

RETROSPECT AND PROSPECT OF RESEARCH INTO CHINA'S EQUIPMENT MANUFACTURING INNOVATION NETWORK INTRODUCTION TO THE THEME ISSUE

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1 Overview: the development of China's equipment manufacturing industry

China's equipment manufacturing industry is developing rapidly and its status is rising fast. The equipment manufacturing industry is characterized by high technology content, significant industrial relevance, obvious economies of scale and strong support for other industries. It is one of the most important industrial sectors in China. In 2018, the output value of China's equipment manufacturing industry reached 43 trillion yuan (6,4 trillion €), ranking first in the world, accounting for more than 20% of China's total industrial output value and accounting for more than one third of the global equipment manufacturing output. In addition, since 2000, the average annual growth rate of China's equipment manufacturing industry's output value has been more than 10%, which is one of the main drivers of China's economic growth. Since China's reform and opening up in 1978, China's equipment manufacturing has increased innovation capacity and output value. From the perspective of the types of invention patent owners, the development of China's equipment manufacturing industry can be divided into three stages. During the first stage, the central monopoly stage (1978-1999), the innovation capacity of the research institutes and large state-owned enterprises administered by the central ministries was far higher than that of higher education institutions and private enterprises, and the development of the equipment manufacturing industry was slow. The second stage can be referred to as the multi-actor co-government stage (2000-2005). The number of invention patents granted to institutions of higher learning and private enterprises has increased significantly, forming a pattern of higher education institutions, central ministries and commissions, private enterprises, large state-owned enterprises and other innovative entities moving side by side. China's equipment manufacturing industry developed much faster. In the third stage, in which enterprises take the leading role (2006-present), the number of patents granted for private enter-

prises has increased substantially. The proportion of private enterprises and large state-owned enterprises in the total number of patents in the industry has gradually increased. Since 2010, the proportion of patents has increased by more than 70%. The scale of China's equipment manufacturing industry has expanded so rapidly that it has gradually become the world's largest equipment manufacturing industry (WANG et al. 2016). From the perspective of industrial branches, computer, communications and other electronic equipment manufacturing (1), automobile manufacturing (2), and electrical machinery and equipment manufacturing (3) are important sectors of China's equipment manufacturing industry. In 2016, the above three branches' shares of the total output value of China's equipment manufacturing industry were 24.1%, 19.6%, and 18.1% respectively (CSP 2017).

Large shares of China's equipment manufacturing industry are located in so-called equipment industrial parks, mainly including aviation equipment industrial parks, satellite and application industrial parks, rail transit equipment industrial parks, marine engineering equipment industrial parks and intelligent manufacturing equipment industrial parks. China's equipment industrial parks are characterized by a profound geographical concentration, with many locations in the Yangtze River Delta, the Pearl River Delta, along the Beijing-Tianjin-Hebei-Bohai Sea, in Shanghai, in Shenzhen (Guangdong), in Beijing, in Deyang (Sichuan), in Chongqing, in Changsha (Hunan), in Xuzhou (Jiangsu), in Wuhu (Anhui), in Xi'an (Shaanxi) and in Shenyang (Liaoning).

2 Chinese central government policy

The Chinese central government attaches great importance to upgrading and innovation in the equipment manufacturing industry, as evident from a sequence of policy documents. In June 2006, the State Council issued the "Several Opinions on Accelerating the Revitalization of

Equipment Manufacturing Industry”, encouraging all sectors of society to invest and participate in the construction of China’s equipment manufacturing industry, and preparing the system for private enterprises to play a major role. In May 2012, the Ministry of Industry and Information Technology of the Central Government issued the “Twelfth Five-Year Development Plan for High-end Equipment Manufacturing Industry”, which focused on high-end equipment manufacturing as a target of government support, and promoted a move from “Made in China” to “Created in China”. In May 2016, the State Council issued the “National Innovation Driven Development Strategy Outline”, proclaiming the determination and strategic arrangements for building an innovative country, which includes an emphasis on the innovativeness of industrial technology systems. In December 2016, the Ministry of Industry and Information Technology and the Ministry of Finance jointly issued the “Intelligent Manufacturing Development Plan (2016-2020)”, which listed intelligent manufacturing equipment, key common technology innovation, intelligent manufacturing and industrial internet as priority areas within the manufacturing industry.

Despite fundamental upgrading and innovation along with continuous policy support, however, evident challenges remain. These were acknowledged, for example, on 13 July 2018, when Xin Guobin, deputy director of the Ministry of Industry and Information Technology and director of the “National Manufacturing Power Construction Leading Group Office” pointed out in the “2018 National Manufacturing Power Construction Expert Forum” that more than 95% of manufacturing and testing equipment for key parts and finished commodities such as instruments, launch vehicles, large aircraft, aero engines and automobiles still rely on imports. Compared with developed countries, China’s equipment manufacturing industry is large in scale, but, on average, uses relatively backward technology, depending heavily on Western technology. Politicians and administrators thus urge the promotion of integration of production, education and research, the encouragement of independent innovation and the improvement of the enterprise innovation network. In June 2018, General Secretary of the CPC Central Committee and President Xi Jinping pointed out at the 19th Academician Conference of the Chinese Academy of Sciences and the 14th Academician Conference of the Chinese Academy of Engineering that it is

necessary to fully understand that innovation is the first impetus for providing high-quality scientific and technological supply, and for supporting the construction of a modern economic system. In March 2019, Premier Li Keqiang pointed out in his government work report that the main work in 2019 included insisting on innovation to lead development and unleash development dynamics. The focus shall be on promoting the high-quality development of the manufacturing industry, strengthening the industrial base and technological innovation capabilities, accelerating the construction of manufacturing powers and improving the integration mechanism of production, education and research with enterprises as the mainstay.

3 Review of China’s equipment manufacturing enterprise innovation network research

With the technological revolution and technological advancement, the production, distribution and use of knowledge and technological innovation are playing an increasingly important role in regional economic development (DICKEN 2014). Along with the deepening of economic globalization and integration, the dominant innovation paradigm has also changed from the traditional closed linear model to the modern open network model. The innovative network, especially the collaborative innovation network types of different regions, the spatial patterns and processes of enterprise innovation activities and the regulation of innovative networks have gradually become one of the frontier scientific issues of economic geography (BATHELT et al. 2018). From the perspective of the history of economic geography, the early location theory and regional econometric models have solved the problem of enterprise location and industrial layout, but have not been able to explain the phenomenon of high-tech enterprises gathering in specific places. More recent concepts stress the unique value of local innovation and development and the institutional and cultural foundations of economic geography. High-tech industrial parks and their location factors have thus become the focus of economic geography, but related studies are often too focused on the description of agglomeration phenomena. Asking for a deeper analysis, the Manchester School (e.g. DICKEN 2014) focuses on the shaping of global production and innovation networks and the passive integration of local governments by multinational corporations. However, it largely ignores the independent innovation activi-

ties of developing countries and their impact on the development of global networks. Evolutionary geographers such as BOSCHMA (2005) point out that more emphasis should be placed on the close integration of time and space, and that insufficient attention is paid to the practice of developing countries. However, despite the weaknesses of conceptual perspectives applied, scholars outside China have achieved remarkable results in the research on innovation networks in equipment manufacturing enterprises, as highlighted by the following examples. MITCHELL (1991) analyzed the evolution of the medical equipment manufacturing industry in the United States from 1954 to 1988 and pointed out that the ways and means of innovation cooperation between academic institutions and enterprises have changed with time. VEUGELERS and CASSIMAN (1999) analyzed the relationship between the size of the Belgian equipment industry and the innovation development strategy and found that large enterprises are better at using internal and external innovation resources, while small enterprises tend to choose a single innovation strategy (independent research or external purchase). WOERTER and ROPER (2010) analyzed the data of Irish and Swiss equipment industry panels and pointed out that domestic and overseas market demand has little impact on corporate innovation, and the characteristics of the company's own attributes are the key to determining the ability of enterprises to innovate. CLAUSS (2012) pointed out that the long-term stable harmonious relationship between German SMEs and suppliers is conducive to innovation, while short-term interim relations are not conducive to innovation. EGBETOKUN (2015) analyzed the innovation performance of Nigerian equipment industry enterprises and pointed out that the open innovation strategy only applies to the initial stage of enterprise development. LIEFNER and ZENG (2016) discuss the foundations, obstacles and prospects of indigenous innovation in China's equipment manufacturing industry. CALIGNANO et al. (2018), taking the Italian Apulian Aerospace Region as an example, emphasize the importance of innovation networks for the development of industrial clusters. There are fewer research results published by Chinese economic geographers on the innovation network of equipment manufacturing enterprises. Most of them have been carried out from the perspectives of industrial clusters, and have analyzed and evaluated industrial network structures, industrial upgrading paths and innovation capabilities. For example, FENG (2009) believes that the equipment industry innovation cluster consists of three core parts: the

core enterprise network, the innovation platform support network and the environmental system network. The core enterprise network mainly includes suppliers, producers and service providers based on industrial chain cooperation. MA AND ZENG (2019), based on the field survey data, analyzed the innovation network of the petroleum equipment manufacturing industry in Dongying City, Shandong Province, and pointed out that Dongying's closed innovation network is mainly controlled by state-owned enterprises. Most important among the internal factors affecting network structure are Chinese government support, Shandong's more conservative local culture, and the relatively remote geographical location of Dongying. WANG et al. (2016) conducted a preliminary study on the cooperation and innovation network of industry, academia and research in China's equipment industry with the help of panel data such as patents, and summarized its network characteristics and its influencing factors. LIN (2016) studied the innovation model of the heavy chemical industry and its spatial organizational change from the perspective of cluster power stratification. XIE and ZHANG (2015) calculated the total factor productivity of the high-tech industry in the nine provinces and two cities of the Yangtze River Economic Belt from 2004-2013 and pointed out that the technological progress is the main driving force for the development of high-tech industries, while the macroeconomic environment, the innovation environment and industrial competition play a supporting role. ZENG (2016) discussed the development history, departmental and spatial structure characteristics and future development prospects of the equipment manufacturing industry in the Yangtze River Economic Belt based on a large amount of literature and data analysis. CAO et al. (2018) used structural equation modeling to discuss the differences, paths and mechanisms of the impact factors of different types of high-tech industries in Shanghai.

4 Prospects for research and this theme issue's contribution

The few selected contributions mentioned above show that economic geographers have examined the types, patterns, processes, mechanisms, effects and regulation of innovation networks of equipment manufacturing enterprises, and have obtained a number of valuable insights. Future research will have to pay more attention to the need for a better theoretical understanding of the de-

velopment of the innovative network of Chinese equipment manufacturing enterprises in the light of global and local, real and virtual, and two-way interaction between developed and developing countries. Such an understanding will have to be based on a multi-faceted analysis of the innovation network of China's equipment manufacturing enterprises that validates and enriches the hypotheses of enterprise innovation network theories based on China's reality and contributes to building China's innovative network space governance model.

The four papers included in this theme issue provide this kind of empirically based contributions, both from Western and from Chinese perspectives. LIEFNER and KROLL (2019) discuss ways to broaden the analytical perspective of comparative regional innovation research and to include factors that have so far seldom been considered. LIN and WANG (2019) analyze the relation between innovation, geographical proximity and network ties with quantitative models. The chapter authored by WANG et al (2019) examines drivers of innovation efficiency, while LYU et al. (2019) broaden the focus towards the integration of overseas partners in innovation strategies and networks.

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