Research on Knowledge Exchange Model among Regional Innovation Network

Zheng Zhan[1], Deng Lu[2]
1 School of Business and Management, University of Economics & Business, Shijiazhuang, P.R.China, 050061
2 School of Statistics, Central University of Finance and Economics, Beijing, P.R.China, 10080
(E-mail: zz050108@163.com, denglu521@sina.com)

Abstract Based on the spatial economics and regional innovation cooperation theory, this paper modified and redefined the spatial knowledge spillover model by Caniels, and then made empirical analysis on the influence factors of knowledge exchange among members in the innovation network via panel data method. This paper takes forward fixed traffic distance. Then it has proved the important influence from social capital and knowledge complementary capacity to knowledge exchange level and talks about the degree of influence.
Key words Regional innovation network; Knowledge exchange; Influence factor; Via panel data method

1 Introduction

The direct reason of constructing regional innovation network of area lies in limit of single organization's innovation ability and resource. Single organization can acquire spillover effect of knowledge flow and accumulate more new knowledge and resource. Innovation network functions in the integration of innovation resources, the achievement of spillover effects, the breakthrough in technical obstacle, the reduction of innovation risk. The improvement in industrial division and cooperation affects directly on the regional innovation cost, efficiency and output. To achieve such functions, it requires the main body of innovation system to make full use of the technological resources and broad cooperation within the region. Then it forms the local and regional innovation network that accelerates the resource flow and development of the knowledge innovation. It is definitely profitable on enriching theory and demonstration theory which improve regional cooperation and layout of regional cooperation's pattern.

The knowledge spillover models constructed by Caniels (2000) and (Zhu Meiguang 2006) deserved farther researching. The models describe calculation method of regional knowledge spillover efficiency. However, measurement of actually spillover of models still depends on dominant knowledge and region data. The models should be modify for making knowledge spillover externally and finding the requirement of technology cooperation and innovation exchange between different regions. The direct reason of constructing regional innovation network of area lies in limit of single organization's innovation ability and resource. Single organization can acquire spillover effect of knowledge flow and accumulate more new knowledge and resource. Innovation network functions in the integration of innovation resources, the achievement of spillover effects, the breakthrough in technical obstacle, the reduction of innovation risk. The improvement in industrial division and cooperation affects directly on the regional innovation cost, efficiency and output. To achieve such functions, it requires the main body of innovation system to make full use of the technological resources and broad cooperation within the region. Then it forms the local and regional innovation network that accelerates the resource flow and development of the knowledge innovation. It is definitely profitable on enriching theory and demonstration theory which improve regional cooperation and layout of regional cooperation's pattern.

2 Theory Model

The model of Caniels (2000) and (Zhu Meiguang 2006) can tell us influencing variable and spillover mechanism. Knowledge spillover is happening natural passive about knowledge exchange and transfer. However active knowledge exchange and transfer do not be clearly expressed in their model. As far cautious as I say it can be explained perfectly with knowledge complementation variable and social capital variable. RIN is a system based on knowledge cooperation and exchange and this analysis framework is different from spatial knowledge spillover model supposing technology chase. It is closely connective to spatial cooperation.

The new RIN knowledge exchange model is as following.

First of all, the proposition of innovation member's knowledge exchange model based on regional cooperation is as six items.

ⅰ: The increase of RIN knowledge storage is direct proportion with whole innovation level and economic improvement of the regional.

ⅱ: Information and traffic convenience between regions is direct proportion with knowledge exchange between regions. Knowledge absorption capability is direct proportion with the knowledge exchange opportunity gotten from one region to another.

ⅲ: The adjacent degree is inverse proportion with regional knowledge exchange. At the same time the adjacent distance is the least region number though region i to region j. The distance of path can be calculated.

ⅳ: The bigger the ratio between the difference of two regions study capability inside innovation network should achieve the smaller the knowledge exchange potential. By contraries the smaller the difference of two regions study capability the can make the bigger the knowledge exchange potential. Meanwhile the bigger the study capability composed by difference of regional study capability and regional study capability can make the bigger the exchange capability. So it is the smaller adversely.

ⅵ: The higher of social capital connection level can stand for the higher the trust level. So the study potential capability and the basic innovation flat is as better as knowledge exchange level.

The model of regional innovation network knowledge exchange is as below.

$$K_{ij} = \frac{(E_i \times E_j)^a (F_i \times F_j)^b \times \zeta_{ij}^c \times \psi_{ij}^h}{D_{ij}^d} e^{-m(\frac{1}{\delta_i} G_{ij})^2} = \frac{E_{ij}^a \times F_{ij}^b \times \zeta_{ij}^c \times \psi_{ij}^h}{D_{ij}^d} e^{-m(\frac{1}{\delta_i} G_{ij})^2} \quad (1)$$

Make $A_{ij} = (G_{ij}/\delta_i)^2$, $f = -m$, it is as follow.

$$K_{ij} = \frac{E_{ij}^a \times F_{ij}^b \times \zeta_{ij}^c \times \psi_{ij}^h}{D_{ij}^d} e^{fA_{ij}} \quad (2)$$

Compare to the models before this model of RIN knowledge exchange has some characters.

(1) The variable to be explained has another new definition. K_{ij} has represented knowledge spillover from region i to region j before. The K_{ij} of this paper means region i probably receiving knowledge exchange and output capability from region j. The knowledge exchange level includes obvious and recessive knowledge.

(2) The modified variable of study capability is $(E_{ij}^a \times F_{ij}^b)$ in before model. E_{ij}^a represents information convenience factor and F_{ij} represents traffic convenience factor.

(3) D_{ij} represents membersadjacent level of innovation network. This variable makes the divisive concept combine one single concept of adjacent level and geographic distance. Here it only emphasizes on the effect of knowledge exchange by regions adjacent level. The parameter d is one how degree adjacent level affects knowledge exchange.

(4)Because the research proposition is changing and this paper makes technology chasing coefficient $\mu_i = 0$ of the variable $e^{-(\frac{1}{\delta_i} G_{ij} - \mu_i)^2}$ in old model. G_{ij} is study capability gap inside RIN and this variable means study capability difference. $e^{-m(\frac{1}{\delta_i} G_{ij})^2}$ is the factor which study capability of region i and capability gap between region i and j affects knowledge exchange of region j. m is a coefficient which this item influences knowledge exchange though membersof RIN. So it calls $A_{ij} = (G_{ij}/\delta_i)^2$ the study capability item.

(5) ζ_{ij} is a new variable and it indicates knowledge complementation level between region *I* and region *j*. Knowledge complementation defines from the angle of paper cooperation level and industry similitude level in this paper. The coefficient c expresses the efficiency from knowledge complementation impacting on knowledge exchange.

(6) ψ_{ij} is a new variable and it indicates social capital factor. It expresses the impaction level from knowledge exchange between region *I* and region *j*. The coefficient h expresses the efficiency from social capital impacting on knowledge exchange. In addition, variable of study capability is definitely explained into the social capital capability.

3 Data Selection and Analysis Method

The formula (3) is the linear equation based on the formula (2). It is a change of using logarithmic operation. Then it will estimate the formula (3). Otherwise, logarithmic operation can avoid the heteroscedasticity inside model possibly. The model is using logarithmic operation as following.

$$\begin{aligned}\log(K_{ij}) = a\log(E_{ij}) + b\log(F_{ij}) + c\log(\zeta_{ij}) \\ +d\log(D_{ij}) + h\log(\psi_{ij}) + fA_{ij}\end{aligned} \tag{3}$$

It is explained as above, all variables represent the effect degree between region *I* and region *j*. This study selects data from 31 provinces of Chinese. Concretely, K_{ij} uses patent cooperation data, standardization data of sum of SCI and CSCD represents knowledge exchange level. These variables is achieved as the colligate score of factors analysis such as information convenience variable E_{ij}, traffic convenience variable F_{ij}, study capability G_{ij}, knowledge absorptive capability $\delta_{i.}$ Furthermore, spatial distance variable and complementary capability variable and social capital variable are calculated by some index indirectly. The calculation process and data is ignored because constraint paper space.As for every variable is from mutual data among 31 provinces data of each one is a matrix likes 31 rows and 31 lines.

4 Mixed Estimation Model

4.1 Mixed estimation model constitution

This paper will give mixed estimation to model (3). The pooled model of panel via data is as following definition.

The row vector is composed by six dependent variables such as $y_{it} = \log(K_{ij})$, $\boldsymbol{X}_{it} = [\log(E_{ij}), \log(F_{ij}), \log(\zeta_{ij}), \log(D_{ij}), \log(\psi_{ij}), A_{ij}]'$. The purpose of this estimation is focus on average impact from dependent variables to independent ones but ignoring difference characters of different regions. The average impact value will compare to the value of each region.The estimation result of model is as follows. The table 1 shows standard deviation of parameter estimation value.

$\log(K) = 3.28 - 0.80*\log(D) + 0.32*\log(E) - 0.02*\log(F) + 0.50*\log(\zeta) + 1.11*\log(\psi) + 8.87*A$

(1)Model diagnostic test

It can be seen that the parameter is tested significance obviously from the estimation result and the other parameters are tested significance. Goodness of fittest is higher than 60 percent and more than 60 percent information of dependent variables can be explained. Value of Statistics proves error without self-correlation. Using log function for each variable can eliminate heteroscedasticity. Therefore, the model of this paper is constructed reasonably. Except for it said above variable of traffic convenience is not significant because variable set in model maybe a little wrong.

Table 1 Model Estimation Result

variable	Parameter estimation value	Standard deviation	*T* statistical value	probability
Constant item	3.28	0.17	19.44	0.0000
log(*D*)	- 0.80	0.10	-8.15	0.0000
log(*E*)	0.32	0.04	8.01	0.0000
log(*F*)	-0.02	0.02	-0.83	0.4059
log(ζ)	0.50	0.19	2.60	0.0096
log(ψ)	1.11	0.08	13.34	0.0000
A	8.87	0.99	9.01	0.0000

(2)Economic meaning of parameters

If using log function on dependent and independent variables the parameters stand for elasticity. Here parameter value of log(*D*)is -0.8 so every 1 percent distance *D* increases every 0.8 percent knowledge exchange rate will decrease. The same as before the elasticity is 0.32 from information convenience *E* to knowledge exchange. The elasticity is 0.5 from knowledge complementation capability ζ to knowledge exchange. The elasticity is 1.11 from social capital capability ψ to knowledge exchange. Last study capability *A* is not using log function and the elasticity is 8.87 from this variable to knowledge exchange. It means every unit *A* increases log(*K*)will increase 8.87. This result maybe caused by less knowledge gap between two regions and less absorption capability itself or biggish knowledge gap and biggish absorption capability.

(3) standardization parameter

As for multiple regression model parameter of regression can not distinguish if the dimension is disunity about dependent variables. Then it should change regression parameter as formula (4) so the

multiple regression model can explain the importance of dependent variables.

$$\hat{\beta}_j' = \hat{\beta}_j s(x_j)/s(y) \quad j = 1, 2, \ldots, 7 \tag{4}$$

According to formula (4.1), $\hat{\beta}_j'$ is standardization coefficient and $s(x_j)$ is estimation of each parameter inside table 1. Mixed standard error of each dependent variable is represented by $s(x_j)$. $s(y)=s(\log(K_{it}))$ expresses mixed standard error of dependent variable $\log(K_{it})$. Except for constant item standardization parameter of each dependent variable is showing in table 2.

Table 2 Standardization Parameter of Mixed Estimation Model

Variable	$\log(D)$	$\log(E)$	$\log(\zeta)$	$\log(\psi)$	A
Standardization parameter	-0.0567	0.0012	0.0054	0.1328	0.0435

Standardization parameter value can differ directly. The value can judge which dependent variable has more impact on independent variables. The utility of traffic convenience F_{ij} will be ignored because the parameter of the variable shows no significance. As for knowledge exchange of RIN the standardization parameter value indicates the most frontal important factors which includes social capital capability firstly and study capability secondly and knowledge complementary capability and information convenience. But spatial distance factor has negative impact on knowledge exchange.

4.2 Modified traffic convenience

From above mixed estimation model the parameter of variable F_{ij} shows no significance. So F_{ij} isn't useful to explain knowledge exchange. Next it will analyze reparative effect by F_{ij} *to* D_{ij} and modify the model of formula (1) in order to get better economic explanation by parameter estimation.

(1) reparative effect analysis with traffic convenience F_{ij} and spatial distance D_{ij}

Theory and demonstration result all indicate longer the spatial distance can decrease knowledge exchange level. Otherwise F_{ij} concerns degree of general traffic convenience between different regions so it should affect knowledge exchange theoretically.

The demonstration result shows indistinctive with this factor. Even now it can not eliminate this variable from model. From another point of view formula (1) has not seriously considering the connection between traffic convenience and spatial distance. If considering reparative effect on knowledge exchange it can make traffic convenience and spatial distance into on variable.

This paper will use division function between F_{ij} and D_{ij} for unchanging adverse effect from spatial distance to knowledge exchange. F_{ij}/D_{ij} replaces the one before. In addition, it uses exponent function for F_{ij}/D_{ij} so the new knowledge exchange model is changed as formula (2).

$$K_{ij} = E_{ij}^{a} \times \zeta_{ij}^{c} \times \psi_{ij}^{h} \times e^{b(\frac{F_{ij}}{D_{ij}})} \times e^{fA} \tag{5}$$

The metric model is changed by log function as formula (4.4).

$$\begin{aligned} \log(K_{ij}) = a\log(E_{ij}) + b(F_{ij}/D_{ij}) \\ + c\log(\zeta_{ij}) + h\log(\psi_{ij}) + fA_{ij} \end{aligned} \tag{6}$$

(2)Modified mixed estimation model

It estimates the formula (4.3) and parameter estimation and economic meaning are following.

$$\log(K) = 2.16 + 0.25 * \log(E) + 5.87 * F/D + 0.83 * \log(\zeta) + 1.05 * \log(\psi) + 0.83 * A$$

As is shown is table 3 all parameters indicate significance on knowledge exchange after modifying distance variable. Furthermore, goodness of fittest of model is better than the first model (3). Meanwhile the new model does not possess autocorrelation and diagnostic. It makes clearly that modified model (6) is more reasonable than model (1).

Parameter value of $\log(E)$ is 0.25 and this proves 1 percent information convenience increases knowledge exchange rate will mount up 0.25 percent. The elasticity from knowledge complementary ζ to knowledge exchange is 0.83. The value proves traffic convenience making up decrease effect for knowledge exchange. Therefore, the modified model is reasonable.

Table 3 Estimation Result of Modified Mixed Model

Variable	Parameter estimation value	Standard deviation	*T* statistical value	probability
Constant item	2.16	0.14	14.90	0.0000
log(*E*)	0.25	0.02	10.27	0.0000
F/D	5.87	1.35	4.35	0.0000
log(ζ)	0.83	0.18	4.54	0.0000
log(ψ)	1.05	0.09	12.26	0.0000
A	8.03	0.99	8.09	0.0000

Furthermore above studies is not enough and how bigger of above parameters can not decide its impact on knowledge. It need standardize parameter for differing importance of dependent variables. At first it get standardization error 2.50, 3.30, 0.05, 0.34, 0.91, 0.05 by calculating log(*K*), log(*E*), *F/D*, log(ζ), log(ψ) and *A*. With method of formula (4.1) the standardization parameters of each variable are got in table 4.

Table 4 Standardization Parameters of National Mixed Estimation Model

variable	log(*E*)	*F/D*	log(ζ)	log(ψ)	*A*
Parameter value	0.33	0.12	0.11	0.38	0.16

The firstly important standardization parameter is social capital and information convenience secondly and knowledge study capability thirdly and knowledge complementary capability and traffic convenience level. Meanwhile, modified model isn't changing the knowledge exchange function by knowledge complementary and social capital. This part it makes whole nation as one innovation network and estimates factors parameter and differs the different impact degree. Next part it will consider some sub-nation innovation network.

5 Conclusion

The spatial cooperative member knowledge exchange model is constructed in this paper. Based on planet via data it gives demonstration to RIN of nation so tests model reasonably. The variables of model except traffic convenience all impact on knowledge exchange obviously. So it puts two variables of traffic convenience and spatial distance into single variable and takes the new one into new model. Demonstration proves rationality with modified model and explains more significance of economy. These conclusions will offer a basic flat for theory and demonstration study of innovation cooperation.

References

[1] Caniels M.C.J. Knowledge Spillovers and Economic Growth[M]. Edward Elgar Cheltenham UK Northanmpton MA.USA, 2000: 125-136
[2] Zhu Meiguang. Rearch on Spatial Knowledge Spillover and China Regional Economy Development[D]. Beijing Institute of Technology, 2006: 69-83 (In Chinese)
[3] China Technology Statistics Yearbook (2000-2009)[M]. 2000-2009:State Statistics Bureau, 25-69
[4] China Statistics Yearbook(2000-2009)[M]. China Statistics Press, 2000-2009:12-98
[5] China Patent Information Network[EB/OL]. Http://www.patent.com.cn/
[6] China Science Metric Index- Paper and Quotation Statistics[R]. Beijing Chinese Academy of Sciences Literature and Information Center, 2005-2008
[7] Xiao Zheng. Panel Data Analysis[M]. Beijing: Beijing University Press, 2005:165-178 (In Chinese)