

Literature Review: Industrial Structure and Knowledge Spillover

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Abstract—Knowledge has become one of the decisive factors in the development of modern industry. And knowledge spillover is of great significance to the development of industry. Therefore, it is necessary to study the knowledge spillover effect for industry. Due to the large differences in characteristics of various sub-sectors, further research on knowledge spillovers in various sub-sectors and differences in knowledge spillovers in different regions and industries has an important role in promoting regional economic growth and industrial development.

Keywords—MAR spillover; Jacobs spillover; Porter spillover

I. INTRODUCTION

At present, China is in the stage of economic development dominated by industry, and industrial development is the main engine for promoting regional economic growth. The differences in economic development in various regions of China are largely related to the imbalance of industrial development levels. Linking the productivity of industrial development in a country or region is one of the important factors that distinguish developed regions from underdeveloped regions.

Knowledge spillover is a highly cross-theory and multidisciplinary concept. Many economic branch theories such as the new economic growth theory and the new trade theory use the concept of knowledge spillover to explain agglomeration, innovation and regional growth. Knowledge spillovers are closely related to industrial agglomeration. In the process of regional economic growth, agglomeration economy is an important driving force, and knowledge spillover is an important factor in innovation and industrial progress.

Knowledge is valuable information and non-competitive and non-exclusive. It can be considered that knowledge spillover is the unconscious spread of knowledge, and knowledge spillover has the characteristics of public property, unconsciousness and unpaid. Therefore, knowledge spillover can be defined as: the knowledge recipient unconsciously acquires external knowledge and applies the knowledge to his own business, but does not give the knowledge creator any compensation, or the compensation given is less than the cost of knowledge creation.

By definition, knowledge spillover has the following two characteristics: First, due to the externality of knowledge and the nature of public goods, it cannot be occupied by the creator alone, and this overflow is unconscious, no compensation and involuntary; second, the spillover of knowledge may cause losses to the creator, because the recipient of knowledge does not make the for the creator or much less than the value of its creation, but in general the spillover makes a positive effect on the economy and welfare of society.

Knowledge spillover is a very complicated economic and social phenomenon. Knowledge spillovers are divided into horizontal knowledge spillovers, vertical knowledge spillovers, and joint knowledge spillovers. They can be divided into knowledge spillovers of the propagation process and knowledge spillovers of the use process. There are positive spillovers and negative spillovers of spillover effects. From the point of whether it can be coded, it can be divided into explicit and tacit knowledge spillover. The spillover of tacit knowledge is mainly in the neighborhood, and the overflow of explicit knowledge is not restricted by geographical scope.

The knowledge spillover effect refers to the socio-economic value, which refers to an economic externality. That is, when an individual possesses new knowledge, it cannot hinder the use of such knowledge by other individuals. When a new knowledge is discovered, this knowledge will be rapidly spread in the economy, and the whole society. Thus it can promote the productivity, technology progress and economic development. But the creators, who initially possess this new knowledge, have not obtained all the benefits from the increase in the productivity of the whole society caused by this effect.

II. THE DEVELOPMENT OF KNOWLEDGE SPILLOVER

The study of knowledge spillovers has a long history and is an important concept of endogenous growth theory, new economic geography and other economic branches to explain agglomeration, innovation and regional growth. Originally Arrow (1962) and Romer (1986) introduced knowledge into production functions and pointed out that the non-competitive and partial exclusivity of knowledge is the root cause of knowledge spillovers. The initial research on knowledge spillovers was limited to enterprises, but with the

development of research, a large number of empirical studies have shown that there is no direct and significant relationship between innovation input and output at the micro level of the enterprise, thus Audretsch and Feldman (1996) [1] pointed out that it is not appropriate to treat enterprises as observation objects of knowledge spillovers. Based on this, many scholars turned to the externalities of spatial research knowledge, especially the mechanism of knowledge spillover in the urban and regional space, and the characteristics of knowledge spillovers to promote agglomeration, innovation and growth processes. In explaining the mechanism of knowledge space spillover by Jaffe et al (1993) [2] and Acs et al (1999) [3] and in the research of promoting knowledge spillover through agglomeration, and the role of knowledge spillovers in urban and regional economic growth, Black and Henderson (1999) [4], Glaeser and Saiz (2004) [5] shown that innovation could be promoted from knowledge spillovers. Anselin et al. (1997) [6], Keilbach (2000) [7], Funke and Niebuhr (2005) [8], Costa and Iezzi (2004) [9] began exploratory use of spatial data and spatial econometric methods to measure knowledge spillovers on regional economic growth and income impact.

In recent years, scholars have begun to focus on the phenomenon and research of knowledge spillover under the industrial structure. In the aspect of industrial development, the knowledge spillover effect is introduced on the spatial basis to study in the regional level. And the industrial structure refers to the proportion of various industries, the structural features including the composition of the industry and the interrelationship between the various industries.

III. MECHANISM AND DEFINITION

A. Mechanism of Knowledge Spillover

In terms of research on the mechanism of knowledge spillover, the existing literature usually studies from four aspects: the exchange of employers, industry-university-research integration, entrepreneurs' activities and trade investment. Almeida and Kogut (1999) [10], Los and Verspagen (2000) [11], Audretsch and Feldman (2004) [12] illustrate the flow of talents in different spatial domains and promoting knowledge to interact and be spread between different groups and regions. And social networks and social capital affect the efficiency of knowledge spillovers. Ciccone and Peri (2006) [13] and Carlino et al. (2007) [14] show that population density is positively correlated with urban competitiveness and innovation performance, and plays an important role in the flow of ideas, and meanwhile Stuart and Sorensen (2005) [15] emphasizes the important role of personnel mobility in tacit knowledge spillovers. Zhuang Xiaojiang (2016) [16], Rong Shuai et al. (2017) [17], Sun Yongbo and Ding Wei (2018) [18] verified the flow of talents by issuing questionnaires to different industrial clusters. The important role of exchanges between industry and academic institutes' cooperation has created a potential for knowledge spillovers. Fischer and Varga (2003) [19] have demonstrated that knowledge created at Austrian universities can produce spillover effects that promote innovation and development in the technology industry.

Wang Liping (2005) [20], Qu Yong (2007) [21], Liu Xiaobin (2008) [22], Yan Lilin and Zhu Guilong (2014) [23], Zhang Sheng and Xi Xun (2018) [24] analyze the role of industry, academia and research in promoting innovation and growth through theoretical evidence or the case study; Lechner and Vidar (2014) [25] point out that entrepreneurs can gain a large amount of tacit knowledge in entrepreneurial regions and cooperate with others to facilitate a large amount of knowledge spillovers. The geographical proximity of entrepreneurs has promoted knowledge spillovers, and Jiang Feifei (2016) [26], Li Yu et al. (2017) [27] illustrate that entrepreneurial initiative has a significant impact on knowledge spillovers between firms. Trade is an important channel of technology and knowledge spillover. Especially for the goods, it is an important transmission channel for materialized technical knowledge spillovers. Dyah et al. (2016) [28], Matija Rojec (2018) [29], Laixiang Sun et al. (2018) [30] do the research through FDI, innovation and knowledge spillovers in different countries, which proves that FDI has a positive effect on knowledge spillovers and innovation to host countries in a certain range. In China, such as Meng Lingyan (2012) [31] and Wang Jiancheng (2017) [32] respectively studied difference impact from FDI between different region and industries. Most studies agree that knowledge spillovers exist. But knowledge spillovers leave no obvious traces, so it is difficult to explain the mechanism of their occurrence. Modeling the knowledge spillover is indirect.

B. Classification of Industrial Structure

Industrial structure is an important factor affecting economic growth. It has been confirmed many times that it promotes China's economic development and also brings external spillover effects. The concentration of industry has always been the main issue of regional economics, especially the external effects brought about by the spatial agglomeration form the same industries or heterogeneous industries. External spillovers, as a specific form of technological advancement within or between industries, are critical to economic growth and industrial development. If the specialized industrial structure plays a leading role, similar enterprises will be concentrated in a specific area; if the diversified industrial structure plays a leading role, the development of enterprises in this industry will be needed. In a diversified industrial environment, the research on the knowledge spillover effect and the source of innovative ideas should be shifted from the inside of the industry to the exchange of ideas and diffusion of the technology between industries.

At present, researchers mainly explain the relationship between industrial structure specialization, industrial structure diversification, industrial environmental competitiveness and knowledge spillover. And they also study the effect of three aspects of knowledge spillover on innovation performance, industrial development and economic growth. The consensus in the academic world is that knowledge spillovers have a significant impact on the development of industry. However, for different industrial structures, scholars have different views on the impact of

knowledge spillovers. Generally speaking, they are divided into the following three viewpoints:

- Marshall, Arrow and Romer believe that knowledge comes from companies within the industry, and the monopolistic market structure is conducive to knowledge innovation and regional economic growth. That is, the higher the concentration of industry in a certain region, the knowledge spread between companies within the industry more easily. So it is more conducive to develop the industry. This specialization spillover is called MAR knowledge spillover or MAR externality. Companies within the same industry have great similarities and correlations in terms of technical elements. The aggregation in geospatial space is conducive to the exchange and sharing of technology, better intensifying the development of the entire industry chain, and improving overall performance.
- Jacobs believes that knowledge spillovers come from companies in different industries. If the degree of industrial diversification in a region is higher, it is more favorable for knowledge to spread in this environment, and it is more favorable to develop the region's economy. This diversified spillover is called Jacobs knowledge spillover or Jacobs externality. The enterprises clustered in the region are characterized by great differentiation and diversity. These enterprises have the initiative to innovate and strengthen the exchange of economic activities, which is more conducive to the development of regional economy. However it is the opposite of the knowledge spillover effect of MAR.
- Porter agrees with MAR's view that knowledge spillovers originate in the same industry and believes that specialized industrial structures are more conducive to knowledge spillovers the development of the industry. At the same time, he believes that regional competition can force companies to innovate and bring more momentum to economic growth. The spillover caused by this kind of competition is called Porter knowledge spillover or Porter externality.

IV. KNOWLEDGE SPILLOVER EFFECT

With regard to the relationship between knowledge spillover and agglomeration, innovation, growth, knowledge spillovers exhibit endogenous interactions with agglomerations. The different industrial structures formed by agglomeration have different effects on innovation and growth. And it is acknowledged that the influence of knowledge on spatial spillover decays with distance. Endogenous economic growth theory also believes that knowledge accumulation is the source of regional economic growth, and innovation is an intermediate variable. Knowledge spillover can promote innovation and innovation can promote growth. Knowledge spillovers lead to economic growth by promoting spatial agglomeration [33].

About the field of knowledge spillover and growth, an important empirical research is to study the knowledge spillover effect within or between industries from the perspective of industrial structure. Industrial structure is an important factor affecting economic growth. In the theory of regional economic growth, the change of regional industrial structure has always been an important factor for its growth. In recent years, many relevant literatures on economic growth have emphasized the important role that intellectual capital investment plays in economic growth. As a specific form of knowledge and technology diffusion within or between industries, external spillover effects play an important role in economic growth and industrial development. In the field of research on industrial structure and knowledge spillover, it mainly starts from three aspects: the effects of knowledge spillover and industrial structure specialization (MAR spillover), industrial structure diversification (Jacobs spillover) and industrial structure competitiveness (Porter spillover) on regional economic growth.

A. International Literature

Henderson (2001) [34], YIH-LUAN C et al. (2012) [35], Bishop and Gripaios (2010) [36], Liang and Goetz (2018) [37] and other scholars have proved that the spillover from specialization, the MAR knowledge spillover, has a positive effect on innovation and economic growth. But they have reached different conclusions due to the different regions and time. Henderson(2001)[34] used the panel data to get the fact that companies in high-tech industries can get positive effects from other companies in the same industry, verifying the existence of MAR knowledge spillovers and its positive effect. YIH-LUAN et al. (2012) [35] empirically studied the Hsinchu high-tech industry in Taiwan, which proved that knowledge spillovers led to the accumulation of high-tech industries in Hsinchu, reflecting the existence of MAR knowledge spillovers and marking MAR knowledge spillover that has a positive effect on the company's net sales growth. Liang and Goetz (2018) [37] studied the relationship between industrial technology intensity and the impact of agglomeration economies on industrial growth through three-digit NAICS industries in the US states. And the results confirm that industries with lower technology intensity can promote employment growth through regional specialization. Contrary to them, Bishop and Gripaios (2010) [36] used 23 industries as samples to examine the impact of externalities on employment growth in the UK. The results showed that industry specialization had a negative impact on employment growth.

Empirical researches on the diversified knowledge spillover effects, Bishop (2008) [38], Bishop and Gripaios (2010) [36], Pede (2013) [39], O'Connor et al. (2018) [37], Liang and Goetz (2018) [37] used different models to confirm the positive effects of diversified industrial structure on innovation, employment, and economic growth. Among them, Bishop and Gripaios (2010) [36] found that the impact of Jacobs spillovers varied between different industries, and pointed out the positive impact of competition. O'Connor et al. (2018) [40] divided diversity spillovers into related and

unrelated diversity, pointing out that unrelated diversity knowledge spillovers have a greater positive impact. Liang and Goetz (2018) [37] found that technology-intensive industries are more likely to benefit from Jacobs spillovers. From the foreign literature, it is not difficult to find that under different industrial structures, scholars consider competition environment, Porter knowledge spillover, less. And they haven't yet reached the same conclusion on the impact of the knowledge spillover.

B. Literature from China

Most of the scholars from China believe that MAR spillover effect and Jacobs spillover effect are positive to innovation and economic growth. For example, Li Jian and Yu Yue (2018) [41] found that MAR externalities and Jacobs externalities have a positive impact on innovation capabilities through panel data of provinces in China. However, many scholars have found that the effects of spillover effects are not the same, Duan Huijuan and Liang Qi (2009) [42], Su Hongjian and Zhao Jian (2011) [43], Jin Chunyu and Wang Weiqiang (2015) [44], Liu Qipeng et al. (2015) [45] used the different industries' data and different methods to verify the positive effects of MAR spillover effect and Jacobs spillover effect. And it is considered that the specialization industrial structure, the MAR spillover effect, is more conducive to technological advancement and economic growth than the diversified spillover effect. Other scholars such as Liu Manfeng and Wu Zhuoxian (2013)[46] used 54 high-tech industrial development zones in China as the object to measure the MAR and Jacobs knowledge spillover effect in China's high-tech industrial clusters. The results showed that the MAR effect in coastal developed areas is large and Jacobs effect was small; while in the west undeveloped areas the results were just the opposite. Zhang et al. (2017) [47] used provincial panel data to study the different effects in the three externalities of different high-tech industries in China. The results showed that the MAR spillover effect in the computer and office equipment manufacturing industry was positive. But in this industry, there is no Jacobs spillover. Peng Xianghe and Jiang Chuanhai (2011) [48], Cheng Zhonghua and Liu Jun (2015) [49] used provincial and municipal panel data in China respectively, and found that the impact of Jacobs spillover on innovation is much greater than the MAR spillover effect.

There are also a few Chinese scholars who have empirically found that MAR knowledge spillovers and Jacobs knowledge spillovers do not exist in all industries and regions, nor are they all positive. Wu Sanmang and Li Shantong (2011) [50] used data from 169 manufacturing industries in 31 provinces and autonomous regions in China to analyze the impact of specialization, diversification and competition on manufacturing growth. The results showed that within the national sample, specialization spillover (MAR externality) has a negative impact on manufacturing growth, while a diversified industrial structure (Jacobs externality) is good to manufacturing growth. Similarly, Zhang et al. (2017) [47] found that in pharmaceutical manufacturing, electronics and communication equipment manufacturing, and medical equipment and instrumentation

manufacturing, MAR spillovers have a negative impact on industrial development, while Jacobs spillovers will not have a negative impact on the development of the industry.

In the study of Porter knowledge spillover effect, scholars have various opinions. For example, Long Zhihe and Cai Jie (2008) [51] conducted an empirical study on the knowledge spillover effects in the development of industries across the country and sub-regions. And they found that there is a significant MAR spillover and Jacobs spillover, but there is no Porter effect. Peng Xianghe and Jiang Chuanhai (2011) [48] empirical results show that Porter's externality has a negative impact on innovation. On the contrary, Liu Fineng et al. (2015) [45], Cheng Zhonghua and Liu Jun (2015) [49], Wu Sanmang and Li Shantong (2011) [50] conducted empirical research on different levels by selecting manufacturing data and found that the Porter spillover effect has a positive effect on both manufacturing innovation and manufacturing growth. In studies of comparing the effects in different industries and different regions, Zhang Chi et al. (2017) [47] found that although they are all high-tech industry, Porter spillover effect does not exist in the pharmaceutical manufacturing and medical equipment and instrumentation manufacturing industry, in the electronics and communications equipment manufacturing and computer and office equipment manufacturing industries, Porter spillovers have a positive impact on industry development. Li Jian and Yu Yue (2018) [41] analyzed the panel data of provinces and autonomous regions in China, finding that Porter's externalities have different roles in different regions of East, Mid and West. They have positive effects in the east and negative effects in the west. Jin Chunyu and Wang Weiqiang (2015) [44] used the spatial panel model to empirically analyze the relationship between the knowledge spillover effect of industrial agglomeration and industrial economic growth in China. They found that the role of Porter spillover in local industry is not significant, but Porter spillovers in neighboring regions have had a positive effect on local industrial economic growth.

Many scholars have empirically analyzed the effects of MAR spillovers, Jacobs spillovers and Porter spillovers on innovation or industrial economic growth by selecting different industries in different regions. Although the conclusions are inconsistent, in general, in the manufacturing industry, MAR knowledge spillovers play a more prominent role in mature industries, however Jacobs spillovers play a more important role in emerging high-tech industries. Porter spillover effects in developed regions are more likely to be positive effects. While the impact of Porter spillovers in less developed areas may be insignificant or even negatively impacting the economy.

V. SPATIAL CORRELATION OF KNOWLEDGE SPILLOVER

Due to the locality and spatial rooting characteristics of spatial spillover of knowledge, geographical proximity has an important impact on the efficiency of knowledge spillover. Thus the influence of knowledge spillover has a certain spatial extent on the economic growth. The distance increases and the influence decreases. Today's literature considers the estimation errors that may result from inter-

regional interactions, spatial correlations, and spatial heterogeneity. So many scholars have introduced some spatial measurement methods, such as spatial lag models (SLM), spatial error models (SEM), spatial Dubin models (SDM), and Geographical Weighted Regression (GWR). These new methods better verify the geospatial effects of knowledge spillovers in regional growth.

Bode (2004) [52] used spatial econometrics to prove the existence of knowledge spillovers in Germany. The results showed that regions with low R&D density were susceptible to cross-regional knowledge spillovers, but regions with high R&D may only have knowledge spillovers within the region. Baltagi B. H. et al. (2014) [53], Fingleton B et al. (2018) [54] were confirmed that the relationship between spatial effects of knowledge spillovers and economic development existed. Caragliu A (2016) [55] measured knowledge spillovers based on different adjacent weighting matrices and focused on the relationship between knowledge spillovers and society and technology. O'Connor et al. (2018) [40] used the spatial econometric model finding that spatial knowledge spillover effects exerted positive impact on employment growth.

In China, many scholars study the spatial correlation of knowledge spillovers, innovation and economic growth through different dimensions. For example, Wu Yuming (2007) [56], Anyuan and Zhong Yun (2013) [57], Li Wei and He Yili (2017) [58] used provincial, city or county-level data to verify the relations between knowledge spillovers and urban growth as well as innovation. There is a spatial correlation between them and these scholars point out the impact of geographic distance on knowledge spillovers. Some scholars also have compared spatial patterns in different regions, such as Long Zhihe and Zhang Xinzhi (2007) [59], Li Xiaofei et al. (2018) [60] found a spatial imbalance between regional economic development. Especially Li Xiaofei et al (2018) [57] pointed out that the influence of spatial knowledge spillovers is gradually decreasing from east to west. For the comparison of empirical models, Wang Qingxi et al. (2013) [61] found that the estimation of spatial panel analysis is more accurate than ordinary panel analysis. And the inter-provincial spillover effect of China's high-tech industry is obvious. Ye Qianting et al.(2018) [62] do the empirical researches on knowledge spillover of "time-area-industry" three-dimensional unbalanced panel industrial data in Guangdong Province, and found that the spatial multi-level error moving average (HSEMA) model can reflect the economic reality better than the ordinary spatial model. Liu Chengkun and Zhang Xiuwu (2018) [63], Xu Qiuyan and Fang Shengfei (2018) [64, 65] studied the spatial effects of knowledge spillovers within different industries in the province level. And they found significant positive spillover effects among these industries. For Xu Qiuyan and Fang Shengfei (2018) [64, 65] studied the impact of the financial and logistics industries on economic growth, which showed the specialization spillover effect has a positive impact on the economy.

With the development of spatial econometrics, knowledge spillovers have become more and more valuable in regional and geographical research. Due to the particularity of knowledge, knowledge spillovers are more

likely to occur in adjacent regions. But there is no doubt that knowledge spillovers have spatial effects.

VI. CONCLUSION

In summary, although in the endogenous growth theory, the previous researches have already concluded the relationship between space and regional growth, there is no consensus on the relative importance of specialization and diversification. As well, there is no definite evidence for the effect of the industrial competition environment. So the industrial policy options for promoting innovation and growth in the region are also different. And the size of the three kinds of knowledge spillovers, how the industrial structure affects knowledge spillovers and whether knowledge spillovers promote economic development need to be judged through empirical research. According to different empirical results, different regions can choose different industrial policies to promote regional innovation and economic growth. And meanwhile, the proper policies can increase employment in these regions.

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