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Research on the Influence of Multi-Dimensional Distance on Patent Cooperation Between China and Countries Along the "One Belt and One Road"

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Abstract— *This paper uses the PATENTSCOPE database under the World Intellectual Property Organization to manually retrieve the number of patent cooperation between China and other 64 countries along the "One Belt and One Road", establishes a panel negative binomial regression model, and comprehensively analyzes the effect of multi-dimensional distance on patents in China and countries along the route. The impact of cooperation, focusing on the impact of technological distance, institutional distance and geographic distance. The research draws the following main conclusions: The institutional distance and geographic distance between China and the countries along the route have a significant negative impact on patent cooperation; the impact of technological distance on the number of patent cooperation is in an inverted U shape.*

Keywords— *Geographic distance; institutional distance; international patent cooperation; multi-dimensional distance; technological distance; One Belt and One Road.*

I. INTRODUCTION

Patent cooperation is essentially a kind of technological innovation cooperation. According to the research results of domestic and foreign scholars, some scholars believe that the main factors affecting technological cooperation include market environment, technical capabilities, geographical location, economic development level, cooperation experience, scientific research funding and personnel input, etc. However, some scholars have paid attention to the influence factor of technical cooperation is subject proximity, also known as distance, and its influencing factors include technology, system, geography, culture, economy, cognition, social and organizational distance and so on. According to previous research, it can be found that there are a large number of organizations in the main body will tend to look for other organizations to carry out various cooperation, in order to achieve the purpose of technological innovation, so as to obtain more high-quality resources, can improve their own innovation efficiency, Obtain greater innovation results that cannot be obtained by independent innovation in related fields, and share the costs and unpredictable risks generated in the innovation process with other innovation subjects. The reason why the cooperative entities produce these behaviors can be attributed to the urgency of innovation time, the complexity of innovation behavior and the high instability of the benefits that innovation can bring as an activity that promotes scientific and technological progress. In order to carry out technical cooperation more efficiently between innovation subjects, it is necessary to overcome the cooperation barriers caused by institutional distance, geographical distance, cultural distance, economic distance and technological distance. The distance between the two parties in each dimension is a crucial factor of their own attributes. What is the relationship between the multi-dimensional distance between the subjects and the technical cooperation efficiency of the two parties is a question worthy of in-depth exploration.

II. LITERATURE REVIEW

In 2013, General Secretary Xi Jinping proposed a major initiative to jointly build the "One Belt and One Road", which has aroused widespread response in the international community. In the past ten years, innovative cooperation among "One Belt and One Road" countries has emerged in many fields, proving that it is not only a The road of economy and trade is also the road of hope for scientific and technological cooperation and cultural exchanges among countries along the route. Based on this, many scholars at home and abroad have begun to conduct in-depth research on the patent cooperation between China and the countries along the "One Belt and One Road". Some scholars discussed the influence of multi-dimensional distance on cross-border patent cooperation, and put forward scientific suggestions and countermeasures.

Promoting international technical cooperation between my country and the countries along the "One Belt and One Road" is a high concern of the academic circles and the whole society. Ye Yangping used the data of the Patent and Trademark Office to analyze the current situation of technical cooperation between patent applicant countries. Yang Chunping put forward the concept of patent combination index on the basis of trade combination index. Using the patent data of China and countries along the route on the website of the World Intellectual Property Office, it is concluded that China is more proactive in patent relations with countries along the route. strong conclusion. These documents provide a reference for the study of patent cooperation, highlighting my country's core position in the "One Belt and One Road" scientific and technological cooperation.

In recent years, distance has played a pivotal role in the fields of world economic development research,

organizational innovation cooperation research and other fields. Generally speaking, distance is subjectively thought of as geographic distance, that is, the distance between the two parties in the sense of space. Some researchers believe that geographic distance is a factor in determining international patent cooperation, but this view was soon overturned by the French related research school. The effect of dimensional distance on the innovation efficiency of technological cooperation between subjects. But in fact, it also includes many other distances that may be closely related to international technical cooperation, such as technological distance, institutional distance, economic distance, cognitive distance, cultural distance and social distance.

Looking back on the previous studies on multi-dimensional distance, many of them have not been confirmed and the credibility is low, especially the empirical research from Chinese data is extremely lacking. Therefore, based on the perspective of multi-dimensional distance, this research focuses on the three major distances of technical distance, institutional distance and geographic distance. With the help of related research as the academic basis, the PATENTSCOPE database under the World Intellectual Property Organization (WIPO) is used to search China and other 64 distances. The number of patent cooperation in the countries along the "Belt and Road", the negative binomial regression analysis method is used to empirically analyze the impact of multi-dimensional distance on the number of patent cooperation between China and the countries along the "Belt and Road", which is the basis for the "Belt and Road" initiative in international technology cooperation. It can provide reference for further implementation in the field, so as to carry out international scientific and technological cooperation in a targeted manner.

III. Research Hypothesis

A. The Effect of Institutional Distance

Every country has a specific institutional environment, which promotes institutional differences between organizations in different countries, and institutional distance reflects the existence of laws, policies, values, beliefs and customs in different countries. difference. When countries carry out technical cooperation, there will be obvious institutional distances, which will lead to the formation of barriers between the two parties in innovation cooperation, and their behavior will be affected by the institutional environment. In the existing literature, scholars mainly study the role of institutional distance in international business behavior from the perspective of cooperation subjects obtaining innovation results through legal channels. The conclusion shows that the greater the institutional difference between the two countries, the more difficult it will be for innovation subjects to adapt to each other. The sense of distance brought by the system increases the difficulty of knowledge transfer between each other, that is, the institutional distance will cause obstacles to both parties and reduce the possibility of technological innovation cooperation between the two parties. Due to the large differences in laws and regulations and market environment between countries with large institutional distances, in order to achieve cooperation, more learning costs and communication costs must be paid. In addition, both parties must establish uniform rules. In the process of joint R&D cooperation with programs, differences and contradictions may arise in this process, thereby increasing the uncertainty of cross-border technological cooperation and reducing innovation efficiency. Therefore, this paper proposes the following assumptions.

H1: Institutional distance has a significant negative impact on international patent cooperation performance.

B. The Effect of Technological Distance

Jaffe proposed the concept of technical distance in 1986, which indicates the degree of difference in the level of technological development between the two parties. The technical distance in the process of international patent cooperation refers to the degree of non-overlapping of technical foundations or experiences between countries. When the two parties conduct technical cooperation, if the overlapping degree of knowledge and technology is small, it will weaken the subject's access to and Using each other's technology will not stimulate innovation, and even hinder the process of technological cooperation. Branstetter et al. used the differences of patent portfolios to measure technological distance, and the results showed that the impact of technological distance on innovation alliance output was negative. In addition, according to the research of previous scholars, in the fields with small technical distance, the cooperation subjects sum up and invest in technical experience respectively, and integrate the technical innovation capabilities of both parties, thereby producing new technical cooperation results. Using PCT international patent data co-invented between 60 countries from 1999 to 2018, Li Lin et al. used QAP regression analysis to explore that technological distance plays a positive role in cross-border cooperation and innovation. The empirical research results of some scholars show that there is a non-linear relationship between technological distance and technological cooperation innovation. Chi Jiayu et al. used patent data filed by 189 companies to obtain an inverted U-shaped relationship between technical distance and patent cooperation performance. When the technical distance between the two parties is very large, there may be obstacles in understanding, which will increase the cost of learning and communication. technical experience, thereby promoting the implementation of innovation achievements, but there will be a certain point where the technical distance is too small, which will weaken the complementarity of knowledge, and it will be difficult to stimulate the production of technological innovation cooperation results. In other words, there is an optimal state. Only a technically appropriate distance can ensure better cooperation performance between the two parties. At this time, the cooperation subjects can save time and effort in communication and have enough room for innovation. Based on the above analysis, this paper proposes the following assumptions.

H2: The effect of technological distance on the performance of international patent cooperation is in an inverted U shape.

C. The Effect of Geographical Distance

Regarding the influence of geographical distance on cooperative innovation, most literature research results show that geographical distance will hinder the cooperation between subjects, and geographical distance will weaken the willingness of both parties to cooperate and innovate. The greater the spatial distance between the two countries, the geographical dispersion of scientific researchers will reduce the work quality of technical team members, which is not conducive to the spillover of technical knowledge, and is not conducive to the collaborative innovation of both parties. It will also increase learning and communication. costs, thereby reducing the possibility of technological innovation cooperation between entities. Petruzzelli used the research data of the cooperation between enterprises and universities to apply for patents, and the empirical results show that the influence of geographical distance on the innovation effect of industry-university cooperation is significant. The research of Liu Zhiying et al. shows that geographic distance has a significant negative effect on collaborative innovation performance among organizations. Although many studies have shown that the geographical distance between subjects will inhibit cooperation, some scholars have put forward the opposite view. Countries can break through the barriers of geographical distance to achieve knowledge exchange with each other. At the same time, with the improvement of transportation facilities and the reduction of transportation costs, some scholars have proposed that geographical distance is no longer a significant obstacle to international technological innovation cooperation. the opinion of. This paper believes that although modern communication technology is very mature and provides great convenience for effective communication between everyone, in the process of international technical cooperation, there are many important tacit knowledge that need to be communicated face-to-face. Only through more accurate communication, such as short-term on-site visits and meetings, this approach will soften the contradictions in remote communication, thereby promoting the process of technological cooperation and innovation. Therefore, the negative impact of geographic distance on technical cooperation, although weakening over time, is still significant. Therefore, this paper proposes the following assumptions:

H3: Geographical distance has a significant negative impact on international patent cooperation performance.

IV. Data Sources And Variable Measures

A. Data Sources

The main data used in this paper come from the PATENTSCOPE database of the World Intellectual Property Organization (WIPO), the World Bank (WDI) database, the Payne table of PWT9.1 version, the geographic database of CEPII and the WGI database. This paper selects China and 64 countries along the "Belt and Road" as the research object.

B. Variable Measurement

- International patent cooperation level

Regarding the indicators to measure the level of international patent cooperation, this paper selects the number of patent cooperation between China and countries along the “Belt and Road”. Advanced search was used in the PATENTSCOPE database, with the years from 2003 to 2018 as the patent application date, and the inventor's nationality field was searched one by one in China and other 64 countries along the route, with the English code of the country as the search condition, to search for the cooperation relationship between the two countries, and obtain the number of patent applications for mutual cooperation between China and the other country. For example, to search for the data of joint invention patents between China and Singapore in 2003, enter the search formula "AD([01.01.2003 TO 31.12.2003] AND IADC:(CN)AND IADC:(SG)".

- Institutional distance

Regarding the measurement of institutional distance, this paper refers to the method of Huang Xinfei and other scholars, uses the "Global Governance Index" to measure the quality of a country's institutions, and uses the difference between the scores of the institutional variables of countries along the "Belt and Road" and the scores of China's institutional variables to measure the two. Institutional distance between countries. The Global Governance Index involves a total of six dimensions of measurement indicators, namely the level of rule of law, government effectiveness, corruption control, regulatory quality, voice and accountability, and political stability. In this paper, the arithmetic mean of these six indicators of a country is used to measure the comprehensive score of its institutional quality. The absolute value of the difference between the comprehensive scores of the two countries' institutional quality reflects the institutional distance between countries. The data comes from the WGI database. Denote the institutional distance as ins.

- Technical distance

Regarding the measurement of technological distance, this study draws on Madsen's practice and selects total factor productivity as a measure of technological distance. At the same time, referring to the practice of Albrizio et al., the technological distance is expressed as the ratio of total factor productivity between China and the countries along the "Belt and Road". The natural logarithm of the total factor productivity data of China and countries along the route can be obtained from the Payne table of PWT9.1 version, where TFP is the total factor productivity index of the countries in the table. Denote the technical distance as tec.

- Geographic distance

Regarding the measurement of geographic distance, most scholars use the spatial distance between major cities in two countries to measure. This paper draws on Zhao Yicheng’s method and uses the straight-line distance from Beijing, the capital of China, to the capitals of countries along the “Belt and Road” to represent the geographic distance. From the geodatabase in CEPII. Denote the geographic distance as geo.

- Host country market size

The consumption level of a country’s citizens reflects its market size and market vitality. The richer the country, the more emphasis it will have on technological innovation and

breakthroughs. This paper selects the country's per capita GDP to measure the market size. Logarithmic processing. The data comes from the World Bank database, recorded as gdp.

- Language Differences

Language differences between countries hinder the flow of tacit knowledge and are not conducive to the establishment of a deeper sense of trust between the two parties. Therefore, this paper uses dummy variables to reflect the language differences between the two countries. When China and countries along the route use the same common official language, the value is 0, and when they use different common official languages, the value is 1. The data comes from the geographic database in CEPII, denoted as lan.

- International level

The level of internationalization reflects the degree of economic exchanges between a country and other countries, especially in terms of trade volume. Countries with a high level of internationalization can reflect their willingness to be inclusive and transnational cooperation. to measure the level of internationalization of a country. The data comes from the World Bank database, denoted as int.

- Cultural and educational level

When the subjects carry out technical cooperation, they often need the participation of scientific and technological talents with higher education. The data comes from the World Bank database, denoted as cul.

V. Model Settings

In order to test the influence of multi-dimensional distance on the patent cooperation between China and the countries along the "One Belt and One Road", the econometric model constructed in this paper is as follows:

$$patent_{it} = \beta_0 + \beta_1 x_{it} + \beta_2 controls_t + \varepsilon_{it}$$

In the formula: $patent_{it}$ represents the number of patent cooperation between China and countries along the "Belt and Road", x_{it} represents multi-dimensional distance, including institutional distance, technological distance and geographic distance, and $controls_t$ represents control variables, including host country market size, cultural and educational level, language differences and internationalization level. is a random disturbance term.

Since the number of patents is a non-negative integer, this paper should adopt the regression method of measurement variables. Both the negative binomial distribution model and the Poisson model are suitable for patent data, but the Poisson distribution satisfies the condition that the mean of the number of patent cooperation is equal to its variance.

Through the following descriptive statistical analysis of the variables, it is found that the variance of the number of patent cooperation between my country and the countries along the "One Belt and One Road" is much larger than its mean, that is, the sample data has a large dispersion, which leads to excessive patent data of the dependent variable. dispersion problem. In the previous literature on patents, most scholars will use the negative binomial model, because the negative binomial model can better solve the problem of sample over-dispersion than the Poisson model. Therefore, this paper adopts the negative binomial distribution. model to complete the empirical analysis.

VI. Empirical Analysis

A. Descriptive Statistics and Correlation Analysis

The empirical part of this paper is done with the help of stata16 software. First, Table 1 is the descriptive statistical analysis of each variable, and Table 2 is the correlation matrix of the independent variables. The results show that the absolute values of the correlation coefficients between the independent variables are all less than 0.7, indicating that the variables have good discriminant validity. Then the variance inflation factor test was performed on the regression variables, and the results showed that the VIF values were all less than 5, indicating that there was no serious multicollinearity problem between the variables, and the estimated results were accurate.

TABLE 1. Definitions of main variables and descriptive statistics

Variable	N	mean	S.D.	Min	Max
patent	1024	1.25	4.93	0	52
ins	1024	0.63	0.47	0.03	2.13
tec	1024	0.31	0.16	0.01	0.87
geo	1024	5.61	1.70	1.17	7.72
gdp	1024	9146	12577	142.10	85076
lan	1024	56.72	21.36	0.14	0.87
int	1024	97.02	51.39	0.17	437.31
cul	1024	37.07	22.83	0.13	93.54

TABLE 2. Correlation coefficient matrix and variance inflation factor of each explanatory variable

Variable	ins	tec	geo	gdp	lan	int	cul
ins	1						
tec	0.102***	1					
geo	0.202***	0.215***	1				
gdp	0.494***	0.229***	0.200***	1			
lan	0.342***	0.141***	0.446***	0.659***	1		
int	0.424***	-0.074**	0.0370	0.398***	0.352***	1	
cul	0.292***	-0.247**	0.406***	0.233***	0.494***	0.359***	1
vif	1.58	1.35	2.12	3.23	2.70	1.49	1.90

Note: ***p<0.01, **p<0.05, *p<0.1 indicate significance at the 1%, 5% and 10% levels, respectively. The same below.

B. Hypothetical test

This paper uses the panel negative binomial regression random effects model to test the hypothesis, and the test results are shown in Table 3.

According to the results of Model 1, the four control variables of the host country's market size, language difference, internationalization level, and cultural and

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educational level have a significant impact on patent cooperation between China and countries along the "Belt and Road".

Model 2 adds the independent variable institutional distance on the basis of model 1, which aims to test the influence of the institutional distance between China and the countries along the "Belt and Road" on the number of patent cooperation. The regression coefficient is -1.003 and is at the level of 5%. Significant (P<0.5), the test results show that the institutional distance has a significant negative effect on patent cooperation, that is, the smaller the institutional distance between the two countries, the greater the potential in the number of patent cooperation, which verifies the hypothesis H1.

Model 3 is based on model 1 by adding the independent variable technology distance, which aims to test the impact of technology distance between China and countries along the "Belt and Road" on the number of patent cooperation. The regression coefficient is -5.338 and is at the level of 1%. Significant ($p < 0.01$), indicating that technical distance has a significant negative effect on patent cooperation. In order to test whether there is a nonlinear relationship between the impact of technical distance on patent cooperation, the square term of technical distance is added to Model 5. The regression results show that the coefficient of technical distance is negative and significant at the 1% level ($p < 0.01$). , while the coefficient of the square term of the technical distance is negative, which is also significant at the 1% level ($p < 0.01$). Based on this, it can be concluded that the impact of technological distance on the number of patent cooperation between China and countries along the route has an inverted U-shaped relationship, which verifies the hypothesis H2.

TABLE 3. Negative binomial regression results

Variable	Model1	Model2	Model3	Model4	Model5
ins		-1.003**			
		(-2.52)			
tec			-5.338***		-1.454***
			(-8.41)		(-1.09)
geo				-0.962***	
				(-9.62)	
tec*tec					-2.034***
					(-3.32)
gdp	0.000***	0.000***	0.000***	0.000***	0.000***
	(4.13)	(5.18)	(4.70)	(5.80)	(5.11)
lan	-0.041***	-0.024***	-0.039***	-0.010*	-0.019**
	(-4.87)	(-3.01)	(-4.70)	(-1.26)	(-2.49)
int	0.002***	0.002**	0.005**	-0.004**	0.002*
	(0.87)	(0.77)	(2.22)	(-1.96)	(1.05)
cul	0.040***	0.030***	0.039***	0.051***	0.029***
	(5.68)	(4.77)	(5.57)	(8.16)	(4.63)
constant	0.859**	0.893**	1.297**	6.799***	0.615**
	(0.96)	(1.05)	(1.40)	(6.20)	(0.72)
N	1,024	1,024	1,024	1,024	1,024
Chi²	83.14	147.93	89.24	173.11	162.19

Model 4 added the independent variable geographic distance on the basis of model 1 to test the influence of geographic distance between the two countries on the number of patent cooperation. The test results showed that the regression coefficient was -0.962, and it was significant at the 1% level ($p < 0.01$).), indicating that geographic distance has a significant negative impact on international patent cooperation, that is, the farther countries are geographically separated, it will hinder the dissemination of tacit knowledge between the two parties, which is not conducive to communication, thus reducing the efficiency of patent cooperation. Suppose H3 passes validation.

C. *Robustness check*

In order to avoid the influence of endogeneity problem on the model estimation results, this paper adopts the method of substitution regression to test the robustness of the research results. First, add one to the number of patent cooperation as the explained variable and then take the logarithm, and then use OLS estimation to perform robustness test. The estimation results are shown in Table 4. According to the research results in the table, it can be found that the robustness test is basically consistent with the original hypothesis test results. Therefore, the results of this study are robust and the conclusions are reliable.

TABLE 4. OLS robustness test

Variable	Model1	Model2	Model3	Model4	Model5
ins		-0.020**			
		(-0.05)			
tec			-3.087***		-2.832***
			(-3.18)		(-2.28)
geo				-0.600***	
				(-6.28)	
tec*tec					-4.753**
					(-1.16)
gdp	0.000***	0.000***	0.000***	0.000***	0.000***
	(6.54)	(6.14)	(7.00)	(6.32)	(6.82)
lan	-0.035***	-0.035***	-0.030***	-0.016	-0.030***
	(-3.57)	(-3.56)	(-3.02)	(-1.53)	(-3.05)
int	0.025***	0.025***	0.024***	0.021***	0.024***
	(7.87)	(7.65)	(7.56)	(6.68)	(7.63)
cul	0.035***	0.035***	0.027***	0.047***	0.027***
	(4.67)	(4.62)	(3.44)	(6.26)	(3.44)
constant	-0.353**	-0.347***	0.612**	1.846***	0.849**
	(-0.73)	(-0.70)	(1.08)	(3.13)	(1.40)
N	1,024	1,024	1,024	1,024	1,024
R²	0.181	0.179	0.187	0.210	0.188

VII. CONCLUSIONS AND POLICY SUGGESTION

A. *Analysis conclusion*

This paper adopts a negative binomial regression model and incorporates three dimensions of distance to empirically analyze the impact of technological distance, institutional distance and geographic distance on the patent cooperation between China and countries along the "One Belt and One Road". From the overall regression results of the full sample, the patent cooperation between China and countries along the route is significantly affected by technological distance, institutional distance and geographic distance.

Technical distance plays a significant role in the process of international patent cooperation. Too large or too small technical distance between countries is not conducive to the development of technical cooperation activities. In other words, there is an optimal technical distance. When China is looking for technology partners, it can choose the optimal

distance, which is conducive to the integration of various resources and improves the efficiency of patent cooperation results.

Institutional distance has a negative impact on patent cooperation between China and countries along the route, that is, the output of patent cooperation results is significantly affected by the differences in the institutional environment between countries, which confirms the point of this paper. Due to the differences in regulation and cognition between countries, the two parties of multinational cooperation with a large institutional distance will have difficulty in understanding each other, which will hinder the cooperation in completing the task of patent cooperation, and weaken the willingness and possibility of initial cooperation.

Similar to the institutional distance, the geographic distance is significant and the coefficient is negative, which verifies the point of view that the geographic distance has a negative correlation with the patent cooperation between China and countries along the Belt and Road, which indicates that the geographic distance between the two countries will hinder the patent cooperation between the two parties. In the environment of long geographical distance, it is not conducive to the communication and exchange of tacit knowledge, and the communication of information is not smooth, which hinders the channels of technology dissemination, and increases the communication cost between China and countries along the route.

B. Policy suggestion

First of all, in terms of cooperation mechanism, countries should speed up the construction of a community of interests and a community of destiny, expand the scope and intensity of innovation between both parties in the field of patent cooperation, and provide a superior environment for information flow and policy support. The key is to promote the flow of resources between subjects, and to improve the negative effects brought about by technical, institutional and geographical distance through policy communication, knowledge exchange, and financial integration.

Secondly, in the selection of cooperation partners, it is necessary to accurately grasp the optimal technical distance, fully consider the significant negative impact of geographic distance and institutional distance, formulate differentiated cooperation strategies, and select the optimal partner according to the conditions of the cooperation partner. . In a good cooperation environment, promote the formation of mutually beneficial norms and a sense of trust between countries, and actively participate in cooperation in core technology fields.

Finally, in terms of cooperation mode, you can use the complementarity of advantageous resources to carry out the "One Belt and One Road" international academic forum and establish international patent transfer institutions to achieve more cooperation in key technology fields, thereby enhancing your position in the cooperative relationship. and influence.

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