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Research Technology Transactions Network from the Perspective of Multi-Dimensional Proximity: Based on University Technology Transfer

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Abstract

As innovation trends continue to transcend organizational boundaries, the frequency of university-industry technology transactions continues to increase. The multi-dimensional proximity theory is the main theory for studying university-industry cooperative innovation. Although many scholars study the transformation of scientific and technological achievements between university and industry, more research data focus on static perspective research, technology transformation between enterprises, fixed technology transactions dominated by core enterprises, etc. Therefore, my research will analyze the dynamic mode analysis of different transaction stages, the barriers in university technology transformation, and the transaction form of university's scientific research. This paper regards universities as the research subject, and chooses geographic factors, organizational factors, social factors, institutional factors, and technical factors as variables, so as to explore the technology transactions network of their technology.

Keywords

The Multi-dimensional Proximity Theory; Technology Transactions; University-Industry Technology Transactions.

1. Introduction

Since the 21st century, with the deepening of the globalization of science and technology, technology trading has become an important way to help innovation organizations obtain core technology and achieve innovation goals. University and S&T Institutes, as the main source of disruptive technology, have been provided the advanced idea that the university should influence people's lives beyond the classroom, which is known as the "Wisconsin Idea". In term of theory, the multi-dimensional proximity theory mainly focuses on five factors, namely geographic factors, organizational factors, social factors, institutional factors, and technical factors, which analyzes university-industry cooperative innovation comprehensively. In term of practice transformation, four modes and relevant thirteen specific forms have been widely applied in real life. But, considering the external factors about human resource, property protection, extensive cooperation, external influence, sharing degree, and revenue performance, the transformation effect of every transfer mode is different. Therefore, it is of far-reaching significance to study the transformation of scientific and technological achievements in universities, so as to explore the practice path of disruptive technological innovation transformation, the form of transforming technological innovation into popularization, and the mode of science and technology management in practice.

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2. Research Design

2.1. Research Methodology

A. Qualitative analysis. This research uses the qualitative analysis method to summarize and sort out the existing literature, and explores the impact of technology transactions behavior in universities and research institutes through factors of geography, organization, society, system, technology.

B. Quantitative analysis. This paper applies the Separable Time Series Exponential Random Graph Model (STERGM) to analyze dynamic technology transactions, and integrate the node attribute characteristics and the network endogenous structure from the perspective of exogenous multi-dimensional proximity. This paper also tests the reliability and validity of the questionnaire samples to ensure the applicability of the questionnaire design and the reliability of the sample data.

2.2. Data Sources

A. Patent transfer data. This study focuses on the new generation of information technology during 2001-2021. It uses its patent transfer data to build a technology trading network, and the data comes from the "incopat" patent retrieval platform.

B. Research background data. This paper focuses on the network of University Technology Transfer, and the research background data is mainly from Web of Science. It includes the most influential core academic journals in social sciences and other fields, such as the Institute for Scientific Information (ISI), three major citation databases (SCI, SSCI and A&HCI) and two chemical databases (CCR and IC).

3. Project Objectives

Since the 21st century, with the deepening of the globalization of science and technology, technology trading has become an important way to help innovation organizations obtain core technology and achieve innovation goals. At the same time, as innovation trends continue to transcend organizational boundaries, the frequency of university-industry technology transactions continues to increase. The multi-dimensional proximity theory is the main theory for studying university-industry cooperative innovation. [1]

To investigate this trend, many scholars employed the multi-dimensional proximity theory, first proposed by the French School of proximity dynamics in 2000, to study the effects of various innovative organizational relationships. In addition, scholars are also interested to explore attributes of the transaction subject and structures of the transaction networks. Nevertheless, there are still some unknown areas that need further exploration despite abundant studies of the subject:

First of all, most of the existing studies were based on a static perspective on the formation mechanism of network relations, which ignored the possibility that the motivation of trading relations establishing and dissolving will also change as the technology transactions networks change.

Second, more research focuses on technology transactions among enterprises instead of technology transactions of universities and scientific research institutions. However, as the enterprises proportion of patent industrialization rate and patent licensing rate have been far higher than those of universities and scientific research institutes, according to the 2021 China Patent survey report, there comes a subsequent need to study ways to promote technology transactions of universities and scientific research institutes.

Third, there is a lack of analysis of the trading behavior of diverse parties. The previous analysis focused more on the large-scale enterprises, which would have a greater probability to strike a

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deal backed by their existing market shares and customer reserves, these enterprises will. However, in the future, as technology transactions networks decentralize, more SME entities and project individuals will enter the network system. Behaviors of big firms might not be applicable to predict those of the SMEs and individual actors.

Therefore, the research objectives include:

A. Studying factors that drive the establishment and dissolution of relationships in different technology transaction stages, especially in the field information technology, so as to better explain the mechanism of the formation and dissolution of technology transactions networks.

B. Researching universities technological achievements, technology transformation, start-up derivative enterprises and so on, to better study the factors which hinder technology transactions of these organizations, and further explore the technology transformation theory of universities and scientific research institutions.

C. Studying the participants in the transactions of scientific and technological achievements among university-industry technology, as well as the relationship and operation mechanism between multiple participants.

4. Research Background

From theoretical research perspective, technological innovation and management have gradually become the focus of international research. In recent years, the number and diversity of literature related to "innovation" has grown year by year, and "innovation research" has become an "emerging scientific field" [2]. In terms of related papers and literature research, the literature comes from the most influential core academic journals in the field of social sciences such as SCI, SSCI, A&HCI, CCR, IC, etc. Through the Web of Science core collection database shows that there are 43,828 related documents from 1962 to 2019, of which Innovation, Performance, Firm, Management, Knowledge, Research & development, and Technology are the top seven high-frequency words. From the perspective of static research, the current research hot pots on innovation are increasing year by year, and there will be more breakthroughs in the dynamic perspective of actual cases in the future.

Table 1. Ranking of Top 15 Keywords [3]

Ranking of Top 15 Keywords			
Num	Frequency	Year	Keyword
1	17 640	1981	innovation
2	7 525	1990	performance
3	4 724	1994	firm
4	4 120	1992	management
5	3 908	1996	knowledge
6	3 395	1994	research and development
7	3 363	1991	technology
8	3 171	1991	strategy
9	3 090	1990	model
10	2 541	1995	organization
11	2 500	1994	impact
12	2 427	1994	industry
13	2 320	2001	absorptive capacity
14	2 312	1995	perspective
15	2 275	1998	capability

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From university start-ups to technology-based enterprises, a practical technological and economic model is needed. On the main body of university technological innovation, from start-up teams to real enterprises, there are numerous countries and academic institutes focused on the relevant research. In practice, there are also many successful cases, including technology transformation of university research institutes such as DARPA, basic science pioneers such as Stanford University, venture capital focused on basic science investments such as DIUx and IP Group.

Table 2. Ranking of Top 10 Core Technology Management Research Subjects [4]

Ranking of Top 10 Core Technology Management Research Subjects				
Num	High Volume Countries		High Volume Institutes	
	Volume	Countries/areas	Volume	Institutes
1	9 408	Peoples R China	808	Wuhan University Technology
2	8 780	USA	383	Zhejiang University
3	4 227	England	302	University Manchester
4	2 266	Germany	319	Harvard University
5	2 163	Italy	278	University Cambridge
6	2 054	Spain	276	Erasmus University
7	1 861	Netherlands	241	University Sussex
8	1 489	France	240	Bocconi University
9	1 427	Australia	233	MIT
10	1 413	Canada	230	Copenhagen Business School

5. Research Scope

5.1. Variables

Existing literature employing the multi-dimensional proximity theory has identified many relevant factors. For example, WANG Wanqiu [5] researched on the relationship between technology mergers and acquisitions from the perspective of technology proximity, Sun [6] analyzed the influence of geographical proximity and economic proximity on technology transfer, LIU Fengchao[7] found that the geographical, technological and institutional proximity between organizations has a positive effect on the formation of trading networks, Drivas[8] proved that the influence of geographical distance in patent transactions decreases with time, WANG Chongfeng [9] found that the increase of industrial structure distance will reduce the technology flow within the region and increase the inflow and outflow of patented technology outside the region, LIU Chengliang [10] concluded that geographical, technological, social and industrial proximity will all affect the intensity of technology transfer among urban subjects. On the study of the transaction subject's own attributes and the transaction network, Bi-anchi [11] found that the previous technology transfer experience of an enterprise will have a significant impact on the transfer performance, Ferraro [12] proposed that the degree of distribution and transitivity are related to the formation of the relationship between technology transfer and the evolution of network self-organization, Yang [13] proved that the network's degree, centrality and structural hole play an important role in technology diffusion.

Based on the above literature review, combined with the characteristics of the relationship between technology transactions behavior, this study will take geographical proximity [14], organizational proximity [15], social proximity [16], institutional proximity[17] and technological proximity [18] as exogenous variables.

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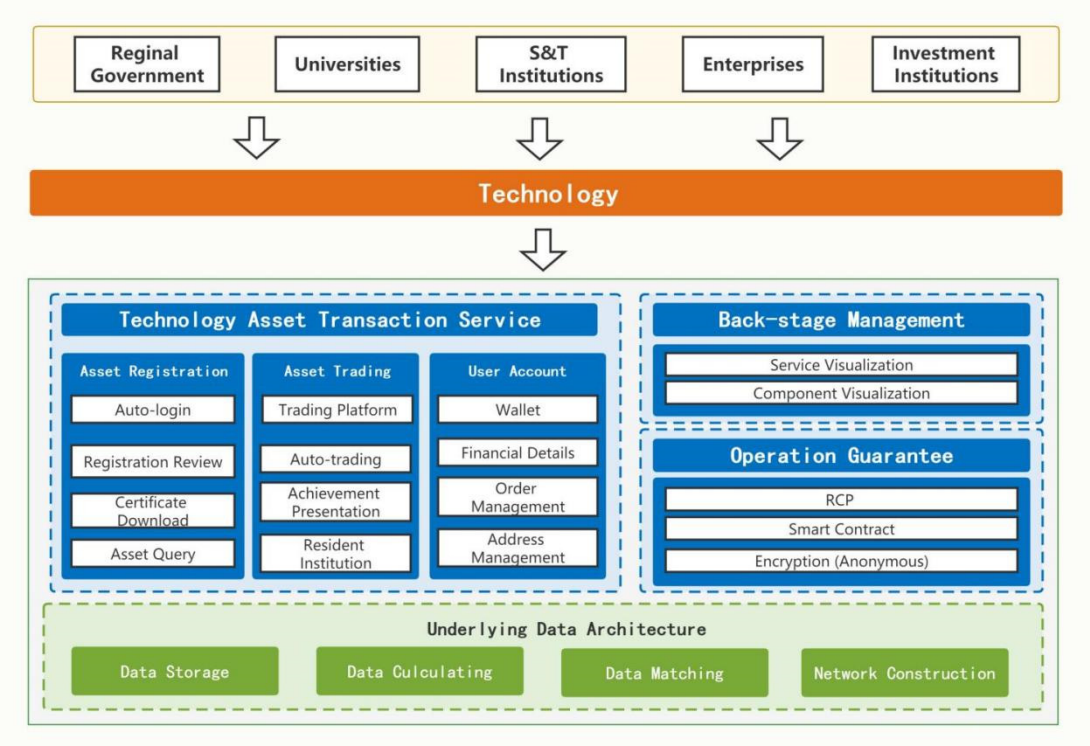
5.2. Participating Factors of Network

This study focuses on universities and scientific research institutes, and explores the technology transactions network of their technology. Fitjar, researched that university research intensity and firm network scope.[19] Furthermore, while geography has a strong influence on university-industry interaction[20]. Liu Xiaoya, etc. [21] proposed that with the development of the times, the influence of geography and internalization are negatively related to the maintenance of transaction relations, while regulation and technology are positively related to the maintenance of transaction relations. Society has no clear guidance for the maintenance of transaction relations. JIANG Ting, [22] in the research of technology transactions platform system divided the whole technology transactions data block model into two parts, namely, provincial regional platforms and industry cloud systems. They proposed that the platform stores and enters the technical asset data, which then transmits to the industry cloud system.

With reference to the digitalization of the technology trading system, we can also systematize the technology trading between universities and industries.Therefore, the key actors in the process are universities, and the participating roles include local governments, relevant enterprises and investment institutions. The functions of the technology asset transaction system include data storage, data matching, asset transaction service, back-stage management and data processing technology. The university-industry simulated transaction Network System Framework is as follows.

Table 3. Network System Framework



5.3. Transfer Mode & Data Subject

This study focuses on the new generation of information technology during 2001-2021. It uses its patent transfer data to build a technology trading network, and the data comes from the "incopat" patent retrieval platform.

At present, the transformation mode of scientific and technological achievements in universities has many forms. In general, there are 4 main types, namely project development, platform construction, intelligent property disposal and regional tech hub (see *Table 4*).

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According to Kwadwo Atta-Owusu's, etc. research [23] and Wu Chunming's research [24], which compared the influencing factors of the four modes, the following table quantifies the effectiveness of each influencing factor, and obtains the weighted average of each transformation form. The weighted average formula is:

$$\overline{x} = \frac{x_1 w_1 + x_2 w_2 + \cdots\cdots + x_n w_n}{w_1 + w_2 + \cdots\cdots + w_n} \quad (1)$$

Among that, the number of variables is denoted by n , the quantitative value of the score is denoted by xn, and the weight of each factor is denoted by wn.

According to the numerical comparison of weighted averages (shown by the *Figure 2*), the school enterprise engineering center is the more effective and mature form of technology transformation.

Table 4. Main Modes of Technology Transfer in Universities

Main Modes of Technology Transfer in Universities								
Mode	Specific Form	Main Features						Weighted Average
		Human Resource (w=15%)	Property Protection(w=15%)	Extensive Cooperation (w=15%)	External influence (w=15%)	Sharing Degree (w=15%)	Revenue Performance (w=25%)	
Project Development	Entrusted Research	1	1	1	-1	1	1	0.70
	Co-research	1	1	1	-2	1	1	0.55
	Consulting Service	1	1	1	-2	1	1	0.55
Platform Construction	Research Base	2	2	2	-2	2	2	1.15
	Derivative Enterprises	2	2	2	-2	2	3	1.15
	Personnel Training	3	2	1	-2	2	2	1.15
Intellectual Property Disposal	Technology Transfer	2	2	2	-2	1	1	1.00
	Technology License	2	3	2	-2	1	2	1.15
	Technology Evaluate	3	3	3	-3	1	3	1.30
Regional Tech-hub	Industrial Technology Alliance	2	2	3	-2	3	2	1.45
	Local Research Institute	2	2	3	-3	3	2	1.30
	School-Enterprise Engineering Center	2	3	3	-2	3	2	1.60
	Regional Technology Transfer Office	2	3	3	-2	2	2	1.45

1= Not Good; 2 =Median; 3=Good

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6. Research Conclusion and Prospects

6.1. Research Conclusion

In terms of influencing variables, the empirical study on the evolutionary dynamics of trading networks shows that the formation of relationships in the initial stage of trading is mainly affected by geographical proximity and social proximity. In the mature stage, organizational proximity and social proximity play a more significant role in the formation of transaction relationships; In the adjustment stage, it is easier to form technology trading links between subjects with institutional proximity, organizational proximity and social proximity. At the same time, geographical proximity is not conducive to the long-term maintenance of trading relationships, and the relationship between subjects with institutional proximity is more difficult to dissolve. In the stage of industrial regeneration, organizational, social, institutional, and technological proximity will promote the formation of technological trading relationships. Compared with the promotion of geographical proximity and organizational proximity on the dissolution of trading relationships, institutional, social, and technological proximity will have an important impact on strengthening trading relationships.

In term of transfer mode, considering human resource, property protection, extended cooperation, external influence, sharing degree, revenue performance these factors, through the effect analysis of weighted average, it is concluded that the *School Enterprise Engineering Center*, *Regional Technology Transfer Office* and *Industrial Technology Alliance*, as the first echelon, have the best effect on the transformation of scientific and technological achievements between universities and industries. And *the Local Research Institute*, *Technology Evaluate*, *Technology License*, *Research Base*, *Derivative Enterprises*, and *Personal Training,* as the second echelon, have weak transformation effects. While *Technology Transfer*, *Entered Research*, *Co-research* and *Consulting Service*, as the third echelon, are easy to operate, due to weak property rights protection, small project size, unfixed scientific researchers and other factors, the transformation of scientific and technological achievements has achieved poor results.

6.2. Prospects

This paper briefly expounds the importance and urgency of studying the technology transactions network of universities and research institutes. The future specific values and importance are as follows:

A. The existing researches involving colleges and universities are biased towards theoretical research and lack practicality. The reason is partly due to the "thesis system" teaching evaluation mechanism of colleges and universities. On the other hand, it is due to the lack of docking between universities and industries, which leads to scientific research remaining only on paper.

B. Studying the dynamic technology transactions model of universities and scientific research institutions will help universities and scientific research institutions to build a stable trading partnership, so as to enrich the trading network with technology as the main body, because technology transactions are easily affected by geography, organization, system, society, technology and other aspects, technology transactions show dynamic changes.

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