Impact of agglomeration spillover in spatial difference of innovation activities

—panel data analysis of China manufacturing industry

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Abstract: From the viewpoint of economic geography，the paper aims at investigating determinants of spatial difference of innovative activities. Basing on the Hypotheses of spillover effect of industry agglomeration, our main purpose is to identify the extent to which the degree of industrial specialization or diversity in the region may affect the innovative output in a particular local industry. Moreover, we test if any relevant difference arises with respect to the role of diversity in metropolitan areas and in high-tech sectors.

Key words: Innovation, Industry agglomeration, Specialization, Diversity

As the practice of industry agglomeration and research are deeply expanded, the impact of industry agglomeration in spatial difference of innovation activities has attracted great attentions. The industrial spatial development mode is considered to be the main factor of corporations' successful innovation. Base on the research of the technology innovation in the subsection industries of manufacture, the promotion effect form industry agglomeration to innovation activities is analyzed in this article.

1 Main empirical findings

1.1 Theory summary

The hypothesis that industry agglomeration has a positive effect on innovation activities is originated from the dissertation of Marshall (1890), who had described the innovation atmosphere in the agglomeration areas to demonstrate that, compared to scattered firms, the innovation in those firms located in the agglomeration areas was more pervasive and fast. Krugman (1991) made a further emphasize that firms in the agglomeration areas, with more access to the innovation information, are provided with more opportunity of innovation recur to the trust and social connection of people.

The effect of different structure of industry agglomeration to the innovation was always in the spotlight in academe. There are two opinions in the *New Growth*

Economic Theory. One considers that the effect mainly consists in neighbor firms of the same industry, which means that the more a single industry agglomerated in certain location, the better benefit will be made to innovation. This point of view is called specialization or MAR externality. Another viewpoint, called diversification or Jacobs externality, states that the effect mainly consists in neighbor firms of correlative industries, and the diversity of atmosphere is more propitious to innovation.

1.2 Demonstration summary

Corresponding to the theory researches, the demonstration researches are also divided into two levels:

First of all is the study to validate the correlativity between industry agglomeration and innovation activities. The new innovation economy (Jaffe, 1989; Feldman, 1994) made use of the knowledge-production function to find the conjunction system between them and also some empirical analysis.

Secondly is the discussion of effect of different industry agglomeration structure to the innovation. Catherine（2000）made a compare study of the manufacture of Italy and the unite kingdom and found that the specialization of industries added a positive effect on innovation activities, while the effect of diversification to innovation differed in these two countries。Feldman (1999) validated the effect of different industry agglomeration structure to the innovation and economic development by using the firms' innovation data of the USA in 1982. His study have some opposite findings, which was the effect of specialization was not so significant but diversification had a remarkable effect on the innovation and economy. By a research of 25 industries×93 regions in Italy, Stefano (1998) found that industry agglomeration had significantly positive effect on innovation and the diversity of the agglomeration was more favor for innovation. Raffaele （2000）also did a research of 85 industries×784 regions in Italy and concluded that innovation had positive correlation with both the two agglomeration structure ,and especially the diversification had a remarkable effect on high-tech industries and metropolises [3].

In the literature searches of China, we found that some domestic scholar (Long, 2005) discussed this problem mainly in the aspect of theory analysis. So, our study will find the effect of industry agglomeration to the innovation activities by quantitative analysis.

2 The spatial difference of innovation activities in Chin ese manufacture industry

2.1 The measurement of innovation activities

To describe the spatial characteristics of innovation in manufacturing industry, the first problem to solve is the measurement of innovation activities.（*Griliches*,1979）Measuring innovation mainly by the three indicators *patent, patent citation,* and *innovation record* is one way [4].We consider the measurement by new products indicators to better incarnate the value-realization principle, and realize more authenticity in the market economy.

2.2 The spatial distribution of innovation activities

We design the innovation density indicator to review the spatial distribution of innovation activities, which eliminates the scale difference of the province. Figure1 below shows us the innovation density level by the area of the circles, a bigger circle indicating more denseness of innovation in this province and also more powerful innovation capacity.

Form figure1 we can see that the innovation in China's manufacturing shows obvious region agglomeration. Innovation activities most fasten on the east inshore provinces, while most inner provinces are lack of innovation energy. In our study, 79.93% zero-innovation counties are from middle and west China, and the innovation activities of east province takes up 74.31% of the whole innovation activities in China.

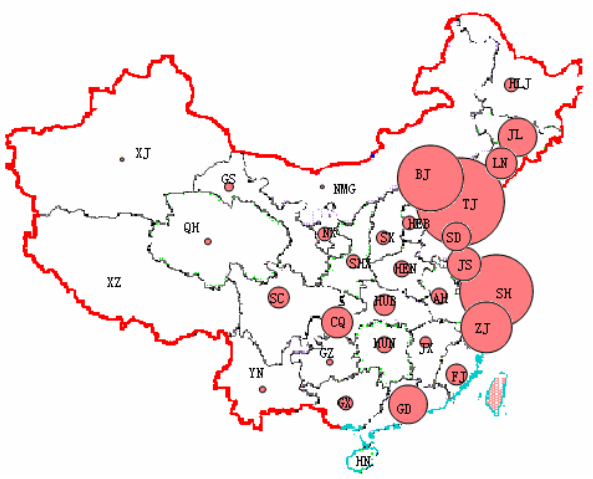

Figure1: Spatial distribution of manufacturing innovation activity

2.3 The consistency of innovation activities and in dustry agglomeration in production

In order to reveal the coherence in spatial distribution of manufacturing innovation activity and production, we use regional Gini coefficient for 3-Digit SIC manufacturing industry to describe the spatial distribution of their production and innovation activities in 2807 counties in China. (Figure2 and Figture3)

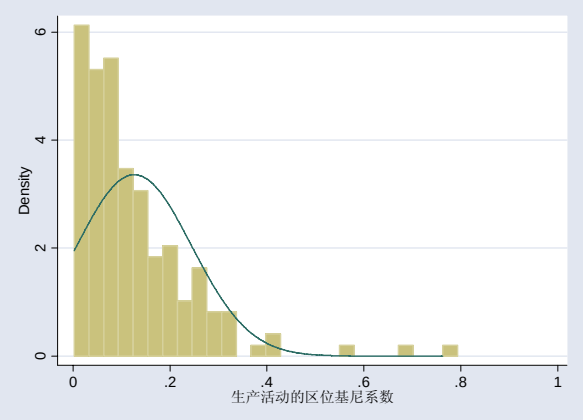

Figure2: Histogram of regional Gini coefficient for 3-Digit SIC manufacturing production activities

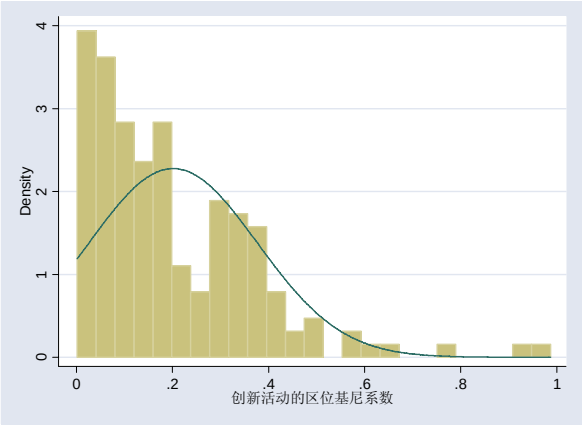

Figure3: Histogram of regional Gini coefficient for 3-Digit SIC manufacturing innovation activities

The exploration of the data form 3-Digit SIC manufacturing found that the 3-Digit SIC manufacturing industries did show some spatial agglomeration characteristics to some extent and this characteristic share the coherence between production and innovation. This finding provides evidence from description statistics for our model below, estimating their relationship.

3 Data and model specification

3.1 Data source and specification

The basic data of our research is from the database of state-own and big scale non-state-own manufacturing firms in 2006.Combination of regions × industries is made to get data of 2807counties×161 3-Digit SIC manufacturing industries in 2006.

3.2 Econometric specification and model selection

We use the linear model to study the effect to innovation of the two agglomeration structure (specialization and diversification) [4]:

$y = f(x, w, z)$

In the model above, y denotes innovation output of certain region and certain industry, x denotes innovation input of certain region and certain industry, w denotes the characteristics of certain region, and z denotes the characteristics of certain

industry.

We define specification index as PS_{ij} to reflect the level of specification of industry i in region j [5]

$$PS_{ij}=\frac{(\text{Gross Industrial Output Value}_{ij}/\sum_{i}\text{Gross Industrial Output Value}_{ij})}{(\sum_{j}\text{Gross Industrial Output Value}_{ij}/\sum_{i}\sum_{j}\text{Gross Industrial Output Value}_{ij})}$$

We also define diversification index as PD_j to reflect the level of diversification in region j. [5]

$$PD_{j}=\frac{[1/\sum_{i}(\text{Gross Industrial Output Value}_{ij}/\sum_{i}\text{Gross Industrial Output Value}_{ij})^{2}]}{[1/\sum_{i}(\sum_{j}\text{Gross Industrial Output Value}_{ij}/\sum_{i}\sum_{j}\text{Gross Industrial Output Value}_{ij})^{2}]}$$

Porter (1990) pointed out that the technical flow between correlative industries is not allowed to ignore. *Feldman* (1999) introduced the concept of *common science-base* industries groups [3]. Following the measurement of *Feldman*（1999）, we define specification index of industries groups SBS_{ij} to reflect the specification level of the correlative industries groups of industry i in region j.

$$SBS_{ij}=\frac{(\text{Gross Industrial Output Value}_{ij}^{k}-\text{Gross Industrial Output Value}_{ij})/\sum_{i}\text{Gross Industrial Output Value}_{ij}}{\sum_{j}(\text{Gross Industrial Output Value}_{ij}^{k}-\text{Gross Industrial Output Value}_{ij})/\sum_{j}\sum_{i}\text{Gross Industrial Output Value}_{ij}}$$

In the formula above, k=1…6, indicating industries groups with the same science basic, $i\in k$.

In order to control the influence caused by the different market level and denseness of technology, we introduce two groups of dummy variables.

Market level dummy variables:

$$DM_{j}=\begin{cases}1 & \text{the region reaches vice-province level and above}\\ 0 & \text{others}\end{cases}$$

Dummy variables for denseness of technology:[1]

$$DTH_{i}=\begin{cases}1 & \text{high tech industry}\\ 0 & \text{others}\end{cases}$$

[1]The partition of high tech industry in manufacturing is based on the *high tech industry catalogue* printed and distributed by the National Bureau of Statistics in July 2002.

Our study set the innovation output density of industry *i* in region *j* $INN_{ij,}$ which equals to new product output/ gross industrial output value, as the dependent variable. And we calculate the proportion of R&D input to Revenue from sale to reflect the innovation input level of industry *i* in region *j*.

4 Model enactment and analysis

4.1 Model enactment

There are 60193 samples which is 0 of the dependent variable-innovation output density INN_{ij}, taking up 80.2% of the whole samples。The OLS estimation of these data will be a biased estimation, and we use the Tobit model and two-step model to fit it as a rule（Green,1997）.The likelihood ratio test of Tobit model and two-step model [2]reveals that the two-step model is the feasible one [6].

The two-step model is a regression model in which the probability of restricted observations and that of non-restricted observations are independent（*Cragg*,1971）.The model tries to figure out the effect of the manufacturing industry agglomeration structure to the innovation capacity in the steps.

In the first step, we use the *Probit* model to review that influenced by the industry agglomeration, whether the industry have the innovation capacity or not[3].

$$PINN_{ij} = \alpha + \beta_1 R\&D_{ij} + \beta_2 PS_{ij} + \beta_3 PD_j + \beta_4 SBS_{ij} + \beta_5 DM_j * PD_j + \beta_6 DTH_i * PD_j + \varepsilon_{ij}$$

$$\text{In this formula, } \begin{cases} PINN_{ij} = 1 & INN_{ij} > 0 \\ PINN_{ij} = 0 & INN_{ij} = 0 \end{cases} \quad (1)$$

In the second step we use the *Truncate* model to review the level of innovation capacity that influenced by the industry agglomeration.

$$INN_{ij} = \alpha + \beta_1 R\&D_{ij} + \beta_2 PS_{ij} + \beta_3 PD_j + \beta_4 SBS_{ij} + \beta_5 DM_j * PD_j + \beta_6 DTH_i * PD_j + \varepsilon_{ij}$$

$$\text{In this formula, } INN_{ij} > 0 \quad (2)$$

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[2]Likelihood Ratio $\lambda = -2[\ln L_T - (\ln L_P + \ln L_{TR})]$=3983.73, Prob >= χ^2 =0.00. In the formula, L_T is the controlled likelihood value of *Tobit* model, *Lp* is the separated fitted likelihood value of *Pobit* model, and L_{TR} is the separated fitted likelihood value of Truncate model.

[3]In order to discuss the influence of region and industry characteristics to the Jacobs exterior, our model introduces intersect variables *DMj*PDj* and *DTHi*PDj*.

4.2 The result of demonstration analysis

The model calculations in our study use the software Stata8.2, and Table 1 shows the result of maximum likelihood estimation of *Probit* and *Truncate* models. We can see from the table that the model have passed the econometric test, and the result support our hypothesis that industry agglomeration did make some positive effect on the innovation capacity of the industries.

Table1: Estimates of determinants of the localization of innovative activities

Estimation Methods	Model（1）		Model（2）	
	Probit Model		*Truncate* Model	
	Coefficient	$\partial y / \partial x$	Coefficient	$\partial y / \partial x$
Innovation input				
R&D	11.266 ***	0.0383	0.1340 ***	0.007
Agglomeration structure				
PS	0.3634 ***	0.043	0.0157 ***	0.0283
PD	0.7530 ***	0.200	-0.020	-0.0817
SBS	0.0250	0.043	-0.002	-0.0567
Region characteristics				
PD*DM	0.4741 ***	0.022	0.0479 ***	0.0347
Industry characteristics				
PD*DTH	-0.0258	-0.005	0.0329 ***	0.0098
Constant	-0.8773 ***	—	0.0395 ***	—
DM=0 DTH=1	-0.517	—	0.104	—
DM=1 DTH=0	-0.598	—	0.061	—
DM=1 DTH=1	-0.273	—	0.126	—
Log Likelihood	-30015.39		7199.12	
Likelihood-ratio test of rho=0 $P>\chi^2$	0		0	
Sample capability	75034		14841	

Note：* indicate the significance of 1%**

Concretely, the innovation input has significant effect on the cultivation of innovation capacity and the improvement of innovation level. As the innovation input density increase 1%, the innovation probability, viz. Prob. (INN_{ij}=1) will increase 0.038%. And to those industries who have already had the innovation capacity, if the

innovation input density of them increase 1%, the innovation level will increase 0.007%。

Specification index *PS* also has significant effect on the cultivation of innovation capacity and the improvement of innovation level. When certain industry agglomerates in certain region, the innovation activities of this industry are more flourish than the average level of manufacturing industry. As the level of specification increase 1%, the innovation probability, viz. Prob. (INN_{ij}=1) will increase 0.043%. And to those industries who have already had the innovation capacity, if the level of specification increase 1%, the innovation level will increase 0.028%.This finding is opposite to the empirical result of the study conducted by *Audretsch*（1999）and *Kelly*（1999）of the USA. But our finding are consistent with the empirical result of the study of *Pacci*（2001）of Italy。Different from the USA, China abounds agglomeration region of traditional industries, which enhance the promotion effect of specification to the innovation activities, and the middle and small firms in this agglomeration region are easier to benefit from the innovation atmosphere there.

Diversification index *PD*, has inconsistent effect on the cultivation of innovation capacity and the improvement of innovation level. As the level of diversification increase 1%, the innovation probability, viz. Prob. (INN_{ij}=1) will increase 0.2%. And to those industries who have already had the innovation capacity, the level of diversification no longer have significant effect on the increase of innovation level. And the review of diversification in different regions and industries indicated that for industries from the region with high market level and high technology denseness, diversification has significant promotion on the cultivation of innovation capacity and the improvement of innovation level, and the effect is remarkably bigger than the industry from the region with relatively low market level and low technology denseness. This finding is consistent with the result of the study on the high tech industries in the metropolises of the USA by *Glaeser et al* (1992) and *Henderson et al*(1995).

Specification index of industries groups *SBS* also has positive effect on the cultivation of innovation capacity and the improvement of innovation level, which confirms the viewpoint that technology is inclined to diffuse along the industry chain with technology superposition（*Porter*,1990）.Therefore, an integrated technical chain will upgrade the innovation capacity in the agglomeration region. More comparison of Specification index *PS* and Specification index of industries groups *SBS* reveals that

the effects of them on the cultivation of innovation capacity and the improvement of innovation level have biggish difference. And the promotion from specification of single industry is higher than that from technology superposition, which means that the innovation activities of Chinese industry mainly benefit form the inner technology flow of single industry, while the promotion from technology flow between correlative industries is relatively weak.

5 Conclusion

According to the statistics description and model estimation of the innovation activities of manufacturing industries in China, the conclusions below are obvious:

The region agglomeration of innovation and production are coherent and both the two agglomeration structure (specialization and diversification) make different promotion to innovation activities. And the positive effect of specialization not only comes from the level of specialization of inner certain industry, but also from the level of specialization of industries groups which have the technology relativity.

The model estimating result shows that the effect of diversification is influenced by the market level of the region and technology denseness of the industry. For the region with a higher level of market or an industry high tech denseness, diversification plays a more prominent role in promoting innovation.

As a result, we conclude that the stratagem of industries agglomeration is an important component of the development of region industry, and the direction of specialization should be paid more attentions to build up the distinctive industries, which is a crucial factor in the upgrade of innovation. Moreover, cultivating the relative industries with technology connection and promoting the development of vertical industries chains is propitious to the improvement of innovation capacity. As the technology is upgrading and the market level is enhanced, the conversion of attention point from vertical specification to horizontal diversification will be a good choice considering the situation. In the new stage of industries agglomeration, the horizontal connection should be emphasized to develop the relating industries and construct an industries atmosphere with diversity.

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