Summer 5-28-2021

A Study on the Characteristics of Regional Social Network for Patent Technology Transfer of China’s “985 Project” universities

Xiaoli Li
School of Management, Wuhan Textile Univerisy, China

Zihan Peng
School of Management, Wuhan Textile Univerisy, China

Hao Zhou
School of Law and Business, Wuhan Institute of Technology, China, zhouhaoli@163.com

Full Research Paper

A Study on the Characteristics of Regional Social Network for Patent Technology Transfer of China's "985 Project" universities

Xiaoli Li[1], *Zihan Peng*[1], *Hao Zhou*[2*]
[1]School of Management, Wuhan Textile Univerisy, China
[2]School of Law and Business, Wuhan Institute of Technology, China

Abstract: Using social network analysis (SNA) method, this study analyzes the regional social network characteristics of patent technology transfer of China's "985 Project" universities. In analyzing university's patent technology transfer network, density, centrality and the number of network edges, etc. are calculated, and the block results are obtained using the Concor method. The study shows: There are obvious differences in outdegree centrality and indegree centrality of each region where "985 Project" universities are located , and the central and western regions are relatively backward; Block 1 and Block 2 are the most active regions of university patent technology transfer activities; The linear fitting coefficient demonstrates that the stronger is constant stronger, and it is particularly important to improve the ability of patent technology transfer in the central and western regions; Betweenness centrality of Liaoning, Tianjin, Fujian, Hubei and Hunan are relatively high to play a role in radiation of technology transfer in the neighboring provinces, etc. All the above results provide directions for improving China's university patent technology transfer.

Keywords: University patent technology transfer, technology transfer, regional network

1. INTRODUCTION

Universities have increasingly been seen as a driver of economic growth (Mowery et al., 2001) [1] , especially in emerging technology (Etzkowitz et al., 2000; Vallas&Kleinman, 2008) [2-3] while Patent is a technical right protected by official certification, which has a series of advantages such as strong authority, complete information and large amount of data [4], so it is of great significance to study the related activities of university patent technology to promote economic growth. According to the subject of patent technology implementation, university patent technology transfer can be divided into two types: One is to transfer to derivative enterprises; the other is to transfer to other enterprises and individuals, which specifically includes the transfer of patent application rights, the transfer of patent rights, and the licensing of patented technology. This research mainly examines the transfer of university patent technology to the third party, namely the second type. Based on literature survey, the research of university patent technology transfer focuses on the motivation and type of transfer between universities and enterprises (Chang, 2017) [5], or analyzes the patent cooperation behavior based on small sample of universities from the middle and micro levels of patent cooperation behavior [6] while there are few studies on the specific characteristics of China university patent technology transfer. In addition, the "985 project" represents the highest level of university scientific research in China, so the research on patent transfer of "985 Project" university can better reflect the implementation efficiency of patent technology in China, and is conducive to exploring the experience of university technology transfer in China. This paper attempts to analyze the specific situation of university patent transfer activities in China from the perspective of "985 project" universities. Although Renmin University of China and Central University for nationalities are also included in the "985 Project", these two universities focus on humanities disciplines and have less patents. Therefore, the patent transfer of China "985 Project" universities involved in this study does not include these two universities.

* Corresponding author. Email: zhouhaoli@163.com (Hao Zhou)

2. RESEARCH DESIGN

2.1 Research method

Social network analysis is a quantitative analysis method developed by sociologists based on mathematical methods and graph theory. It has been developing rapidly since 1990s. Social network similar to a map is a collection of actors and their relationships. Each actor is a single node in the network map. The association between actors forms the connecting line in the network diagram. With the development of social network analysis, social network analysis tools are also constantly introduced and optimized. In particular, Ucinet software developed by Linton Freeman provides a convenient application tool for social network analysis. Ucinet is a powerful social network analysis software. It was originally written by Linton Freeman, an authoritative scholar of social network research at the University of California, Irvine. Later, it was mainly maintained and updated by Steve borgatti of Boston University and Martin Everett of University of Westminster. Ucinet software can read text files, KrackPlot, Pajek, Negopy, VNA and other files, and can process 32767 network nodes. At the same time, it integrates Netdraw, which includes one-dimensional and two-dimensional data analysis, and mage which is being developed for 3D presentation and analysis, as well as Pajek's Free application program for large-scale network analysis. In recent years, social network research has also been applied in the field of patent measurement. Patent technology transfer network relationships reflects the set of actors and their relationships. Using social network analysis method and related tools can deeply understand the overall network structure and individual network characteristics of patent technology transfer, which is helpful to provide ideas for expanding patent technology transfer channels.

2.2 Data source

Due to the confidentiality of technology transfer contract, it is difficult to obtain the relevant information of patent transfer from universities. However, transfer of patent technology need to be filed or registered with the State Intellectual Property Office, so the relevant information of university patent transfer can be obtained by querying the Patent Affair Database of State Intellectual Property Office, including patent transfer type, transfer object, transfer time, etc., which constitute the main data source of this study. In order to ensure the accuracy of the data, this study retrieved patent transfer from the Patent Affairs Database of State Intellectual Property Office for patent transfer of individual "985 Project" University from 2005 to 2015, including patent right transfer, patent application right transfer and patent licensing respectively. Finally, the original data were aggregated, cleaned and filtered, and 9018 records of patent transfer of "985 Project" University were obtained. The data for this study covers the time period 2005-2015.

2.3 Indicator setting

Network relationship features include the overall network characteristics and individual characteristics of actors. The whole network analysis regards the actor set in the network as a whole, and analyzes the attribute characteristics and rules of the network as a whole. Indicators that measure the overall structural characteristics of social networks generally include indicators such as network centrality, network density, and network cohesion. Centrality indicators are commonly used to measure the influence of individual actors [7], and can also evaluate superiority or privilege of individual actors in the network, and even prestige [8]. Freeman (1979) once proposed such indicators as degree centrality and betweenness centrality to describe the centrality of actors in the network [9]. Wassermann & Faust (1994) proposed that the simplest intuitive definition of the centrality of an actor is that the core member must be the most active and has the most connections with other actors in the network [10]. The specific indicators are set as follows:

2.3.1 Network centrality

Network centrality is the degree to which a group of actors in a network link up the network around a central point. It depicts the overall centrality of the network and reflects the structural center of the graph (Liu Jun, 2004). The steps to calculate the concentration degree are as follows: first, find the maximum centrality value (Cmax) in the network graph, then calculate the difference between the value and the centrality (C_i) of any other node, so as to obtain multiple "differences"; then calculate the sum of the differences; finally divide the sum by the maximum possible value of the sum of the differences [11].The network concentration is denoted as C. The higher C is, the higher the degree of centralization of university patent technology transfer network structure is, and the larger the regional gap is; the smaller C is, the lower the centralization degree of university patent technology transfer network structure is, and the patent technology transfer is more balanced among regions. The calculation formula of the network centrality C is as follows in equation (1):

$$C = \frac{\sum_i^n (c_{\max} - c_i)}{\max\left[\sum_i^n (c_{\max} - c_i)\right]} \tag{1}$$

2.3.2 Network density

Network density reflects the closeness of the relationship between actors in social network. The greater the network density, the closer the relationship between actors. In graph theory, density represents the compactness of each node in a graph. If there are n nodes in the directed network graph, there may be n (n-1) lines at most. The density of a graph is defined as the ratio of the total number of relationships actually in the graph to the maximum possible total number of relationships. The calculation formula is as follows in equation (2), denoted as D, where l represents the actual number of lines in the graph, i and j represent the members in the network, X_{ij} represents the relationship between members i and j, if there is a relationship between them, it is 1, and if there is no relationship, it is 0. The value range of network density is [0, 1]. A complete graph is a graph in which all vertices are adjacent, and its density is 1.

$$D = \frac{l}{n(n-1)} = \frac{\sum_{i=1}^n \sum_{j=1}^n x_{ij}}{n(n-1)} \tag{2}$$

2.3.3 Block model

The theory of block model was first put forward by White & Burman and other scholars in 1976. Block model is mainly used to describe the location of network actors, and it is an algebraic analysis of social role description [12]. The block model divides the actors in the network into different subgroups according to density, distance, or other criteria, usually called blocks, and compares the tightness within the block and the sparseness outside the block. Generally speaking, the analysis of the block model includes two steps: dividing the block and determining the value of the block. Firstly, the actors are assigned to each block of the network by using Concor or hierarchical clustering method. Then, according to some criteria, such as complete fitting, 0-block standard, 1-block standard, α - density index, etc., the values are calculated in each block, so as to understand the overall structure of the network. The α-density metric method is the most commonly used, where α is the critical density value and is often expressed by the average density value of the network, which is also the evaluation criteria used in this study.

2.3.4 Degree centrality

Degree centrality is also known as individual centrality. The concept of degree centrality comes from the concept of "Star" in sociometrics, which indicates the relationship between the actor and other actors in the network. The greater the value of degree centrality, the more connected the actor is to other actors. Degree centrality is an indicator at the individual level. The measurement of degree centrality of an actor is the number of external contacts of the actor, which is the so-called node degree in graph theory. In directed network relations, degree centrality can be divided into outdegree centrality and indegree centrality. The calculation formula of outdegree centrality and indegree centrality is respectively shown in equation (3) and (4). Where a_{ij} represents the number of contacts that actor i points to other actor j; a_{ji} represents the number of contacts that other actor j points to actor i. In the patent transfer network, indegree centrality and outdegree centrality respectively measure the important role of regions in the transfer of university patent technology.

$$Outdegree_i = \sum_{j=1}^{n} a_{ij} \tag{3}$$

$$Indegree_i = \sum_{j=1}^{n} a_{ji} \tag{4}$$

2.3.5 Betweenness centrality

Betweenness centrality, referred to as intermediary degree, is equivalent to the concept of "bridge" in social metrology. If an actor withdraws from the network relationship, the original sub network of the actor will be disconnected, resulting in other actors in the sub network unable to get contact with each other. If an actor has a high degree of mediation, it means that the actor acts as a middleman to connect many unrelated actors and build a bridge for them. Suppose that the number of shortcuts between actor j and actor k is represented by g_{ik}, where the number of shortcuts between j and k passing through actor i is represented by $g_{jk(i)}$; the ability of actor i to control the interaction between j and k is represented by $b_{jk(i)}$, that is, the probability of i being on the shortcut between j and k, then $b_{jk(i)}= g_{jk(i)}/g_{jk}$. Adding the betweenness centrality of all the actors corresponding to the actor i in the network relationship graph to obtain the betweenness centrality of the actor i, the formula is shown below in equtation (5). In the university patent transfer network of this study, betweenness centrality is used to measure the position and dominance of a region in the university patent transfer network. If the betweenness centrality of a certain region is high, it means that this region acts as a bridge between regions in university patent transfer activities [13].

$$Betweenness_i = \sum_{j}^{n}\sum_{k}^{n} b_{jk}(i),\ j \neq k \neq i, 并且 j < k \tag{5}$$

3. CONSTRUCTION OF PATENT TECHNOLOGY TRANSFER NETWORK

In this study, the collected patent technology transfer data of China's "985 Project" universities from 2005 to 2015 were classified and counted according to the regions where the transferor and the transferee of the patent technology were located, and an adjacency matrix of 38*38 was constructed, and part of this matrix is as shown in Table 1.The "rows" in the matrix are 33 regions and 5 countries that accept the patent technology of China's "985 Project" universities, and the "columns" in the matrix represent 18 regions where China's "985 Project" universities transferred the patented technology out, and 13 regions or countries added in order to construct the adjacency matrix. The grid value at the intersection of the rows and columns in the adjacency matrix represents the number of patent technologies transferred to the regions in columns from the regions in rows where "985 Project" universities are located; the grid value of the diagonal of the adjacency matrix represents the number of patent technologies implemented within the region where the "985 Project" universities are located. The constructed 38*38 adjacency matrix was input into Ucinet software and the data format was converted. Then NetDraw was used to visualize the regional network relationship of the patent technology transfer for "Project 985" university region as shown in Figure 1. The square nodes in the figure represent regions where the patent technology is transferred out or in. Node size in Figure 1 is set according to the number of patent technology transfer of that region received from "Project 985" universities, that is, the larger the node is, the more patents received from "Project 985" universities. The connection between nodes represents the strength of patent technology transfer between regions, that is, the thicker the connection is, the more frequently the patent technology transfer occurs between regions. The arrows in the line point to the regional transferee of the patent technology. In order to reflect more intuitively the patent technology transfer status of the regions to which the "985 Project" universities belong and other regions, the low intensity of patent technology transfer (i.e. the frequency of patent technology transfer is less than 10 times) is filtered out in

Figure 1, and a simplified map of the regional distribution of patent technology transfer of the "985 Project" universities in China is obtained, as shown in Figure 2.

Table.1 Adjacency matrix(part)

	Jiangsu	Shandong	Guangdong	Beijing	Anhui	Zhejiang	Hubei	Hunan	Liaoning	Fujian	Gansu	Sichuan
Jiangsu	772	9	15	9	9	1	4		1	3		
Shandong	15	156	14	21	1	7	2	1	1	2		1
Guangdong	19	8	53	9	5	14	9	9	1	7		1
Beijing	243	26	229	953	4	2	12	6	6	14		17
Anhui	3				26	1				2		
Zhejiang	67	25	42	18	14	571	3	1	12	3		8
Hubei	126	3	48	21	3	22	253	1	2	4		
Hunan	22	1	22	17	6	15	4	233		5		5
Liaoniang	27	8	3	11	2	13		3	16	1	1	1
Fujian	1		6	8	4	1				56		
Gansu			1	1							16	
Sichuan	62	11	42	14	1	33	1	4	2	3		197

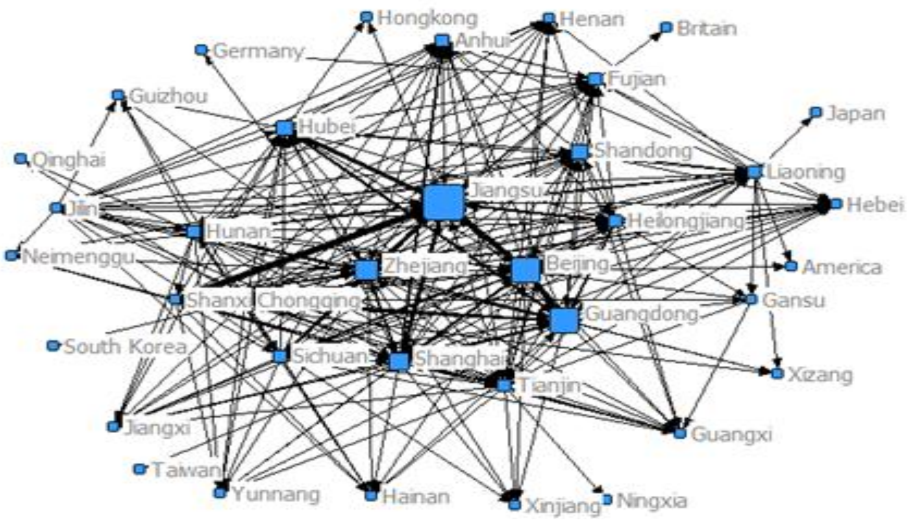


Figure 1. Regional distribution network diagram of university patent technology transfer

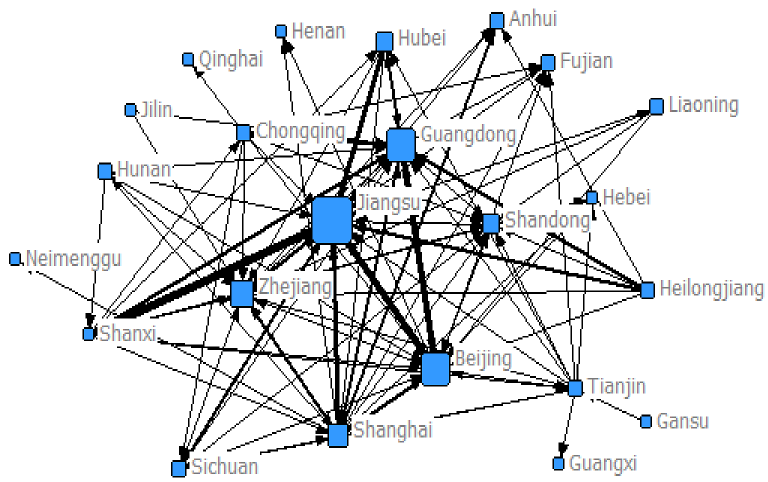


Figure 2. Regional distribution network diagram of university patent technology transfer (simplified diagram)

4. THE EMPIRICAL ANALYSIS

4.1 Analysis of the overall network characteristics

Ucinet software was used to calculate the overall characteristic parameters of the regional network of patent technology transfer of "985 Project" universities, including density, number of network edges and network centrality, as shown in Table 2 which shows that except for a few years, the network density and the number of network edges showed an overall rising trend from 2005 to 2015, indicating that the network connection of patent technology transfer was getting closer and closer, and the frequency of patent technology transfer was increasing. Network indegree centrality reflects the concentration of patent technology introduction regions. Table 2 shows that from 2005 to 2015, the regions in which the patent technology is introduced into are relatively dispersed, and they have a trend of centralization from 2010 to 2014, but the distribution concentration of the regions was decreased significantly in 2015, suggesting that some regions firstly introduced university patent technology, and then drove other regions to actively adopt new technology. Therefore, China's introduction of patent technology stepped in a new level in 2015, and this turning point is relatively obvious. However, this conclusion needs to be further verified by future follow-up studies. Network outdegree centrality reflects the concentration of patent technology export regions where the "985 Project" universities are located and this indicator did not show obvious fluctuations from 2005 to 2015, which indicates that the patent technology transfer of each "985 Project" university has a balanced increase in horizontal implementation, and each "985 Project" university attaches more importance to university patent technology transfer activities.

Table 2. Overall network parameters by year

Year	Network density	number of network edges	indegree centrality	outdegree centrality
2005	0.0135	85	3.273%	3.009%
2006	0.0121	51	3.351%	4.045%
2007	0.0185	93	2.514%	3.155%
2008	0.1202	352	2.802%	2.907%
2009	0.2617	820	4.102%	2.690%
2010	0.3435	998	6.099%	4.526%
2011	0.3713	1135	4.621%	4.139%
2012	0.3841	1118	7.205%	4.020%
2013	0.4211	1615	5.104%	4.385%
2014	0.4701	1443	6.727%	2.660%
2015	0.3606	1334	2.982%	3.553%

According to the network management of regions of patent technology transfer from 2005 to 2015, the block results are obtained by using CONCOR method. And the regions involved in the patent technology transfer network of "985 Project" universities in China from 2005 to 2015 can be divided into 6 blocks in total. The first block consists of 7 regions, specifically Jiangsu, Shanghai, Hubei, Beijing, Liaoning, Heilongjiang and Shanxi; The second block consists of four regions: Chongqing, Sichuan, Tianjin and Zhejiang; The third block consists of three regions: The United Kingdom, Jilin and Hunan; The fourth block includes two regions, specifically Gansu and Japan; The fifth block consists of six regions: Guangdong, Qinghai, Shandong, Fujian, Ningxia and the United States. Block 6 consists of 11 regions, specifically Anhui, Hebei, Yunnan, Guangxi, Shanxi, Xinjiang, Hainan, Jiangxi, Inner Mongolia, Henan and Taiwan. Block 7 consists of four regions, specifically Korea, Germany, Guizhou, and Xizang. Block 8 comprises a region, specifically Hong Kong. Meanwhile, the density and interval density of a single block are calculated by CONCOR method, and the overall density of the network is calculated, as shown in Figure 3 (a). Among them, the internal interaction between Block 1 and Block 2 is relatively frequent. Secondly, the transfer out or introduction of patent technology between Block 1 and Block 2 is relatively active. In addition, Block 1 and Block 2 each have a higher frequency of patent technology transfer out to Block 5. The other blocks have no strong interaction and loose structure. The whole network density α is 2.6947, Considering that the foreign regions involved in the university patent technology transfer network are included, and the amount of university patent technology transferred to foreign countries is very small at present, this part of data reduces the entire network density value, so the obtained α is corrected by rounding, and the value of α is adjusted to 3 as a critical value to get a 0-1 block image matrix shown in figure. 3 (b). The image matrix is calculated as shown in the following formula in equation (6). A highly generalized simplified network diagram is drawn according to the image matrix information, and the inter-block structure is shown in Figure. 3 (c). It can be seen that Block 1 and Block 2 are the most active regions in university patent technology transfer activities. Firstly, Block 1 and Block 2 have a high level of patent technology transfer activity within their own block; In addition, there is a lot of interaction between Block 1 and Block 2, with Block 1 having more patent technology transfer output to Block 6 and Block 5, and Block 2 having more output to Block 5. The activity of Block 1 and Block 2 is directly related to the number of "project 985" universities and the capacity of the patent technology transfer in these two blocks. In addition, these regions are economically developed and have a strong ability to absorb the patent technology of universities. Moreover, the long-term cooperative relationship of patent technology transfer is also conducive to solidify the inter-block and intra-block trading relationship. A simplified diagram of the network provides direction for finding potential areas to target for patent technology transfer.

$$B_{ij} = \begin{cases} 1, & if\ a_{ij} > \alpha \\ 0, & else \end{cases} \tag{6}$$

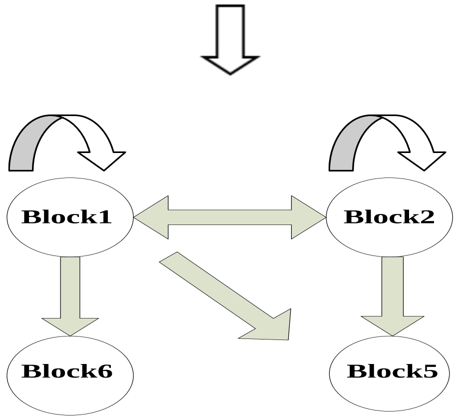
Block	1	2	3	4	5	6	7	8
1	30.024	11.071	1.667	0.357	14.000	3.013	0.179	0.714
2	12.464	11.167	1.000	0.000	11.750	2.977	0.438	0.000
3	2.952	2.417	0.167	0.000	2.389	1.030	0.167	0.000
4	0.071	0.875	0.000	0.000	0.083	0.048	0.000	0.000
5	2.929	1.208	0.722	0.000	1.233	0.500	0.208	0.000
6	0.078	0.023	0.000	0.000	0.030	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Network density=		2.6947

(a)Regional network block model density matrix of "Project 985" university patent technology transfer

⇩

Block	1	2	3	4	5	6	7	8
1	1	1	0	0	1	1	0	0
2	1	1	0	0	1	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0

(b)Regional network image matrix of university patent technology transfer



(c) Simplified map of the regional network of patent technology transfer of "Project 985" universities

Figure 3. Regional network block model of university patent technology transfer

4.2 Analysis of characteristics of network actors position

Ucinet software is used to respectively calculate indegree centrality and outdegree centrality of the individual "985 Project" university patent technology transfer region, as shown in Table 3.There are obvious differences in both outdegree centrality and indegree centrality among different regions, which proves that there is a serious imbalance in patent transferring behavior in different regions [14]. In terms of regional outdegree centrality, the number of patent technology transfer from Beijing and Shanghai has respectively exceeded 1000. Secondly, Jiangsu, Zhejiang, Guangdong and other regions also rank higher. The difference of this indictor is firstly directly related to the number of "project 985" universities in the output regions， such as Beijing with a total of 6 "985 project" universities, Tsinghua university, Peking University, Beijing University of Aeronautics and Astronautics, Beijing Institute of Technology, Beijing Normal University, China Agricultural University; Shanghai with a total of 4 "985 project" universities, Shanghai Jiaotong university, Tongji University, Fudan University and East China Normal University; Xi 'an with a total of 3 "985 project" universities. Secondly, the regional outdegree centrality is directly related to the patent strength and patent technology transfer ability of "985 project" universities, and regional support, such as Jiangsu, Zhejiang and Guangdong where "985 project" Universities are not concentrated, but Southeast University, Zhejiang University and South China University of Technology in those regions have outstanding patent output and technology trading ability. At the same time, Jiangsu, Zhejiang and Guangdong as economically developed regions attach more importance to technology transfer and industrial innovation, which leads to the higher outdegree centrality. As far as the regional indegree centrality is concerned, this indicator directly reflects the state of patent technology introduction of various regions in China from "985 project" universities. Among them, Jiangsu has the largest number of patent technology introduction with 2029, followed by Beijing, Guangdong, Zhejiang and Shanghai with a relatively large number of patent introductions; while the number of patent technology introduction from "985 project" Universities is relatively small in China’s central and western regions and other regions. The central and western regions have relatively weak independent innovation capacity and relatively backward economic development. Therefore, these regions should actively introduce and absorb the advanced technology of other regions to catch up with and surpass in economy. In addition, the scope of patent technology transfer activities in China's "985 Project" universities is still relatively small, as well as the geographical location and degree of technological innovation and other factors lead to the less demand for patents of "985 Project" university from Taiwan, Hong Kong, Macao and foreign countries.

On the whole, the indegree centrality and outdegree centrality of "985 Project" university patent technology transfer reflect that there are obvious differences in the export and introduction of regional patent technology in general, among which the economically developed regions have outstanding advantages and the number of patent technology export and introduction is the most. But is the gap of the export or introduction of patent technology transfer among regions narrowing, or is it widening? In this study, Ucinet software is used to calculate the annual indegree centrality and outdegree centrality of each region from 2005 to 2015, and this value is taken as the dependent variable of each year variable. The linear fitting coefficient of indegree centrality and outdegree centrality of each region is obtained by using slope function in Excel [15], as shown in Table 3. The results show that the export and introduction of patent technology in most regions show an increasing trend, and the fitting coefficient of out of center degree is high in Beijing, Jiangsu, Shanghai, Zhejiang and Chongqing. It can be seen that the export of patent technology of "985 project" universities in these regions grows most rapidly, and the fitting coefficient of outdegree centrality is high in Jiangsu, Beijing, Guangdong, Zhejiang and Shanghai, so it can be seen that the patent technology export from these regions is increasing, while the central and western regions play little role in promoting the transfer of patent technology, and the increasing rate is significantly smaller than that in economically developed regions. It can be seen that in terms of university patent technology transfer in different regions, China shows the situation that the strong regions always keep strong, so it is particularly important to improve the patent technology transfer ability in the central and western regions.

The betweenness centrality of each region from 2005 to 2015 is calculated using Ucinet software as shown in Table 3. Betweenness centrality can be used to measure the intermediary role of a region in the university patent technology transfer network. If betweenness centrality of a region is higher, it indicates that the region plays a role of bridge between regions in the university patent technology transfer network activities, and the radiation effect of geographical location is obvious. The difference of betweenness centrality of regional patent technology transfer is directly related to the ability of regional patent technology transfer, followed by the geographical location advantage. Technology spillover has the characteristics of geographical space, and it is easy to form the technology divergence area in the neighboring provinces or within 800 kilometer [16]. Table 3 shows that Zhejiang, Beijing, Shanghai and Tianjin have the highest degree of betweenness centrality, which indicates that these regions have strong technology spillover capacity and play a key role in promoting the whole country's technology transfer capacity. In addition, although Liaoning, Tianjin, Fujian, Hubei and Hunan do not have advantages in outdegree centrality and indegree centrality, the degree of betweenness centrality of these provinces is higher than that of other provinces which shows that these provinces play a greater role in the bridge of regional patent technology transfer, and play a radiation role in the technology transfer of surrounding provinces. In order to promote the ability of patent technology transfer in the central and western regions, these provinces can be used as the engine regions of patent technology transfer.

Table 3. Regional degree centrality and betweenness centrality

Region	Outdegree	Indegree	Outdegree coefficient	Indegree coefficient	Betweenness	Region	Outdegree	Indegree	Outdegree coefficient	Indegree coefficient	Betweenness
Beijing	1652	1191	34.92	23.87	37.327	Hebei	–	83	–	1.25	–
Shanghai	1124	710	16.85	10.76	37.073	Jiangxi	–	29	–	0.78	–
Jiangsu	848	2029	20.6	47.3	24.187	Neimenggu	–	21	–	0.42	–
Zhejiang	808	898	13.18	11.5	66.54	Shanxi	–	21	–	0.53	–
Shanxi	709	200	16.23	4.83	6.903	Xinjiang	–	10	–	0.15	–
Guangdong	624	1183	7.31	15.1	25.945	Yunnan	–	30	–	0.33	–
Hubei	513	323	8.57	5.4	12.189	Guangxi	–	53	–	0.66	–
Chongqing	489	270	12.15	6.12	6.694	Henan	–	40	–	0.91	–
Tianjin	406	229	4.6	3.34	33.037	Xizang	–	9	–	0.31	–
eilongjiar	401	189	8.1	4.72	16.468	Guizhou	–	6	–	0.009	–
Sichuan	399	300	5.71	4.95	4.53	Ningxia	–	1	–	0.009	–
Hunan	359	273	5.84	4.93	19.775	Qinghai	–	11	–	0.35	–
Shandong	240	330	4.06	5.94	5.837	Hongkong	–	5	–	-0.15	–
Liaoning	189	155	3.75	3	36.197	Taiwan	–	1	–	0.009	–
Jilin	98	72	0.973	0.9	3.278	outh Kore	–	1	–	0.018	–
Fujian	91	140	2.36	2.82	26.772	Germany	–	3	–	-0.045	–
Anhui	35	152	-0.2	3.66	0.948	America	–	3	–	0.054	–
Gansu	26	20	0.7	0.68	0.3	Britain	–	2	–	0.091	–
Hainan	–	17	0	0.21	–	Japan	–	1	–	0	–

5. CONCLUSIONS

In this study, Ucinet software is used to calculate the relevant parameters of regional network of "985 Project" university patent technology transfer. In the analysis of the overall network characteristics, we calculate the density, the number of network edges, the degree of network centralization and other overall characteristic parameters, and use the Concor method to calculate the simplified network diagram of the university patent technology transfer block model. In the analysis of the individual characteristics of the network actor position, we calculate outdegree centrality and its linear fitting coefficient for the export regions of "985 Project" university patent technology transfer, and indegree centrality and its linear fitting coefficients for the introduction regions of "985 Project" university patent technology transfer.

The results show that: ①during 2005-2015, the network density and the number of network edges showed an overall upward trend, and the indegree centrality shows that there was a centralization trend in the patent technology introduction region from 2010 to 2014, but the distribution concentration degree of patent technology introduction region decreased obviously in 2015; ②From 2005 to 2015, China's "985 Project" university patent technology transfer network involves a total of six blocks, in which Block 1 and Block 2 are the most active regions of university patent technology transfer activities. Block model results indicate the possible direction of patent technology transfer for each region; ③There are obvious differences in outdegree centrality and indegree centrality of each region, and the central and western regions are relatively backward; ④The linear fitting coefficient shows that for China's university patent technology transfer, the stronger is constant stronger, and it is particularly important to improve the ability of patent technology transfer in the central and western regions; ⑤The betweeness centrality parameter shows that although Liaoning, Tianjin, Fujian, Hubei and Hunan did not have advantages in outdegree centrality and indegree centrality, the betweenness centrality of these provinces was relatively high, which indicates that these provinces played a larger role as a bridge for regional patent technology transfer and played a radiation role in the technology transfer of surrounding provinces, so it is necessary to promote the patent technology transfer in Central and Western regions of China. These provinces can be regarded as the engine areas of patent technology transfer.

ACKNOWLEDGEMENT

This research was supported by the Educational Science Planning of Hubei Province under Grant 2020GA036, and supported by the Education Department of Hubei Province under Grant 20Y083 and DSS20191201.

REFERENCES

[1] Mowery D, Nelson R, Sampat B, et al. The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole Act of 1980 [J]. Research Policy, 2001, 30(1): 99-119.

[2] Etzkowitz, H.,Webster, A., Gebhardt, C., Terra, B.R.C. The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm[J]. Research. Policy, 2000, 29 (2), 313–330.

[3] Vallas, S.P., Kleinman, D.L. Contradiction, convergence and the knowledge economy: the confluence of academic and commercial biotechnology[J]. Socio-Economic Review, 2008, 6(2), 283–311.

[4] Song Lan, Qin Yunlong, Li Minsi. A study on patent licensing network of the six central provinces under “the Belt and Road “Strategy in China[J]. Science &Technology Progress and Policy, 2013,34(14): 37-44. (in Chinese)

[5] Chang S H. The technology networks and development trends of university-industry collaborative patents[J]. Technological Forecasting and Social Change, 2017, 118(5): 107-113.

[6] Lu Yikai, Shi Liang, Zhang Shanshu. Study on the characteristic and case of university-involved patent collaboration based on the social network analysis[J]. Journal of Modern Information, 2015, 35(8): 69-74. (in Chinese)

[7] Brass D J, Burkhardt M E. Centrality and power in organizations [J]. Networks and organizations: Structure, form, and action, 1992, 191(215):198-213.

[8] He Jiayuan. A study of the social network of high school geography teachers' GIS study participation [D]. Taiwan University, 2012. (in Chinese)

[9] Freeman L C. Centrality in social networks: conceptual clarification [J]. Social networks, 1978, 1(3): 215-239.

[10] Wasserman S, Faust K. Social network analysis: Methods and applications [M]. Cambridge university press, 1994.

[11] Liu Jun. Introduction to social network analysis [M]. Social Science Literature Press, 2004. (in Chinese)

[12] White H C, Boorman S A, Breiger R L. Social structure from multiple networks. I. Blockmodels of roles and positions [J]. American Journal of Sociology, 1976, 81(4): 730-780.

[13] Liu Jun. Holistic net analysis handout: UCINET Software practical guide [M].Shanghai: Gezi Press, 2009. (in Chinese)

[14] Wang Yuandi, Chen Fengzhen, Li Min. A Study on patent licensing spatial distribution and flow networks of research institutions in China [J]. Journal of Intelligence, 2016, 35(1): 57-63. (in Chinese)

[15] Zhao Sangmei, Si Hongmei, Du Huadong. Analysis of cross-regional technology transfer based on network model [J]. R&D Management 2013, 25(5): 54-61. (in Chinese)

[16] Fu Miao. Geographical distance and technological spillover effects: a spatial econometric explanation of technological and economic agglomeration phenomena [J]. China Economic Quaterly, 2009, 8(4): 1549-1566.(in Chinese)