Research on the Characteristic Indicator System for Technology Transfer from the Perspective of Patent Transfer: Postprint

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Abstract

[Purpose/Significance] Develop a characteristic indicator system for technology transfer to identify patents with application potential in advance, provide information support for patent technology transfer, and promote the transfer and transformation of technological achievements. [Method/Process] Based on objective factual information regarding patent transfer behaviors, define datasets of transferred and non-transferred patents, analyze and compare characteristic differences between the two, construct a technology transfer characteristic indicator system based on patent documents themselves across four dimensions: technology, law, market, and entity, and conduct statistical testing of indicators as well as empirical model testing. [Results/Conclusion] Basic characteristic indicators derived from patent documents themselves can predict technology transfer, with relatively balanced influence among indicators and no dominant indicators. An empirical SVM model tests the predictive validity of this indicator system, preliminarily achieving the construction and validation of a technology transfer characteristic indicator system applicable at the national/regional, institutional, and individual patent levels, demonstrating the practicality of this method.

Full Text

Research on Technology Transfer Characteristic Indicator System from the Perspective of Patent Transfer

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Abstract:
[**Purpose/Significance**] This study aims to construct a technology transfer characteristic indicator system to identify patents with application potential in advance, provide information support for patent technology transfer, and promote the transformation of technological achievements.
[**Method/Process**] Based on objective factual information regarding patent transfer behavior, we defined transferred and non-transferred datasets, analyzed and compared their characteristic differences, and constructed a technology transfer characteristic indicator system grounded in patent documents themselves across four dimensions: technology, law, market, and subject. Statistical tests and empirical model validation were then conducted on these indicators.
[**Result/Conclusion**] The basic characteristic indicators based on patent documents can predict technology transfer, with relatively balanced influence across indicators and no dominant indicator. The predictive validity of the indicator system was tested using an SVM model, achieving preliminary construction and validation of a technology transfer characteristic indicator system applicable at the national/regional, institutional, and individual patent levels. This method demonstrates practical utility.

Keywords: patent assignment; technology transfer; patent prediction; intelligence analysis; SVM

Promoting the transfer and transformation of scientific and technological achievements represents a crucial task in implementing innovation-driven development strategies, playing a vital role in integrating science and technology with economic development and in driving societal progress through technological advancement. Compared to other forms of scientific and technological information, patents encompass over 90% of the world's latest technical information, serving as an important measure of national scientific and technological innovation capacity and technology transfer levels, as well as the first step for academic researchers to commercialize their work. Currently, the assessment of patent value has gradually shifted from relying solely on application volume metrics to comprehensive evaluation combining quantitative measurement with industrial practice of patented technologies. Therefore, research on technology transfer prospects based on patent information is essential for identifying high-value patents and guiding technological innovation policies and practical applications.

Technology transfer and transformation comprise two distinct stages: achievement transfer and achievement transformation. These two processes are not interdependent; transformation may occur with or without transfer, and transferred achievements may not necessarily undergo transformation. Wikipedia defines technology transfer as the process by which individuals or organizations holding technology or scientific achievements change their ownership to another individual or organization. The Law of the People's Republic of China on Promoting the Transformation of Scientific and Technological Achievements (2015) defines transformation as "activities conducted to improve productiv-

ity levels through subsequent testing, development, application, and promotion of scientific and technological achievements until they form new technologies, processes, materials, or products, and develop new industries." This study focuses on patent technology transfer—the process of changing patent ownership—without extensively exploring whether the technology or achievements undergo subsequent transformation.

Patent licensing and patent assignment constitute the two primary forms of technology transfer implementation. Patent licensing authorizes others to use the patent within certain rights through licensing contracts, while patent assignment achieves technology transfer through direct changes in patent ownership. Compared to licensing, patent assignment more directly reflects technology transfer and is frequently used as an important indicator for patent value assessment. However, predicting patent transfer often requires reference to patent value levels, which does not fully resolve the problem of prospect estimation.

Given this background, this study examines patent transfer information to construct transferred and non-transferred patent datasets, analyzes the characteristics of transferred patents, establishes a characteristic indicator system, and uses statistical methods and quantitative prediction models to test the system's validity. The goal is to identify patent transfer characteristics, construct a technology transfer characteristic indicator system applicable at national/regional, institutional, and individual patent levels, provide information support for patent technology transfer, promote the transformation of scientific and technological achievements, offer references for government science and technology innovation policy formulation, and help identify patents with application potential to better guide corporate patent portfolio strategies.

Literature Review

Technology transfer research based on patent citation and cooperation information is relatively extensive, primarily involving the mining of technology transfer patterns and identification of potential technology recipients. Current research on technology transfer based on patent transfer information remains limited, mostly focusing on patentee types to explore characteristics, pathways, and trends of patent transfer.

Patent cooperation indirectly reveals technology transfer through cooperative networks among patent entities, with existing research covering social network structure analysis of cooperation patterns, mining of cooperation characteristics, and evolutionary game models of technology transfer networks. However, while patent cooperation information can reflect technology flow to some extent, it cannot directly demonstrate technology transfer intensity.

Patent citation information helps track technology development trajectories and reflects technology transfer trends from the perspective of technological dependency and continuity. Since the early 1990s, scholars have explored the role of patent citations in field innovation and knowledge flow. R. Eito-Brun proposed

applying Bradford's Law to patent citation analysis to identify core patentees and explore enterprise transformation patterns in innovation fields. I. Ji et al. suggested that applicants co-citing IPC patents may become potential recipients of technology transfer. Patent citations help identify inter-industry technology transfer but focus on retrospective analysis of past transfers, making it difficult to predict opportunities for new technology flows. Additionally, some citations are added by patent agents or examiners based on novelty and inventive step requirements.

Research on technology transfer based on patent transfer information is scarce both domestically and internationally. Foreign studies often focus on economic data such as corporate R&D expenditure and equity returns, analyzing and predicting patent transfer behavior from a commercialization perspective. Bozeman clarified conceptual issues of technology transfer and the roles of institutional entities like universities and governments. Serrano explored patent transfer patterns from technical field and patentee type perspectives, noting significant differences in relative transfer probabilities across different technical fields and patentee types. Dahlborg et al. proposed a patent transfer pattern prediction framework based on changes in patentee types before and after transfer. Xie et al. presented a patent transfer model based on combinatorial optimization and intelligent computing, though focusing on transfer revenue optimization. Madeira et al. analyzed biopharmaceutical patent transfer behavior in Brazil from the patentee type perspective, noting that individual patentees primarily operate patents through cooperation with enterprises.

Domestic scholars mostly use patent transfer information as a patent evaluation indicator for domain trend analysis, construct patent transfer networks to explore technology transfer characteristics, and study regional patent transfer evolution paths. Few scholars conduct shallow theoretical analysis of patent transfer, mostly in early-stage research. Predictive research on patent transfer is particularly limited, with some scholars constructing weighted directed networks of patent technology transactions to predict transaction opportunities and technology flow directions between technology supply and demand entities in patent transfer networks.

However, technology transfer prediction is a complex and dynamic research problem. From an intelligence research perspective, a universally applicable technology transfer indicator system is currently lacking. Existing quantitative studies rely on economic indicators such as R&D expenditure and corporate market value, which only meet national/regional level assessment needs and cannot achieve measurement at institutional or individual patent levels. In indicator system construction, researchers tend to select composite indicators like technology intensity, easily overlooking basic patent document information. Yet indicators based on patent documents themselves are easily accessible, understandable, and calculable, can directly represent patent characteristics, and are applicable to individual patent prediction as well as national and institutional patent portfolio transfer prediction needs, holding universal significance.

Therefore, this study focuses on patent transfer information characteristics to construct a basic indicator system grounded in patent documents themselves, enabling quantitative prediction of patent transfer at national/regional, institutional, and individual patent levels.

Indicator System Construction

Existing studies on patent indicator systems typically unfold across three dimensions: technology, market, and law. Patent transfer behavior has particularities, and the original patentee as the first owner plays a non-negligible role in patent transfer. Therefore, this study adds a subject dimension to the three dimensions of technology, law, and market to explore the characteristics and influence of original patentees in patent transfer.

Technology Dimension

Existing technology dimension indicators primarily include technology breadth, patent citation (citing) counts, and non-patent reference counts. The IPC (International Patent Classification) organizes and manages patents from a functional perspective, directly reflecting technical categories and technological intersection degrees. Technology breadth can be represented by IPC subclasses, with existing research indicating that important patents often have greater technology breadth. Patent citation information reflects technological relevance and development trajectories, indicating economic value, with its importance in technology transfer measurement continuously mentioned and validated since the 1990s. Non-patent reference counts measure the relationship between patented technology and scientific research, with scholars noting its important role in evaluating patent industrialization potential and its ability to represent patent value in pharmaceutical and chemical fields.

In addition to these four indicators, patents have territorial characteristics, and the national distribution of citations can reflect the geographical scope of technology transfer. Therefore, this study introduces two indicators: citing country count and cited country count (identified by the two-letter country codes in patent numbers). Inventor count also reflects patent technical level to some extent; more inventors may indicate more technical points in a patent. Scholars have explored inventor factors' impact on patent quality, and this study examines inventor count as a technology dimension indicator to explore its influence on technology transfer.

Legal Dimension

Legal dimension indicators in existing research primarily include claim count, patent maintenance time, and patent litigation. Claims define the scope of legal protection, with more claims indicating more comprehensive protection—a role validated in patent value assessment. Patent maintenance is typically represented by renewal fee payments; longer maintenance time means higher

maintenance costs, indicating that the patent generates economic benefits exceeding maintenance fees, thus reflecting patent value. Since 1986, studies have used patent renewal to assess patent value, though more renewals also mean less remaining patent term, making the relationship between renewal count and patent transfer worth exploring. Patent litigation is a means for patentees to protect legitimate rights, involving high costs and lengthy cycles. Therefore, litigated patents are generally considered to have relatively high technical and economic value, with research indicating only economically valuable patents undergo litigation and that biotechnology patents may become the next concentrated "battlefield" for U.S. patent litigation.

Market Dimension

Existing patent transfer research often approaches from the patentee type perspective, as different institution types have different tendencies toward patent transfer. Research institutions primarily undertake technology R&D, while enterprises focus on technology market operation. This study categorizes original patentees into five types (see Table 1). Besides patentee type, regional distribution of patentees also differs in patent transfer behavior, with original patentees widely distributed and significant regional disparities in patent numbers, requiring focus on key countries/regions in empirical analysis.

Patent family size and equity returns are commonly used market dimension indicators for patent evaluation. A patent family refers to a group of patents with common priority rights filed in multiple countries, regions, or international patent organizations, with family size reflecting international layout. Putnam first used patent family size as a patent measure in 1996, noting its suitability for patent value assessment. Similarly, considering patent territoriality, this study introduces patent family country count to reflect geographical distribution. The Patent Cooperation Treaty (PCT) provides a convenient and efficient international patent application pathway, with patents filed through PCT more likely to obtain broad international market layout, thus introducing "whether filed through PCT" as a market dimension indicator. Market value and equity returns are first-hand market indicators that are difficult to obtain and only reflect macro patent market conditions. This study's selected market indicators are indirect market indicators based on patent characteristics, representing patent market conditions from the side.

Subject Dimension

Transferors and transferees are direct participants in patent transfer, directly reflecting transfer pathways. Specifically, the original patentee (referring to the transferee institution of the inventor's first transfer, not the inventor who filed the patent application) influences whether a patent undergoes its first inter-institutional transfer through their value judgment and market positioning. Therefore, this study introduces subject dimension indicators to explore their impact on patent transfer.

Integrating technology, law, market, and subject dimensions and following principles of accessibility and comprehensiveness, we obtained 15 secondary indicators based on patent documents themselves (see Table 2).

Data Preparation

Research Object Selection

This study selected U.S. patents as the empirical research object. The U.S. patent examination process is rigorous, with high application and maintenance costs and complete legal status information, providing good support for patent transfer characteristic research. Compared to engineering and social sciences, bioscience researchers participate in patent commercialization at higher rates, with active patent transfer behavior, making it suitable for technology transfer characteristic research. Therefore, the empirical study focuses on U.S. biopharmaceutical patents, retrieving 25,745 patents from the Derwent Innovation (DI) database based on CAS's biopharmaceutical field definition and expert screening. After cleaning 170 patents with substantial information missing and 567 pledged patents, we obtained a patent set of 25,008 patents. The dataset spans 40 years from 1978 to March 2018 (retrieval date: April 18, 2019).

Definition of Patent Transfer

Compared to China's patent application process, U.S. patent applications have particularities. 35 U.S.C. §111 states that U.S. patent applications must be submitted in writing by the inventor; §118 stipulates that if the applicant is not the inventor, the applicant must be the true interested party; §261 specifies that both patent application rights and patent rights are transferable. Therefore, for U.S. patents equivalent to China's "employee invention patents," inventors must sign a personal-to-institution transfer application at the time of filing.

This "employee invention" transfer is common in U.S. patents but lacks actual research significance as it cannot reflect genuine technology transfer. To avoid interference from such transfers in characteristic research, this study does not use ASSIGNMENT information in patent legal status as the criterion for patent transfer. Instead, it defines transferred patents as those with at least one inter-institutional transfer, and non-transferred patents as those with no ASSIGNMENT records or only personal-to-personal, personal-to-institution, or institution-to-personal transfers. Patents involving pledges and those with severely missing bibliographic data were also cleaned.

Empirical Analysis

Statistical Testing

This study used SPSS 21.0 for statistical testing of indicators. Descriptive statistics were first conducted on 10 numerical independent variables (see Table 3).

Except for technology breadth and inventor count, the remaining eight variables showed significant differences in descriptive statistics between transferred and non-transferred datasets. For example, the mean "patent citation count" in the transferred dataset was 25.1, significantly higher than 15.71 in the non-transferred dataset, with median (7) and upper quartile (20) also higher than corresponding values in the non-transferred dataset. Descriptive statistics for five nominal independent variables are shown in Tables 4 through 8 . For instance, patents filed through PCT accounted for 64.4% of transferred data versus only 58.6% of non-transferred data. These preliminary results demonstrate that independent variables can influence patent transfer, though the impact of technology breadth and inventor count requires further testing.

Based on descriptive statistics, significance difference tests were conducted. Kolmogorov-Smirnov tests determined that all 10 numerical independent variables were non-normally distributed, so Wilcoxon rank-sum tests were used to assess significant differences (see Table 3). All asymptotic significances were less than 0.05, indicating significant differences between numerical independent variables and the dependent variable. Chi-square tests were performed on five nominal independent variables (see Tables 4 to 8), with all asymptotic significances less than 0.05, showing statistically significant differences.

Correlation among variables was further tested. Spearman correlation analysis was conducted on 10 numerical independent variables (see Table 9), and Kendall correlation analysis on five nominal independent variables (see Table 10). Except for institution type, the remaining 14 independent variables were significantly correlated with the dependent variable, with correlations mostly between 0.05-0.15, indicating no dominant characteristic. Collinearity diagnosis was performed based on correlation test results (see Table 11), showing that patent family count and patent family country count had collinearity (values 0.74 and 0.93), while other variables showed no obvious collinearity. Factor analysis results (see Tables 12 and 13) showed a Kaiser-Meyer-Olkin measure of 0.673, with principal component extraction explaining only 64.28% of total variance, indicating that the independent variables are not suitable for principal component dimensionality reduction.

Model Testing

Through statistical testing, 13 indicators were obtained that are independent and significantly affect patent transfer. To further test these characteristics' predictive effect in patent transfer, we introduced them into an SVM model. Support Vector Machine (SVM) is a supervised machine learning model applied to linear classification and regression studies with good generalization ability, currently one of the most commonly used and effective classifiers. Libsvm, developed by Professor Chih-Jen Lin of National Taiwan University, implements SVM classification, regression, and distribution estimation functions. This study built an SVM model using Libsvm in Python 3.6.

Data from 1978-2012 (35 years, 16,142 patents) were used as the training set, and data from 2013-2018 (5 years, 8,866 patents) as the test set. The training set contained 5,301 transferred patents and 10,841 non-transferred patents. Considering the impact of imbalanced datasets on feature learning, we used undersampling to process the training data. Randomly selecting 50% of the non-transferred data from the training set yielded 5,375 non-transferred patents, forming a 1:1 balanced dataset with the 5,301 transferred patents, comprising an undersampled training set of 10,676 patents.

Based on statistical test results, institution type showed no significant correlation with the dependent variable and was thus removed. Patent family count and patent family country count were highly correlated and collinear, so one was retained (patent family count). Ultimately, statistical testing yielded 13 relatively independent features significantly related to patent transfer. Introducing these 13 features into the SVM model and testing with the test set achieved an overall prediction accuracy of 63.68%. The selected 13 features can distinguish transferred from non-transferred patents, preliminarily validating the indicator system's predictive validity.

Conclusion and Outlook

This study conducted comprehensive literature review, finding that current technology transfer research mostly involves qualitative analysis based on network structures or national-level prediction based on macroeconomic indicators. These studies often remain theoretical due to difficult-to-obtain indicators or overly complex composite indicator calculations, making them hard to promote in practice. Therefore, this study focuses on objective facts of patent transfer that have already occurred, extracting regular characteristics presented in patent documents. These indicators are directly obtainable from patent documents, easily understood and calculated, with practical utility and universality.

The indicator system was constructed across technology, law, market, and subject dimensions. Statistical tests were conducted on 15 characteristic indicators through descriptive statistics and significance difference tests to assess their impact on patent transfer. Highly correlated and collinear indicators (patent family country count) were removed, yielding 13 relatively independent features significantly related to patent transfer. Introducing these 13 features into an SVM model achieved 63.68% prediction accuracy, preliminarily validating the indicator system's predictive validity.

Although this research has achieved certain applicability, future exploration can continue in several areas: First, patent citation indicators are significantly affected by time factors. This study attempted to correct for temporal effects by dividing citation counts by annual average citation counts, but due to the dataset not being a complete domain dataset, correction results were unsatisfactory. Future work will reference Luo Wenxin's correction index for patent citation temporal factors. Second, applicability testing of the indicator system

should be conducted. This study selected U.S. patents for transfer characteristic identification based on their rigorous application process and complete legal status information. However, patent systems and available text information vary by country. For non-U.S. patent transfer applications, corresponding alternative indicators should be sought for cases differing from the U.S. system, though applicability to non-U.S. patents remains theoretical and requires validation with non-U.S. patent data. Third, the prediction effect of indicators in the model needs optimization. The SVM model built with 13 characteristic indicators in this study has room for accuracy improvement, and future work will explore alternative models to test indicator validity.

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Zheng Siyuan: Research investigation, data analysis, and paper writing;
Wang Xuezhao: Research design and guidance, paper revision and editing.

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