

Development Practice and Breakthrough Path of China's Intelligent Manufacturing

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Abstract: Intelligent manufacturing has become an unavoidable developmental trend in modern manufacturing and is the primary focus of the China Manufacturing 2025 Strategy. Moreover, it is the only method for China's manufacturing industry to go from large to strong. Investigating intelligent manufacturing breakthrough paths is critical for fostering the high-quality development of China's manufacturing industry and accelerating industrial transformation. It is also necessary to practice the "four orientations." In this paper, we investigated the development methods of intelligent manufacturing in China and summarize its essential characteristics based on strategic layout, pilot demonstration, industrial agglomeration, and stage determination. We also investigate the problems that exist in the development process. Currently, some of the standards, policies, technologies, talents, finance, and taxation for intelligent manufacturing cannot meet the developmental requirements of the new era. During the 14th Five-Year Plan period, targeted efforts focused on policy standards, core technologies, and supporting elements are required to foster high-quality growth of intelligent manufacturing. Specifically, China should strengthen its top-level design to improve its policy and standards system, optimize its strategic layout to achieve breakthroughs in core technologies, and improve the institutional guarantee and support of key elements.

Keywords: intelligent manufacturing; policy standards; core technologies; supporting elements; breakthrough path; high-quality development

1 Introduction

A new round of scientific and technological revolution and industrial reform is underway, and intelligent manufacturing has emerged as an unavoidable trend in the modern manufacturing development. The proposal of the Industry 4.0 plan is not only a sign of the prosperity of intelligent manufacturing but also an essential reference for China to comprehensively promote intelligent manufacturing [1]. China places a high premium on China Manufacturing 2025 and has issued major policy documents, such as *China Manufacturing 2025*, *Guiding Opinions of the State Council on Actively Promoting the Internet Plus Action*, and the *Intelligent Manufacturing Development Plan (2016–2020)*, highlighting that China's manufacturing industry is progressing toward intelligent manufacturing [2]. Furthermore, state and local governments have intensively issued relevant supporting policies to explicitly support the development of intelligent manufacturing, which has advanced to a new stage of development.

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Notably, patterns of labor division in the international manufacturing sector are experiencing profound modification, and the unpredictable and unstable variables of China's manufacturing industry's internal and external development environments are gradually rising. The deployment of intelligent manufacturing in China has been hampered by severe international rivalry and the emergence of trade protectionism[3]. In the new era, a clear understanding of these issues is critical to continuously promote the high-quality development of intelligent manufacturing. Therefore, based on a multi-dimensional perspective of intelligent manufacturing practice in China, this paper summarizes the basic characteristics, analyzes the problems faced, and identifies the key points to provide a theoretical reference for the medium- and long-term development of intelligent manufacturing in China.

2 Development practice of intelligent manufacturing in China

2.1 Gradual improvement in strategic layout

The *Intelligent Manufacturing Development Plan (2016–2020)* provides substantial support for the rapid development of intelligent manufacturing in China. Subsequently, the *High-End Intelligent Re-manufacturing Action Plan (2018–2020)* and the *Guidelines for the Construction of National Intelligent Manufacturing Standards System (2018)* were successively released, elucidating the key directions and development areas of intelligent manufacturing. Currently, China's framework for intelligent manufacturing is taking shape. In synchronization with regional development, all regions of China have established provincial action plans, such as the *Guangdong Intelligent Manufacturing Development Plan (2015–2025)* and *Tianjin Special Action Plan for Intelligent Manufacturing*. With the implementation of several enabling policies, intelligent manufacturing has become a crucial means of promoting industrial transformation and constructing and modernizing a robust manufacturing province across the nation [4].

2.2 Comprehensive coverage of pilot demonstration projects

To further promote China Manufacturing 2025, beginning in 2015, the Ministry of Industry and Information Technology launched a special action for a nationwide pilot demonstration of intelligent manufacturing, with a focus on five intelligent manufacturing modes: discrete, process, network collaboration, mass customization, and remote operation and maintenance services, and comprehensively evaluated relevant enterprises. By the end of the year 2020, 305 national pilot demonstration projects involving 92 industries were selected. The leading units of the project were predominantly industry leaders with extensive industrial chains and strong driving forces dispersed across the nation [5].

From 2015 to 2018, the number of national intelligent manufacturing enterprise pilot demonstration projects was 46, 63, 97, and 99, for a total of 233 enterprises, far surpassing the 2015 goal of cultivating 100 intelligent manufacturing pilot demonstration projects during the 13th Five-Year Plan. Regionally, intelligent manufacturing pilot demonstration projects are distributed across 31 provinces and cities, with concentrations in the Yangtze River Delta, the Pearl River Delta, and the Bohai Rim. Among them, the 18 pilot demonstration projects in Shandong, Zhejiang, Guangdong, Jiangsu, and Anhui have accomplished remarkable achievements, with 18 projects in total. Hainan, Jilin, Qinghai, and Tibet have the least number of projects, and the number of projects is 1 (Fig.1).

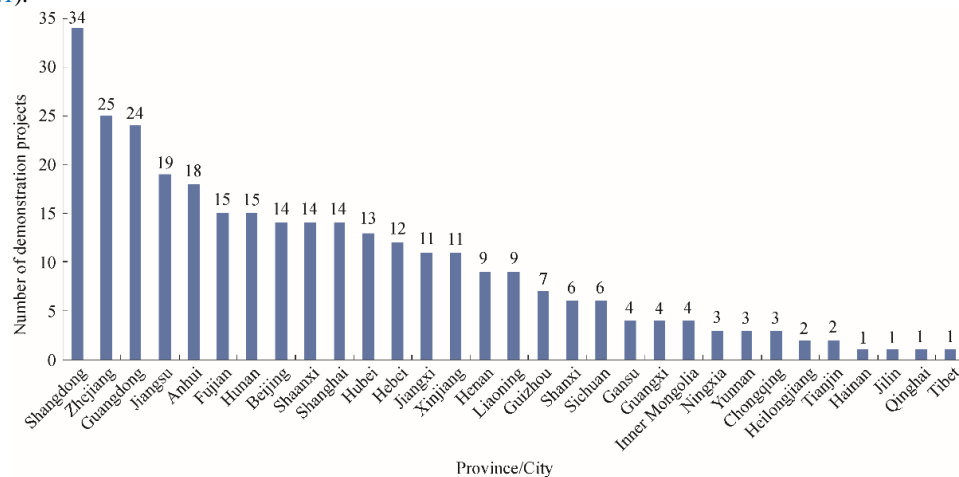


Fig.1. Distribution of intelligent manufacturing pilot demonstration projects in China (2015–2018)

2.3 Preliminary formation of four major industrial clusters

After more than four decades of reform and opening-up, China's manufacturing supply factors have undergone seismic shifts. Developed coastal areas are facing the constraints of labor, energy, land, and other factors, developed coastal areas are urgently required to develop intelligent manufacturing. Driven by a series of policies, a large number of production factors are concentrated in the field of intelligent manufacturing, with the intelligent manufacturing industry in the eastern region taking the lead. Overall, China initially formed a distinctive "3+1" industrial cluster.

Universities and scientific research institutions around the Bohai Rim are relatively concentrated, with outstanding scientific research strength. Relying on the advantages of regional and human resources, the Bohai Rim initially formed an industrial pattern of one core and two wings. For example, Beijing has gathered various production factors, such as talent, technology, and capital, and has outstanding advantages in the direction of industrial Internet and intelligent manufacturing service software [6].

The Yangtze River Delta is not only one of the regions with the most active economic development and the strongest innovation ability in China but is also an important advanced manufacturing base in China. Shanghai, Jiangsu, Zhejiang, and Anhui—one city and three provinces—each promoted their respective strengths and developed in a staggered manner, fostering several industrial clusters with outstanding advantages, synergy, and complementarity, and the development of the intelligent manufacturing industry is relatively balanced. For example, as a strong industrial province, Jiangsu has fully integrated advanced industrial design concepts in China and abroad and has accelerated the creation of a new business card for equipment manufacturing. As an emerging industrial province relying on China Sound Valley, Anhui has gathered nearly 1000 characteristic enterprises such as iFLYTEK Co., Ltd. and Anhui Huami Information Technology Co., Ltd. to actively build a world-class artificial intelligence base.

As an important manufacturing base in China, the Pearl River Delta has a first-mover advantage in promoting the intelligent transformation of the manufacturing industry as a significant manufacturing hub in China. With the emergence of well-known intelligent manufacturing enterprises in recent years, the Pearl River Delta has actively promoted the integrated development of automation and information technology. Additionally, it has drawn major domestic and international corporations to open branches in the area [7]. Guangzhou for example, created a core area for the development of robotics and intelligent equipment industries. Based on the industry's comparative advantages, Shenzhen created an innovative service base for wearable devices.

In the central and western regions, including Hubei, Shaanxi, Sichuan, and other major provinces, intelligent manufacturing is still at the automation level, and the overall development level lags behind the eastern region. Since the implementation of the 13th Five-Year Plan, the central and western regions have taken advantage of historical development opportunities. Leveraging universities and scientific research organizations like Huazhong University of Science and Technology and Xi'an Institute of Optics and Precision Machinery of Chinese Academy of Sciences, they focused on building the laser industry, and accelerated the development of key core parts industry with distinctive characteristics. The intelligent manufacturing industry in the central and western regions is in an accelerated rising stage.

2.4 Initial development of comprehensive capacities

China's intelligent manufacturing sector has gained the necessary experience and produced positive results after five years of rapid development. The national intelligent manufacturing capability assessment, which involved more than 12 000 intelligent manufacturing enterprises, was completed by the China Institute of Electronic Technology Standardization in 2020 [8], but despite the improvement, it is still in its early stages with 75% of the enterprises still operating at level I, 14% operating at level II, and 6% operating at level III, and only 5% were at levels IV and V of high maturity.

From the perspective of industry maturity, discrete manufacturing is slightly more mature than process manufacturing. Products in the discrete manufacturing industry are usually assembled from multiple parts after processing, and the processing procedures are discrete and discontinuous. Discrete industries, such as automobiles and electrical appliances have carried out a lot of exploration and practice in the process of digital transformation to networking and intelligence, and intelligence maturity is relatively high. Process manufacturing, such as oil refining and cement, has a good foundation in process management, but the improvement of intelligence is

relatively slow. Fig. 2 shows the distribution of the top 10 sub-industries with intelligent manufacturing maturity in China.

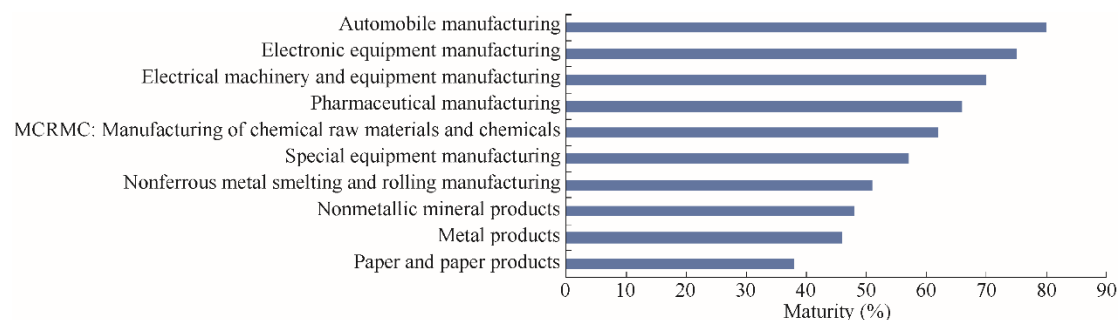


Fig.2. Sub-industries with Top 10 maturity within the intelligent manufacturing industry (2020).

3 Problems faced by the development of intelligent manufacturing in China

3.1 Construction of policy standards system

To advance intelligent manufacturing, policy support and direction are essential. In addition to fostering an environment that supports innovation and the growth of intelligent manufacturing, establishing a sound policy framework helps assist traditional businesses in implementing transformation and upgrading with the aid of intelligent manufacturing technology. Several policies and initiatives to support the growth of intelligent manufacturing in China has had some success, but they have not yet reached their full potential.

First, the gap is primarily seen in the inconsistency of industrial policies. Intelligent manufacturing is a complex and systematic project that involves a long industrial chain and typically spans multiple industries. China is currently concentrating on three areas for the development of intelligent manufacturing: intelligent manufacturing technology, intelligent manufacturing equipment, and intelligent production. However, there needs to be more focus on intelligent management, intelligent services, and intelligent product design, and policy coverage needs to be increased. Many national departments have released regulations to aid in the growth of the intelligent manufacturing sector. For instance, the National Development and Reform Commission has formulated strategic plans for new-generation information technology, high-end manufacturing, and other emerging industries, the Ministry of Industry and Information Technology has led the manufacturing innovation system and policies, the Ministry of Science and Technology was responsible for scientific and technological innovation policies, and the Ministry of Commerce took the lead in establishing the International Cooperation Committee for Intelligent Manufacturing Industry. However, relevant departments pay different attention to different links and industries, which makes it difficult to form a unified, complete, and coordinated policy system that can impact the overall function and implementation effect of the policy.

Second, the current system of standards is not perfect. Industry standards serve as both a catalyst for intelligent manufacturing innovation and a critical tool for major corporations to gain the upper hand in their respective industries. China has long been at the bottom of the global industrial value chain and has little influence or voice in matters regarding industrial manufacturing standards. For instance, the application standards of the Internet of Things in China are not perfect, resulting in equipment incompatibility. The different information systems within many enterprises cannot be integrated. Cross-platform and cross-system integrated applications between enterprises cannot achieve seamless docking, and enterprises sometimes even need to re-establish platforms or systems. Additionally, the top-level framework design for intelligent manufacturing has been completed in significantly developed nations [9], including RAMI4.0 of the German Industry 4.0, and IIRA1.8 of the Industrial Internet of Things of the United States' Industrial Internet of Things. China released the *Industrial Internet System Architecture V1.0* in 2016. However, compared with manufacturing powers, due to the lack of a higher-level system architecture framework, the released architecture is too specific and difficult to expand.

3.2 Key core technical issues

China, as the world's largest manufacturing country, has a complete industrial system; yet, intelligent manufacturing development is still in its early stages, and vital core technology lags far behind the world's manufacturing powers.

First, its fundamental core capability is lacking. Basic research is the wellspring of cutting-edge innovation and development, and it is critical to encouraging the high-quality development of intelligent manufacturing. Although China continues to engage in basic research, its ability to innovate remains limited, and the inadequacies of basic research are visible. The gap between domestic firms' core technology and the world's sophisticated technology has not closed, and some key items (such as measurement and control devices, instruments, sensors, and high-end CNC systems) continue to be imported. Simultaneously, the basic domestic materials structure involved in intelligent manufacturing is irrational, the low-end supply is excessive, the high-end supply is insufficient, and the problem of "not available with good materials" is apparent. The key strategic materials are controlled by other countries, have poor performance stability, and cannot be applied to major equipment in crucial fields; cutting-edge new materials must be developed, the majority of which are in the laboratory research stage, and application and transformation are difficult. During the 13th Five-Year Plan period, China's import rate of essential new materials reached 86%, while self-sufficiency was only 14 %. Domestic industrial robots' major parts and components are still 5 to 10 years behind the world's advanced level [10].

Second, the inadequacies of integrated circuits are readily apparent. China's integrated circuit industry is new and has a shaky base. With rising competition in the international market, its future development faces significant obstacles. For a long time, domestic semiconductor enterprises have adopted follow-up strategies in technology research and development (R&D), and the original innovation power and investment are insufficient, which makes it difficult for products to enter from the low-end market to the medium- and high-end markets and the improvement of brand effect and product reputation is slow. Simultaneously, the domestic integrated circuit industry chain's upstream and downstream coordination is weak. A reasonable division of labor system led by large organizations, supported by small- and medium-sized businesses, enterprise alliances, and an internationally competitive industrial ecosystem must be developed as soon as possible. There are currently no super semiconductor firms in China capable of effectively integrating software, hardware, application services, and other industrial chain linkages. Furthermore, the lack of integrated chips has become increasingly noticeable. Currently, the manufacturing and industrial applications of local chips are becoming tighter, which is not beneficial to China's industrial and consumer electronics firms expanding their market scale. Given the high complexity of integrated circuit manufacturing technology and equipment, it is difficult for China to tackle key problems independently in the direction of lithography machines, high-end ion implantation machines, and photoresists. Therefore, it is difficult to change the situation in which the development of an industry is restricted by others in the short term.

Third, industrial software is lacking. Industrial software is the "fusion agent" of information and industry, and it is widely employed in all stages of intelligent manufacturing. China's industrial software has some technological R&D and service support capabilities; nonetheless, overcoming the development conundrum of weak foundations and demanding applications remains difficult. (1) The supply and demand combination was not tight. Most domestic industrial software is standardized and general-purpose, lacks experience in product customization and new product creation, and cannot fulfill the needs of complicated and changing industrial businesses and scenarios. (2) The competitiveness of businesses is low. Domestic industrial software enterprises are generally small in scale and weak in competitiveness, and domestic industrial software is concentrated in business management and other types with low thresholds. primarily medium- and low-end management software (enterprise resource planning, supply chain management, etc.), while medium- and high-end software such as R&D and design software (computer-aided design, computer-aided engineering, etc.) and engineering software (manufacturing execution control, data acquisition and monitoring control, etc.) rely more on imports, and the problem of "hollowing out" of industrial data is more prominent. (3) Industrial value chains are flawed. Due to the immature market environment and gaps in key technologies, China's industrial software industry chain lacks high-tech and high-value-added service providers; in emerging industries such as industrial big data platforms and overall industrial digital solutions, China has not yet carried out strategic planning and precise layout.

3.3 Key supporting elements

The advancement of intelligent manufacturing is the outcome of collaborative efforts and the complete promotion of numerous supporting variables. Key supporting aspects should suit the needs of this new era's rapid development of intelligent manufacturing. However, other issues make the tremendous leap forward more challenging.

First, employee security is limited. In comparison to traditional manufacturing, the requirement for high-quality professionals in the sector of intelligent manufacturing is more pressing, necessitating complex talents with a diverse set of knowledge and abilities. At present, the quantity and quality of intelligent manufacturing personnel in China are seriously lacking, and talent training is lagging, making it difficult to meet the needs of intelligent manufacturing development in the new era. According to statistics from the Ministry of Human Resources and Social Security, the demand for personnel in the field of intelligent manufacturing in China was 7.5 million in 2020, and the gap will be 3 million. The talent gap is anticipated to reach 4.5 million by 2025 [11].

Second, there are limits on innovation investments. Although China's innovation investment is increasing, and the proportion of overall social R&D investment in GDP has risen to 2.4% by 2020, there is still a significant disparity with industrialized countries. On the whole, the proportion of R&D investment by leading enterprises is low, and their leading role in intelligent transformation is not strong; small- and medium-sized enterprises are restricted by capital, technology, talents, and other factors, and are unwilling to develop and innovate with high costs and risks.

Third, the application of big data faces certain constraints. Industrial big data drive is the core element of intelligent manufacturing. A big data-embedded manufacturing system fosters a data-driven mindset, improves the manufacturing process, and optimizes decision-making mechanisms. Currently, the general level of big data applications in intelligent manufacturing in China is low, as evidenced by the two factors listed below. (1) Big data collection is insufficient and superficial. During the 13th Five-Year Plan era, for example, the digitization rate of China's enterprise equipment reached 50%, but only 23% completed equipment networking and data collecting. As a result, the integrity and effectiveness of data collection cannot be completely assured [12]; some enterprises ignore the importance of data development, a large number of data are shelved, and the data value cannot be fully transformed in time. (2) Big data protection rules are not flawless, and consumer and commercial information security face significant hurdles. From the standpoint of customers, as the customer-to-manufacturer model becomes more common, a great amount of interactive data between consumers and firms will be generated. If this information is leaked, criminals may utilize big data analysis to create user profiles, perform targeted marketing, and even target consumers for fraud. From the perspective of enterprises, with the digitization, networking, and intelligence of manufacturing assets and equipment, enterprise strategy, product design, and intellectual property data are all potential sources of leakage, which are very easy to attack.

Fourth, financial and tax supplies are limited. To give strong assurance of high-quality industrial growth, financial, fiscal, and tax policies should be harmonized with national strategies. China's financial, fiscal, and tax policies supporting the growth of the intelligent manufacturing industry have two major flaws. (1) It is difficult for businesses to acquire financial assistance. Bank loans are still the main source of enterprise financing; however, overall, bank interest rates are relatively high, and there are few financial products in line with the characteristics of intelligent manufacturing enterprises. (2) Compared to the development of intelligent manufacturing in the new era, some of the existing fiscal, taxation, and financial policies are lagging, which cannot meet the development needs of the times and should be improved in time. For example, more and more businesses are already establishing online incubators and collaborating on the design of intelligent products. However, due to the favorable policies of science and technology incubators, the space granted to incubators should be 75% or greater, preventing online design platforms from benefiting from preferential policies [13]. Online fault diagnosis, remote operation and maintenance, and other customer service methods have emerged as intelligent manufacturing development trends. However, they still cannot enjoy preferential treatment equivalent to industrial electricity, water, gas, and heat.

4 Breakthrough paths for intelligent manufacturing in China

4.1 Strengthening top-level design and improving policy standards system

Intelligent manufacturing is the major focus for advancing a manufacturing power strategy. Improving industrial support policy, strengthening the policy guiding framework, and promoting strategy implementation are all important.

First and foremost, the policy's coverage should be broadened. Intelligent management and services are of high added value to the intelligent manufacturing industry chain, according to the intelligent manufacturing smile curve and the development experience of industrialized countries. As international intelligent manufacturing competition heats up, China should learn from developed countries' successful experiences, make forward-thinking plans from

multiple fields, support relevant policies from the perspective of the intelligent manufacturing industry integration system, and improve the policy system covering the entire lifecycle of the intelligent manufacturing industry chain as soon as possible.

Second, the systems of innovation policy must be enhanced. Intelligent manufacturing encompasses numerous management divisions and spans various fields and businesses. It is recommended that the Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, and the Ministry of Commerce integrate their innovation guidance functions and build an innovation policy system led by industry regulators and dominated by enterprises. Simultaneously, the coordination mechanism between various management departments should be improved to encourage the formation of joint forces among the central government, local governments, and enterprises. Based on the different resource endowments and industrial technological advantages in different regions, the development of the intelligent manufacturing industry should be reasonably arranged to avoid homogenization and vicious competition.

Third, the standards system should be improved. Standards for intelligent manufacturing architecture, technology implementation, and application structure should be formulated, and enterprises and scientific research institutes in equipment manufacturing, communication equipment, industrial automation, industrial software development, and integration should be encouraged to jointly participate in the top-level design of standards to effectively solve the problems of openness and compatibility of standards. According to the *Guidelines for the Construction of a National Intelligent Manufacturing Standards System*, building a dynamic update mechanism for the standards system, and establishing an intelligent manufacturing standards system with advanced and efficient characteristics that meet the needs of industrial development is necessary.

4.2 Strengthening strategic layout by developing key core technologies

The fundamental objective for China to achieve high-quality development of intelligent manufacturing during the 14th Five-Year Plan period will be to break through the bottleneck limits of key core technologies.

First, a robust industrial foundation should be constructed. Using the industrial chain as a guide, we aspire to strengthen the independent R&D for the industry's "five bases" (basic materials, basic parts, basic processes, basic equipment, and basic software), and to continually improve the essential basic capabilities of intelligent production. We will actively plan strategic emerging fields and seize the new highlands of intelligent manufacturing technology innovation, such as increasing investment in basic and subversive technology research; deepening the basic research direction of intelligent science, such as cognitive science, neural computing, artificial intelligence, and bionic manufacturing; and promoting the deep integration and development of manufacturing and information technology in intelligent manufacturing.

Second, the strategic plan should be improved. The focus should be placed on key core technologies and the iterative upgrading of technology and industry through policy guidance and market traction. For example, strategic preparations for the localization of lithography machines and photoresists should be developed, and high-end national resources should be concentrated to develop numerous critical core technologies. It is necessary to give full play to the breakthrough leading role of major engineering projects; promote scientific research institutions, universities, and enterprises to jointly tackle bottleneck-oriented technologies; and promote upstream and downstream linkage cooperation between the industrial and innovation chains. It is also necessary to exploit the competitive advantages of leading enterprises; unite domestic and foreign universities, multinational corporations, and scientific research institutions to form a production–university–research–application cooperation mechanism with complementary advantages and benefit sharing; and establish an industrial innovation platform and a scientific research innovation alliance.

Finally, industrial software should be created. Given China's current development and weaknesses in the industrial software industry, fiscal and taxation policies, talent training, intellectual property protection, industrial service systems, and software trade should be implemented to accelerate the systematic development of China's industrial software. Industrial software enterprises should establish a technical exchange and demand platform with manufacturing enterprises in the form of alliances and forums, jointly develop industrial software, and continuously improve product customization and secondary development. It is necessary to strengthen the R&D and promotion of new industrial software, accelerate the construction of fifth-generation mobile communication (5G) application software development and service platforms, and improve the level of 5G innovation and applications in China.

4.3 Improving system guarantee and strengthening support of key elements

The advancement of intelligent manufacturing is inextricably linked to the support and assurance provided by these aspects. It is necessary to vigorously promote the innovation of systems and mechanisms to remove obstacles to the high-quality development of intelligent manufacturing.

First, we optimize the structure of talent supply. We will carry out precise talent recruitment around the world, actively explore the flexible way of talent introduction, and attract overseas high-end talents to return. It is necessary to create a talent pool of intelligent manufacturing scientific researchers at the national and provincial levels, with a focus on reserving talent in critical disciplines such as the 5G Internet of Things, human-machine collaboration, artificial intelligence, intelligent sensing, and precision manufacturing. The construction of intelligent manufacturing disciplines in higher education institutions and vocational schools should be promoted at different levels to cultivate more professional talents for enterprises and scientific research institutes.

Second, the innovation-driven systems must be upgraded. Governments at all levels should place a premium on the strategic importance of intelligent manufacturing innovation and continuously boost R&D investment as a percentage of GDP. It is necessary to integrate the production-university-research-application element resources, continue scientific and technological innovation cooperation and exchanges, break down innovation barriers between industries and enterprises, and promote collaborative innovation in the upstream and downstream of the regional and industrial chain. It is also necessary to cultivate collaborative innovation bases for intelligent manufacturing; assist various enterprises in establishing R&D platforms such as innovation centers, technology centers, and industrial design centers; and promote the implementation of major scientific and technological innovation and breakthrough projects. Focusing on key directions, intelligent manufacturing pilot projects should be promoted to highlight the guiding role of leading enterprises in industry innovation.

Third, we adopted a big data-driven strategy: establish a big data management system that covers the entire lifecycle of big data for all links of manufacturing big data collection, processing, storage, and analysis; optimize statistical means, analysis methods, and backtracking mechanisms; strive for full coverage of manufacturing big data collection, full process monitoring, and zero defects in quality. Cutting-edge big-data mining technology should be used to perform a thorough study of big-data manufacturing and develop important applications and products to fulfill market demand. Big data brokerage and big data technology businesses can be established to provide professional services such as consulting, appraisal, transfer, and rights protection for the transformation and application of big data in the manufacturing industry. Further, it is necessary to improve the relevant legal guarantee system, clarify the development priorities and strategic objectives of manufacturing big data, and strengthen the privacy protection of data collection and processing on the premise of ensuring applications, reasonably limit the scope of user data analysis and result sharing methods, and establish and improve the prevention and control system that covers pre-, during, and post-event risks. It is also necessary to strengthen the punishment for abuse, misappropriation, and infringement of personal and enterprise information, and provide legal guarantees for manufacturing enterprises to carry out intelligent manufacturing applications, transformations, and upgrades using the internet, big data, cloud computing, and other technologies.

Fourth, fiscal, tax, and financial support should be strengthened. (1) Financial support should be increased. We need to increase financial assistance for intelligent manufacturing enterprise projects, direct the government and intelligent manufacturing companies in deep capital and technological cooperation, and develop China's intelligent manufacturing industry ecosystem. (2) Preferential tax policies are needed. Intelligent manufacturing mode innovation should be incorporated into the scope of enterprise value-added tax deduction so that intelligent manufacturing enterprises can reap policy. Given the new economy in the field of intelligent manufacturing, the taxation system should be standardized, and preferential tax policies should be implemented to ensure the healthy development of new intelligent manufacturing models and formats. (3) Financial products should be innovated. Financial institutions should be encouraged to add products and businesses that meet the characteristics and needs of intelligent manufacturing under the premise of laws and regulations, and the innovation and application promotion of intelligent manufacturing modes should be promoted. It is necessary to support venture capital angel funds to invest in intelligent manufacturing enterprises, and alleviate the capital constraints faced by enterprises participating in market competition and maintaining development and growth.

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