Impact of Intergovernmental Science and Technology Policy Synergy on Inter-city Patent Cooperation in Beijing-Tianjin-Hebei Region Based on QAP Analysis

Weijia Kong[1*], Linlin Li[2], Jingwen Qiu[3]
*Corresponding author: wkon0424@163.com, 1637274765@qq.com, mf21140099@smail.nju.edu.cn

[1]College of Economics and Management Beijing University of Technology Beijing, China

[2]College of Economics and Management Beijing University of Technology Beijing, China

[3]School of Information Management Nanjing University Nanjing, China

WeiJia Kong and LinLin Li contributed equally to this work.

Abstract—In 2014, China put forward the strategic plan of Beijing-Tianjin-Hebei synergistic development, but there are always many obstacles to patent cooperation as an important means to promote regional synergistic development. To study whether inter-governmental policy synergy can strengthen inter-regional technological cooperation, this paper constructs weighted undirected networks of policy synergy and patent cooperation for 13 cities in Beijing, Tianjin, and Hebei from 2015 to 2020, respectively, based on the science and technology policy documents of a total of 43 official government websites in Beijing, Tianjin, and Hebei provinces and cities, and the patent cooperation application data in IncoPat global patent database, and conducts correlation analysis and regression analysis using QAP method, to explore the influence mechanism of inter-governmental policy synergy on inter-city patent cooperation. The following conclusions were drawn: First, with the promotion of the Beijing-Tianjin-Hebei cooperative development strategy, the positive promotion effect of inter-governmental policy synergy on inter-city patent cooperation has gradually increased. Secondly, the impact of policy synergy on patent cooperation is continuous and lagging in time. Thirdly, there is still room for improving the promotion effect of policy synergy on patent cooperation, and other channels for promoting patent cooperation should continue to be explored. This study provides decision support for enhancing patent cooperation between Beijing, Tianjin, and Hebei across cities.

Keywords-policy synergy; patent cooperation; QAP analysis; Beijing-Tianjin-Hebei

1 INTRODUCTION

As a region with the most concentrated innovation elements and the most abundant innovation output in China, the Beijing-Tianjin-Hebei region is most likely to lead industrial upgrading and high-quality development through regional collaborative innovation [1]. However, after analyzing the characteristics of the condensed subgroup of the patent cooperation network in the Beijing-Tianjin-Hebei region, it is found that more cooperation happened inner cities and a tight and stable patent technology cooperation network has not been formed across boroughs [2]. Some

MSIEID 2022, December 09-11, Chongqing, People's Republic of China

DOI 10.4108/eai.9-12-2022.2327618

studies illustrated that the quality, geography, economy, social, cognitive and language approaches are all influence factors of cities technical cooperation [3]. There are also studies showing that policy coordination between the regional government is beneficial to economic growth, ecological environment, and social welfare optimization [4][5]. However, there is still a place for cross-regional technical cooperation. Therefore, this paper analyzes the data of science and technology policy and patent cooperation in the Beijing-Tianjin-Hebei region from 2015 to 2020 to study the characteristics of the changing trends of these two factors under the complex social environment and puts forward suggestions to strengthen the cross-regional patent cooperation in Beijing-Tianjin-Hebei region.

2 LITERATURE RESEARCH

2.1 Connotation and Extension of Policy Synergy

There are many answers to the definition and cognition of policy synergy. Wei Chao [6] defines it as promoting the realization of cross-departmental policy goals, it goes beyond the boundary of the existing policy field and the responsibility scope of a single functional department and then integrates policies between different departments, which is a special governance mode. Mulford [7] believes that it is "two or more organizations create new rules or use existing decision-making rules to jointly deal with the similar task environment", referring to the operation process of the government. Peters (1998) and Borloyer (2011) tend to understand it as the ultimate state of maximizing policy efficiency and achieving the accuracy of goals, ignoring the operation and performance in the process and representing a state. At present, in terms of the evaluation dimension of policy synergy, the academic world has experienced changes in policy scale, policy process, policy application, and policy content [8]. The "Metcalfe" scale[9], qualitative matrix[10], multi-dimensional evaluation [11] [12], and other means have been used to quantitatively analyze the degree of policy synergy. However, the application of policy quantification is only limited to the field of innovation policy.

According to what has been discussed above, we could safely conclude that the meaning of policy coordination could be defined as: Introduce respective policies under the condition of mutual support and coordination through different mutual exchanges and cooperation between the government's functional departments, according to its own development needs. The final goal is to ultimately solve complex governance problems and achieve a common management goal or to seek a more common development way of governance. Policy synergy can avoid the "externality" between policies, reduce the cost of policy operation and effectively use the limited policy resources [13]. The application preference of policy synergy shows a tendency of centralization, which is often applied to cope with economic shocks and realize regional integration [14]. At present, the technology policy coordination in Beijing-Tianjin-Hebei mainly focuses on promoting resource sharing, transferring and transforming achievements, promoting poverty alleviation through science and technology, strengthening the construction of key research areas, and promoting the application of scientific and technological achievements in other fields.

2.2 Inter-city Patent Cooperation in Beijing-Tianjin-Hebei Region

Patent cooperation refers to individuals from enterprises, scientific research institutions, or government departments in different regions who, through the exchange of technical experience and sharing of scientific research results, cooperate to complete a certain invention and then apply for a proprietary technology recognized by the state and protected by law on an open basis. Patent cooperation can bring about rapid knowledge accumulation, a high invention rate, and higher-value innovation [15], and has a significant promoting effect on technology transfer [16]. When the patent cooperation network is strengthened, the efficiency and quality of innovation achievements transformation can be improved. By promoting technology transfer, the quality of economic growth can finally be promoted [17].

Studies have pointed out that from 2013 to 2018, the Beijing-Tianjin-Hebei collaborative innovation index increased by more than four times; The number of joint patents between the three regions increased by 49% [18]. Studies have also shown that the number of patent cooperation within Beijing is far greater than the inter-provincial cooperation in Beijing, Tianjin, and Hebei. The frequency of patent cooperation among science and technology subjects in Beijing, Tianjin, and Hebei is less, and the degree of aggregation is weak [19]. In terms of cooperation characteristics, the patent cooperation between enterprises is the main one, followed by the cooperation between enterprises and research institutes, and the cooperation between enterprises and universities is relatively small. Moreover, the patent cooperation between different cities does not show a positive correlation with the spatial geographical distance [20]. As can be seen from the above, cross-regional cooperation between the three places is not close.

At present, researches on inter-city patent cooperation are mostly focused on the Yangtze River Delta and the Guangdong-Hong Kong-Macao Greater Bay Area. For example, Curley [21] found that the number of inter-city cooperative patents in the Yangtze River Delta region is related to time, cultural proximity between cities, geographical proximity between cities, and proximity of urban innovation capacity. Patent cooperation tends to concentrate on the regions with large patent output; Zhang Ruofan [22] found that the inter-city cooperation network of the Guangdong-Hong Kong-Macao Greater Bay Area presented a significant marginal core structure. In the Bay Area, the applicant cooperation network is sparse and the small-world characteristics are not significant. There are more opportunities for industry-university-research cooperation in the Bay Area, but fewer opportunities for inter-city cooperation in the region. As can be seen from the above, for different urban agglomerations, their internal patent cooperation characteristics and distribution are different.

2.3 Study on the Impact of Inter-governmental Policy Synergy on Inter-city Patent Cooperation

There are few studies on the influence of policy synergy and patent cooperation, but it can also be found from literature research that there is a certain relationship between policy implementation and inter-city technical cooperation. For example, Liu Hua [23] proposed a cooperative operation mode of policies for the construction of a technology transfer system. All decision-making departments are closely linked and interact with each other to help build an efficient technology transfer system. Tang Heng [24] studied the evolution of the collaborative network of patent creation incentive policies and found that the collaboration among departments of patent creation incentive policies was mainly provincial horizontal department collaboration.

Few scholars have studied the relationship between the two concepts of "policy collaboration" and "patent collaboration". Therefore, based on existing studies, this paper will study whether inter-governmental policy synergy can be a factor affecting inter-city patent cooperation.

3 DATA COLLECTION AND PROCESSING

3.1 Data Collection and Processing of Science and Technology Policies

The main data sources of Beijing-Tianjin-Hebei science and technology synergistic development policy documents are 43 official government websites of provinces (municipalities directly under the central government) and cities (districts directly under the central government) in the Beijing-Tianjin-Hebei region, including 1) the official government websites of Beijing and its Science and Technology Commission, Science and Technology Association, and Science and Technology Bureau; 2) the official government websites of Tianjin and its Science and Technology Bureau and Science and Technology Association; 3) the government websites of Hebei Province and the official websites of its 11 prefecture-level cities and the official websites of the Technology Bureau and the Technology Association. Using crawler tools to crawl policy documents with the keywords "(Beijing-Tianjin-Hebei or science and technology or innovation or intellectual property) and (cooperation or collaboration or synergy)", the reserved fields are document title, issuing city, release date, website address; policy time is January 1, 2015 - December 14, 2020. Excluding duplicated documents and excluding all texts such as government departments' replies to NPC deputies and CPPCC members' suggestions, a total of 7707 policy documents were obtained.

This paper gives the judgment of inter-governmental policy synergy based on setting joint issuance and policy documents with similar contents as synergy and constructs a policy synergy matrix by counting the total number of policies that meet the criteria of the synergy between two regions. By manually reading a large number of documents, 7269 policy documents that are not related to the synergistic development of science and technology in Beijing, Tianjin, and Hebei are excluded, leaving 438 documents.

For the 438 policy documents after the screening, a weighted undirected matrix C is constructed by year for the policy synergy among multiple cities in the three regions. For the joint issuances that can be retrieved from the three regions, the issuing city of document A is the city i and the issuing city of document B is city j, then $C_{ij}=1$. Because there are few joint issuances among governments, this paper also judges the policy synergy among the three regions from the perspective of policy content similarity. Due to the small corpus and unsatisfactory calculation results using methods such as word vectors, the policy content similarity is read and judged manually. The rules are as follows: (a) If the policies of city p are similar, then $C_{pp}=1$. (b) If b policies of the city i are related to c policies of city j, and b is smaller than or equal to c, then $C_{ij}=c$. (c) If the documents of different years are similar, the later release time is used as the time point to judge the synergy. Finally, the policy synergy matrix among 13 cities in Beijing, Tianjin, and Hebei from 2015 to 2020 is obtained.

3.2 Data Collection and Processing of Patent Cooperation

The data of patent cooperation applications in this paper were obtained from the IncoPat global patent database, and the collection time was limited from January 1, 1960, to December 31, 2020, and the area codes of Beijing, Tianjin and Hebei were 11, 12 and 13, respectively, and were searched by the search formula: **AD= [19600101 TO 20201231] AND AP–PC= (11 OR 12 OR 13)**. A total of 218,931 valid invention patents was screened. The patent titles, abstracts, PC classification numbers, applicants, Chinese applicant cities, and national economic classifications were downloaded year by year (2015-2020).

The collected patent data are processed as follows: 1) Delete non-cooperative patents. Set the cooperation data as patents with the number of applicants greater than or equal to 2. The data that do not meet the requirements were deleted, leaving 54,054 valid patents. 2) Filter the data of patent cooperation where the patent applicants are all from Beijing, Tianjin, and Hebei. Delete the data containing applicants from other provinces, and delete a total of 21,809 patents. 3) Screen the data of inter-regional patent cooperation between Beijing, Tianjin, and Hebei, with a total of 26,489 patents.

The weighted undirected matrix W of patent cooperation among multiple cities in the three regions is constructed according to the year. The rules are as follows: (a) when the same patent contains two applicants, where applicant A is the city i and applicant B is city j, then $W_{ij}=1$; (b) when the same patent contains three or more applicants, where the applicant cities are i, j and p, then $W_{ij}=1$, $W_{jp}=1$, and $W_{ip}=1$. Finally, the patent cooperation matrix among 13 cities in the Beijing-Tianjin-Hebei region from 2015 to 2020 is obtained. The specific process of data collection and processing is shown in Fig. 1.

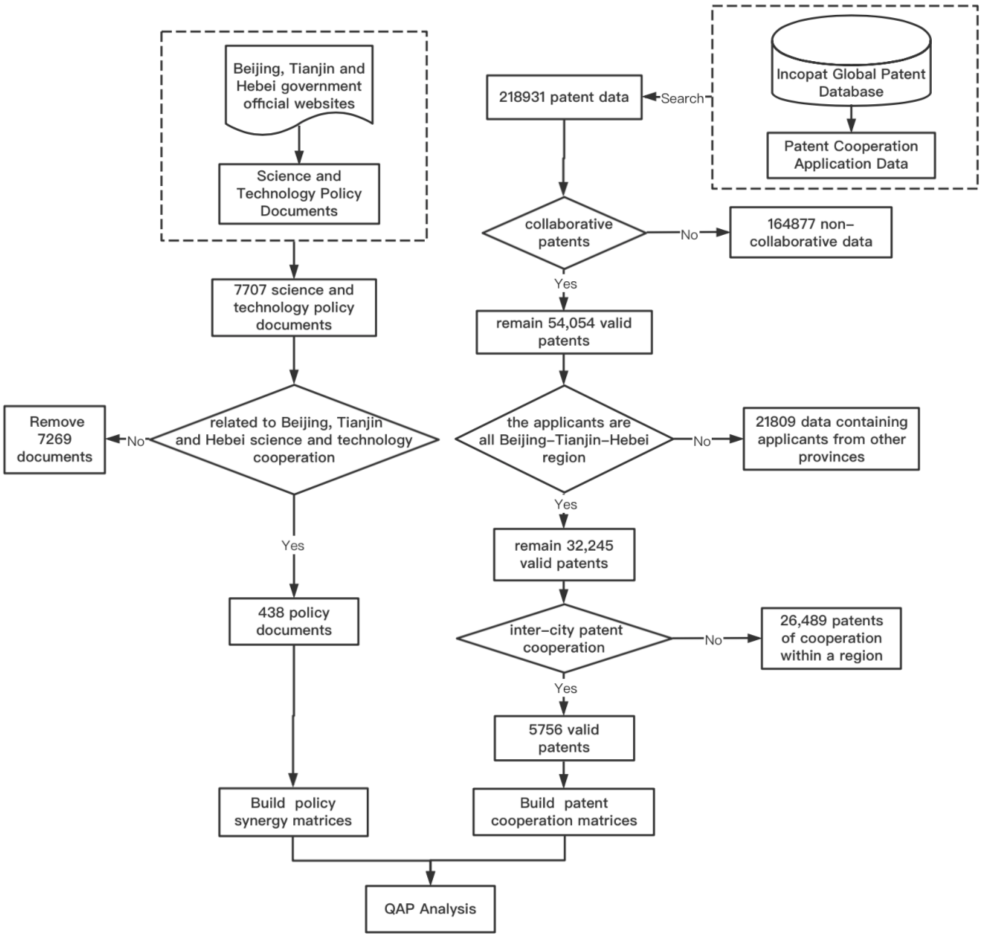
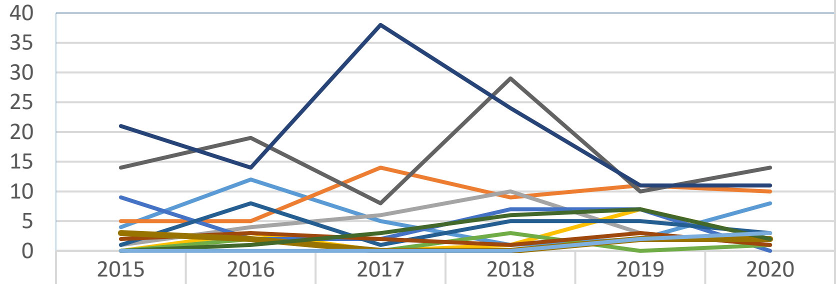


Fig. 1. Flow chart of data collection and processing

3.3 Data, Statistics of Technology Policy and Patent Cooperation

In terms of the number of policy issuances, the three cities with the highest number of issuances from 2015-2020 are Tianjin (27%), Shijiazhuang (21%), and Beijing (12%). The trend of changes in the number of issuances in each city varies from year to year, but the overall number of issuances remains stable from year to year, with the total number of issuances in 2015-2020 being, respectively, 60 (14%), 75 (17%), 79 (18%), 96 (22%), 70 (16%), and 58 (13%). Details are shown in Fig. 2.



	2015	2016	2017	2018	2019	2020
Baoding	4	12	5	1	2	8
Beijing	5	5	14	9	11	10
Cangzhou	1	4	6	10	3	1
Chengde	0	3	0	1	7	2
Handan	9	2	2	7	7	0
Hengshui	0	2	0	3	0	1
Langfang	1	8	1	5	5	3
Qinhuangdao	2	3	2	1	3	1
Shijiazhuang	14	19	8	29	10	14
Tangshan	3	2	0	0	2	2
Tianjin	21	14	38	24	11	11
Xingtai	0	1	3	6	7	2
Zhangjiakou	0	0	0	0	2	3

Fig. 2. Statistics on the number of science and technology policies issued by 13 cities in the Beijing-Tianjin-Hebei region from 2015 to 2020

Based on the network construction method, the policy synergy network and patent cooperation network among 13 cities in Beijing, Tianjin, and Hebei from 2015 to 2020 are organized and visualized with the help of Gephi 0.9.2, as shown in Fig. 3 and Fig. 4. The node size depends on the degree of nodes and the thickness of edges depends on the number of cooperation between nodes.

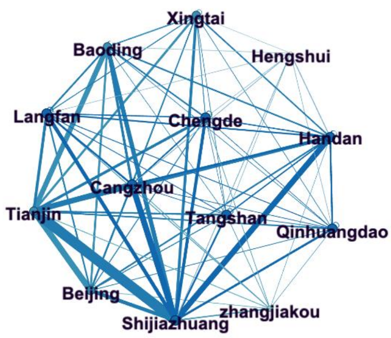


Fig. 3. Beijing-Tianjin-Hebei Inter-governmental Science and Technology Policy Synergy Network, 2015-2020

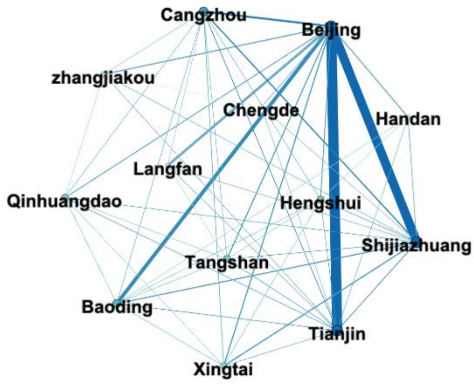


Fig. 4. Beijing-Tianjin-Hebei Inter-city Patent Cooperation Network, 2015-2020

From Fig. 3, it can be obtained that Tianjin-Shijiazhuang, Beijing-Tianjin are more closely connected, followed by Shijiazhuang-Cangzhou, Shijiazhuang-Handan, Tianjin-Cangzhou, Tianjin-Baoding, Shijiazhuang-Baoding, and other cities are more sparsely connected. From Fig. 4, it can be obtained that the edge weights in the patent cooperation network are mainly concentrated in Beijing-Tianjin and Beijing-Shijiazhuang, accounting for 57% of the total weights. Beijing-Baoding, Beijing-Langfang, and Beijing-Cangzhou are next, and the links among other cities are sparse.

4 STUDY ON THE IMPACT OF INTERGOVERNMENTAL POLICY SYNERGY ON INTER-CITY PATENT COOPERATION

4.1 Research Methodology

QAP (Quadratic Assignment Procedure) can solve the "relationship" problem between one relationship matrix and another relationship matrix. The core principle of QAP is to perform a large-scale random permutation of two matrices that are spuriously correlated due to covariance, and perform a nonparametric test for each permutation, and since the independent variables are not required to be independent of each other, all the coefficients obtained after the random permutation are aggregated, and the distribution of coefficients is used to determine whether the initial coefficients pass the significance test.

4.2 Correlation Analysis between Policy Synergy and Patent Cooperation Networks Based on QAP

Using the QAP correlation method, the correlation coefficients between the group of networks of policy synergy and the group of patent cooperation can be calculated. The specific process uses UCINET6 and imports the policy synergy matrix and patent cooperation matrix along with the path Tools -> Testing Hypotheses -> Dyadic(QAP) -> QAP correlation for a total of 6 years from 2015 to 2020, and the results are shown in Table 1.

Table 1 Correlation analysis between policy synergy and patent cooperation from 2015 to 2020

Patent Cooperation \ Policy Synergy	2015	2016	2017	2018	2019	2020
2015	-0.064 (0.424)					
2016	-0.085 (0.243)	0.026 (0.335)				
2017		0.05 (0.285)	0.329* (0.059)			
2018			0.316* (0.07)	0.303* (0.055)		
2019				0.303* (0.06)	0.086 (0.237)	
2020					0.151 (0.105)	0.406* (0.017)

Note: Significance levels in parentheses, *, **, *** indicates significant at the 1%, 5%, and 10% levels, respectively.

From Table 1, it can be obtained that:

First, from the trend of correlation coefficient changes, the correlation coefficient in 2015 is at the lowest point, and the correlation coefficient in 2015-2017 becomes an upward trend and rises rapidly from 2016 to 2017 to reach a peak in 2017. After 2017, the overall level of the correlation coefficient is maintained at a higher level compared with the previous period, but there are still some fluctuations. It indicates that the impact of science and technology policy synergy on patent cooperation is relatively small in the early stage of synergistic development, but with the deepening of policy synergy among Beijing, Tianjin, and Hebei, its positive impact on inter-city patent cooperation network gradually increases.

Second, the policy synergy has the same direction of influence of inter-city patent cooperation in the same year and the lagged year. In other words, when the two matrices are positively correlated in the current year, the policy matrix is also positively correlated with the inter-city patent cooperation matrix in the following year, and the correlation coefficient changes slightly. It indicates that once the science and technology policy is implemented, it can promote inter-regional patent cooperation for at least two years, reflecting the continuity of this influence over time.

Third, from the perspective of significance level, the results are not significant in 2015 and 2016, but the significance level increases significantly after 2017. It indicates that the impact of policy synergy on patent cooperation is small and insignificant in the early stage of Beijing-Tianjin-Hebei synergistic development, but its impact enhances and the results are significant in most years after 2017.

In summary, although the correlation between inter-governmental policy synergy and inter-city patent cooperation is low from the statistical point of view, considering the existence of other factors affecting patent cooperation, it can be seen that the positive influence of policy synergy on patent cooperation gradually increases from 2015 to 2020, and this influence is persistent in time.

4.3 Regression Analysis between Policy Synergy and Patent Cooperation Networks Based on QAP

In this paper, the inter-city patent cooperation matrix for 2016-2020 is chosen as the dependent variable matrix, and the policy synergy matrix of two years, three years, and four years are respectively taken as the independent variable matrix for analysis to analyze whether there is a time lag in the impact of intergovernmental policy synergy on inter-city patent cooperation.

Table 2. Regression Analysis Of Policy Synergy Matrix And Patent Cooperation Matrix From 2015 To 2020

Explained variables	Explanatory variables	Intercept distance	2015	2016	2017	2018	2019	2020	R^2
2016	15-16	18.7575	-9.2282	1.8139*					0.015
		(0.0000)	(-0.1439)	(0.1061)					
2017	15-16	15.5811	-8.7378*	2.0459					0.019
		(0.0000)	(-0.1558)	(0.1368)					
	16-17	11.3300		-3.6433**	4.1537**				0.145
		(0.0000)		(-0.2437)	(0.4786)				
	15-17	11.4869	-5.2299	-2.7374	4.0335**				0.151
		(0.0000)	(-0.0933)	(-0.1831)	(0.4648)				
2018	15-16	12.1924	-6.6513*	1.9930					0.021
		(0.0000)	(-0.1451)	(0.1630)					
	16-17	9.0968		-2.1907**	3.0227*				0.120
		(0.0000)		(-0.1792)	(0.4259)				
	17-18	4.6150			1.4555*	0.8265			0.114
		(0.0000)			(0.2051)	(0.1638)			
	15-17	9.220018	-4.1044	-1.4798	2.9284**				0.125
		(0.0000)	(-0.0895)	(-0.1210)	(0.4126)				
	16-18	8.1829		-3.1748**	2.1358*	1.2990*			0.152
		(0.0000)		(-0.2597)	(0.3009)	(0.2574)			
	15-18	8.2761	-5.7219	-2.2682	1.9280*	1.4107*			0.162
		(0.0000)	(-0.1248)	(-0.1855)	(0.2716)	(0.2795)			
2019	15-16	6.2764	-1.9476	0.7004					0.013
		(0.0000)	(-0.0994)	(0.1341)					
	16-17	5.0381		-0.8719	1.2139*				0.106

		(0.0000)		(-0.1669)	(0.4004)				
	17-18	3.1276			0.5213	0.4012			0.108
		(0.0000)			(0.1719)	(0.1861)			
	18-19	5.5814				1.0686**	-0.8593**		0.127
		(0.0000)				(0.4957)	(-0.2695)		
	15-17	5.0654	-0.9100	-0.7143	1.1930*				0.108
		(0.0000)	(-0.0464)	(-0.1367)	(0.3935)				
	16-18	4.6171		-1.3254**	0.8052*	0.5985*			0.143
		(0.0000)		(-0.2537)	(0.2656)	(0.2776)			
	17-19	4.9037			0.5215	0.8175*	-0.8595**		0.143
		(0.0000)			(0.1720)	(0.3792)	(-0.2695)		
	15-18	4.6437	-1.6328	-1.0667	0.7460*	0.6303*			0.148
		(0.0000)	(-0.0833)	(-0.2042)	(0.2460)	(0.2924)			
	16-19	5.8756		-1.1164*	0.7607*	0.9174**	-0.7226**		0.167
		(0.0000)		(-0.2137)	(0.2509)	(0.4255)	(-0.2266)		
2020	15-16	1.8655	-0.4765	0.0330					0.002
		(0.0000)	(-0.0539)	(0.0140)					
	16-17	0.8516		-1.0958***	1.0015**				0.335
		(0.0000)		(-0.4655)	(0.7328)				
	17-18	-0.4518			0.7275**	-0.1219			0.209
		(0.0000)			(0.5324)	(-0.1255)			
	18-19	0.5987				0.2529*	-0.0505		0.056
		(0.0000)				(0.2602)	(-0.0351)		
	19-20	-1.2250					0.0039	0.6033**	0.165
		(0.0000)					(0.0027)	(0.4054)	
	15-17	0.8396	0.4025	-1.1655***	1.0107***				0.337
		(0.0000)	(0.0456)	(-0.4951)	(0.7396)				
	16-18	0.8191		-1.1309***	0.9698***	0.0462			0.336
		(0.0000)		(-0.4804)	(0.7097)	(0.0476)			
	17-19	-0.3468			0.7275*	-0.0973	-0.0508		0.209

		(0.0000)			(0.5324)	(-0.1002)	(-0.0353)		
	18-20	-1.2020				0.0195	-0.0132	0.5932**	0.165
		(0.0000)				(0.0201)	(-0.0091)	(0.3985)	
	15-18	0.8132	0.3574	-1.1875***	0.9828***	0.0393			0.338
		(0.0000)	0.0404	-0.5044	0.7192	0.0404			
	16-19	0.6605		-1.1572***	0.9755***	0.0061	0.0910		0.338
		(0.0000)		(-0.4915)	(0.7138)	(0.0062)	(0.0633)		
	17-20	-1.2437			0.5702**	-0.1643	-0.0279	0.3628**	0.243
		(0.0000)			(0.4172)	(-0.1691)	(-0.0194)	(0.2437)	

From Table 2, it can be obtained that:

Firstly, in general, excluding the regression results of the policy synergy matrix in 18-19 and the patent cooperation matrix in 2020, as well as the regression results of the policy synergy matrix in 15-16 for all explanatory variables, all other regression results are greater than 0.1, with the maximum value of 0.338. It shows that the policy synergy variables in the first 2-4 years can explain 10%-33. 8% of the variation of inter-city patent cooperation in the Beijing-Tianjin-Hebei region.

Secondly, from the trend of R^2, when the independent and dependent variables have the same interval years, R^2 is gradually increasing with time, which again indicates that the influence of policy synergy on patent cooperation gradually increases from 2015 to 2020. Moreover, the coefficient of determination gradually increases when the independent variable matrix is the same, but the time of patent cooperation matrix is shifted backward, which indicates that the influence of policy synergy on patent cooperation has a time lag, that is, policy synergy has a greater impact on patent cooperation for a while after its policy is issued.

5 RESEARCH CONCLUSIONS AND SHORTCOMINGS

The policy documents on science and technology cooperation in the official websites of Beijing, Tianjin, and Hebei governments and the patent cooperation data in IncoPat were collected to establish an intergovernmental policy synergy network and an inter-city patent cooperation network for 13 cities for a total of six years from 2015 to 2020. The relationship between the two is studied based on QAP method. The following conclusions were obtained: First, the influence of intergovernmental policy synergy of inter-city patent cooperation increases with time. Second, the impact of intergovernmental policy synergy on inter-city patent cooperation is continuous and lagging in time. Third, there is still room to improve the promotional effect of intergovernmental policy synergy on inter-city patent cooperation, and it is necessary to continue to explore other channels to promote inter-city science and technology cooperation in the Beijing-Tianjin-Hebei region.

The shortcomings of this study are: the selection of policy documents and the collaborative research and judgment of similarity may be affected by the subjective judgment. Therefore, it is necessary to further expand the corpus and combine artificial judgment with quantitative calculation in the future.

REFERENCES

[1] Sun Yukang, Li Guoping. Research on evaluation and promotion of collaborative innovation level in Beijing-Tianjin-Hebei [J]. Progress in Geography.2017, 36(01): 78-86.

[2] Changchun Mei1, Jikun Cong 1, Shannv Jin 2. Research on the characteristics and efficiency of innovation, cooperation in Beijing-Tianjin-Hebei Region: Based on the analysis of patent and paper data. Journal of Hebei University of Technology (Social Science Edition). 2019,11(02)

[3] Jiao Meiqi, Du Debin, Gui Qinchang, Hou Chunguang. "One Belt And One Road" perspective Study on the evolution characteristics and influencing factors of urban technical cooperation network. Geographical Research. 201,40(04):913-927

[4] Kernf, Kivimaaip, Martiskainen M. PolicyPackaging or PolicyPatching? The Development of ComplexEnergyEfficiencyPolicyMixes [J]. Energy Research& Social Science, 2017,23 (01): 11-25.

[5] Kwond, Kimy H. Welfare Effects of foreign Aids Policy Coordination among Asymmetric Donor Countries [J]. Dia Economics & Finance, 2015,30 (11) : 455-467.

[6] Wei Chao. Connotation, Characteristics, and Realization Conditions of Policy Coordination. School of Foreign Law and Politics, Tianjin Foreign Studies University. Theoretical Guide, 2016,(01):56-59

[7] Mulford C·L·andRogersD·L· (1982) ·Definitions and Models· In Rogers C·L· and Whetten D·A· (eds·) Interorganizational coordination: going research and implementation, IowaStateUniversityPress Ames.

[8] ZHOU Yingnan, LIU Xiaolu, GONG Ning. Analysis of the connotation of policy synergy, decision-making evolution mechanism, and application status. Management modernization. 2017,37(06):122-125.

[9] Metcalfel. International Policy Co-Ordination and Public Management Reform[J]. International Review of Administrative Sciences.1994, 60(02): 271-290.

[10] BoonekampPGM. Actual Interaction Effects Between Policy Measures for Energy Efficiency——A Qualitative Matrix Method and Quantitative Simulation Results for Households[J]. Energy.2006, 31(14): 2848-2873.

[11] Peng Jisheng, Zhong Weiguo, Sun Wenxiang. Policy measurement, policy co-evolution and economic performance: An empirical study based on innovation policy [J]. Managing the World, 2008 (09).

[12] Zhang Guoxing, Gao Xiulin, Wang Yingluo et al. Measurement, synergy and evolution of China's energy conservation and emission reduction policies: A study based on policy data from 1978 to 2013 [J]. China Population, Resources, and Environment, 2014 (12).

[13] Zhu Guangxi. Policy synergy: functions, types, and approaches -- based on literature analysis. Journal of Guangdong Institute of Administration.2015, 27(4): 20-26.

[14] WANG Hai, XU Guannan. Policy synergy, official turnover, and firm innovation: empirical evidence from policy texts of strategic emerging industries. Journal of Finance and Economics, 2017, (01): 33-40

[15] Gao X , Guo X , Guan J. An analysis of the patenting activities and collaboration among industry-university-re-search institutes in the Chinese ICT sector[J]. Scientometrics, 2014, 98 (1): 247-263.

[16] Cui Bin, Dong Kun, Xu Haiyun. Research on the impact and action path of patent cooperation on technology transfer: A case study of a domestic scientific research institution [J/OL]. Information Theory and Practice: 1-12 [2020-07-12].
[17] Xu Lei. Can inter-city patent cooperation in the Yangtze River Economic Belt improve the quality of economic growth? Commercial Economics No.3, 2021 Total No.535
[18] GUAN Yanxin, LIU Liqing, ZHOU Hui. The integration construction of Beijing, Tianjin, and Hebei technology market from the perspective of Hebei Province. Science and Technology, China. 2021,(05)
[19] Shi Anjie, Qiu Jingwen, Zhao Shiyu. Patent technology cooperation and link prediction among science and technology subjects in Beijing-Tianjin-Hebei region [J]. Modern Information Science and Technology, 2020,4 (1): 178-183.
[20] TANG Heng, GAO Liangzhou, LIU Guifeng. Spatiotemporal evolution of the patent cooperation network of industry, university, and research in Beijing, Tianjin, and Hebei. Journal of Information, 2017,36 (10).
[21] Ke Li. Study of the characteristics and influencing factors of trans-city patent cooperation in the Yangtze River Delta
[22] Zhang Ruofan, Zhao Ziqi, An Mingyang. Network structure and link prediction of patent cooperative application in the Guangdong-Hong Kong-Macao Greater Bay Area. Inventions and Patents in China, 201,18(3).
[23] Liu Hua, Zhou Ying. Research of Technology Transfer Policy System and Its Cooperative Operation Mechanism in China. Science Research Management. 2012,33(03):105-112.
[24] Tang Heng, He Jinrun, Sun Yinglin, He Yingqi. Research on the evolution of the collaborative network of incentive policies for patent creation. Science and Management of Science and Technology, 2019,40(9): 48-62