Analysis and Research on the Sleeping Beauty Phenomenon in Patent Literature Postprint

Authors: Li He, Yuan Cuimin, Xie Mengfan

Date: 2023-07-26T00:00:00+00:00

Abstract

[Purpose/Significance]"Sleeping Beauty" literature describes the phenomenon of delayed recognition in scientific papers, and the phenomena of delayed discovery and delayed attention also exist in technical literature. After reviewing relevant research on Sleeping Beauty, patent dormancy phenomena, and patent citation analysis in the literature, this concept is introduced into patent information analysis to reveal the existence of the Sleeping Beauty phenomenon in patent literature.[Method/Process]Based on patent and citation information released by the United States Patent and Trademark Office (USPTO) and the National Bureau of Economic Research (NBER), Sleeping Beauty patents are identified using the classic identification method for Sleeping Beauty literature, their characteristic distributions are analyzed, and typical cases are selected for study.[Results/Conclusion]The results demonstrate that the Sleeping Beauty phenomenon also exists in patent literature and possesses characteristics unique to patent documents, laying a foundation for the subsequent identification and awakening of Sleeping Beauty patents, and thereby providing solutions for the early discovery and utilization of such valuable patent literature, promoting knowledge flow and technological iteration, improving research efficiency, and accelerating scientific discovery.

Full Text

Preamble

Volume 63, Issue 6, March 2019
ChinaXiv Cooperative Journal

Analysis and Study on the Phenomenon of Sleeping Beauty in Patent Literature

Li He, Yuan Cuimin, Xie Mengfan
School of Management, Jilin University, Changchun 130022

Abstract

[**Purpose/Significance**] The "sleeping beauty" literature describes the phenomenon of delayed recognition in scientific papers, and similar patterns of delayed discovery and attention also exist in technical literature. After reviewing research on sleeping beauties in academic literature, sleeping patent phenomena, and patent citation analysis, this study introduces the concept into patent information analysis to reveal the existence of sleeping beauty phenomena in patent documents. [**Method/Process**] Based on patent and citation information released by the United States Patent and Trademark Office (USPTO) and the National Bureau of Economic Research (NBER), this paper employs classical identification methods for sleeping beauty literature to identify sleeping beauty patents, analyzes their characteristic distributions, and selects typical cases for in-depth study. [**Result/Conclusion**] The results demonstrate that the sleeping beauty phenomenon indeed exists in patent literature and exhibits unique characteristics specific to patent documents. This research lays a foundation for the subsequent identification and awakening of sleeping beauty patents, providing solutions for early discovery and utilization of such valuable patent documents to promote knowledge flow and technological iteration, improve research efficiency, and accelerate scientific discovery.

Scientific papers exhibit delayed recognition through "sleeping beauty" literature, and patent literature contains similar phenomena known as "sleeping patents" and "submarine patents." These patent documents initially receive little attention, but with technological evolution and the implementation of patent strategies, the protected technologies become significant forces in their respective fields. Thus, delayed recognition, attention, and discovery occur not only in scientific literature represented by academic papers but also in technical literature dominated by patent documents [1]. The identification and study of sleeping beauty literature are based on citation analysis. Similar to the reference structure and citation patterns of academic papers, patent documents also exhibit sleeping beauty phenomena.

2 Literature Review

Patent applicants must disclose prior patents that form the basis of their invention in accordance with legal requirements, and patent applications must provide complete descriptions of the technological foundations and process levels [2]. Unlike scientific papers where authors are responsible for citations, patent citations include not only those marked by inventors but also those added by patent examiners, patent agents, and even the public based on actual citation circumstances

and patent characteristics, in compliance with patent law requirements. Patent citation relationships serve as technological links and hold significant value in patentometrics, revealing technology flows and diffusion, mapping knowledge structures, and tracking scientific and technological development [3].

Previous research on sleeping patents has focused on market competition and patent strategies. This study attempts to combine sleeping beauty identification and analysis methods with patent citation analysis, returning to the literature attributes of patents to examine sleeping patents from a citation perspective and reveal the sleeping beauty phenomenon in patent documents.

2.1 The "Sleeping Beauty" Phenomenon and Its Meaning in Literature

In scientific research, the value of publications is typically recognized soon after publication, with citations increasing annually and peaking 2-6 years after publication depending on the subject area, journal type, and content, becoming hot topics in the field before gradually declining until they are no longer cited [4]. The citation curves of such typical documents generally follow a normal distribution [5]. However, some documents do not gain recognition of their importance and value at publication, only beginning to attract attention and receive substantial citations after several years. Scholars have studied this phenomenon, naming it resisted discoveries [6], premature discoveries [7], and delayed recognition [8], attributing it to research being too advanced for contemporary knowledge levels or unable to be verified by existing technology. The phenomenon is also related to research topics, scientific communities, and scientists' attitudes toward the research [6]. In 2004, A.F.J. van Raan adopted the fairy tale metaphor to define this phenomenon as "sleeping beauty literature," which gained widespread acceptance: a sleeping beauty in science refers to a publication that receives little attention after publication (the sleep period) before suddenly attracting massive attention (awakened by the prince) [9], with a typical citation curve shown in [Figure 1: see original paper]. The most classic sleeping beauty literature is Mendel's 1865 paper on plant hybridization experiments, which was only rediscovered 34 years later [10].

Current research on sleeping beauty literature has achieved considerable scale, making significant progress in conceptualization, characteristic description, identification methods, formation mechanisms, awakening mechanisms, and case studies. Regarding conceptualization, scholars have continuously refined van Raan's classic definition. For instance, in 2012, Chinese scholars Li Jiang and Ye Ying further enriched the concept based on citation curve characteristics and the "flash in the pan" phenomenon, proposing the concept of "all-element sleeping beauties" [11]. Identification methods are abundant, primarily divided into quantitative methods and curve-fitting approaches. Quantitative methods include parameter-based approaches (such as van Raan's three-indicator method [9] and Costa's quartile method [12] and its improvements) and parameter-free objective indicator methods (such as the "beauty coefficient" method [13]). Ci-

tation curve identification methods include Li Jiang's citation curve analysis framework [14]. Additionally, J. Wang et al. used case analysis to reveal awakening mechanisms and propose awakening strategies [15]. Du Jian and Wu Yishan also systematically studied identification methods for sleeping beauty and prince literature [16] and awakening mechanisms [1]. This demonstrates that sleeping beauty literature research has formed a relatively mature theoretical and methodological system.

2.2 Research on Patent Sleeping Phenomena

The patent sleeping phenomenon refers to patents that are no longer used or fail to inspire other patents after authorization, primarily meaning they are not commercialized or applied in actual production. A typical case illustrates this phenomenon: The Institute of Process Engineering, Chinese Academy of Sciences, applied for a patent on decoupled combustion technology in 1995. The technology addressed heating furnace combustion and exhaust emissions, receiving authorization in 1998, but was not widely applied until the winter of 2017. At the time of application, China had not yet recognized the hazards of nitrogen oxides, making the technology clearly ahead of the market. It took 20 years for the patent to gain attention and be promoted, finally realizing its value. This shows that delayed discovery exists in both scientific papers and technical literature.

Foreign scholars have conducted extensive research on sleeping patents from market competition and patent race perspectives. In corporate competition, firms may apply for patents on new technologies as comprehensively as possible to maintain monopoly positions, potentially resulting in patents that are neither used nor licensed to others—termed sleeping patents [17]. In specific market environments, corporate strategies of preemptive patent application may lead to sleeping patents [18]. Research suggests sleeping patents may be more innovative and warrant awakening measures [19], though forced implementation of sleeping patent strategies may constrain competitors while potentially harming corporate R&D motivation [20]. Chinese scholar Tang Yaojia proposed the concept of "patent sleeping" in 2006 [21], after which scholars studied the phenomenon, causes, and awakening mechanisms, defining patents as assets and categorizing them into active patents, blocking patents, and sleeping patents based on application degree, with some being low-quality or non-compliant problem patents [22], as shown in [Figure 2: see original paper]. Causes include interest differences, excessive institutional intervention, imperfect patent generation mechanisms, intellectual property protection issues, and information asymmetry in patent transaction markets [23]. Awakening sleeping patents relies on patent quality evaluation and effective patent transactions, as well as balancing interests, improving laws and regulations, and intervention systems.

A special category within sleeping patents is "submarine patents," which refer to patents (particularly U.S. patents subject to patent system constraints) that file continuation applications for various reasons to extend the application pe-

riod, keeping the invention secret until industrial technology matures. Once technological change occurs and industrial development is mature, the patent is granted, allowing the patentee to avoid others using the patent and obtain substantial licensing fees [24]. This sleeping state is intentionally created as an important patent strategy and layout method [25], significant for obtaining high returns but controversial as a monopolistic competition practice that is detrimental to scientific development and technological evolution, prompting changes in patent examination systems to curb such behavior [26][27].

Previous research on patent sleeping phenomena has discussed patent utilization and transformation from business and legal perspectives, essentially treating patents as assets. This study focuses on the literature perspective of patents, returning to their documentary characteristics. After patent authorization, long-term lack of attention, failure to inspire other patents, or not becoming foundational patents for technological iteration also represent sleeping states, primarily manifested in not being cited by other patent documents. Existing research on "zero-citation" and "low-citation" patents uses citation data at a specific time point to analyze invention levels hierarchically, finding that zero-citation patents represent micro-invention technologies [28]. This study analyzes historical citation data and temporal distribution characteristics from a patent citation and bibliometric perspective, expanding the concept of sleeping patents and providing a new research perspective.

2.3 Patentometrics and Patent Citation Analysis

Scholars proposed using quantitative methods to analyze patent information as early as the 1940s [29]. With increasingly standardized patent information storage and improved accessibility, researchers focused on patent attributes themselves, advancing patent information analysis. In the 1980s, CHI Research, a well-known U.S. patent information analysis company, introduced bibliometric methods to patent information analysis, expanding research methods and thinking patterns. In 1994, F. Narin formally used quantitative methods to analyze patent information [31], becoming a pioneer in the field. Subsequently, Narin's research became more extensive and in-depth, gradually establishing patentometric research methods while enriching bibliometrics.

Similar to scientific papers, patents as important scientific and technical documents may contain overlooked yet valuable research results or important content with research potential if not cited or transformed for a long time. Low-cited patents cannot be simply classified as "junk" patents; their value may be undiscovered. Patentometric research mainly includes analysis of patent quantity, patent citations, and patent relationships [32], demonstrating the importance of patent citation analysis. Patent citation analysis can discover patent technology value, grasp technology development trajectories and knowledge diffusion paths [33], and determine technology life cycles and maturity through time series analysis of citations. Patent citation indicators mainly include citation counts and citation frequency, which have expanded to include references to patent and

non-patent literature, science linkage, current impact index, and technology strength [34] as patent systems and analysis methods evolve. Patent citation analysis demonstrates excellent representation at macro, meso, and micro levels [35], playing an important role in evaluating corporate development status and supporting decision-making.

China's patent applications and grants increase annually, but utilization and conversion rates remain low, constraining healthy economic development and causing R&D resource waste [36]. This study attempts to introduce sleeping beauty literature theory into patent information analysis, using patent citation information to identify sleeping beauty patents and explore the phenomenon in patent literature.

3 Research Methods and Data Foundation

Patentometrics and bibliometrics share deep roots; patentometrics initially adopted many bibliometric methods and theories, and patent documents share many structural similarities with scientific papers. Therefore, borrowing new theories and methods from bibliometrics for patentometrics is well-founded. Sleeping beauty literature is a recent summary of delayed recognition phenomena in scientific papers and represents a new concept in bibliometrics. Introducing the sleeping beauty concept into patentometrics enriches patent information analysis methods and thinking, particularly for patent citation analysis.

This study uses patent information, including basic patent data and citation information, applying classical sleeping beauty literature identification methods to identify potential sleeping beauty patents. Combining sleeping beauty indicators with patent characteristics, it conducts overall feature analysis of identified sleeping beauty patents and selects typical cases for analysis to reveal the sleeping beauty phenomenon in patents, laying a foundation for further research.

The most classical sleeping beauty identification method is van Raan's three-indicator approach, which identifies typical sleeping beauty literature characteristics and is widely used in scientific sleeping beauty research. This study employs this method for patent sleeping beauty identification. Van Raan's three indicators are:

1. **Sleep Depth (cs)**: The average annual citation frequency during the sleep period, divided into deep sleep ($ $1 citation per year) and light sleep (1-2 citations per year).
2. **Sleep Length (s)**: The duration of deep or light sleep.
3. **Awakening Intensity (cw)**: The average annual citation frequency in the four years after awakening.

Based on analysis of literature data under different parameters, van Raan derived the sleeping beauty formula:

$$N = f\{s, cs, cw\} \sim s^{-2.7} \cdot cs + 2.5 \cdot cw$$

Following parameter settings from van Raan and related studies, this paper sets sleep depth at cs $\leq$ 2 citations per year, sleep length at s $\geq$ 5 years, and awakening intensity at cw $\geq$ 5 citations per year.

The data foundation is the NBER Patent Data Project, which includes all U.S. utility patents and their citation relationships from 1976-2006 published by the National Bureau of Economic Research. In 2001, NBER published "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools," explaining data content, patent citation indicators, analysis methods, and cases [37]. The database contains over 4.85 million patent records (sample shown in), including patent number, assignee code, application year, grant year, and International Patent Classification (IPC) codes. Citation data includes over 23.65 million citation pairs (sample shown in), with each record expressing a citing-cited relationship identified by patent numbers, facilitating forward citation statistics and analysis. The database provides sufficient and effective data for identifying patent sleeping beauties and supports characteristic analysis.

Since U.S. patents have an 18-month protection period from the application or priority date, the database stores both application and grant years. For identification accuracy, this study uses the grant year as the starting point for cited patents and the application year as the citing time for citing patents.

4 Patent Sleeping Beauty Literature Characteristics and Typical Case Analysis

From 23.65 million citation pairs and 4.85 million patent data records, 15,016 sleeping beauty patents were identified, accounting for approximately 0.31%. Previous studies identified sleeping beauty papers at about 0.01%-0.1% of ordinary papers [1], indicating that under current identification methods, the proportion of sleeping beauties in patent literature is higher than in scientific papers. NBER patent data is not updated after 2006, but this has minimal impact on forward citation distributions for early patents. To better observe annual citation patterns and curve characteristics, the author retrieved forward citation information from the USPTO website using the "Referenced By" field to update patent information and compensate for the time gap, enabling statistical analysis of annual distributions for drawing citation curves of typical cases.

4.1 Characteristic Analysis of Patent Sleeping Beauty Literature

4.1.1 Annual Application Distribution of Patent Sleeping Beauty Literature Statistics on application years of all patents and identified sleeping beauty patents in the NBER database were compiled, with annual and overall proportions calculated as shown in . Since NBER data is not updated after

2006 and van Raan's method requires at least a 6-year time window, no sleeping beauty patents appear for 2002-2006. Overall, U.S. patent applications continue increasing, as do sleeping beauty patents. However, because sleeping beauty patents require a relatively long sleep period before being discovered and valued, the number decreases in later years. As the timeline extends, more sleeping patents will be awakened, increasing these numbers.

From the proportion perspective, during 1981-1992, annual sleeping beauty proportions exceeded 0.5%, with the overall proportion for patents with sleep windows over 6 years exceeding 0.35%. Over time, this proportion will be much smaller than the actual occurrence rate, indicating many patents were not well utilized upon authorization. For technology documents with high technological content and innovation, this proportion is significant. In some years, thousands of patents became sleeping beauties, not receiving attention for 5 or more years, causing major losses to scientific research and technological development.

The causes of sleeping beauty patents are complex: similar to papers, the authority of inventors and assignees in their technical fields significantly impacts citation patterns. Whether the technology matches contemporary technological development stages also matters—when sleeping beauty patents represent advanced technology, they often cannot gain immediate recognition until technology develops to the appropriate stage. Additionally, whether the relevant community atmosphere and attitudes can accept novel or unique patents affects value recognition. Patents operate within a complex system, making causes of sleeping beauty patents more diverse than in papers.

4.1.2 Sleep Length of Patent Sleeping Beauty Literature According to van Raan's method, sleep length must be at least 5 years. Statistical results are shown in . The most common sleep length is 6-10 years, with over 1,000 patents in each category, accounting for 59.89% of total sleeping beauty patents. Those with 11-20 years account for 31.37%, and over 20 years account for 4.14%. Thus, sleeping beauty patents with 6-20 year sleep lengths represent the largest proportion. When identifying, predicting, and awakening sleeping beauty patents in a field, patents from 6-20 years before the current research time point should be the main focus. Older patents are more disconnected from current technology and methods, making their contribution and breakthrough probability smaller, with higher awakening costs and difficulty.

4.1.3 Awakening Intensity of Patent Sleeping Beauty Literature This study sets awakening intensity as the average annual citation frequency in the four years after awakening at cw ≥ 5. Statistics on identified sleeping beauty patents are shown in [Figure 3: see original paper]. The most common awakening intensity is 5-10 citations per year, followed by 10-20 (excluding 10). Patents with intensities of 20-30 (excluding 20) and 30-40 (excluding 30) are similar in quantity and relatively few, while those above 40 are minimal. Thus, most sleeping beauty patents have awakening intensities of 5-20 citations, indi-

cating awakening is a gradual process. Chinese scholar Li Jiang suggests that higher awakening intensity means lower probability, with no direct relationship to sleep depth and length [10]. For patent sleeping beauties, when patent value is significant and technical contributions match technological development, high awakening intensity is more likely.

4.1.4 International Patent Classification Distribution The International Patent Classification (IPC) is an international patent classification and retrieval tool. A complete classification consists of sections, classes, subclasses, and groups. Patents are not limited to fixed fields, and applicants and examiners may assign multiple classification codes corresponding to technical themes. Therefore, one patent can have two or more different classifications. The identified sleeping beauty patents have 18,568 IPC records, with section-level distribution shown in [Figure 4: see original paper].

From most to least frequent, sections are: G (Physics), H (Electricity), A (Agriculture), B (Operations; Transporting), and C (Chemistry; Metallurgy), each accounting for 10%-25%. Sections E (Fixed Constructions), F (Mechanical Engineering, Lighting, Heating), and D (Textiles, Paper) each account for less than 5%, indicating most sleeping beauties appear in sections A, B, C, G, and H.

Considering overall patent distribution in the database, the proportion of sleeping beauty patents by section from largest to smallest is shown in . Sections A, E, G, and H are more likely to produce sleeping beauty patents, though more patents in a section do not necessarily mean more sleeping beauties. For example, section B has the second-highest total patent volume but the second-lowest sleeping beauty proportion.

shows the top 20 classes by patent volume. A61 (Medical or Veterinary Science; Hygiene), H01 (Basic Electric Elements), H04 (Electric Communication Technique), G06 (Computing; Calculating; Counting), and G01 (Measuring; Testing) account for larger proportions, with A61 being the largest. Similar to previous results, sections with large sleeping beauty patent quantities do not necessarily have high probabilities of producing them.

4.2 Typical Case Analysis of Patent Sleeping Beauty Literature

A typical case was selected from identified sleeping beauty patents: Patent No. 4558333, titled “Liquid jet recording head,” applied for on July 1982, assigned to Canon Kabushiki Kaisha (Japan), with IPC B41J2/16 (20060101); G01D015/18. According to the International Patent Classification Table (8th Edition, 2006.01) [38], this patent primarily concerns nozzle manufacturing, construction, and usage for printing equipment like printers. Print heads are core printer components. Siemens applied for the earliest inkjet printing patent in 1951, but commercialization took decades until Siemens launched the first commercial inkjet printer in 1977. During the same period, Canon was conducting related research, launching its second “Excellent Enterprise” plan in

1982 and introducing the world's first compact copier using a dark combination method, the "PC10/PC-20" [39]. This patent represents Canon's important R&D achievements during that period.

During its sleep period (1982-1989), citations to this patent came mainly from its competitor and strategic alliance partner Hewlett-Packard (see), demonstrating HP's high attention to Canon. Additionally, Canon (self-citation), Kodak, and Spectra each cited the patent once, indicating these companies were involved in R&D and layout in liquid print heads and referenced Canon's results.

The patent was awakened in 1990, with most citations from Canon's self-citations, followed by HP with minimal proportion compared to the self-citation rate. Other companies like Ricoh (Japan's largest copier manufacturer), Xerox (world's largest modern office equipment manufacturer), Seiko Epson, and Google also cited the patent occasionally. High self-citation rate indicates high participation and strong self-inheritance capability in the technology field [40]. Canon's patent was an early important R&D achievement in printers, contributing significantly to subsequent corporate and industry technological development. As printer technology matured and R&D directions changed, citation volume decreased in recent years.

5 Conclusion and Outlook

Patent information mining and transformation are currently important issues. Drawing on research ideas and analysis methods from scientific sleeping beauty literature, this study explores the sleeping beauty phenomenon in patent literature based on NBER patent data and USPTO data. Through identification and characteristic analysis of patent sleeping beauty literature, this paper provides a research foundation for subsequent identification and awakening. Key findings include:

1. The proportion of identified patent sleeping beauty literature is slightly higher than that of scientific papers, indicating differences between scientific and technical literature. Patent literature is more prone to sleeping phenomena due to patent systems and accessibility factors.

2. Sleep lengths of patent sleeping beauty literature concentrate between 6-20 years. With citation data ending in 2006, identified patents mainly distribute in 1981-1992. Patents with excessively long sleep periods cannot effectively support cutting-edge technology development, but retrospective study of patents within effective timeframes has high potential for breakthrough discoveries. This study found that higher awakening intensity correlates with fewer patents. When patent value is significant and technical contributions match technological development, high awakening intensity is more likely. Additionally, IPC distribution analysis shows that sections with large sleeping beauty quantities do not necessarily have high probabilities.

3. Case analysis reveals that sleeping and awakening of patent literature may correlate with corporate development strategies, market competition, technological development, and industrial structure changes. Moreover, patent citation motivations differ from scientific papers due to patent system influences [41]. When competitors cite a patent, it may be to avoid the technology. Therefore, highly cited patents are not necessarily valuable, and critical attitudes do not indicate errors in cited patents. Citation relationships themselves represent attention to cited parties, embodying knowledge links and technological iteration.

This study has limitations: it does not exclude self-citations, and citation data is not updated to the present, so results may differ as technology evolves. However, historically generated citation data is not significantly affected. This study aims to tentatively identify and reveal the sleeping beauty phenomenon in patents. Future research will focus on differences between sleeping beauty patents and papers, distinguishing citation motivations and effects, and improving identification methods by incorporating patent characteristics to contribute to sleeping beauty patent identification and awakening, providing new perspectives for patent information analysis theory and practice.

References

[1] Du J. Research on Identification Methods and Awakening Mechanisms of "Sleeping Beauty" Literature [D]. Nanjing: Nanjing University, 2017.
[2] Jaffe A B, Trajtenberg M, Fogarty M S. Knowledge spillovers and patent citations: evidence from a survey of inventors [J]. American Economic Review, 2000, 90(2): 215-218.
[3] Chen L. Do patent citations indicate knowledge linkage? The evidence from text similarities between patents and their citations [J]. Journal of Informetrics, 2017, 11(1): 63-79.
[4] Amin M, Mabe M. Impact factors: use and abuse [J]. International Journal of Environmental Science and Technology, 2000, 1(1):
[5] Egghe L, Rao I K R. Citation age data and the obsolescence function: fits and explanations [J]. Information Processing & Management, 1992, 28(2): 201-217.
[6] Barber B. Resistance by scientists to scientific discovery [J]. Science, 1961, 134(3479): 596-602.
[7] Stent G S. Prematurity and uniqueness in scientific discovery [J]. Scientific American, 1972, 227(6): 84-93.
[8] Cole S. Professional standing and the reception of scientific discoveries [J]. American Journal of Sociology, 1970, 76(2): 286-
[9] Van Raan A F J. Sleeping Beauties in science [J]. Scientometrics, 2004, 59(3): 467-472.
[10] Li J. Review on "Sleeping Beauty" and "Flash in the Pan" phenomena in science [J]. Journal of Academic Libraries, 2016, 34(3): 38-43.
[11] Li J, Ye F Y. The phenomenon of all-elements-sleeping-beauties in scientific

literature [J]. Scientometrics, 2012, 92(3): 795-
[12] Costas R, Van Leeuwen T N, Van Raan A F J. Is scientific literature subject to a 'sell-by-date'? A general methodology to analyze the 'durability' of scientific documents [J]. Journal of the Association for Information Science and Technology, 2010, 61(2): 329-339.
[13] Ke Q, Ferrara E, Radicchi F, et al. Defining and identifying sleeping beauties in science [J]. Proceedings of the National Academy of Sciences, 2015, 112(24): 7426-7431.
[14] Li J, Jiang M L, Li Y T. Research on citation curve analysis framework: taking Nobel laureates' citation curves as examples [J]. Journal of Library Science in China, 2014, 40(2): 41
[15] Wang J, Ma F, Chen M, et al. Why and how can "sleeping beauties" be awakened? [J]. The Electronic Library, 2012, 30(1): 5-18.
[16] Du J, Wu Y S. Research on identification methods for sleeping beauty and prince literature [J]. Library and Information Service, 2015, 59(19): 84-92.
[17] Gilbert R J, Newbery D M G. Preemptive patenting and the persistence of monopoly [J]. The American Economic Review, 1982, 72(3): 514-526.
[18] Leung C M, Kwok Y K. Real options game analysis of sleeping patents [J]. Decisions in Economics and Finance, 2011, 34(1): 41-65.
[19] Palomeras N. Sleeping patents: any reason to wake up [R]. Barcelona: IESE Business School, 2003. NO. d/506.
[20] Weeds H. Sleeping patents and compulsory licensing: an options analysis [R]. Coventry: University of Warwick, 1999. NO. 577.
[21] Tang Y J, Sun L. Analysis and governance of "patent sleeping" in patent transformation [J]. China Soft Science, 2006(8): 73-78.
[22] Yuan X D. Formation mechanism and prevention of sleeping patents [J]. Science Research Management, 2009, 30(4): 168-174.
[23] Zhang Y Q. Research on the dilemma and governance of "patent sleeping" in China [J]. Scientific Management Research, 2013, 31(4): 49-52.
[24] Soininen A H. Open standards and the problem with submarine patents [C]//The 4th conference on standardization and innovation in information technology. Geneva: IEEE, 2005: 218-231.
[25] Sun Z G. Research on countermeasures against submarine patents [J]. Science and Technology Management Research, 2012, 32(9): 167-170.
[26] Tang W, Liu C. Analysis of submarine patent strategies and their legality under patent treaties [J]. Administration and Law, 2012(9): 104-108.
[27] Lei M M. On the defense of laches in U.S. patent infringement and its reference [D]. Beijing: Beijing University of Chemical Technology, 2011.
[28] Luan C J, Hou H Y, Wang X W. Do major inventions have more obvious technological diversification characteristics? [J]. Science of Science and Management of S.& T., 2014, 35(4): 66-73.
[29] Seidel A H. Citation system for patent office [J]. Journal of the Patent Office Society, 1949, 31(5): 554.
[30] Yang Z K. Patentometrics and Patent System [M]. Dalian: Dalian University of Technology Press, 2008: 21-22.
[31] Narin F. Patent bibliometrics [J]. Scientometrics, 1994, 30(1): 147-155.

[32] Wen T X. Patent Informetrics [M]. Beijing: Science Press, 2017: 8.
[33] Armando A, Plaza L M. The transfer of knowledge from the Spanish public R&D system to the productive sectors in the field of biotechnology [J]. Scientometrics, 2004, 59(1): 3-14.
[34] Gao J P, Ding Y. Review of patentometric indicators [J]. Library and Information Service, 2011, 55(20): 40-43.
[35] Ma T C, Li G J, Jiang S, et al. Patent quality evaluation indicators and their application in patentometrics [J]. Library and Information Service, 2012, 56(24): 89-95, 59.
[36] Zhang G F, Han N. Discussion on causes and activation paths of "sleeping patents" [J]. Study Tribune, 2013, 29(8): 70-73.
[37] Hall B H, Jaffe A B, Trajtenberg M. The NBER patent citation data file: lessons, insights and methodological tools [R]. Cambridge: National Bureau of Economic Research, 2001.
[38] State Intellectual Property Office of P.R.C. International Patent Classification Table (8th Edition, 2006.01) [EB/OL]. [2017-12-28]. http://www.sipo.gov.cn/wxfw/zlwxggfw/zsyd/bzyfl/g
[39] Canon China. Corporate history [EB/OL]. [2018-01-01]. http://www.canon.com.cn/about/history/overvie
[40] Zhao Y J. Patent citation analysis methods and applications [J]. Library and Information Service, 2009, 53(6): 11-15.
[41] Li R, Meng L S. On differences between patent citation behavior and journal paper citation behavior in revealing knowledge associations [J]. Journal of the China Society for Scientific and Technical Information, 2010(3): 474-478.

Author Contributions

Li He: Research direction determination, research plan guidance, paper revision and completion.
Yuan Cuimin: Research plan design, data collection and analysis, paper writing.
Xie Mengfan: Data analysis and processing.

Note: Figure translations are in progress. See original paper for figures.