Research on the Development Strategy of China's Intelligent Manufacturing Industry from the Perspective of Patent Analysis

Xiangzhi Zhang, Jinhui Xu, Yuming Chang, Jiaxi Liu

East China Jiaotong University, Nanchang, China

Abstract

Intelligent manufacturing, as a new production method resulting from the deep integration of the new generation of information and communication technology and advanced manufacturing technology, is an important direction of global manufacturing reform, and all major countries in the world have issued support policies for intelligent manufacturing from the height of national strategy. With "Made in China 2025" as the beginning, China has issued a series of intelligent manufacturing development plans, opinions, plans and guidelines from the macro perspective of national development in recent years, and after the rapid development in recent years, China's intelligent manufacturing industry has entered the "key reform period" from the "policy dividend period". "Under this background, it is necessary to give certain suggestions for the development of China's intelligent manufacturing industry by means of patent search and analysis, based on the results of patent information analysis, so as to play the key role of intellectual property rights in the development of China's intelligent manufacturing industry and to promote the high-quality and sustainable development of China's intelligent manufacturing industry.

Keywords

Patent analysis; Intelligent Manufacturing; Development Strategy.

1. Introduction

With the advent of the era of industry 4.0, the global industrial manufacturing industry ushered in the era of intelligent manufacturing. At present, major countries in the world have issued supporting policies for intelligent manufacturing from the height of national strategies (such as Germany's "Industry 4.0" plan, Japan's "New Robot Strategy" plan, the United States's "reindustrialization" plan, India's "Make in India" plan, etc.). Compared with traditional manufacturing industry, intelligent manufacturing industry has the following characteristics: Less human resource costs. Reduce the number of personnel, reduce the proportion of human cost; High flexibility. Real-time dynamic product planning to meet customer needs, to achieve seamless docking of each production link, the whole production process can be monitored, shorten the conversion time of production tasks; disintermediation. P2P customer relationship brings innovation of business model, and the relationship between manufacturing enterprises and customers becomes closer. Regionalization. Reduced economies of scale and decentralized processing capacity allow rapid redefinition of requirements and production processes that are more responsive to customer needs; Quickly and iteratively launch new products. With the widespread use of 3D printing, 3D scanning and new materials, the production of products is becoming more efficient. Because of the advantages mentioned above, intelligent manufacturing technology is widely regarded as the key technology fulcrum to guide the transformation of traditional manufacturing industry in the future, and increasingly become the main battlefield for major countries to compete for the world's industrial leadership. In this context, it is necessary to give some suggestions for the development of China's intelligent manufacturing industry by means of patent retrieval and analysis, so as to better play the key

role of intellectual property rights in the development of China's intelligent manufacturing industry, and promote the high-quality and sustainable development of China's intelligent manufacturing industry.

2. Patent information retrieval and analysis of China's intelligent manufacturing industry

2.1. Retrieval Preparations

The decomposition of patent technology is the primary step for patent information retrieval. According to the Intelligent Manufacturing Development Plan (2016-2020) issued by the Ministry of Industry and Information Technology of China, intelligent manufacturing technology can be divided into intelligent manufacturing equipment technology and intelligent manufacturing integration technology. Including high-grade CNC machine tools and industrial robots, additive manufacturing equipment, intelligent sensing and control equipment, programmable logic controller (PLC) and so on. Based on the results of literature analysis and the general situation of each technical key point and the needs of patent analysis operation, this paper decomposes relevant technologies and makes corresponding technical decompositions table. For specific decompositions, see Table 1. On this basis, this paper uses the patent retrieval and analysis platform of the State Intellectual Property Office to analyze and study the patent application status of China's intelligent manufacturing industry (patent data retrieval period is up to December 31, 2020). The general development trend of the industry, the provinces with more advanced technology development, the distribution of patent technology focus and some important patent applicants were explored.

Table 1. Resolution table of intelligent manufacturing technology

First level technical branch	Secondary technical branch
Intelligent manufacturing equipment technology	Intellectualization of CNC machine tools
	Controller intellectualization
	Robot intelligence
Integrated technology of intelligent manufacturing	Big data technology
	Industrial software

2.2. Total patent technology data of China's intelligent manufacturing industry

In this section, we searched the patent data of five secondary branches of intelligent manufacturing technology through the patent retrieval and analysis platform of the State Intellectual Property Office. As of December 31, 2020, there were 6,374 patent applications in the field of CNC machine intelligence in China. In the field of robot intelligence, China has 2,684 patent applications; In the field of intelligent controller, China has a total of 911 patent

applications; Industrial software and big data technologies received 5,168 and 7,775 patent applications respectively.

2.3. Life cycle analysis of Intelligent manufacturing technology in China

Generally speaking, every technology has four stages: start-up, growth, maturity and decline. In patent analysis, when the number of patent applications and applicants for a certain technology is relatively small, it indicates that the technology at this stage is still in the initial stage of experimental development, and has not been commercialized. When the number of patent applications for the technology increases significantly and the number of applicants increases, it indicates that the technology has entered a stage of steady development. When it is found that the number of patents continues to increase while the number of applicants remains unchanged, it indicates that the technology has entered the full maturity stage. However, when the number of patents remains unchanged and the number of applicants is greatly reduced, it indicates that the technology is in a declining stage. After market elimination, only a few dominant manufacturers survive, the commodity type is fixed and the technology has no progress.

In this section, we searched the patent data of five secondary technology branches of intelligent manufacturing technology through the patent retrieval and analysis platform of the State Intellectual Property Office, and obtained the technology life stage information of Intelligent manufacturing technology in China. Through data analysis, it is found that China's intelligent manufacturing technology is now in the stage of comprehensive development. For example, in the field of intelligent CNC machine tools, only two applicants submitted two patent applications in China in 1985. "Mechanical Position Feedback Hydraulic Low Speed Servo Mechanism" submitted by Changchun Institute of Optics and Fine Mechanics, Chinese Academy of Sciences on April 1, 1985 (application No. CN85101613) and "Improved Color Display in NUMERICAL Control System" submitted by General Electric Company on July 17, 1985 (Application No. CN85105474). In 2020, 1,165 Chinese filed 868 patent applications. In the field of robot intelligence, only one applicant in China submitted one patent application in 1985, namely "Industrial Robot for various Purposes" (application Number CN85109415) submitted by Kuka Welding Equipment and Robot Co., LTD on December 28, 1985. In 2020, 666 patent applicants filed 418 patent applications in China. In addition, the number of patent applicants and the total number of patent applications in China have shown an explosive growth trend in recent years in the three technical branches of industrial software, big data technology and intelligent controller. The above data show that intelligent manufacturing technology has entered a comprehensive development period in China, and new technologies, new products and new formats will continue to emerge.

2.4. Regional analysis of China's intelligent manufacturing technology

In this section, we searched the patent data of five secondary technology branches of intelligent manufacturing technology through the patent retrieval and analysis platform of the State Intellectual Property Office, and obtained the regional distribution of patent applications of intelligent manufacturing technology in China. Through data analysis, it is found that the main source of intelligent manufacturing technology patent applications in China is the eastern provinces and cities with developed economy, and there is a large gap between the eastern and western regions. For example, in the field of intelligent CNC machine tools, as of December 31, 2020, China had a total of 6,374 patent applications, of which Jiangsu province accounted for 13.15%, about equal to the total number of patent applications of Anhui, Shandong, Hubei and Liaoning provinces. Jiangsu, Guangdong, Zhejiang, Shanghai and Beijing contributed nearly half of the total number of patent applications in China. Among the 2,684 patent applications in the field of robot intelligence, Jiangsu, Guangdong, Shanghai and Beijing have a total of 1,038 applications, accounting for 38.69% of the total. In addition, in the total number of patent applications in industrial software, big data technology, intelligent controller and other fields,

the economically developed provinces and cities in eastern China all accounted for a considerable share. This shows that the economically developed eastern provinces and cities are the leading regions of intelligent manufacturing technology in China.

2.5. Analysis of important applicants for patents in China's intelligent manufacturing technology

In this section, through the patent search and analysis platform of the State Intellectual Property Office of China, we will search for patent data on five secondary technical branches of intelligent manufacturing technology, and obtain the distribution of important applicants for intelligent manufacturing technology patents in China. From the data point of view, state-owned enterprises and colleges and universities are the main force in the research and development of China's intelligent manufacturing technology. For example, in the two intelligent manufacturing integration technology sub-fields of big data technology and industrial software, State Grid Corporation of China ranks first in the number of patent applications. Number and proportion of patent applications of this enterprise are: big data technology (90, 1.03%), industrial software (51, 0.88%). But in the two intelligent manufacturing equipment technology sub-fields of robot intelligence and CNC machine tool intelligence, South China University of Technology and Huazhong University of Science and Technology become the leaders in the number of patent applications. Among them, South China University of Technology possess 41 patent applications in the field of robot intelligence, accounting for 1.37% of the total patent applications, and Huazhong University of Science and Technology possess 104 patent applications in the field of CNC machine tool intelligence, accounting for 1.54% of the total number of patent applications. In addition, some private enterprises with strong R&D capabilities have also begun to layout the area of intelligent manufacturing technology patents. For example, in the field of controller intelligence, Huawei Technologies Co., Ltd. ranks first in the number of patent applications with 18 patent applications, accounting for 1.82% of the total number of patent applications.

2.6. Analysis of China's intelligent manufacturing technology distribution and key fields

In this section, through the patent search and analysis platform of the State Intellectual Property Office of China, we will search for the five secondary technology branches of intelligent manufacturing technology, and compare the IPC international patent classification number to obtain the distribution of the technology key fields of China's intelligent manufacturing technology. Through data analysis, it is found that among the five secondary technology branches of intelligent manufacturing technology, big data technology has a total of 5370 patent applications in the G06 (calculation, extrapolation or counting) category, accounting for 69.07% of the total (7775). Indicating that G06 is the main patent layout area of big data technology. Controller intelligence has a total of 278 patent applications in the G05 (control, regulation) category, accounting for 30.51% of the total (911), followed by G06 (calculation, extrapolation or counting) category, with a total of 196 patent applications, accounting for 21.51%. It indicated that the G05 and G06 categories are the main patent layout areas for controller intelligence. The patent layout area of the industrial software technology branch is also dominated by the G05 and G06 categories, accounting for 24.75% and 20.96% of the total number of patent applications (5168), respectively. In the patent layout area of the intelligent branch of robots, B25 (manual tools, lightweight mobility tools, handles of manual instruments, workshop equipment, manipulators) category occupies an absolute advantage, with a total of 1069 patent applications, accounting for the total number of patent applications (2684) 39.83%. In the intelligent branch of CNC machine tools, the patent layout area is concentrated in B23 (machine tools, metalworking) and G05, accounting for 57.88% and 20.24% of the total number of patent applications (6374) respectively.

3. Main problems in the development of China's intelligent manufacturing industry

3.1. The technology research and development started late, and the independent innovation ability is insufficient

China started late in the development of intelligent manufacturing industry. During the 12th Five-Year Plan period, China further clarified the need to accelerate the development of high-end intelligent equipment technology manufacturing industry, and only in recent years did China continue to increase the national financial and support investment in high-end intelligent parts manufacturing and equipment technology research and development. By contrast, The United States, Japan, Germany and other countries have developed intelligent manufacturing technology layout as early as decades ago. A large number of Western information technology enterprises represented by International Business Machines Corporation (IBM) now firmly occupy the technological advantage of the international intelligent manufacturing industry. The late start of the research and development of intelligent manufacturing technology directly leads to the current intelligent manufacturing equipment industry in China although it has made great development and progress, but there is still a great distance from the intelligent equipment manufacturing industry. In addition, in the world, China's low-end intelligent manufacturing equipment technology has great advantage, but in the middle and high end manufacturing equipment industry and high-end core technology, intelligent manufacture equipment industry in China is still highly dependent on foreign high-end core key technology, lack of independent innovation ability and the core key technology research and development capabilities. Compared with the United States, Germany, Japan and other countries, the overall competitiveness and technological level of China's intelligent manufacturing and equipment R&D industry is relatively backward, and the prices of important technologies and key components are heavily dependent on foreign imports. At the same time, the comprehensive performance and operation stability of the products produced by China's intelligent manufacturing equipment industry are not high, which is not conducive to the intelligent and advanced of China's intelligent manufacturing equipment industry, nor is it conducive to the healthy development of China's intelligent manufacturing equipment industry. The reason is largely due to the lack of internal independent innovation ability in China's intelligent manufacturing industry, which can easily lead to excessive dependence on external technology, resulting in a vicious circle.

3.2. Social supporting services still need to be improved, and innovative achievements are difficult to be applied

At present, China's intelligent manufacturing field of social supporting services can not meet the needs of industrial upgrading enterprises has become one of the core problems restricting the development of China's intelligent manufacturing industry. With the continuous improvement of their business and strength, many Chinese intelligent manufacturing enterprises are in urgent need of a set of systematic intelligent manufacturing solutions tailored for their own development needs. However, in the current Chinese market, the number of such service providers is small and their capabilities are uneven. In the face of various needs of different industries, these suppliers are difficult to provide personalized and customized intelligent manufacturing system solutions, leading to failure to meet market demand. On the other hand, due to the lack of sufficient platform for verifying innovation achievements and the incomplete industrial innovation service system in China, the achievements developed by various innovation subjects cannot be fully commercialized and applied in industry. Even if a small part of the innovative achievements have been promoted and applied to a certain extent, it is difficult to produce satisfactory results.

3.3. The talent introduction and education system is still to be improved, and there is a lack of high-end compound talents

At present, although China's intelligent manufacturing industry shows a trend of rapid development, but the talent introduction and cultivation system of related industries is still very imperfect. On the one hand, China lacks a perfect policy system for the introduction of high-end talents in the intelligent manufacturing industry. Although some regions have carried out the introduction of high-end talents, the lack of policy guidance leads to the lack of flexibility and standardization of work, and it is difficult to be implemented in the long term. on the other hand, China's institutions of higher learning and scientific research units for the talent cultivation of intelligent manufacturing industry still exists some shortage, institutes in colleges and universities cultivate a number of intelligent manufacturing equipment industry personnel often due to the scientific research colleges and universities did not set up the mechanism of university-enterprise cooperation and lack of exercise, the theory and practice can't together, For the development of intelligent manufacturing equipment industry elite talent adverse. The above two reasons jointly lead to the lack of complex high-end talents in China's intelligent manufacturing industry, which greatly affects the talent supply capacity of China's intelligent manufacturing industry. Therefore, China is in urgent need of establishing a sound talent induction and education mechanism in the field of intelligent manufacturing industry.

4. Suggestions on the development of China's intelligent manufacturing industry from the perspective of patent analysis

4.1. Increase investment in technology research and development to promote the upgrading of traditional industries

Judging from the results of the life cycle analysis of China's intelligent manufacturing technology, China's intelligent manufacturing technology is at a stage of comprehensive development. New technologies, new products and new business formats will continue to emerge. Especially in recent years, the number of patent applicants and patent applications for intelligent manufacturing technology has shown explosive growth. Major universities and colleges, state-owned and private enterprises have vigorously carried out research and development of intelligent manufacturing technology, showing a special attention to intelligent manufacturing technology. With the changes in the economic development pattern and the requirements for high-quality economic development, China urgently needs to transform and upgrade its traditional industries. This requires increased investment in technology research and development at the strategic level for intelligent manufacturing technologies. Especially in the key areas of patented technology development. It also requires technology to catch up and even lead in the key development stage of intelligent manufacturing technology. And promote the transformation and upgrading of China's traditional industries and achieve the goal of high-quality economic development in China.

4.2. Strengthen domestic technology exchanges and optimize regional technology distribution

From the data of patent applicants of China's intelligent manufacturing technology, state-owned enterprises and major universities and colleges are the main force in the research and development of intelligent manufacturing technology, with strong technology research and development strength and high patent holdings. However, from the perspective of the overall social and economic structure, small and medium-sized enterprises lacking sufficient R&D capabilities are often the main technology demanders in the market. The mismatch between the supply side and the demand side of technology has led to a large number of idle patents in major state-owned enterprises and colleges and universities. Therefore, it is necessary for

China to optimize the technology distribution pattern of domestic intelligent manufacturing from a strategic perspective. First, the government should prompt the formation of regional intelligent manufacturing intellectual property alliances, build a regional intelligent manufacturing patent pool, awaken a large number of "sleeping patents" from large domestic state-owned enterprises and colleges and universities, and meet the technical needs of the development of domestic small and medium-sized enterprises. The second is to advocate industry-university-research cooperation. On the one hand, colleges and universities should make rational use of scientific research advantages, follow the basic principles of market guidance, actively implement national and local policies, coordinate the funding and income distribution system, and stimulate the enthusiasm of scientific and technical personnel for intellectual property creation. On the other hand, it is necessary to encourage scientific workers to establish pragmatic scientific and technological values, make scientific research fit the actual situation of China's intelligent manufacturing industry, make technology research and development adhere to the "utility" standard, and guide scientific and technological workers to devote themselves to practical innovations. In-depth exploration of the development needs of the intelligent manufacturing industry, and the application of scientific and technological achievements to the practice of China's intelligent manufacturing industry. Finally, universities and institutes with strong R&D capabilities should be encouraged to connect with industry entities, and focus on key industrial technology research and development according to the actual technological needs of industrial development, so as to realize the efficient use of R&D human and material resources and meet the actual needs of industrial development.

In addition, from the perspective of the horizontal comparison of China's provinces, the eastern economically developed provinces and cities, such as Zhejiang, Guangdong, Jiangsu, etc., are the technological leaders in China's intelligent manufacturing technology. The technological imbalance between the eastern and western regions also will continue for a long time. Therefore, it is necessary to give full play to the advantages of overall policy planning and layout with Chinese characteristics, and timely carry out intelligent manufacturing technology exchanges and cooperation between developing and developed provinces. Optimize the regional technology distribution pattern of China's intelligent manufacturing industry through multiple means such as regional technical exchanges and cooperation. Fully integrate the technology research and development resources of various provinces and cities to promote the development of China's intelligent manufacturing industry.

4.3. Identify key technical directions and efficiently use R&D resources

China is a late-developing country in intelligent manufacturing technology, and there is a certain gap in the accumulation of advanced technology research and development with the United States, Germany and other pioneering countries. Therefore, if China wants to achieve the goal of technology catching up and even leading, it is bound to find the current technological research and development focus of intelligent manufacturing technology, and make a reasonable tilt of research and development investment in the key direction of intelligent manufacturing technology. For example, from the analysis results of the focus of intelligent manufacturing technology, in the big data technology branch of intelligent manufacturing technology, the G06F (electric digital data processing) subcategory is the main distribution area of patent applications. It shows that the data processing sector is the main research and development direction of the big data technology branch at present. Data processing technology is also a key research and development direction of large investment and high output in the branch of big data technology. Therefore, it is necessary to give a certain degree of tilt in terms of R&D investment.

5. Conclusion

With the advent of Industry 4.0 era, the global industrial manufacturing industry has ushered in the era of intelligent manufacturing. Compared with the traditional manufacturing industry, the advantages of intelligent manufacturing technology, such as dehumanization, less human resource costs and high flexibility, make it increasingly become a key technology tuyere to guide the transformation and upgrading of the traditional manufacturing industry, and is becoming the main battlefield of major countries to compete for the world's industrial leadership.Under the background that China's intelligent manufacturing industry has entered the "key reform period" from the "policy dividend period", it is even more necessary to give full play to the role of intellectual property rights as the key innovation guarantee in the development of China's intelligent manufacturing industry, and encourage the use of patent navigation and other means to promote the high-quality and sustainable development of China's intelligent manufacturing industry.

Acknowledgements

References

[1] Wang Dexian, Wang Yuesheng. Japan in the development of intelligent manufacturing experience and the enlightenment to China [J]. Journal of tax and economy, 2019 (01) : 20 to 24.

[2] Yin Hua, YU Hao, Xie Qing. Research on intelligent Transformation and upgrading of Manufacturing enterprises based on value chain optimization [J]. China Science and Technology Forum, 2021(03):113-122.

[3] Yu Bo, Pan Aimin. China's Intelligent manufacture equipment industry international competitiveness and promoting the mechanism study [J]. Journal of xiangtan university (philosophy and social sciences edition), 2021, (4) : 74-79.

[4] Guo Jin. Research on Path Selection of Traditional Manufacturing Enterprises towards Intelligence [J]. Journal of Humanities,2021(06):69-78.

[5] Wu Wangyan, LIU Junyu. Intelligent manufacture promote transformation and upgrading of Chinese industrial mechanism and path of research [J]. Journal of xi 'an university of finance and economics, 2020 (3) : 19 to 26.

[6] Liu Shuchun, Lin Hanchuan. Strategic countermeasures of internationalization of manufacturing standards in China [J]. Macro quality research,2020,8(06):80-95.

[7] Zhu Ya. Research on logic and Strategy of Intelligent Manufacturing driving Traditional Industry transformation and Upgrading [J]. Social sciences of henan,2019,27(12):61-66.