Trend

The patent application trend analysis explores the technological development process of the building energy-saving industry with the changes of the number of patent applications over time. The whole life

cycle theory divides the development of a certain technology into four stages: the germination period, the growth period, the maturity period and the recession period. The figure 2 shows the distribution law of the patent application quantities of the building energy-saving industry over time based on the analysis of patent statistics method.

FIGURE 2
DISTRIBUTION OF PATENT APPLICATIONS FOR BUILDING ENERGY EFFICIENCY INDUSTRY OVER TIME



As can be seen from the figure 2, the building energy-saving industry first appeared in the patent application in 1999. To the end of the statistical periods, its technological development experienced three stages which were the germination period (1999-2006), the rapid growth period (2006-2010) and the maturity period (2010-2016).

First, the germination period: from 1999 to 2006, the average growth rate of patent applications in the field of building energy conservation was only 12.5%. It can be clearly seen that the patent application themes of the whole industry mainly involved some subdivision technology fields such as the indoors air conditioning systems and the lighting devices, the initial concepts of building energy conservation were formed. But the technology development was relatively slow.

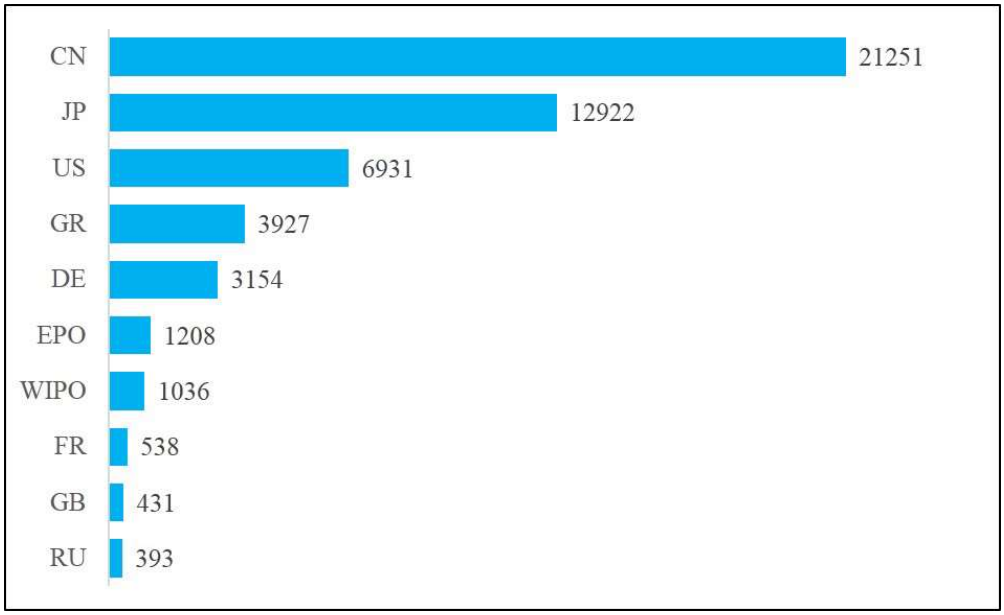
Second, the rapid growth period: from 2006 to 2010, the entire building energy-saving industry ushered in a period of rapid growth. Most enterprises in the world, especially Japan's Matsushita and Toshiba, realized the important strategic position of building energy-saving technologies and carried out lots of technical researches. The research is highlighted by the rapid increase in the number of patent applications. In 2010, the number of applications reached 3,657. Third, the maturity period: From 2010 to 2016, with the improvement of global technological innovation, the development of building energy-saving industry has entered a period of stable maturity. The number of patent applications per year has remained at around 3,700. In 2013, it reached the patent year of the industry, the peak of the application volume was 4053 pieces. Due to the certain lag of the patent application disclosure, the statistics of 2016 and 2017 may not be comprehensive, but it can be seen that the global building energy-saving technology is currently or will be in a stable and mature period.

Regional Distribution of Patent Layout

The regional distribution of patent applications can reflect the layout of technological innovation entities in the worldwide to some extent, and then analyzes the innovative regional distribution intelligence information of a certain technology, which helps the industry to carry out global technological innovation and patent layout strategies. This paper applies the EPTV analysis model and the

patented metrological analysis method to obtain the distribution of the top 10 patent application countries or regions in the building energy conservation industry. As shown in figure 3, terms of the amounts of patent applications, the number of patent applications in China exceeds 20,000 in a leading position, which is 164.46% of Japan, three times of the United States. In addition, the number of patent applications in this technical field in Korea is nearly equal to Germany.

FIGURE 3
GLOBAL GEOGRAPHICAL DISTRIBUTION OF PATENT APPLICATIONS FOR BUILDING ENERGY EFFICIENCY INDUSTRY



P-Dimension Analysis

Analysis of Patent Applicant

The patent applicants are the innovation subjects of technologies. Therefore, this paper adopts the patent measurement analysis method and combines the applicants who belong to the same innovation subject, and selects the top ten patent applicants in the building energy conservation industry as the analysis objects. The Table 1 shows the research results.

TABLE 1
THE TOP TEN PATENT APPLICANTS IN BUILDING ENERGY EFFICIENCY INDUSTRY

Standardized applicant	Patent Quantity （item）	First patent application time （year）	Applicant country	Percentage (%)
Toshiba	1207	1981	Japan	21.49%
Mitsubishi	802	1973	Japan	14.28%
LG Group	733	1998	Korea	13.05%
Panasonic Group	558	1988	Japan	9.94%
Daikin	441	1979	Japan	7.85%
Midea Group	428	2009	China	7.62%
Hitachi	407	1979	Japan	7.25%
Siemens	363	1972	Germany	6.46%
Sharp	341	1996	Japan	6.07%
Kerry	336	2001	United States	5.98%

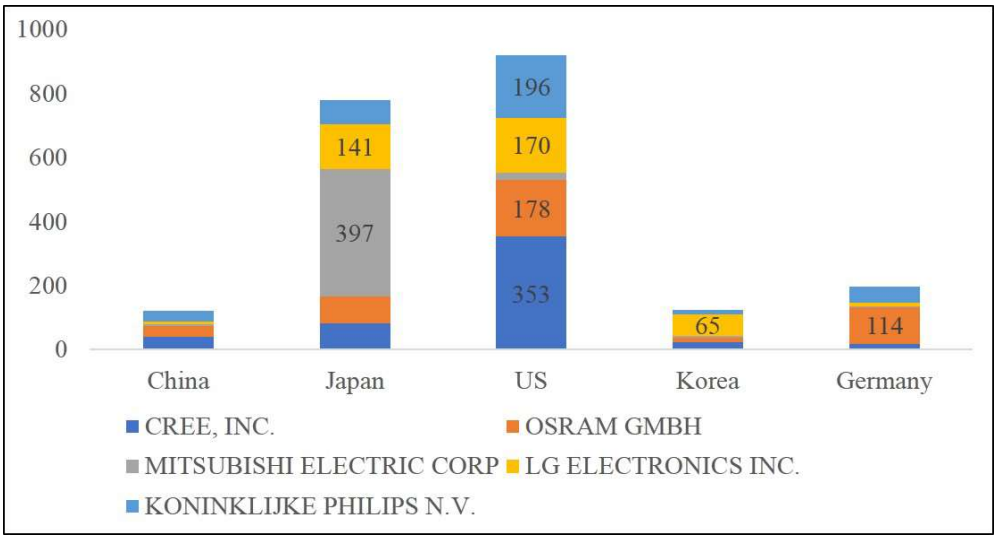
Among the top ten applicants, there are 6 Japanese companies, especially the Toshiba accounts for 21.49%, which indicates that the innovation subjects are concentrated in Japanese companies in the field of building energy-saving technology, owning a strong technology accumulation and numerous patent applications. In contrast, the innovation subjects in Korea, China, Germany and the United States are relatively scattered. However, it is worth noting that the Siemens, in Germany, first filed a patent application in the field of building energy-saving technology as early as 1972, which was extremely forward-looking in this field.

Analysis of Cited Applicant

Patents may be cited by the patent or non-patent literature, and patents and non-patent documents may also be cited. The study of citation relationships between patents is called patent citation analysis. In recent years, researches on patent citation analysis have been carried out at home and abroad (Narin & Olivastro, 1998; Yang, Chen & Jin 1999; Wolfgang & Martin, 2003; Hsiao & Torvik, 2019), studying the relationships and development laws between patent documents. The number of patent citations reflects the importance of the technologies included in the patents to some extent (Du, Li, Haunschild, Sun, & Tang, 2019; De Paiva Britto, Costa Ribeiro, Araújo, Da Matta Machado & Da Motta e Albuquerque, 2019). In this paper, the patent custody method is used to analyze the patent citation information in the field of building energy-saving technology, and the distribution of the top five patent applicants in the number of citations is shown in figure 4.

As shown in figure 4, the patent applicants who applied for patents in the US have the most times of citations, the next is Japan, which indicates that important technologies in the field of building energy-saving technologies are produced in the United States or Japan, and constitutes the core competition opponent in the field. Specifically, the Mitsubishi Corporation's patents applied in Japan reached up to 397 citation times, followed by Philips's patents applied in the US reaching up to 353 citation times. This shows that these innovative entities have key technologies and basic patents in the field of building energy-saving technology and they are the founders of this technology field.

FIGURE 4
DISTRIBUTION MAP OF APPLICANTS FOR PATENTS IN BUILDING ENERGY EFFICIENCY INDUSTRY



T-Dimension Analysis

The T-dimension analyzes the patent technology field of the building energy-saving industry through the technical composition, which helps to deeply understand the global technology researches and development directions of the building energy-saving industry. The IPC classification number group will not cover a wide range of technical fields like the large or small classes, nor would it be like a group specific to a certain subdivision technology field. Therefore, this paper selects the indicators of the IPC classification number (large group), which is accepted internationally. To study the technical composition types of the building energy-saving industry patents, the table 2 shows the distribution of the top ten IPC groups.

TABLE 2
TOP 10 IPC GROUP TECHNOLOGY DISTRIBUTION TABLES FOR BUILDING ENERGY EFFICIENCY INDUSTRY

IPC (Large group)	Technical content	Patent Quantity (item)	Percentage (%)
F21V23	Arrangement of circuit components in or on the lighting device	17135	18.84%
F21V29	Cooling or heating device	16336	17.97%
F21Y101	Point light source	12458	13.70%
F21S2	Illumination system not included in large groups F21S4/00 to F21S 10/00 or F21S 19/00, e.g. modular construction	7723	8.49%
F24F11	Control system or equipment, safety system or equipment	7163	7.88%
F21V19	Fixing the light source or lamp holder	6879	7.57%
F24F5	Air conditioning systems or equipment not included in the F24F1/00 or F24F 3/00 group	6862	7.55%
F21S8	Prepare a fixed installation of lighting	6632	7.29%
F21V17	Fixing of components of a lighting device, such as a shading device, a lampshade, a refractor, a reflector, a filter,	5922	6.51%
F21V21	Support, suspension or connection device for lighting devices	3821	4.20%

As shown in Table 2, the patent quantities of the classification number F21V23 and the F21V29 are equivalent, accounting for one-third of the top ten technical branch applications volumes. This indicates that the technologies related to the lighting, cooling or heating devices are the technical branches of the hot research in the building energy-saving industry, which have formed some patent layout. In addition, the subdivision technical fields, such as the building control system, the light source and the components of the lighting device and the auxiliary support structure, constitute the key research directions of the building energy-saving industry.

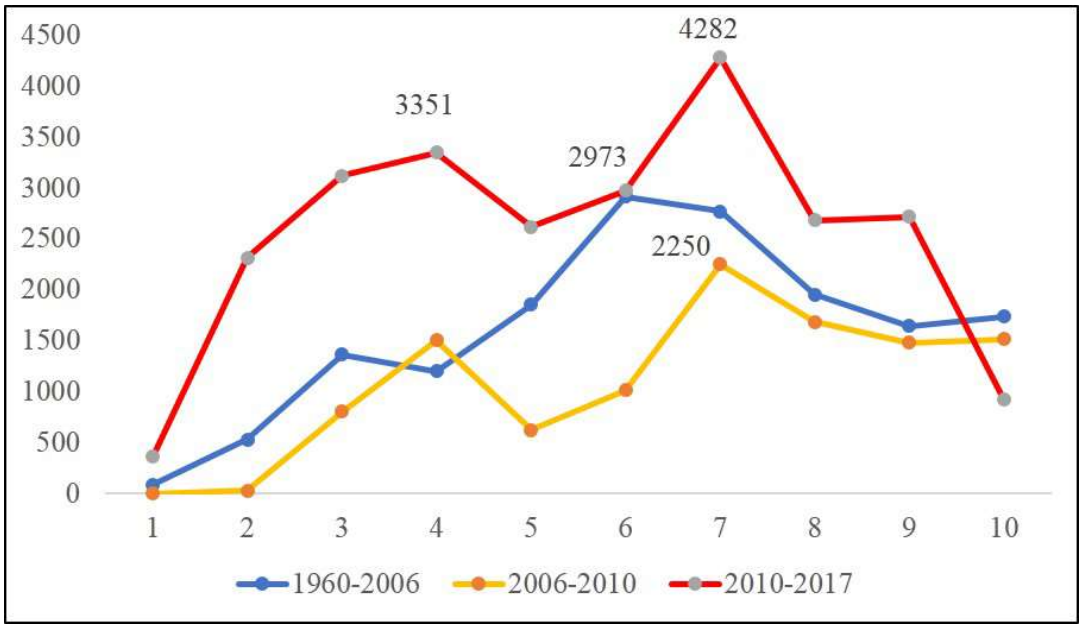
EPTV Dimension Association Analysis

Applying the EPTV model, and performing the in-depth patent value analysis from the G-V dimensions, E-V dimensions and P-V dimensions help to focus on the layout of the high-value patents in the building energy-saving industry from different angles. Then this paper further analyzes the competition situation of the building energy-saving industry.

Patent Time-Value Analysis

By analyzing the volume of the patent applications, it can be seen that the development of building energy-saving industry has experienced the germination period and rapid growth period, and now is in the stage of technology maturity. In order to analyze the technological innovation level of each innovation subject at different stages, this paper takes the three stages of the construction industry as the research objects, and the patent value distribution is shown in figure 5.

FIGURE 5
DISTRIBUTION OF PATENT VALUE AT DIFFERENT STAGES OF DEVELOPMENT OF BUILDING ENERGY-SAVING INDUSTRY



Analyzing the macro comparisons, it is found that the patent value in the mature period of the construction industry is the highest, on the contrary the patent value of the germination period is higher than the patent value of the growth period. The reasons behind it are analyzed:

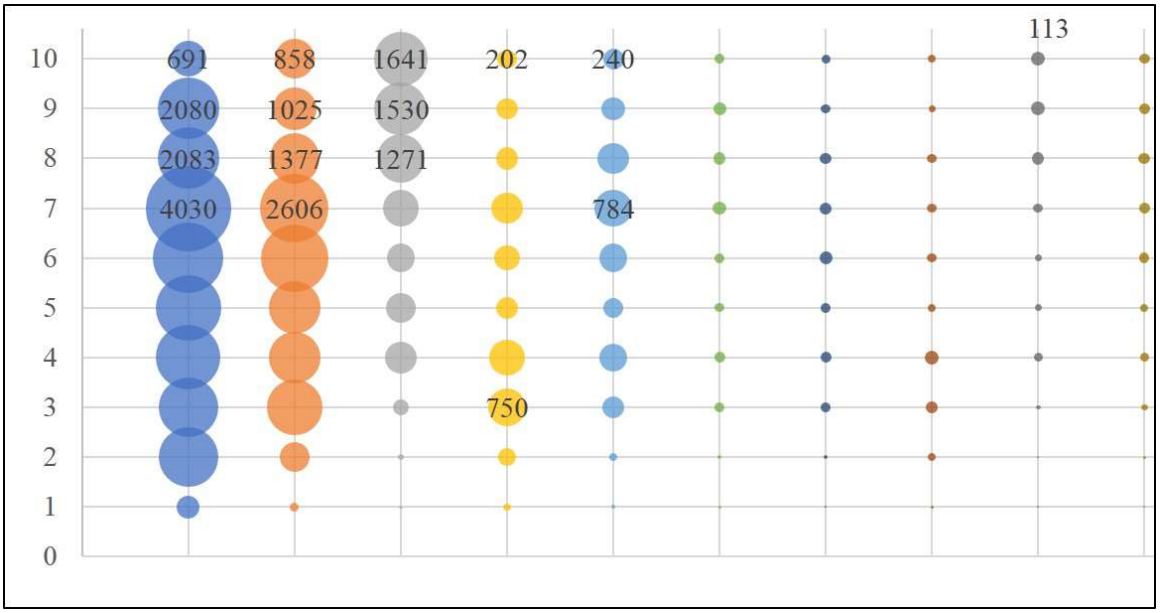
First, in the germination period of the construction industry, the main innovation entities focused on the concepts of energy conservation and the principle technologies, the qualities of patent in the aspects of creation, application and protection are relatively high. By the time of industrial maturity, with the deep development of technologies and the long-term technical accumulation, the technologies protected by its patents have gradually industrialized, and the patent value has been showing up.

Second, during the rapid growth period of the construction industry, although patent applications quantities have increased sharply, the technologies included in patents are mainly concentrated on cooling devices, lighting devices, light sources and some circuit components, mainly due to the relevant innovation entities at this stage were awarded of the great commercial value of the building energy-saving industry, and has launched various research in the relative areas and related supporting technologies. Therefore, a large number of innovations and patent applications have been generated, but these innovations are mostly applied in the subdivision field, so their technologies and patent value were not prominent. From the micro analysis, it is found that the value of the patents in the three stages is mainly distributed in the higher patent value areas of 5-8 points, especially the application number of high-value patent scoring 7 points has reached a peak of 4282 during the mature period, and the high-value patents scoring 9-10 points are rare, which indicates that with the development of related technologies and the continuous innovation of the patent creation protection strategies, the high-value patents commonly generate in the mature periods and the germination period. At the same time, it is obvious that there are more high-value patents scoring 10-point in the germination period and growth period than the number of the patents in the region during the maturity period, most of the new high-value patents were created during the germination and growth periods of the industry. When it come to the maturity period, the development of various technologies is relatively well-equipped, and the difficulty of producing high-value patents is further increased.

Patent Area-Value Analysis

As far as the global patent distribution in the construction energy-saving industry from the G-dimension, China's patent applications exceeded 20,000, followed by Japan and the United States. In order to further analyze the patent value of these countries or regions, this paper selects the top 10 countries and regions possessing high-value patents in the global building energy-saving industry, the patent value distribution is shown in figure 6.

FIGURE 6
BUILDING ENERGY-SAVING INDUSTRIAL AREA - PATENT VALUE DISTRIBUTION MAP



In the field of building energy-saving technology, the patent value degree of China, Japan and the United States rank among the top three, but the patent value degree of the Chinese patents are mainly distributed in the range of 5 to 8 points, of which the ratio scoring 9 to 10 points in the United States accounts for a large proportion in the high value range of 9 to 10 points, followed by Japan. This shows that in the field of building energy-saving technology, the highest-value patents are mainly concentrated in the United States and Japan, and higher-value patents are distributed in China, Japan and the United States.

Patent Applicant-Value Analysis

By analyzing the E-dimension, there are 6 Japanese companies among the top ten applicants. In comparison, the innovation entities in Korea, China, Germany and the United States are scattered. In order to further analyze the patent value distribution of each applicant, this paper selects the top 10 applicants of the high-value patents in the field of the global building energy-saving technologies, and focuses on analyzing the proportion of the high-value patents scoring 5-8 and 9-10 points. The proportion of patents is shown in Table 3.

TABLE 3
PROPORTION OF HIGHER VALUE PATENTS AND HIGH VALUE PATENTS OF MAJOR GLOBAL APPLICANTS

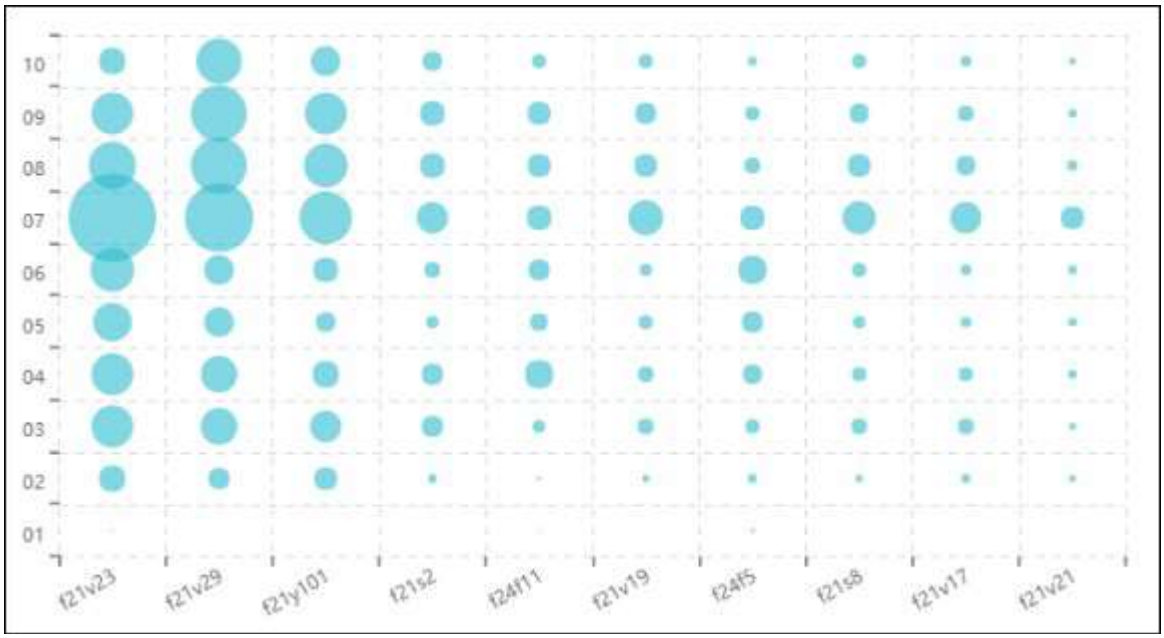
Patent Value / Applicant	1	2	3	4	5	6	7	8	9	10	5～8	high value
Toshiba	4	28	94	117	106	195	245	127	138	153	55.76%	24.11%
Mitsubishi	0	30	104	91	94	117	126	107	78	57	55.22%	16.79%
LG Group	3	19	105	158	50	41	68	82	110	97	32.88%	28.24%
Panasonic Group	0	9	28	69	37	48	95	93	84	96	48.84%	32.20%
Daikin	1	8	27	44	71	97	66	39	56	32	61.90%	19.95%
Midea Group	1	3	2	157	67	92	47	37	20	3	56.64%	5.36%
Hitachi	0	12	42	39	34	77	79	45	48	31	57.74%	19.41%
Siemens	0	2	28	34	37	21	35	51	69	89	39.34%	43.17%
Sharp	0	0	6	18	11	36	80	91	40	59	63.93%	29.03%
Kerry	0	0	3	13	16	20	15	49	90	131	29.67%	65.58%

The table 3 shows that among the high-value patents scoring 5 to 8 points, the Sharp Corporation in Japan ahead of the other patent applicants with the proportion of 63.93%, the second and the third are Japanese companies, the Gold and Hitachi. In addition, China's Midea Group ranked the fourth with the proportion of 56.64%. This shows that the Sharp, Daikin and Hitachi are more active in the area of the building energy-saving technologies, and they have a large number of high-value patents, which are potential competitors in the building energy-saving industry. For the high-value patents of 9 to 10 points, the Kerry company in the US accounted for as the proportion of 65.58%, which is the three times than Japan's Matsushita Group (32.20%), Germany's Siemens company ranked between the Kerry and the Panasonic Group. It can be seen that the Kerry company has lots of high-value patents, occupying a very important position in the field of building energy-saving technology, which may constitute the strongest competitor in the building energy-saving industry, the second is the Siemens in Germany, which has a long period of technological accumulation in the electrification and the technical field of the automation segmentation, and may also constitute a strong competitor in the building energy-saving industry.

Patent Technology-Value Analysis

It can be seen from the P-dimension analysis that the classification number F21V23 and F21V29 together account for one-third of the top ten application volume of the technology branch. In order to further analyze the patent value distribution of each technology branch of the building energy-saving industry, as shown in figure 7.

FIGURE 7
BUILDING ENERGY-SAVING INDUSTRY TECHNOLOGY - PATENT VALUE DISTRIBUTION MAP



From the point of the horizontal analysis, the top three of the amounts of the high-value patents in the building energy-saving industry are the subdivision technologies of F21V23, F21V29 and F21Y101, especially the F21V29 technology branch gathering in the 9-10 high-value area, which indicates that the cooling or heating devices and the arrangement of circuit components in or on the lighting devices are the hot research directions of the energy-saving building industry, which has birthed a large number of new technologies and high-value patent layouts. In the development of the construction industry, the developer can avoid these hotspots and conduct researches on sub-technical fields such as F21V17 or F21V21. In terms of the longitudinal analysis, the amounts of the patents scoring 7 points of the patent value degree in the technical field of the classification number F21V23 is the largest, reaching up to 3,760, almost twice than the distribution in the 3-9 sub-regions, the patents scores 7 points in the technical areas of the classification number F21V29 ranking the second and the classification number F21Y101 ranking the third. It shows that the patent value degree of each sub-technical field mostly concentrates in the higher degree of patent value areas, and there are fewer high-value patents distributing at9-10 points relatively.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

Based on the EPTV model and through the patent intelligence analysis, this paper can draw the following conclusions. First, China is in a leading position in terms of the amounts of patent applications, but the high-value patents mainly concentrate in the United States and Japan. From the analysis of patent applicants, it can be seen that the innovation entities of the Japanese companies are more concentrated in the field of building energy-saving technology, and they have obtained strong technical accumulation and a large number of patent applications. In contrast, the innovation entities in Korea, China, Germany and the United States are relatively scattered.

Second, the value of the patents in the mature period of the construction industry is the highest, the value of the patents in the germination period is higher than the value of the patents in the growth period, and most high-value patents are generated during the germination period and the growth period.

Third, the companies of Sharp, Daikin and Hitachi are more active in the innovation field of building energy-saving technologies, and reserve a large number of high-value patents, which are the potential competitors in the building energy-saving industry.

Fourth, the Kerry company in American has a great deal of high-value patents, standing at a very important position in the field of building energy-saving technologies, which may constitute the strongest competitor in the building energy-saving industry. The next is the Siemens in Germany, which has a long-term technical accumulation in the subdivision technology field of electrification and automation, and may also become a strong competitor of the building energy-saving industry.

Fifth, the arrangements of circuit components in the cooling, heating devices and the lighting devices are the hot research directions of the building energy-saving industry. This has resulted in a large number of new technologies and high-value patent layouts.

Based on the patent value orientation, this paper constructs a new patent competitive intelligence analysis model called the EPTV model, introduces the patent value dimension into the analysis model, and relatively analyzes the building energy-saving industry from multiple perspectives of G-V, E-V and P-V. Relatively speaking, the EPTV patent intelligence analysis method based on the patent value orientation has the following advantages. First, the method introduces the patent value dimensions into the EPTV model, and analyzes the patent competition intelligence of the building energy-saving industry from the perspective of high-value patents, providing the patent analysis methods with new perspective. At the same time, the method meets the actual needs of China's cultivation of high-value patents, and lays the foundations for the intelligence analysis of the high-value patents cultivation in China. Second, through the correlation analysis of time, regions, applicants and technologies and patent value, the researchers can grasp the in-depth interpretation of the countries or regions with high-value patents in different development periods of the building energy-saving industry, and the major applicants in these countries or regions have how many high-value patents, and the layouts of the specific subdivision technology fields, so as to further identify the core competitors and the potential competitors of the building energy-saving industry and their layouts.

Policy Implications

This paper also provide some countermeasures and suggestions for the technical innovation and development of China's building energy-saving industry. Based on the above analysis conclusions and the actual needs of the development of China's building energy-saving industry, there are some specific recommendations:

First, the patent layout needs more actively and cultivate high-value patents. Through the analysis of the patent intelligence in this paper, it is found that the world's major high-value patents in the building energy-saving industry are deployed in three sub-technical fields of lighting, cooling or heating and light sources. Therefore, it is suggested that when China's building energy-saving industry carry out researches and patent layout in the construction industry. They can avoid these hotspots, conduct technical researches on these sub-technical fields such as the F21V17 (lighting device components) or F21V21 (support, suspension or connecting devices for lighting devices), and fully apply the patent intelligence analysis methods to further analyze the layout of the patents in these technical fields, thus to implement the patent excavation, patent layout, form a multi-dimensional patent protection network, and cultivated a series of high-value patents and patent portfolios.

Second, the industrial integration needs to continuously improve the industrial chains. According to this paper’s analysis, it is found that although there are a large number of patent applications in the building energy-saving industry in China, the applicants' rankings are far behind those of Japanese and American companies. This shows that the innovation entities of China's industry are scattered and do not form the companies with the core competitiveness. Therefore, it is recommended that China's building energy-saving industry should strengthen the industrial integration, reunite power, and strengthen the unified management of the intellectual properties. After a certain period of accumulation, Chinese enterprises may occupy a place in the building energy-saving industry. In addition, most of the current high-value patents concentrate in the fields of lighting, cooling or heating subdivision technologies, and

the layout of the industrial chains is not perfect. Therefore, it is recommended to continuously improve the industrial layout in the weak sections of the global layout, encourage the upstream and downstream enterprises in the industry chains to tackle the common technology bottlenecks together, further strengthen the industrial application speed of the technological research results, and promote the R&D resource sharing system.

Third, core technology researches needs more innovation protection. At present, most of the high-value patents in the building energy-saving industry are concentrated in developed countries or regions such as the United States and Japan, especially the American Kerry Company, the German Siemens Company. And the Japanese Sharp Corporation, Daikin Corporation and Hitachi, which all attach great importance to the industrial core technology researches, have experienced a long-term technology accumulation. Thus, they have led to the forefront of the industry and have been constituted the strong competitors of the industry. In contrast, China does not have sufficient technological researches and innovation achievements in various sub-technical fields of the building energy-saving industry. Therefore, it is recommended that China's building energy-saving industry needs to pay more attention to the research and development of the core technologies based on the patent layout.

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REFERENCES

Beijing IncoShare Technology Co., Ltd. (2018). CN 108460698A, Beijing, China.

Beijing IncoShare Technology Co., Ltd. (2018). CN 108629708A, Beijing, China.

Byungun, Y., & Yongtae, P. (2007). *Development of new technology forecasting algorithm: hybrid approach for morphology analysis and conjoint analysis of patent information*. IEEE Transactions on Engineering Management.

De Paiva Britto, J. N., Costa Ribeiro, L., Araújo, L. T., Da Matta Machado, G. T., & Da Motta e Albuquerque, E. (2019). Knowledge flows, changing firms' competences and patent citations: an analysis of the trajectory of IBM. *Economics of Innovation and New Technology*, 28(4), 317-3

Deng, J., Yu, X., & Cui, L.G. (2014). Study on the Competitive Situation of China's Cloud Computing Industry Based on Patent Information. *Journal of Intelligence*, 33(7), 50-56.

Dodoo, A., Gustavsson, L., & Tettey, U. Y. (2017). Final energy savings and cost-effectiveness of deep energy renovation of a multi-storey residential building. *Energy*, 135, 563-576.

Du, J., Li, P., Haunschild, R., Sun, Y., & Tang, X. (2019). *Patent citations to scientific papers as early signs for predicting delayed recognition of scientific discoveries: a comparative study with instant recognition*. ArXiv preprint arXiv:1906.07953.

Han, X.C., & Lei, Y. (2017). Analysis of Theory and Practice of Cultivating High-value Patent. *China Inventions & Patents*, 14(12), 8-14.

Hsiao, T. K., & Torvik, V. I. (2019). Knowledge transfer from technology to science: The longevity of paper-to-patent citations. *Proceedings of the Association for Information Science and Technology*, 56(1), 417-421.

Huang, L.C., Chang, L.L., & Miao, H. (2016). Analysis of competition situation of elderly welfare technology based on ESTP-Chain four-dimensional analysis method. *Science and Technology Management Research*, 36(12), 213-219.

Huang, L.C., Gao, Y.Q., & Wu, F.F. (2014). Analysis of the Competitive Situation of Global High-Speed Railway Technology Based on Patent Data. *Journal of Intelligence*, 33(12), 41-47.

Jin, Y.F. (2015). Study on the Technical Competition Situation of China's Mining Fan Industry-Based on Patent Perspective. *Journal of Intelligence*, 34(1), 49-54.

Li, W.J., Liu, G.F., & Lu, Z.P. (2015). Study on the Competitive Situation of China's Big Data Industry Based on Patent Analysis. *Journal of Intelligence*, 34(7), 65-70.
Lou, Y., Wang, X.T., & Huang, L.C. (2016). Research on Beijing's aging industry based on patents. *Journal of Intelligence*, 35(1), 45-50.
Lou, Y., Wang, X.T., & Huang, L.C. (2015). Analysis of the status quo of China's low carbon clothing industry based on patents and its countermeasures. *Journal of Intelligence*, 34(9), 54-60.
Ma, T.Q., & Zhao, X. (2018). Exploration of the Connotation and Acceptance Factors of High-value Patent. *China Inventions & Patents*, 15(03), 24-28.
Miao, H., Song, Y.X., & Huang, L.C. (2015). CMTO four-dimensional analysis method of competitive intelligence analysis and its application. *Journal of Intelligence*, (8), 4.
Narin, F., & Olivastro, D. (1998). Linkage between patents and papers: An interim EPO/US comparison. *Scientometrics*, 41(1-2), 51-59.
Olivieri, L., Caamaño-Martín, E., Moralejo-Vázquez, F. J., Martín-Chivelet, N., Olivieri, F., & Neila-Gonzalez, F. J. (2014). Energy saving potential of semi-transparent photovoltaic elements for building integration. *Energy*, 76, 572-583.
Qiu, H.H., & Yang, J. (2018). An Assessment of Technological Innovation Capabilities of Carbon Capture and Storage Technology Based on Patent Analysis: A Comparative Study between China and the United States. *Sustainability*, 10, 231-251.
Shen, J.H., & Zhang, N. (2014). Research on Competitive Situation of Chinese Fuel Cell Vehicle Technology Based on Patent Analysis. *Journal of Intelligence*, 33(7), 27-32.
Sher, F., Kawai, A., Güleç, F., & Sadiq, H. (2019). Sustainable energy saving alternatives in small buildings. *Sustainable Energy Technologies and Assessments*, 32, 92-99.
Shih, M.J., Liu, D. R., & Hsu, M. L. (2010). Discovering competitive intelligence by mining changes in patent trends. *Expert Systems with Applications*, 37(4), 2882-2890.
Tekić, Ž., Dražić, M., Kukolj, D., Nikolić, L., Kukolj, S., & Vitas, M. (2015). Psalm-patent mining tool for competitive intelligence. *Tehnicki Vjesnik*, 22(6), 433-1440.
Wang, B., Liu, S., Ding, K., Liu, Z., & Xu, J. (2014). Identifying technological topics and institution-topic distribution probability for patent competitive intelligence analysis: A case study in LTE technology. *Scientometrics*, 101(1), 685-704.
Wolfgang, G., & Martin, M. (2003). Patents cited in the scientific literature: An exploratory study of 'reverse' citation relations. *Scientometrics*, 58(2), 415-428.
Yang, X., Yu, X., & Liu, X. (2017). Research on the competitive situation of graphene industry technology based on patent intelligence. *Journal of Intelligence*, 36(12), 75-81, 89.
Yang, X., Yu, X., & Liu, X. (2018). Obtaining a Sustainable Competitive Advantage from Patent Information: A Patent Analysis of the Graphene Industry. *Sustainability*, 10, 560-585.
Yang, Z., Liu, B., & Zhao, H.B. (2004). Energy Saving in Building Construction in China: A Review. *International Journal of Green Energy*, 1(2), 209-225.
Yang, Z.G., Chen, H., & Jin J.T. (1999). Statistics and Analysis of Chinese Patentes Cited by SCI Sources. *Information Science*, 17(4), 422-428.
Yu, X., & Zhang, B. (2019). Obtaining advantages from technology revolution: A patent roadmap for competition analysis and strategy planning. *Technological Forecasting and Social Change*, 145, 273-283.
Zhang, C.B., Shen, X.L., & Ding, W. (2015). Analysis of Domestic Alternative Energy Patent Information-Based on the Dual Perspectives of Technology Subjects and Patent Owners. *Journal of Intelligence*, 34(1), 55-60.
Zhang, Y.W., & Lan, X.Y. (2003). One of the methods of corporate strategy and competition analysis-patent analysis method. *Journal of the China Society of Information Science*, (08), 808-810.
Zheng, D., Yu, L., Wang, L., & Tao, J. (2019). Integrating willingness analysis into investment prediction model for large scale building energy saving retrofit: Using fuzzy multiple attribute decision making method with Monte Carlo simulation. *Sustainable Cities and Society*, 44, 291-309.