Identifying University Patent Transfer Targets from a Product/Technology Vertical Extension Perspective: A Case Study of the Aerogel Field (Postprint)

Authors: Li Jianfei, Wu Hong, Cui Zhe, Han Meng

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Abstract

[Purpose/Significance] Patent transfer target identification is of great significance for universities to conduct targeted patent promotion, enhance patent transfer efficiency, and achieve innovation-driven economic development. [Method/Process] This study performs semantic extraction on university patent information and enterprise multi-source data, constructs a domain technology tree that reflects enterprises' vertical extension needs for products/technologies, and finally establishes a technology-demand matching model between universities and enterprises to identify patent transfer clients based on their degree of matching. [Results/Conclusion] Using university patents in China's aerogel field as a case study for empirical validation of the identification method, the results demonstrate that the proposed method can accurately identify university patent transfer targets with vertical extension needs for products/technologies, address the information asymmetry problem between supply and demand, and serves as an effective means to promote university patent transfer and achieve precise alignment between technological innovation and market demand.

Full Text

Preamble

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Research on Identifying University Patent Transfer Objects from the Perspective of Product/Technology Vertical Extension—A Case Study of the Aerogel Field

Li Jianfei, Wu Hong, Cui Zhe, Han Meng

Institute of Information Management Research, Shandong University of Technology, Zibo 255049

Abstract: [Purpose/Significance] Identifying patent transfer objects is crucial for universities to push patents effectively, improve patent transfer efficiency, and realize innovation-driven economic development. [Method/Process] This study conducts semantic extraction of university patent information and enterprise multi-source information, constructs a domain technology tree that reflects enterprises' product/technology vertical extension needs, and finally establishes a technology-demand matching model between universities and enterprises to identify university patent transfer customers based on their matching degree. [Result/Conclusion] Taking university patents in China's aerogel field as an example to validate the identification method, the results demonstrate that this approach can accurately identify university patent transfer objects with product/technology vertical extension demand, address the information asymmetry between supply and demand, and serve as an effective means to promote university patent transfer and achieve precise docking between scientific innovation and market demand.

Keywords: Product/Technology Extension; University Patent; Patent Transfer; Object Identification

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This study defines university patent transfer as involving only patent right transfer and patent licensing, excluding subsequent profitable implementation activities such as production, manufacturing, and sales. Patent transfer represents a critical pathway for transforming university scientific achievements into real productive forces and holds strategic importance in China's scientific innovation system. Universities, as key suppliers of scientific achievements, constitute a major force in patent R&D: in 2019 alone, they obtained over 90,000 invention patents, accounting for 25% of the domestic annual total [1]. However, despite hoarding massive invention patents, universities' conversion rate remains merely 4.5% [2], wasting substantial scientific resources and hindering the transformation of inventions into productive forces. Among the many factors causing difficulties in university patent transfer, the disconnect between university research and market needs, limited research management resources, and unclear patent transfer objects are particularly significant. If universities can identify patent transfer objects among numerous enterprises, they can conduct targeted, high-quality patent promotion, thereby facilitating precise docking between university scientific innovation and industrial demand.

2 Literature Review

2.1 Patent Transfer Object Identification

Traditional patent promotion methods include technology transaction seminars organized by governments, telephone negotiations, and services provided by third-party intellectual property agencies [3], where enterprise personnel randomly and spontaneously select patent recipients. This "casting a wide net" communication approach has not achieved scale or organization, remains detached from spontaneous civilian docking models, yields low response rates, and fails to enable comprehensive understanding of each other's technical capabilities between supply and demand sides, such as creativity level, technology maturity, and implementation difficulty. In recent years, some universities and governments have cooperated to establish intellectual property transaction service platforms, attempting to bridge the "last mile" between universities and markets [4], but these platforms' operational mechanisms remain immature, lacking effective management and maintenance, thus playing a minimal role in university patent transfer. With the development of big data and information technology, intelligence analysis methods provide new research space for patent transfer. X. Wang et al. extracted SAO (Subject-Action-Object) triple structures from patent titles and abstracts to analyze the similarity of technology characteristics and R&D directions among patentees, identifying potential patent transfer customers [5]. Zhang Xian et al. combined keyword co-occurrence analysis and topic identification methods to construct a patentee-technology co-occurrence network, judging the degree of technological intersection among right holders to identify patent entities likely to establish cooperative relationships [6]. I. Park et al. employed patent text semantic mining and citation analysis methods to construct a visualized patent assignee hierarchy map for identifying potential R&D partners [7]. Xu Haiyun et al., drawing on "knowledge spillover" and "knowledge potential" theories and incorporating patent market economy elements, analyzed the dynamics and conditions of university-enterprise scientific cooperation and identified industry-university-research cooperation objects [8]. W. Seo et al. used the product database developed by KISTI and USPTO granted patents as data sources, mining the technological development dynamics of leading enterprises with similar technological changes to target enterprises to identify their technology needs [9]. Yi Huifang analyzed the textual and content features of enterprise technology demand documents to excavate university patent operation customers with explicit needs [10]. While these methods can somewhat reduce the blindness of patent transfer, their shortcomings include: some studies ignore the particularity of patent texts, simply transplanting bibliometric methods to patent transfer object mining with limited market factor integration and overly idealized logical reasoning; a few studies focus on enterprise product and development needs, but due to limited accessible explicit needs and topic clustering's tendency to omit important information embedded in certain keywords, there remains a need to identify patent transfer customers based on each enterprise's potential needs for industrial development and tech-

nological improvement.

2.2 Industrial Chain Extension

The industrial chain is a traditional concept, with numerous scholars defining it from various perspectives including forward-backward linkages, formation mechanisms, value-added processes, and network structures. Yang Gongpu argued that an industrial chain is a network structure formed by industries based on forward and backward relationships, essentially representing supply-demand relationships among industries [11]. Li Xinqin defined it as a strategic relational chain with value-added functions, formed by competitive or potentially competitive enterprises in a certain geographic area, centered on a particular industry, and linked with related industry enterprises through products and technologies [12]. Wang Qiuju also defined the industrial chain as a "chain-network organization" in her article "Analysis of Industrial Chain Connotation and Structure," affirming industrial division of labor, sequential linkages, and value addition [13]. Integrating these definitions, an industrial chain is a value-added chain formed by multiple enterprises with upstream-downstream relationships in related industries, centered on the final product needed by users. By extension scope, it can be divided into external and internal industrial chains. External industrial chain extension goes beyond a single industry to related industries, while internal industrial chain refers to extending from a single process, production stage, or economic activity node to other businesses within the same industry. Recent research from the industrial chain extension perspective has mostly focused on topic identification [14], technology evolution, technology layout [15], and competitive intelligence analysis, becoming important content in intelligence analysis methods. However, few studies combine enterprise industrial extension technology needs with university patent transfer.

2.3 Domain Technology Tree

A domain technology tree is a tree structure used to characterize technical features and relationships in a specific field, typically containing product elements and relationships between technologies and functions [16], which helps objectively grasp technology implementation and development status in related industries. B. Yoon et al. studied mobile phone components to construct a technology tree from a product perspective, reflecting associations between product elements and technologies [17]. S. Choi extracted SAO structures from patent texts and built a technology tree based on topic clustering to reflect technology theme evolution relationships [18]. Yi Huifang constructed a multi-dimensional technology tree containing patents, functions, and application fields to mine multi-dimensional technical information from university patents [10]. Zhai Dongsheng, based on TRIZ theory, extracted semantic features such as functions, scientific effects, and efficacy from related patents to construct a patent technology tree reflecting patentees' technology distribution characteristics [19]. G. Fantoni et al. organized technology-related content from functional,

behavioral, and structural levels using requirements, objectives, functions, and behaviors as main features to form a technology tree [20]. Current applications of domain technology trees mostly focus on product technology composition or feature extraction of technology-related elements. Although a few scholars have applied them to university patent promotion, their usage still relies on topic clustering for patent attribute association construction, with scarce research combining patent technology information with enterprise development-related products and technology opportunities for industrial extension demand mining and analysis.

Addressing the problem of insufficient integration between patent transfer and market demand in existing research, this study, from the perspective of product/technology vertical extension, fully utilizes publicly available multi-source Web information to construct a domain technology tree reflecting industrial extension demand, proposes a technology (patent)-demand matching method that can help enterprises achieve vertical extension of their internal industrial chain, and aims to identify university patent technology transfer objects specifically, promote the industrial application of university patents, and achieve precise docking between university scientific innovation and market demand.

3 Research Methodology

The methodology consists of three parts: information extraction, domain technology tree construction, and patent-demand matching. (1) Information extraction: In addition to extracting technical, functional, and technical solution fields from university patent texts, it also extracts various fields from enterprise patent texts and their publicly available products, business scopes, and demand documents on the Web. (2) Technology tree construction: Breaking previous dependence on patent technology and function theme clustering, starting from upstream products/technologies, using their functional effects as clues, and combining enterprises' publicly available business domains to identify unimplemented technologies in industrial extension, thereby constructing a domain technology tree reflecting potential demands for product/technology vertical extension. Additionally, technical information directly obtained from enterprise demand documents is regarded as explicit demand. (3) Patent-demand matching: Comprehensively utilizing extracted university and enterprise patent fields and enterprise demand fields derived from the technology tree, establishing university and enterprise datasets respectively, constructing tf-idf term frequency matrices, and using cosine similarity results between university patent fields and enterprise demand fields in the datasets as the basis for university patent promotion.

3.1 Information Extraction

University patents are first treated as transferrable patents, using them as clues to collect enterprise information. Since patent texts contain rich scientific and technological information with standardized structure, facilitating standardized

extraction [21], this study combines manual judgment to first segment sentences containing technical fields, functions, technical solutions, and efficacy in patent texts, then uses Python natural language processing technology for text segmentation, part-of-speech tagging, and rule-based extraction of various fields. Enterprise information mainly includes various types of information in the Web environment, such as business scope, patent technology, product functions, and investment demands, primarily obtained through web crawler technology and extracted using the same steps as patent information extraction. Specific methods are shown in Table 1 .

3.2 Domain Technology Tree Construction

Current applications of domain technology trees in identifying potential patent transfer objects are relatively single, mostly using patent technology information to construct relationships among product components, technologies, and technical functions in specific technical fields, thereby identifying patentees with high similarity in technical composition and development routes as patent technology transfer objects, which lacks objectivity. Therefore, this study improves existing technology trees by fully utilizing multi-source Web information, using enterprises' upstream products/technologies as basic attributes, linking their unique functions, business domains, and products to construct a domain technology tree reflecting vertical industrial chain development, and analyzing enterprises' internal industrial extension potential needs.

As shown in Figure 1 [Figure 1: see original paper], starting from enterprises' upstream products/technologies, the "enterprise," "upstream product/technology," "function," and "business domain" fields are sequentially linked with solid lines based on their functional characteristics and existing business domains. Then, combining publicly available product/technology information from enterprise websites and patent databases, it verifies whether downstream business domains have extended applications of their upstream products/technologies. If implemented, the connection between "function" and "business domain" in Figure 1 is a solid line; otherwise, it is a dotted line, representing that the upstream product/technology has not yet extended to the enterprise's existing downstream business domain, indicating a technology gap. Letters on the connections represent specific enterprises, thus obtaining potential needs for internal industrial extension of each enterprise. Additionally, since some enterprises have publicly disclosed investment information or technology demand documents on technology transaction websites, this study treats them as explicit demands.

3.3 University Patent-Demand Matching

Based on the extracted technical functions, efficacy, technical solutions, and other information from university patents to be transferred, as well as enterprises' vertical extension demand information, technology (patent)-demand matching between universities and enterprises is conducted. Specific steps are:

(1) On the basis of text preprocessing, establish university and enterprise datasets containing multi-type fields. The university patent dataset includes three fields: function, technical solution, and efficacy of downstream products/technologies obtained through semantic extraction. The enterprise dataset includes three fields: upstream product/technology and function extracted from multi-source Web information (including patents), and downstream technology demand derived from the domain technology tree. The datasets are established for the following reasons: In the university patent dataset, the technical solution field corresponds to the same type of upstream product/technology used in enterprises, the efficacy field corresponds to technical effects consistent with enterprises' upstream products, and the technical function field corresponds to technical means that can extend enterprises' upstream products/technologies. Thus, a technology (patent)-demand matching model is constructed to help enterprises achieve industrial extension.

(2) Matching rules are formulated based on the basic principles of the matching model. University patents to be transferred can be implemented after improvement and perfection based on enterprises' upstream products/technologies, with matching performance and without imposing excessively high additional costs on enterprises, thereby evaluating the rationality of university patent promotion. Specific matching examples are shown in Table 2 . Taking the first row as an example, "thermal insulation coating preparation," "adding SiO2 aerogel microspheres…," and "thermal insulation" in the university patent fields correspond to "thermal coating," "SiO2 aerogel," and "thermal insulation" in the enterprise demand fields, respectively, thus considered a match.

(3) To improve matching efficiency in the dataset, this study uses tf-idf value calculation to establish term frequency matrices for the dataset, facilitating feature classification of each row's word vector. The main idea is: if a word or phrase appears frequently in one article (tf) but rarely in other articles (idf), it is considered representative of that article's features with good category discrimination ability [22]. Each row in the dataset represents the efficacy features of a university patent or the technology demand of an enterprise. Additionally, cosine similarity—the cosine value of the angle between two vectors—is used to measure similarity between text vectors [23], calculating the similarity degree between extracted university patent technology fields and each enterprise demand field, quickly and efficiently identifying the enterprise demand field with the highest matching degree, supplemented by manual judgment to identify patent transfer objects. The entire process is implemented through Python programs.

4 Empirical Study

4.1 Data Sources

The empirical study takes Chinese university invention patents in the aerogel field as an example. As a new material widely concerned in the scientific community, aerogel has the lowest density, highest porosity, and extremely low thermal conductivity, and can be widely applied in thermal insulation, fireproofing, anticorrosion, waterproofing, energy absorption, buffering, and carrier materials. It has been listed by the National Development and Reform Commission as a key national energy-saving and low-carbon technology promotion project. Using the PatSnap database as the data source for patent retrieval, the study combines literature research and expert knowledge to treat enterprise patents on aerogel and its preparation technology as upstream and university patents on aerogel products such as blankets, boards, and composites as downstream. For university patents, Retrieval Formula 1: (TTL_{ALL}:(aerogel AND preparation)) AND AN:(university OR college) AND APD:[* TO 20191231] yielded 549 university patents. Retrieval Formula 2: (ABST_{ALL}:(aerogel)) AND AN:(university OR college) AND APD:[* TO 20191231] yielded 785 university patents with "aerogel" in abstracts. Using Excel's COUNTIF formula to remove duplicates resulted in 242 downstream university patents. The enterprise upstream patent retrieval formula was: (TTL_{ALL}:(aerogel AND preparation)) AND AN:(company) AND APD:[* TO 20191231], yielding 275 enterprise patents with "aerogel" and "preparation" in titles, retrieved on April 28, 2020. To ensure accurate division between upstream and downstream patents, manual judgment was applied to supplement the database retrieval results, cleaning data with research institutes as patentees and other noise data, finally obtaining 262 university patents and 139 enterprise patents. Additionally, the authors obtained information on 25 enterprises with independent aerogel preparation capabilities from corporate websites, Baidu Enterprise Credit, Kehui Network, Xianji Network, and Ji E Network, identifying their aerogel types and functions, avoiding the constraint that patent transfer objects must own upstream aerogel patents. The study involved 129 enterprises with factories in China as potential university patent transfer objects.

4.2 Information Extraction and Technology Tree Construction

First, using Python natural language processing technology and established extraction rules, semantic extraction was conducted on patent titles and abstracts to obtain technical functions, efficacy, and technical solutions for upstream and downstream aerogel patents. Partial results are shown in Table 3 .

For the extracted functions and efficacy fields of enterprise upstream aerogel patents/products, combined with multi-source Web information extracted through manual judgment and web crawler technology, domain technology trees reflecting vertical extension of the aerogel material industrial chain were constructed by linking enterprise names, aerogel types, functions, and downstream

business domains. Then, combining publicly available products, patents, and demand documents from enterprise websites, unimplemented technology gaps in vertical extension of products/technologies in enterprises' existing business domains were linked to build the domain technology tree. Partial results are shown in Figure 3 [Figure 3: see original paper]. The figure categorizes enterprises' aerogel products, function types, and downstream business domains to present their mastery of industrial technologies and key technologies awaiting implementation. Connections and letters between "aerogel," "function," and "business domain" fields reflect enterprises' actual product functions and business scopes. Dotted lines indicate unimplemented product/technology extensions and existing technology demands, marked for subsequent extraction of each enterprise's technology needs.

4.3 Customer Identification Based on Patent-Demand Matching

(1) Combining extracted fields such as technical functions, efficacy, technical solutions, and products from patent texts and web information, as well as vertical extension demands implied in the domain technology tree, university and enterprise datasets were constructed. To ensure the rationality of product/technology vertical extension in the aerogel field, extensive patent retrieval was conducted using the PatSnap database, screening out feasible enterprise demands based on whether corresponding patent technology achievements existed domestically. Finally, the university dataset contained 262 downstream patent fields, and the enterprise dataset contained 157 enterprise demand fields, including 145 potential demands and 12 explicit demands. Partial results are shown in Figure 4 [Figure 4: see original paper].

(2) To ensure matching rationality, following the established technology (patent)-demand matching model and adhering to the principle of "enterprise benefit realization," university patent transfer object identification was conducted. Python programming was used to calculate tf-idf values for enterprise data and convert the dataset into term frequency matrices. A program was designed to return the top 5 enterprise demand fields with highest cosine similarity to university patent fields for quick matching. Additionally, domain experts scored the difficulty and benefit realization effect of enterprises accepting downstream application technologies on a 0-10 scale. Partial results are shown in Table 4 .

Ultimately, 98 matched university patent-enterprise demand pairs were identified, including 90 potential demands from 73 enterprises such as Chengdu Xin Keli Chemical Technology Co., Ltd., Suzhou Hongjiu Aviation Thermal Protection Material Technology Co., Ltd., and Sichuan Ruiguang Technology Co., Ltd., and 8 explicit demands from 7 enterprises such as Chengdu Smo Nano Technology Co., Ltd., Suzhou Junyue New Material Technology Co., Ltd., and Hua Ke Thermal Aerogel Co., Ltd. Experts considered enterprises scoring above 5 as university patent transfer objects, successfully identifying 73 enterprises

with potential demands and 7 enterprises with explicit demands, with an overall success rate of nearly 82%, proving the method's effectiveness.

4.4 Results Analysis

The matching success rate for potential demands was lower than for explicit demands, mainly because explicit demands' technical requirements align with mainstream aerogel technology applications, resulting in higher matching success. Potential demands represent broad needs inferred from business scopes, upstream aerogel types, and downstream application gaps, involving numerous downstream application fields, some of which are not mainstream aerogel application areas, thus yielding slightly lower matching success.

Among successfully matched university patents, 7 had actually undergone right transfers and played roles in enterprises' vertical industrial chain extension. For example, Zhejiang University's patent "A Graphene-Based Pressure-Sensitive Electric Heating Film" had its patent rights transferred to Changxing De Xi Technology Co., Ltd. in 2019. The company's business scope previously included graphene and its aerogel materials, medical devices, and electromechanical equipment, and it already possessed technology for applying graphene aerogel to electric thermos cups. The patent's "pressure-sensitive electric heating film that rises to 3000°C with pressure increase and maintains temperature for 0.5-4 hours" could help the company apply graphene aerogel's excellent heat resistance and insulation characteristics to its healthcare and electromechanical equipment fields.

Among successfully matched enterprise demands, the majority fell into the following categories: coating preparation demands accounted for 21% of total demands, ranking first, likely due to aerogel's excellent fireproofing effectiveness, ability to absorb harmful substances, easy construction, and yet-to-be-popularized technology. Other thermal insulation material demands accounted for 9%; although aerogel's outstanding thermal insulation performance has attracted attention, its current technical applications in insulation boards and composite materials are already relatively common, resulting in smaller market demand. Electrode materials and energy storage application demands accounted for 11%, while wastewater treatment and air purification demands accounted for 10%, mainly because carbon aerogel and graphene aerogel preparation technologies have become increasingly mature in recent years, with high porosity, large surface area, and excellent conductivity and electrochemical behavior, thus also having significant market demand, which aligns with real market development. Additionally, demands in medical drug carriers, ceramics, and glass materials accounted for 10%, 9%, and 7% respectively, also showing considerable application prospects.

To verify the method's universality, the study randomly selected 100 graphene production enterprises and 1,000 university patents for transfer object identification. Ultimately, 68 enterprises with matched demands were identified, and

6 enterprises had actually received corresponding university patents in practice, demonstrating the method's ability to effectively utilize multi-source Web information to identify enterprises with product/technology extension needs and achieve precise university patent promotion.

This study has limitations: it identifies university patent transfer objects from the perspective of enterprise product/technology vertical extension without considering enterprise factors such as practical capabilities and leadership willingness, which may affect matching accuracy. Future research will incorporate more factors to improve identification accuracy.

References

[1] Chen Lixin. Conclusions and Discussions No. 4 of the 2019 National Invention Patent Data Statistical Analysis—University Patents are Stronger, Enterprise Patents are Weaker [EB/OL]. [2020-03-02]. http://wap.sciencenet.cn/blog-681765-1221354.html?mobile=1. [2] China National Intellectual Property Administration. 2019 China Patent Survey Report [EB/OL]. [2020-03-20]. http://www.cnipa.gov.cn/zscqgz/1146807.htm. [3] Zhang Jieyin. Research on Regional Knowledge Market Network Intermediary Capacity—Taking Zhejiang Technology Market as an Example [J]. Science & Technology Progress and Policy, 2015, 32(13): 42-46. [4] ZHU X Z, KAI H U. The Design of Patent Transaction Confirmation System Based on Online Technology Marketplaces [J]. Journal of Library and Information Science, 2019, 4(8): 35-43. [5] WANG X, WANG Z, HUANG Y, et al. Identifying R&D Partners through Subject-Action-Object Semantic Analysis in a Problem & Solution Pattern [J]. Technology Analysis and Strategic Management, 2017, 29(10): 1-14. [6] Zhang Xian, Xu Haiyun, Fang Shu, et al. Research on Patent Technology Portfolio Opportunities and Cooperation Potential [J]. Journal of Intelligence, 2015, 34(7): 39-46. [7] PARK I, JEONG Y, YOON B, et al. Exploring Potential R&D Collaboration Partners through Patent Analysis Based on Bibliographic Coupling and Latent Semantic Analysis [J]. Technology Analysis & Strategic Management, 2015, 27(7): 759-781. [8] Xu Haiyun, Wang Chao, Dong Kun, et al. Research on Identification Method of Industry-University-Research R&D Cooperation Objects Based on Knowledge Spillover Effects in Innovation Chain [J]. Journal of the China Society for Scientific and Technical Information, 2017, 36(7): 682-694. [9] SEO W, YOON J, PARK H, et al. Product Opportunity Identification Based on Internal Capabilities Using Text Mining and Association Rule Mining [J]. Technological Forecasting & Social Change, 2016, 105: 94-104. [10] Yi Huifang, Wu Hong. Research on University Patent Transfer Object Identification from the Perspective of Multi-Level Demand Analysis—Taking Graphene as an Example [J]. Library and Information Service, 2020, 64(12): 118-127. [11] Yang Gongpu, Xia Dawei. Modern Industrial Economics [M]. Shanghai: Shanghai University of Finance and Economics Press, 2002: 50-80. [12] Li Wanli. Tourism Industry Chain and China's Tourism Competitiveness [J]. China Economist, 2005(3): 123-124.

[13] Wang Qiuju. Analysis of Industrial Chain Connotation and Structure [J]. Logistics Sci-Tech, 2012, 35(5): 89-91. [14] Feng Mining, Wei Feng, Li Jian, et al. Research on Topic Identification and Technology Evolution from the Perspective of Industrial Chain—Taking 3D Printing as an Example [J]. Journal of Intelligence, 2020, 39(8): 46-52, 62. [15] Li Chang, Wu Hong, Yi Huifang, et al. Research on Technology Layout of China, Japan and US Hydrogen Energy Industrial Chain Based on Improved LDA Topic Model [J]. Journal of Intelligence, 2019, 38(7): 78-84, 91. [16] Zhai Dongsheng, Xia Jun, Zhang Jie, et al. Research on Technology Tree Construction Method Based on Patent Feature Extraction [J]. Journal of the China Society for Scientific and Technical Information, 2015, 34(7): 717-724. [17] YOON B, PHAAL R, PROBERT D. Morphology Analysis for Technology Roadmapping: Application of Text Mining [J]. R&D Management, 2008, 38(1): 51-68. [18] CHOI S, PARK H, KANG D, et al. An SAO-Based Text Mining Approach to Building a Technology Tree for Technology Planning [J]. Expert Systems with Applications, 2012, 39(13): 11443-11455. [19] Zhai Dongsheng, Guo Cheng, Zhang Jie, et al. Method for Recommending Potential R&D Partners Based on Patents [J]. Data Analysis and Knowledge Discovery, 2017, 1(3): 10-20. [20] FANTONI G, APREDA R, DELL'ORLETTA F, et al. Automatic Extraction of Function-Behaviour-State Information from Patents [J]. Advanced Engineering Informatics, 2013, 27(3): 317-334. [21] Jiang Chuntao. Automatic Extraction of Semantic Information from Chinese Patent Texts Using Graphic Methods [J]. Library and Information Service, 2015, 59(21): 115-122. [22] DONG H W, DEO K S, SUH Y C, et al. Multi-Co-training for Document Classification Using Various Document Representations: TF-IDF, LDA, and Doc2Vec [J]. Information Sciences, 2018, 477: 15-29. [23] AI-ANZI F S, ABUZEINA D. Towards an Enhanced Arabic Text Classification Using Cosine Similarity and Latent Semantic Indexing [J]. Journal of King Saud University-Computer and Information Sciences, 2017, 29(2): 189-195.

Author Contributions

Li Jianfei: Responsible for paper framework design, writing, and revision; Wu Hong: Responsible for research methodology design and optimization; Cui Zhe: Proposed modification and improvement suggestions, revised the paper; Han Meng: Provided suggestions and revised the paper.

Abstract: [Purpose/Significance] It is of great significance to identify the object of patent technology transfer for colleges and universities to push patents, improve the conversion rate of patents, and realize economic development driven by scientific and technological innovation. [Method/Process] This paper studied the semantic extraction of university patent information and enterprise multi-source information, constructed the domain technology tree that can reflect the vertical extension demand of enterprise products/technologies, and finally established the technology-demand matching model between universities and enter-

prises, and carried out the customer identification of university patent transfer according to the matching degree. [Result/Conclusion] Taking the university patent in aerogel field as an example, the identification method is verified. The results show that the method can accurately identify the university patent transfer objects with product/technology vertical extension demand, deal with the asymmetric information of supply and demand, and is an effective means to promote the transfer of university patents and realize the precise docking of scientific and technological innovation and market demand.

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