

Research on the Patent Exclusivity Licensing of School-Enterprise Cooperation in Yunnan University

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ABSTRACT

Through analyzing the patent data of 32 universities and enterprises in Yunnan Province, this work studied the relationship between technology maturity, geographical distance between universities and enterprises, and school-enterprise cooperation experience and the tendency of universities to adopt exclusive licensing. Logistic regression model was built for sample data, and Hosmer-Lemeshow test was used to calculate goodness of fit for empirical analysis. The results showed that the goodness of fit and the accuracy of prediction was 0.088 and 80.7% respectively. Technology maturity, cooperative experience and the tendency of exclusive licensing are negatively correlated. Geographical distance is positively correlated with the tendency of exclusive licensing.

Keywords: *Yunnan Province; Undergraduate colleges and universities; Patent licensing; Exclusivity*

1. INTRODUCTION

In recent years, it is one of the important modes of modern technology transfer for colleges and universities to apply for patent license for scientific research technology achievements to enterprises. With the continuous improvement of patent database, more and more scholars study the school-enterprise cooperation according to patent database, so as to reveal the status of the school-enterprise cooperation model in regional economic development. Shen et al. [1] analyzed the factors affecting the exclusivity license of Chinese colleges and universities. In practice, the focus of cooperation between universities and enterprises is the exclusivity clause involved in licensing. As the school-enterprise cooperation is increasingly close, now there are a lot of domestic and foreign literature researches that study the influencing factors of technology licensing tendency in colleges and universities, and get good achievements. However, the important licensing strategy of the university's exclusive licensing tendency (the case that the technology transfer results of a university are only licensed to an enterprise) has not received much attention. What factors affect the balance of results in colleges and universities has not been fully and deeply explored at present. Therefore, it is of great practical significance to study the influencing factors of technological exclusivity license for colleges and universities in Yunnan to promote the transformation of school-enterprise scientific and technological achievements in Yunnan. This work intended to study the influence of technology maturity, geographical distance between universities and enterprises and school-enterprise cooperation experience on the exclusivity tendency of colleges and universities.

2. RESEARCH METHODS

2.1. Research Ideas

First, based on the issues concerned in the cooperation between colleges and universities, this work carried out theoretical research, made assumptions based on the theoretical research, and determined the factors affecting the exclusivity of colleges and universities.

Second, qualitative [2] and quantitative analysis were conducted on the sample data, and virtual variables were set. In this work, the tendency of the dependent variable's exclusivity is bivariate, so binary Logistic regression analysis was selected. The model was built to analyze the sample data, and the relationship between the influencing factors was further analyzed. Finally, the accuracy of the model was tested.

Third, according to the results of empirical analysis, empirical summary and enlightenment were conducted.

2.2. Data Collection

All the sample data required in this work are from the patent retrieval system of the State Intellectual Property Office. First, this work selected 32 undergraduate colleges and universities in Yunnan based on the statistical yearbook database of Chinese colleges and universities and the information of undergraduate universities published by the Ministry of Education. The patent retrieval system of the State Intellectual Property Office was used to collect the patent license records of these colleges and universities as

licensors from January 1, 2010, to December 31, 2019, and analyze the information of cooperative institutions (schools, enterprises), regions, and patent types.

If the patentee is signed as a university and an enterprise, it shall be regarded as the school-enterprise cooperative relationship. Since 13 of the 32 undergraduate universities in Yunnan do not involve school-enterprise cooperation patents, the final sample includes 1001 patent license records between 19 universities and 434 enterprises.

3. RESEARCH PROCESS AND RESULTS

3.1. Research on the Exclusivity of School-Enterprise Cooperation

While looking for partners, colleges and universities tend to look for multiple enterprises to cooperate and license technology. If colleges and universities rely on a single partner, they may face risks caused by inadequate capacity or opportunistic behaviours [3]. To some extent, finding multiple enterprises can reduce the risk in this aspect. In addition, colleges and universities will increase the market share of related products and obtain more licensing fees accordingly. For enterprises, as the licensor, enterprises are more inclined to monopolize the technology in cooperation. When colleges and universities cooperate with more enterprises, they will increase the market share of this technology, which will increase the risk of high investment and low return. At the same time, the process of technology achievement transfer is uncertain, which requires the close cooperation between universities and enterprises, and the two sides provide their own resources. In short, when there is no exclusivity between the technology license between the university and the enterprise, the risk of enterprise income reduction will increase. In this case, enterprises will be more inclined to secure exclusive licenses for technology.

When colleges and universities cooperate with enterprises, if colleges and universities sign exclusive license contracts, enterprises will receive the signal that the universities promise to give up the license option to various parties, which will encourage more enterprises to take risks and participate in technology transfer, thus contributing to the success of technology commercialization. In this work, three important factors affecting the signing of the exclusive license contract are concluded: technology maturity, school-enterprise cooperation experience and geographical distance. The author will study how these factors affect the signing of exclusive licensing contracts.

3.2. Variable Measurement

3.2.1. Explained variables

The explained variable of this work is the exclusive license of colleges and universities, which means that colleges and

universities, as licensors, allow licensed enterprises to use the patent within the scope stipulated in the contract and preclude any third party from using the patent within that scope, but colleges and universities still reserve their right to implement the patent. To be specific, the licensing methods can be divided into ordinary license, monopoly license, exclusive license, cross-license and sub-license. Since there is no cross-license or sub-license in the samples of this study, the first three types are mainly studied. According to the practice of Shen et al., Xiong et al. [4], this study assigns the value of ordinary license to 0, and the value of monopoly license and exclusive license to 1.

3.2.2. Explanatory variables

(1) Technology maturity. According to Xiong et al, the time of license occurrence and application time are treated as years, and the time of license occurrence minus the application time involved in the license filing contract is used as the standard to measure the technical maturity.

(2) Geographical distance. To study the geographical distance between universities and enterprises in Yunnan is to observe whether they are located in the same municipality. The geographical location of colleges and universities can be obtained through the address publicly provided by the patent retrieval system, and the location of the official website of the licensed enterprise is accessed. By introducing virtual variables, if universities and enterprises are located in the same municipality, the variable value is 1; if universities and enterprises are located in different municipalities or provinces, the variable value is 0.

(3) School-enterprise cooperation experience. It can observe whether the two have cooperated before the licensing occurred. The dummy variable is introduced. If the university and the enterprise have cooperative research and development or other relations before the license, the value of the variable is 1; if the university and the enterprise have not cooperated before and have not established any links before licensing, then it is default that the two sides have no cooperation experience, and the value of the variable is 0.

3.2.3. Control variables

(1) The occurrence time of the patent license: generated according to the year in which the license contract was signed, that is, the effective time of the substantive examination of the patent.

(2) Type of patent: dummy variable. If the type of patent being licensed is an invention, the value is 1; if the type of patent being licensed is utility, the value is 0.

(3) Technical capability of the licensed enterprise: this study adopts the cumulative number of patents applied by the enterprise one year before the adoption of the technology license.

3.3. Logistic Regression Analysis Process

Through collecting the patent information applied by colleges and universities in Yunnan, qualitative processing

was carried out on the data, dummy variables were introduced, and assignment variables were shown in Table 1:

Table 1. Dummy variable processing

Dummy variables	Assigned variables
Exclusive licensing tendency	1 - Monopoly license and exclusive license 0- Ordinary license
Geographical distance	1 - Same municipality 0- different municipalities
School-enterprise cooperation experience	1 - Universities are connected with enterprises 0- Universities are not connected with enterprises
Type of patent	1 - Invention patent 0- Utility patent

3.3.1. Select appropriate independent variables and dependent variables

Before Logistic regression [5-6] analysis, univariate analysis should be carried out on the sample data to investigate the relationship between all independent variables and dependent variables, and to screen variables with no statistical significance, so as to ensure the reliability of the

results. SPSS software is used to test whether the data obeyed normal distribution or not, and it is concluded that the original data does not obey normal distribution but approximately obeys binomial distribution. Therefore, Spearman rank correlation coefficient is selected to determine whether these variables are related to the propensity to exclude by correlation. Moreover, at the significance level of 1%, the results are shown in Table 2:

Table 2. Correlation analysis table of influencing factors

Influencing factors	Spearman correlation coefficient
School-enterprise cooperation experience	-0.155**
Geographical distance	-0.091**
Technology maturity	-0.114**
Technical capabilities of licensed enterprises	-0.035
Type of patent	-0.55
Patent licensing time	0.015

** . When the confidence (double measure) was 0.01, the correlation is significant. *.The correlation is significant when the confidence (double measure) is 0.05.

Through the correlation judgment and analysis of the influencing factors, it can be seen from Table 2 that in the process of technology transfer between universities and enterprises, the cooperative experience between universities and enterprises, the geographical distance between universities and licensed enterprises and the technical maturity have significant correlation with the tendency of exclusive license of universities at the level of 0.01. In

addition, it is found that school-enterprise cooperation experience has the highest correlation with the tendency of exclusive licensing and the lowest correlation with the time of patent licensing. The relationship between dependent variables and independent variables in the sample data is further analyzed, and descriptive statistics table 3 is obtained:

Table 3. Descriptive statistics

	Variable	Mean	SD	Correlation
1	Exclusive licensing	0.79	0.409	
2	School-enterprise cooperation experience	0.44	0.497	-0.155**
3	Geographical distance	0.57	0.485	-0.091**
4	Technology maturity	0.67	0.577	-0.147**
5	Technical capabilities of licensed enterprises	77.38	280.736	0.011
6	Type of patent	0.83	0.377	-0.055
7	Patent licensing time	2015.9	2.314	0.027

** . Significant correlation at the.01 level (bilateral).

Table 3 shows the descriptive statistics and correlation of each variable. The mean value of exclusive license of

dependent variable is 0.79, which indicates that 79% of patent license contracts in the sample are exclusive. The average value of school-enterprise cooperation experience of dummy variable is 0.44, which indicates that 44% of patent license universities and licensees have cooperation experience. The mean geographical distance of dummy variable is about 0.57, indicating that 57% of the patented universities and licensees in the sample are in the same municipality.

3.3.2. Test and discussion of the model

Based on the above analysis, binary Logistic regression analysis [7-8] is performed on the dependent variables and independent variables in the sample, and the regression software is SPSS 17.0. Geographical distance, school-enterprise cooperation experience and patent type are binary variables, so they are introduced in the form of dummy variables, taking the last group as the reference group. It can be seen from Table 4 that most of the absolute values of the correlation coefficients between the variables entering the regression are below 0.4, so it can be concluded that there is no multicollinearity problem, and the model can be further analyzed.

Table 4. Analysis of correlation coefficients among variables

	1	2	3	4	5	6
1 Exclusive licensing						
2 School-enterprise cooperation experience	-.155**					
3 Geographical distance	-.099**	.023				
4 Technology maturity	-.147**	-.033	-.47			
5 Technical capabilities of licensed enterprises	.011	.182**	-.030	.036		
6 Patent type	-.055	.032	.046	-.167**	.029	
7 Licensing time	.027	.155**	.097**	.211**	.099**	.414**

** . Significant correlation at the.01 level (bilateral).

Through the correlation analysis between dependent variables and independent variables, it is determined that there is no multicollinearity between each factor, which accords with the regression condition of the model. As can be seen from Table 5 that the total sample is 1001. The logarithmic likelihood value of -2 gradually decreases with the addition of influencing factors in the model, and the effectiveness of the model is gradually enhanced.

Only all the control variables are added in Model 1. As can be seen from the regression results, the patent type, patent license time and licensee's technical ability have no obvious significance to the exclusive license tendency. However, after adding independent variables, the significance of the control variables changed, which indicated that the control variables in the model were not the main factors affecting the exclusivity license tendency of universities. On the basis of model 1, independent variable technology maturity is added. It can be seen that compared with utility model patents, colleges and universities have a higher tendency to adopt exclusive licensing for invention patents ($\beta = 0.535$, $p < 0.05$), and the higher the technological maturity, the lower the tendency to adopt exclusive licensing of colleges and universities ($\beta = -0.658$, $p < 0.01$), indicating that the licensed technology is mature and fully utilized. Getting value from it is the focus of colleges and universities. In the subsequent model, the coefficient of technology maturity is significantly negative at the 1% level. The regression results show that the higher the maturity of the licensed technology is, the lower the tendency of the university to adopt the exclusive licensing strategy is. Therefore, hypothesis 1 is valid.

Model 3 adds the independent variable of the geographical distance between the licensor's university and the licensee's enterprise on the basis of Model 2, and it can be concluded that the closer the geographical distance between the

university and the enterprise, the lower the tendency of the university to adopt the exclusive license ($\beta = 0.488$, $p < 0.01$). The geographical distance is significantly positive at the 1% level in the subsequent model. The geographical distance between universities and enterprises is a dummy variable. From Table 6, it can be concluded that the risk ratio is 0.629, which is significantly less than that of 95% confidence interval of 0.458 to 0.863. When the representative university and the enterprise are located in the same municipality, the possibility of adopting the exclusive licensing strategy is less than that of the university and the enterprise are located in different municipalities. The regression results show that compared with the enterprises located in different jurisdictions, the lower the tendency of colleges and universities to adopt exclusive licensing strategy for licensed enterprises in the same municipality, so it can be concluded that hypothesis 2 is true. In addition, the coefficient of technology maturity and geographical distance is significant at the level of 1%, indicating that this factor is the main factor affecting dependent variables.

Model 4 adds the variable of school-enterprise cooperation experience on the basis of model 3. It can be concluded that, the coefficient of technology maturity ($\beta = -0.751$, $p < 0.01$) and geographical distance ($\beta = 0.454$, $p < 0.01$) between universities and enterprises is significant at 1% level. The later the patent license year, the higher the tendency of universities to adopt the exclusive license strategy ($\beta = 0.085$, $p < 0.05$). The more cooperation experience between universities and enterprises, the lower the tendency of universities to adopt the exclusive licensing strategy ($\beta = -0.076$, $p < 0.01$). School-enterprise cooperation experience is a dummy variable. From Table 6, it can be concluded that the risk ratio is 0.467, which is significantly less than 1. The 95% confidence interval is 0.458 to 0.863, which means that

when universities and enterprises have cooperation experience, they are less likely to adopt exclusive licensing strategy than those without cooperation experience; the tendency of universities to adopt the exclusive licensing strategy is lower for those enterprises with cooperation

experience, so the hypothesis 3 is supported. To sum up, technology maturity, geographical distance between universities and enterprises, and school-enterprise cooperation experience has significant moderating effects on the tendency of universities to grant exclusivity.

Table 5. Binary Logistic regression results

Dependent variable: the exclusive licensing tendency				
	Model 1	Model 2	Model 3	Model 4
Technology maturity	-	-.658***	-.674***	-.751***
School-enterprise cooperation experience				-.876***
Technical capabilities of licensed enterprises	.719	.306	.287	1.474
Type of patent	.084	.535**	.511**	1.858
Licensing time	.392	.395	.399	.085**
Constant	1.314***	1.703***	1.525***	-170.005**
-2 Log likelihood	1033.665	1006.412	997.324	971.516
Cox & Snell R ²	.021	.027	.036	.060
N	1001	1001	1001	1001
Nagelkerke R ²	.036	.042	.055	.093

*. p <0.10, **. p <0.05, ***. p <0.01 bilateral test.

Table 6. Risk estimates

	Value	95% confidence interval	
		Lower limit	Upper limit
Probability ratio of geographical distance	0.629	0.458	0.863
Probability ratio of school-enterprise cooperation experience	0.467	0.343	0.636
N in valid cases	1001		

3.3.3. Model fitting effect test

After studying and discussing the above Logistic regression analysis results, the fitting effect of the model need to be tested. The test and judgment indexes of model fitting effect

mainly include logarithmic likelihood value and pseudo-decision coefficient, prediction model accuracy rate and ROC curve. The model fitting effect is tested mainly through the prediction model accuracy and ROC curve.

(1) Accuracy of prediction model

Table 7. Model prediction table

Observed	Predicted		
	Exclusive license tendency		Percentage correction
	Ordinary license	Monopoly and exclusive licensing	
Step 4 Exclusive license tendency Ordinary license	8	204	3.8
Monopoly and exclusive licensing	3	786	99.6
Total percentage			79.3

Table 7 is the fitting test of the model by adding all the control variables and independent variables on the basis of model 4. It can be seen from Table 7 that the fourth step of stepwise regression (step 4) outputs the above results, with boundary value of 0.5; when no independent variables are added, the correct classification percentage of the model is

78.0%, and the record of correct prediction after adding independent variables accounts for 79.3%, indicating that the model can correctly classify 79.3% of the observations, that is, the inclusion of independent variables can improve the prediction ability of the model.

(2) ROC curve

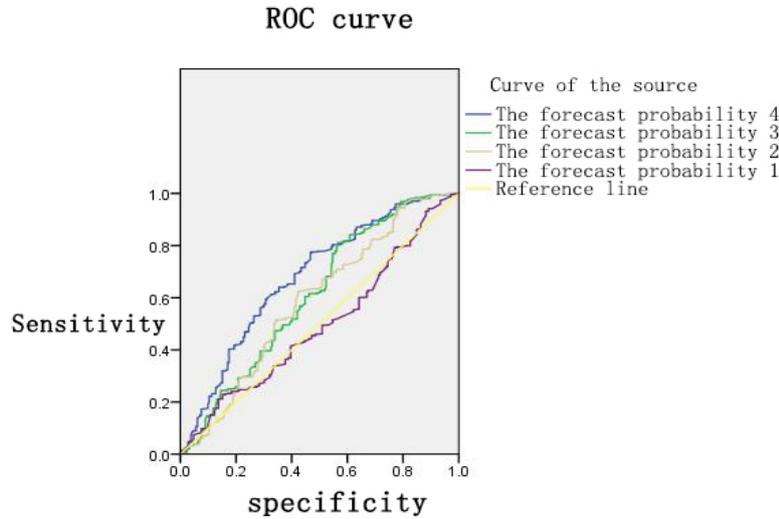


Figure 1. ROC graph

Table 8. Area under curved

Test result variable	Area	Standard error ^a	Progressive Sig. ^b	Asymptotically 95% confidence interval	
				Lower limit	Upper limit
Prediction probability 4	.679	.022	.000	.637	.722
Prediction probability 3	.611	.024	.000	.564	.657
Prediction probability 2	.590	.024	.000	.544	.637
Prediction probability 1	.496	.022	.849	.452	.539

a is for the nonparametric hypothesis, and b is for the null hypothesis

The above ROC curve analysis results show that the AUC of Model 1 is 0.496, the AUC of Model 2 is 0.590, the AUC of Model 3 is 0.611, and the AUC of Model 4 is 0.679. It can be concluded that the model with all independent variables is more accurate and more effective in judging the results.

3.3.4. Goodness of fit test of model

By testing the fitting effect of the model, it is concluded that model 4 is more accurate and the fitting effect of the model is effective. In order to investigate whether the current model can be further improved, and whether the difference between the prediction effect of the current model and the saturation model is statistically significant, and to test the goodness of fit of the model. Since there are many independent variables studied in this work and the work contains continuous independent variables, Hosmer-Lemeshow test is adopted. The analysis results are shown in the table below.

Table 9. Hosmer and Lemeshow test

Steps	Cards	df	Sig.
1	22.059	8	.015

From the analysis results in Table 9, it can be seen that the P value of 0.015 is greater than 0.05, and the original hypothesis is accepted. It is considered that the fitting effect of the model is satisfactory and the influencing factors have statistical significance.

3.3.5. Solution and prediction of regression equation

To sum up, by selecting independent variables and dependent variables in the model, the Logistic regression analysis of variables is carried out under different conditions, so as to test the goodness of fit of the model and predict the correct rate of the model. It is concluded that model 4 (adding all variables) is a relatively "optimal model". Therefore, the independent variables of school-enterprise cooperation experience, geographical distance and technology maturity are regressed with the dependent variable exclusivity tendency, and the results are shown in

the following table:

Table 10. Regression table

Variable	B	S.E.	Wals	df	Sig.	Exp (B)
School-enterprise cooperation experience X_1	-.896	.167	28.908	1	.000	.408
Geographical distance X_2	.472	.170	7.678	1	.006	1.604
Technology maturity X_3	-24.015	.141	41.377	4	.000	0.000
Constants	22.099	.157	.000	1	.000	3.958

According to the actual situation and the previous correlation analysis results, the school-enterprise cooperation experience, technical maturity, geographical distance are taken as influencing factors into the equation for Logistic regression analysis. The results of Logistic regression analysis in Table 10 show that the three variables are significant to the exclusive license tendency of colleges and universities, so the final Logistic regression equation is as follows:

$$\hat{P}_i = \frac{\exp(22.099 - 0.896X_1 + 0.472X_2 - 24.015X_3)}{1 + \exp(22.099 - 0.896X_1 + 0.472X_2 - 24.015X_3)}$$

In the above regression equation, X_1 represents the experience of school-enterprise cooperation; X_2 represents the geographical distance between universities and enterprises; X_3 represents technology maturity cooperation experience between school and enterprise is expressed. It can be seen from the table that the experience of school-enterprise cooperation ($\beta = -0.896$) and the maturity of technology ($\beta = -24.015$) are negatively correlated with

the exclusive license tendency of colleges and universities, and the geographical distance between universities and enterprises is positively correlated with the tendency of exclusivity ($\beta = 0.472$). The above regression equation indicates that compared with enterprises without experience of school-enterprise cooperation, colleges and universities are less inclined to adopt the exclusive licensing strategy for enterprises with experience of cooperation; when the distance between licensed enterprises and universities increases, universities have a higher tendency to adopt the exclusive licensing strategy. The higher the maturity of the licensed technology, the lower the tendency of the university to adopt the exclusive licensing strategy.

Substitute the data into the above equation and take 0.5 as the boundary value of the prediction probability. If $p > 0.5$, it is considered that the university adopts the strategy of exclusive licensing. Through the prediction of this model, the following table is obtained.

Table 11. Prediction of exclusive license tendency

Actual value	Prediction		Accuracy (%)
	Ordinary license	Monopoly and exclusive licensing	
Ordinary license	24	188	11.3
Monopoly and exclusive licensing	5	784	99.4
Total	29	972	80.7

It can be seen from Table 11 that the total number of patents in cooperation between universities and enterprises is 1,001, and the total number of monopoly and exclusive license patents is 789. Among them, 5 patents fail to predict, the accuracy is 99.4%, and the total prediction accuracy of the model is 80.7%. After testing, the final model fitting $p = 0.185 > 0.05$, and it can be considered as a good overall fitting of the model.

4. SUMMARY

Through the collation and analysis of the data, it is concluded that the total number of patents for the school-enterprise cooperation in Yunnan Province from 2010 to 2019 is 1001. The theoretical hypothesis and empirical analysis are carried out to study the influencing factors of the exclusive license tendency in colleges and universities. This work holds that colleges and universities can create more common commitments by adopting exclusive licensing strategy, reduce the risks brought to

enterprises by three factors: geographical distance disadvantage, immature technology and lack of cooperative experience, and realize the market economy value of scientific research achievements in colleges and universities. Through empirical analysis, it is concluded that the higher the maturity of licensed technology, the lower the tendency of colleges and universities to adopt exclusive licensing strategy. Compared with licensees and universities in the same municipality, colleges and universities have a higher tendency to adopt the exclusive licensing strategy for enterprises not in the same municipality. Compared with enterprises without cooperation experience, colleges and universities are less inclined to adopt the exclusive licensing strategy for enterprises with cooperation experience.

REFERENCES

[1] Shen Huijun, Xu Ge, Huang Can. Empirical Study on the Influencing Factors of Technology Exclusive License

in Colleges and Universities[J].Scientific Research, 2019, 37(06):1033-1042.

[2] Ma Liping. Study and Application of Qualitative Data -Study and Application of Modern Statistical Analysis Methods[J]. Beijing Statistics, 2000(02):41-42.

[3] Li Wenjing. Research on Technical Cooperation Innovation of Local Schools and Enterprises from the Perspective of Patent Information - Taking Guangdong as an Example[J].Management Observer, 2017(17):127-128+131.

[4] Xiong Lei, Wu Xiaobo, Zhu Peizhong, et al. Empirical Study on Technology Capability, Host Country Experience and International Technology Licensing - Foreign Enterprises' Technical Licensing of Chinese Enterprises[J].Academic Science, 2014, 32(2):226-235.

[5] Chen Weichang, Cai Yanlang, Zhu Zuming, Yang Hongsheng. Regression Analysis of Risk Factors -

Logistic Regression Analysis [J]. Journal of SoochowUniversity, 1995(05):903-904.

[6] Chesbrough H.W. Open Innovation: The New Imperative for Creating and Profiting from Technology[M]. Boston, Mass: Harvard Business School Press, 2003.

[7] Xu Min, Wang Huimin. Research on the Structure of Patent Cooperation Network between School and Enterprise - Interprovincial Comparison of Universities in Yangtze River Delta Urban Agglomeration Science and Technology Management Studies, 2018, 38(24):87-95.

[8] Yan Yafei, Hu Yanyang, Li Dongsheng. Study on the Influencing Factors of Step-stone Satisfaction Based on Logistic Model[J/OL]. Journal of Shandong Agricultural University (Natural Science Edition), 2020(01):1-5[2020-03-14].