Empirical Test on the intermediary effect of Producer Services Agglomeration Affecting Manufacturing Efficiency: Based on Innovation Ability

Jingwen Li [1 a *]

[1]School of Economics, Sichuan University, Chengdu, China, 610000

[a]email:184508478@qq.com

Keywords: Intermediary Effect; Innovation Ability; Manufacturing Efficiency; Mediation Effect

Abstract: Both academia and practice believe that the knowledge spillover effect of industrial agglomeration can effectively promote industrial efficiency, especially the spatial agglomeration of knowledge-intensive industries can play an important role in the economic development of its surrounding areas and industrial upgrading of related industries. On this basis, this paper focuses on the intermediary path between the agglomeration of producer services and the efficiency of manufacturing industry. Using the data from the year of 2006 to 2015, and the method of Wen Zhonglin's intermediary effect test[1], this paper verifies the intermediary effect of innovation capabilities in the process of the agglomeration of producer services effects manufacturing efficiency. The results show that the innovation capabilities have an incomplete intermediary effect on the relationship between the agglomeration of producer services and manufacturing efficiency. The intermediary effect of innovation ability accounts for 42.13% of the total effect. Moreover, the proportion ranking of intermediary effect of innovation ability in the four sub-producer services industries in order of size from low to high, except "leasing and business service industry", is "financial industry", "information industry", "science industry", "transportation industry". The proportion of intermediary effect of innovation ability is between 15% and 43%. It means that innovation ability plays an important role in transmitting the impact of producer services agglomeration on manufacturing efficiency.

1. Introduction

Since the reform and opening up, the driving force of China's economic growth has mainly come from the development of industry, especially the rapid growth of manufacturing industry. In 2017, China's total GDP was 827.12 billion, the manufacturing output value was 2427.7 billion, which was the largest industry in China's national economic and also the absolute first place world-wide. At present, China's manufacturing output value is more than twice that of the United States, accounting for 33% of the total global share. It can be said that manufacturing industry has become a super star of China's economy in the global market, which not only drives the rapid development of China's economy, but also becomes an important engine of global economic development. However, even our manufacturing industry has made a rapid progress in the process of reform and opening up, the present development model has been challenged severely with the changes of internal and external political, economic and other factors. In the international environment, with the increasing voice of China in all aspects of the world, China, as the world's second largest economy, has become the biggest competitor of the United States. The "Sino-US trade war" directly blocks the export of manufacturing product from China and aggravates the surplus of Chinese manufacturing products. Internally, China's manufacturing industry is in a state of over-competition, with a high level of product homogeneity and frequent "price war" strategy harms the industry's profit margin. At the same time, with the rising prices of various resources, such as labor, land and raw materials, the low-cost advantage of the former manufacturing industry is gradually disappearing. The strategy of "market for technology" makes domestic manufacturers lack the motivation of innovation and R&D, which makes domestic manufacturing industry a disadvantage in global competition. Generally speaking, China's manufacturing industry is facing a

severe development dilemma after experiencing a period of rapid development. Research shows that the agglomeration of producer services can significantly improve the efficiency of manufacturing industry. On the basis of summarizing the knowledge spillovers among different industries, this paper present: “innovation ability" as an intermediary path. To a certain extent, the proposition of this influence mechanism will enrich the related research of industrial agglomeration theory and industrial relevance theory.

2. The Impact Path of Producer Services Agglomeration on Manufacturing Efficiency: Based on Innovation Ability

This paper chooses "information transmission, computer service and software industry", "leasing and business service industry", "scientific research, technical clothing", "Business and geological prospecting industry", "transportation, warehousing and postal industry", and "financial industry" as five sub-sectors of producer services.

2.1 Empirical Analysis of the Impact of Producer Services Agglomeration on Manufacturing via Innovation Ability

In the first step of the intermediary effect test, we have made it clear that the industrial agglomeration of leasing and business services has not significantly promoted the efficiency of manufacturing industry. Therefore, in this section, we only need to verify the significance of the aggregation of producer services and other four sub-sectors on the innovation ability of manufacturing industry.

(1) Model construction

In order to test the impact of producer services agglomeration and four subdivisions of producer services agglomeration on manufacturing innovation ability, the following models are constructed:

$$lnInno_{i,t} = c + \alpha_0 Cluster_{i,t} + \alpha_1 lnNum_{i,t} + \alpha_2 lnRDE_{i,t} + \alpha_3 lnPat_{i,t} + \alpha_4 NE_{i,t} + \mu_i + \upsilon_t + \varepsilon_{i,t} \quad (1)$$

In the model (1), $\mathrm{Inno}_{i,t}$ represents the innovation ability of manufacturing industry of province i in the year of t. $Cluster_{i,t}$ refers to the agglomeration of productive service industry of province i in the year of t, $Num_{i,t}$ refers to the full-time equivalent of R&D personnel of province i in the year of t, $RDE_{i,t}$ refers to the internal R&D expenditure of province i in the year of t, $Pat_{i,t}$ refers to the number of manufacturing invention patents of province i in the year of t, $NE_{i,t}$ refers to the new product development expenditure of province i in the year of t, μ_i υ_t and $\varepsilon_{i,t}$ represents industry heterogeneity, time heterogeneity and random error respectively.

(2) Variable design and data source

Inno is the dependent variable of model (1). Based on the summary of existing research, it is found that scholars usually regard the number of patent authorizations (Groot et al., 2001) [2] and the sales revenue of new products (Feldman and Florida, 1994) [3] as the proxy indicators of innovation ability. Considering that the sales revenue of new products can reflect the market's judgment on the value of new products more directly than the number of patent authorizations (Sha Wenbing, 2013) [4], this paper uses the natural pairs of sales revenue of new products to measure innovation ability.This paper uses the natural pairs of sales revenue of new products to measure innovation ability. The independent variable of the model is producer service industry cluster.

(3) Empirical results and analysis

According to the results in the second column of the table, the impact coefficient of producer services agglomeration on innovation capacity is 2.264, passing the hypothesis test of 1% significance level, indicating that producer services agglomeration can significantly promote the improvement of innovation capacity of manufacturing industry. This result is in line with the theoretical analysis before this paper, and it also verifies the second step of the test of the intermediary effect of innovation ability. The coefficient a is significant, so we should continue the third step of the test.

Table 1 Results of manufacturing innovation ability influenced by producer services agglomeration model

article	Overall level of producer services	Transportation, Warehousing and Postal Service	Information transmission, computer services, etc	Finance	Scientific research, technical services, et
$Cluster$	2.264***	1.047***	1.231***	0.728***	0.743***
	（6.95）	（3.98）	（4.29）	（3.21）	(6.55)
Num	0.264**	0.252*	0.270*	0.293**	0.306**
	（2.05）	（1.84）	（1.99）	（2.14）	(2.36)
RDE	0.293*	0.269	0.278	0.314*	0.233
	（1.67）	（1.45）	（1.50）	（1.68）	(1.31)
Pat	0.170***	0.174***	0.168***	0.166***	0.214***
	（2.83）	（2.74）	（2.65）	（2.58）	(3.51)
NE	0.759***	0.759***	0.762***	0.750***	0.770***
	(6.64)	（6.28）	（6.33）	（6.15）	(6.68)
$cons$	- 4.435*	-2.819	-3.213	-3.296	-3.024
	（-1.79）	（-1.08）	（-1.24）	（-1.25）	(-1.22)
R^2	0.8217	0.8010	0.8028	0.7970	0.8185

Note: *, *** and *** are significant at 10%, 5% and 1% respectively.

The third to sixth columns of Table 1 are the results of four small industries agglomeration, i.e. "transportation industry", "information industry", "finance industry", "science industry", which affect the innovation ability of manufacturing industry. It can be seen from the table that the agglomeration of these four types of industries has a significant positive impact on the innovation capacity of manufacturing industry, that is, the independent variables in the second step of the intermediary effect test have a significant impact on the influence coefficient of the intermediary variables, so the last step of the test procedure is carried out. At the same time, it can be seen that there are some differences in the impact of four types of industry agglomeration on the innovation ability of manufacturing industry. The industrial agglomeration of "information industry" has the highest impact on the efficiency of manufacturing industry, followed by "transportation industry", and the least impact is "science industry" and "financial industry". The impact of industrial agglomeration of these two industries on the innovation ability of manufacturing industry is at the same level. The reason for this may be that the industrial agglomeration of "information industry" is conducive to the transfer of knowledge and technology to the manufacturing industry, so it plays a strong role in promoting the upgrading of manufacturing products and investment in innovation. "Transportation industry" is highly related to manufacturing industry. Its agglomeration makes the transportation of raw materials and products more convenient for manufacturing industry, and makes the new products of manufacturing industry better carry out circulation, thus reflecting the value of manufacturing innovation. Due to the control of risks, the financial industry may not support the technological innovation and product innovation as much as the real estate and high-tech enterprises. As a result, the industrial agglomeration has a positive effect on the innovation ability of the manufacturing industry, but this effect is relatively small.

For the influence of the control variables in the five regressions on innovation ability, we can see that the overall influence direction is basically consistent. Specifically, in the five regressions, except for the information transmission, computer service and software industry, the rest of R&D personnel's full-time equivalent (Num) has a significant positive impact on the innovation ability,

which shows that the input of R&D personnel can effectively provide the innovation ability of manufacturing industry. The R&D internal expenditure (RDE) has a significant positive impact on innovation ability in three regressions, and its influence coefficient is also positive in two non significant results, indicating that research and development investment is the material guarantee for innovation in the industry, and only when the capital is put in place, can the revenue brought by new products be obtained. The number of effective patents (PAT) and new product development expenditure (NE) have significantly positive effects on innovation ability in the five regression, indicating that they have a significant role in promoting innovation ability of the industry and market value brought by new products.

2.2 Research on the Impact of Producer Services Agglomeration and Manufacturing Innovation Ability on Manufacturing Efficiency

(1) Modeling

The first step and the second step of the intermediary effect test of innovation ability have been completed, and the corresponding coefficients are significant. Next, the third step is to put the innovation capacity of manufacturing industry into the model of the impact of producer services agglomeration on manufacturing efficiency. Based on the model (1), the model is established as follows:

$$lnY_{i,t} = c + \beta_0 lnCluster_{i,t} + \beta_1 Inno_{i,t} + \beta_2 FAI_{i,t} + \beta_3 Gov_{i,t} + \beta_4 lnDev_{i,t} + \beta_5 FDI_{i,t} + \mu_i + \upsilon_t + \varepsilon_{i,t} \quad (2)$$

In the model (2), $Y_{i,t}$ represents the manufacturing efficiency of I province in t year, $Cluster_{i,t}$ represents the agglomeration of producer services in I province in t year, $Inno_{i,t}$represents the innovation ability of I province in t year, $FAI_{i,t}$represents the social fixed assets investment of I Province in t year, $Gov_{i,t}$ represents the government branches of I Province in t year. It is concluded that $Dev_{i,t}$ represents the level of economic development of province I in t years, $FDI_{i,t}$represents the amount of foreign investment in Province I in t years, $\mu_i$represents the regional heterogeneity, υ_t represents the time heterogeneity, and $\varepsilon_{i,t}$ represents the random error.

(2) Variable selection

Model (2) is equivalent to the first step of mediation test, in which mediation variables are added to form model (2), so the selection of variables is simply explained here. T Dependent variable (Y): The explanatory variable of model (2) is manufacturing efficiency. According to the foregoing, The commonly used indicators to measure manufacturing efficiency are total factor productivity (Feng Taiwen, 2009; Han Dechao, 2011) [5,6], production efficiency (Wang Zhipeng and Li Zinai, 2003; Wang Zhigang, 2006) [7-8]. According to most existing studies (Xuanye, 2012; Zhang Zhenggang, 2014) [9,10], this paper uses labor productivity as a measure of manufacturing efficiency, specifically, labor. Movable productivity = Gross Industrial output/total number of employees. Consistent with the previous study, according to Glaeser (2002) [11] and Yu Yongze (2016) [12], the final variable to measure the level of agglomeration is the location entropy index. The specific formula for calculating the level of agglomeration is $Cluster = (\frac{PS_i}{X_i}) / (\frac{PS}{X})$.

(3) Empirical analysis results

Table 2 is the final step of the test of the intermediary effect of innovation ability. It aims at the significance of the influence coefficients of the agglomeration of producer services and the innovation ability of manufacturing industry on manufacturing efficiency. It can be seen from the table that the influence coefficients of agglomeration and innovation ability of producer services on manufacturing efficiency have passed the hypothesis test of 1% level, that is, passed the third step test of intermediary effect, and some of them have significant intermediary effect. This shows that the agglomeration of producer services plays a role in promoting the manufacturing rate, partly because the agglomeration of producer services promotes the technological innovation and innovation ability of manufacturing industry, thus promoting the efficiency of manufacturing industry.

Table 2. The Impact of Producer Services Agglomeration and Innovation Ability on Manufacturing Efficiency

article	Overall level of producer services	Transportation, Warehousing and Postal Service	Information transmission, computer services, etc	Finance	Scientific research, technical services, et
$Cluster$	0.355***	0.240***	0.500***	0.411***	0.183***
	（2.72）	（2.56）	（4.94）	（5.35）	(4.26)
$Inno$	0.115***	0.128***	0.109***	0.112***	0.106***
	（4.79）	（5.71）	（4.95）	（5.19）	（4.63）
$lnFAI$	0.352***	0.297***	0.295	0.312***	0.309***
	（3.51）	（2.99）	（3.07）	（3.27）	(3.18)
Gov	0.390	0.325	0.495	0.516	0.391
	（1.01）	（0.85）	（1.32）	（1.39）	(1.04)
$lnDev$	0.733***	0.716***	0.755***	0.746***	0.757***
	（11.90）	（11.87）	（12.81）	（12.88）	(12.56)
FDI	0.106***	0.110***	0.115***	0.116***	0.109***
	(4.93)	（5.07）	（5.51）	（5.57）	(5.15)
$cons$	3.788***	3.919***	3.507***	3.605**	3.867***
	（7.20）	（7.62）	（6.97）	（7.34）	(7.85)
R^2	0.4010	0.4528	0.4432	0.4640	0.4089

Note: *, *** and *** are significant at 10%, 5% and 1% respectively.

The third to sixth ranks in Table 2 are the results of the third step of the intermediary effect of innovation ability corresponding to the agglomeration of four categories of producer services. From the table, it can be seen that the coefficients of the impact of the agglomeration of four categories of producer services and innovation ability of manufacturing industry on manufacturing efficiency are both positive and significant, indicating that there is a part of intermediary effect. The positive impact of the agglomeration of the four industries on the efficiency of manufacturing industry is partly due to the improvement of the innovation ability of manufacturing industry.

The results of the control variables in the five regressions are basically the same. Social fixed assets investment, economic development level and foreign direct investment all have positive effects on the local manufacturing efficiency, which is consistent with the results of the previous paper. However, the effect of government expenditure on manufacturing efficiency is not significant, which is different from the previous results.

Table 3 Analysis of the Mediating Effect of Manufacturing Innovation Ability

Steps and regression coefficients		S	S1	S2	S3	S4
Step one $Y = cX + \varepsilon$	c	0.618*** （5.01）	0.371*** （3.86）	0.651*** （6.46）	0.514*** （6.60）	0.256*** (6.19)
Step two $M = aX + \varepsilon$	a	2.264*** （6.95）	1.047*** （3.98）	1.231** （4.29）	0.728*** （3.21）	0.743*** (6.55)

Step three $Y = cX + bM + \varepsilon$	c'	0.355*** （2.72）	0.240*** （2.56）	0.500*** （4.94）	0.411*** （5.35）	0.183*** (4.26)
	b	0.115*** （4.79）	0.128*** （5.71）	0.109*** （4.95）	0.112*** （5.19）	0.106*** （4.63）
Significance of mediation effect	Conc lu-si on	Significa nt	Significa nt	Significa nt	Significa nt	Significa nt
Mediation effect value	ab	0.2604	0.1340	0.1342	0.0815	0.0788
Mediation effect accounts for total effect（100%）	ab/c	42.13	36.12	20.61	15.86	30.76

Note: *, *** and *** are significant at 10%, 5% and 1% respectively. S and S1 to S4 represent the total producer services, transportation, warehousing and postal industries, information transmission, computer services and software industries, financial industry, scientific research, technical services and geological exploration industries, respectively.

Next, in order to understand the specific situation of the intermediary effect of manufacturing innovation ability, Table 3 focuses on the numerical value and significance of the coefficients of each step, and calculates the size of intermediary effect and the proportion of intermediary effect to the total effect. Table 3 shows that the three-step test coefficients c, a, B and C ^ of aggregation of total producer services and four subdivisions of producer services are significant, and the values of a * B and C ^ (,) are consistent. It shows that the agglomeration of producer services has an impact on manufacturing efficiency, and innovation ability plays a part of the intermediary effect. According to the proportion of intermediary effect, according to the proportion of total effect, the intermediary effect of innovative ability in four categories of producer services is 35.12%, 30.76%, 20.61% and 15.86%, respectively. It can be seen that the intermediary effect of the innovation ability of the aggregation of the total producer services is larger than that of the four sub-sectors, accounting for 42.13%. The reason for this may be that in the regression of the agglomeration of each subdivision of producer services, the degree of explanation for the innovation ability of manufacturing industry is only the efficiency of manufacturing industry brought about by the industry itself, which will further affect the innovation ability, and is also the result of the agglomeration of the industry itself. When examining the intermediary effect from the aggregation of producer services as a whole, the impact of industrial aggregation on the innovation ability of manufacturing industry shows. The improvement of the innovation ability caused by the aggregation of two or even the aggregation of producer services as a whole can be estimated. Because of this, the intermediary effect of innovation ability is higher than that of four sub-industries in the impact of aggregation of producer services on manufacturing efficiency.

3. Conclusion

This paper uses Wen Zhonglin's intermediary effect test method, based on the prespective of innovation ability, to examine whether innovation ability has an intermediary effect on the path of the agglomeration of producer services' impacting on manufacturing efficiency. At the same time, it calculates the proportion of innovation ability to the total effect, which clearly reflects that the influence degree and difference in different producer services agglomeration on manufacturing efficiency through innovation ability.

This is consistent with the theoretical analysis in this paper. Through knowledge spillover effect, producer service industry agglomeration can promote technological innovation and product upgrading in manufacturing industry.

General speaking, the intermediary effect of innovation ability accounted for 42.13% of the total effect. Moreover, the proportion ranking of intermediary effect in innovation ability of the four categories of industries in order of size, from low to high, is "financial industry", "information industry", "science industry", "transportation industry". The proportion of intermediary effect of innovation ability is between 15% and 43%. The level of intermediary effect is relatively high. In short, manufacturing industry is an important industrial pillar of economic development in most regions, the improvement and upgrading of manufacturing efficiency will effect the overall economic development. Improving the industrial cooperation and integration between producer services and manufacturing industry can fully utilize the knowledge spillover effect and competition effect of the agglomeration of producer services, which will eventually improve the manufacturing efficiency.

4. Reference

[1] Wen Zhonglin, Zhang Lei, Hou Jietai, et al. Procedures for testing mediation effects and their applications [J]. Journal of Psychology, 2004, 36 (05): 614-620.

[2] De Groot, Henri LF, Peter Nijkamp, and Zoltan Acs. "Knowledge spill-overs, innovation and regional development."Papers in Regional Science 80.3 (2001): 249-253.

[3] Feldman, Maryann P., and Richard Florida. "The geographic sources of innovation: technological Infrastructure and product innovation in the United States." Annals of the association of American Geographers 84.2 (1994): 210-229.

[4] Sha Wenbing, Absorption Capacity, FDI Knowledge Spillover and Innovation Ability of Domestic-funded Enterprises: An Empirical Test Based on China's High-tech Industries [J]. International Business (Journal of University of Foreign Economic and Trade), 2013 (01): 104-112.

[5] Feng Taiwen. The Impact of Productive Services Development on Manufacturing Efficiency - Taking Transaction Cost and Manufacturing Cost as Intermediate Variables [J]. Quantitative Economic, Technological and Economic Research, 2009 (3): 56-65.

[6] Han Dechao. Study on the Impact of Productive Services FDI on Industrial Enterprise Efficiency [J]. Statistical Research, 2011, 28 (2): 65-70.

[7] Wang Zhipeng, Li Zinai. Study on the Impact of Foreign Investment on the Production Efficiency of Chinese Industrial Enterprises [J]. Managing the World, 2003 (4): 17-25.

[8] Wang Zhigang, Gong Liutang, Chen Yuyu. Decomposition of Interregional Productivity Efficiency and Total Factor Productivity Growth Rate (1978-2003) [J]. Chinese Social Science, 2006 (02): 55-66+206

[9] Xuanye. Spatial Agglomeration of Productive Services and Improvement of Manufacturing Efficiency: An Empirical Study Based on Spatial Spillover Effect [J]. Finance and Trade Economy, 2012 (4): 121-128.

[10] Zhang Zhenggang, Chen Zhiming, Hu Qiling. Research on the impact of producer services on manufacturing efficiency [J]. Scientific Research Management, 2014, 35 (1): 131-138.

[11] Glaeser E L, Laibson D, Sacerdote B. An Economic Approach to Social Capital[J]. Economic Journal, 2002, 112(483): 437-458.

[12] Yu Yongze, Liu Dayong, Xuan Ye. Spillover effect of producer services agglomeration on manufacturing productivity and its attenuation boundary: Empirical analysis based on spatial econometric model [J]. Financial Research, 2016 (2): 23-36