Исследование инноваций в условиях цифровой трансформации обрабатывающей промышленности России и Китая в эпоху цифровой экономики

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Аннотация

В эпоху цифровой экономики обрабатывающая промышленность Китая и России занимает ключевое место в глобальной производственной цепочке; чтобы занять более выгодное положение в мировой структуре конкуренции в обрабатывающей промышленности, страны реализуют цифровую трансформацию посредством инноваций в цифровых технологиях и тем самым повышают международную конкурентоспособность. Правительства обеих стран поощряют предприятия к увеличению инвестиций в строительство умных заводов и цифровых мастерских, активно продвигая цифровую трансформацию обрабатывающей промышленности различными способами, такими как политическая поддержка, информационная инфраструктура и финансовые субсидии. Ключевые технологические приложения для цифровой трансформации интеллектуального производства, как, например, 5G, большие данные, промышленный Интернет вещей, технологии дополненной реальности и искусственный интеллект, используются для повышения эффективности и качества производства. Данные как ключевой ресурс пронизывают весь жизненный цикл производства, способствуют оптимизации производственных процессов и пониманию рынка, а также стимулируют открытые инновации и изменения рыночных механизмов. Исследование технологических инноваций и политического руководства в условиях рыночной конкуренции представляется крайне важным, поскольку инновации являются ключевыми движущими силами обрабатывающей промышленности. На основе анализа данных о производстве двух стран определяется важная роль обрабатывающей промышленности как опоры национальной экономики, а также предлагаются меры по укреплению технологического суверенитета и международного сотрудничества. Согласно результатам исследования, китайско-российская обрабатывающая промышленность, сталкиваясь с тарифными барьерами, геополитическими сложностями, технологическими стандартами, влиянием бренда и другими вызовами, укрепляет технологический суверенитет, налаживает связи и сотрудничество, обращает внимание на инновации, повышает добавленную стоимость продукции, двигается в русле устойчивого развития, активно сотрудничает в диверсифицированной конкуренции на зарубежных рынках, инновационной деятельности для повышения конкурентоспособности рынка.

Ключевые слова

Умное производство, цифровая трансформация, цифровые технологии, инновационная теория, искусственный интеллект, управление данными.

Innovation Research on Digital Transformation of Manufacturing Industry in China and Russia in the Digital Economy Era

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Abstract

In the era of digital economy, the manufacturing industries of China and Russia play a crucial role in the global industrial chain. In order to occupy a more advantageous position in the global manufacturing competition, they achieve digital transformation through innovation in digital technology and enhance international competitiveness. Both governments encourage enterprises to increase investment in smart factories and digital workshops through various means such as policy support, information infrastructure construction, and funding subsidies, actively promoting the digital transformation of the manufacturing industry. The key technology applications for the digital transformation of intelligent manufacturing, such as 5G, Big Data, industrial Internet of Things, augmented reality technology, artificial intelligence, etc., are aimed at improving production efficiency and quality. As a key resource, data runs through the entire lifecycle of the manufacturing industry, driving production process optimization and market insights, promoting open innovation and market mechanism transformation. Research and analysis on technological innovation and policy guidance under market competition are the core driving forces of the manufacturing industry. On the bases of the manufacturing data analysis of the two countries, manufacturing is identified as an important pillar of the national economy, and suggestions for strengthening technical sovereignty and international cooperation are made. Based on the research results, it is proposed that the manufacturing industries of China and Russia actively face challenges such as tariff barriers, geopolitics, technical standards, and brand influence, meanwhile strengthen technological sovereignty, communication, and cooperation, focus on product innovation, improve product added value, achieve independent, controllable, and sustainable development, actively cooperate and participate in diversified overseas market competition, and innovate activities to enhance market competitiveness.

Introduction

The global manufacturing industry is currently accelerating its digital transformation process. The Chinese government has issued strategic plans and policies for the manufacturing industry, encouraging enterprises to increase investment in the construction of smart factories and digital workshops. Russia has released the "National Special Plan for the Digital Economy" and the "2017–2030 Strategy for the Development of the Russian Information Society". At the same time, both countries have strengthened the construction of information infrastructure, promoted the deep integration of artificial intelligence and manufacturing, and improved the efficiency and competitiveness of the manufacturing industry. The theory and practice of using digital technology innovation to achieve digital transformation in China's manufacturing industry, as well as the key technological applications of innovation in the digital transformation of intelligent manufacturing, such as Big Data, the Internet of Things, virtual simulation, artificial intelligence, etc., promote the high-end and intelligent development of the manufacturing industry to improve production efficiency and quality.

The core of the digital economy lies in data resources, which are mainly carried by modern information networks. The integration and application of information and communication technology as well as the digital transformation of all factors are important driving forces for its development. For the manufacturing industry, the core of digital transformation lies in technological innovation and research and development (R&D), which is related to whether China's and Russia's manufacturing industry can successfully achieve transformation and upgrading, thereby enhancing its competitive position in the global industrial chain.

Purpose and methods of the research

The research methodology is based on the analysis of economic theory, scientific literature, articles and Internet resources as well as the synthesis and analysis of the data obtained. Industry 4.0 is a new paradigm, and its transformation is supported by the theory. The innovation theory promotes enterprise innovation, while the theory of national innovation system emphasizes the role of the state. This article analyzes the important support provided by the relevant strategic plans issued by the Chinese and Russian governments for the high-quality development of the manufacturing industry as well as the implementation of new information technology solutions by enterprises in both countries in the digital transformation of the manufacturing industry. The innovation of new digital technologies in application management has improved the production efficiency and quality of industrial enterprises, reduced costs, and applied IT tools such as data management, artificial intelligence, and cloud computing in different business scenarios of the manufacturing industry. The goals in this regard are as follows:

— to show that digital technology has a positive role in promoting the digital transformation of manufacturing;

— to prove that the development strategies and policies formulated by the government are conducive to encouraging the digital transformation of the domestic manufacturing industry;

— to highlight that strengthening international strategic cooperation in manufacturing by various countries is in line with the trend of world economic development.

Many Chinese scholars are dedicated to studying the high-quality development of China's manufacturing industry. For example, the core requirement for digital transformation in the manufacturing industry is to utilize the new generation of information technology [石先梅 2022]. Based on the layout of information infrastructure construction such as 5G communication network, cloud computing center and industrial Internet platform, digital economy takes data information and its transmission as advanced productivity [李春发 et al. 2020]. The digital economy empowers the manufacturing industry by integrating massive amounts of data into valuable production factors for enterprises through means such as Big Data analysis and cloud computing [陈林, 张玺文 2023]. Digital transformation can effectively improve the internal operational efficiency of enterprises [张啸 2024]. Intelligent transformation can be achieved through deepening the integration and application of digital technology[1].

The works of Russian scholars have also raised many strategic and goal issues in industry and manufacturing. Enterprises first need to develop new business models to improve management quality, find the most reasonable development path, identify production bottlenecks, and redesign business processes [Стратегирование цифрового Кузбасса 2021]. The production goals face challenges: creating new transformative and innovative goals as well as the application of modern technology, especially information technology[2]. Industry is one of the main sectors of the economy, which has a significant impact on the quality and speed of national economic growth, and determines the competitiveness of the national economy in foreign markets[3]. The digital economy is defined as an economic activity that relies on information as a key factor of production.

It should be pointed out that researchers from various countries emphasize the innovation and high quality of new manufacturing technologies, and enterprises actively embrace the digital transformation of manufacturing by strengthening technological sovereignty and following the principles of sustainable development.

The dual drive of technological waves and market competition as a driver of the digital transformation of the manufacturing industry

The manufacturing industry is the foundation of a strong country and the cornerstone of its establishment. It is not only an important foundation of the real economy, but also the key to the high-quality development of the future economy of all countries. The sustainable development of traditional manufacturing, enhancing product competitiveness and adapting to global competition to achieve high-quality development cannot be achieved without innovation. In the 1950s, China established an industrial system with the assistance of the Soviet Union [李凌峰 2024]. Currently, China has the world's largest manufacturing scale, but the overall development of traditional manufacturing is large but not strong, comprehensive but not excellent. At the same time, it also faces the dual pressure of emerging countries relying on labor cost advantages to absorb low-end manufacturing industries and developed countries promoting the return of high-end manufacturing industries. There are many contradictions between its development model and modern demand. The Russian government also urgently hopes to improve the priority areas of technological sovereignty, especially in the fields of medicine, chemical industry, machine tool manufacturing, automobile manufacturing, heavy machinery manufacturing, shipbuilding, electronic and electrical engineering, energy, aviation, railways, oil and gas, agriculture, and professional

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[1] 制造业智能化转型提质增效 // Economic Daily [Electronic resource]. URL: http://www.ce.cn/cysc/newmain/yc/jsxw/202409/17/t20240917_39141019.shtml (accessed: 25.01.2025).
[2] Русаков С.А., Сыздыков Р.В. Основы управленческой деятельности. М.: Издательский центр «Академия», 2020.
[3] Савченко В.В. Обеспечение конкурентоспособности промышленных на основе управления закупками: дисс… канд. эк. наук. М., 2017.

machinery manufacturing. However, market competition and digital technology have prompted the Chinese and Russian manufacturing industries to strengthen cooperation and continuously explore on the path of intelligent manufacturing. Meanwhile, Industry 4.0 presents a new manufacturing paradigm [Daemmrich 2017], and the national innovation system and innovation theory provide theoretical support for the transformation towards this paradigm.

The fourth industrial revolution is represented by industrial intelligence, industrial integration and Internet industrialization, and a new technological revolution focusing on artificial intelligence, Big Data, unmanned control technology, information technology, virtual reality and industrial Internet of Things [Nguyen 2024]. The characteristic of this new era is the integration of intelligent, interconnected, and autonomous digital and physical technologies (such as the Internet of Things and robotics), which brings enormous opportunities but also new risks. Schumpeter believed that innovation is the recombination of production factors, including the adoption of new production methods, the opening of new markets, and the realization of new organizational forms for enterprises [Schumpeter 1989]. Innovation theory encourages manufacturing enterprises to constantly seek creative combinations of production factors to achieve breakthroughs in products and production methods, thereby promoting the high-quality development of the manufacturing industry.

The theory of national innovation system holds that modern innovation requires the role of the state, and the government should purposefully construct a national innovation system based on national conditions to promote innovation activities throughout the country [余瀛涛 2012]. The Chinese national innovation system originated from the socialist planned economy system, and with the transition to a market economy system, the fundamental role of enterprises in allocating innovation resources has been increasingly strengthened [张宁宁, 温珂 2022]. China has drawn on the experience of the Soviet Union's five-year plan and formed a national development strategic plan with Chinese characteristics, which plays a strategic and practical guiding role in national innovation and other aspects. The strategies such as "Made in China 2025" and "14th Five Year Plan for the Development of Intelligent Manufacturing" provide important support for the development of China's manufacturing industry in terms of strategic guidance, technological guidance, and industrial ecology construction, and play an irreplaceable role in promoting the high-quality development of China's manufacturing industry.

Digital technology: An innovative driving force for high-quality development of the manufacturing industry

The core of digital transformation in the manufacturing industry lies in technological innovation and research and development, which not only relates to the upgrading and transformation of the manufacturing industry, but also directly affects the country's competitive position in the global industrial chain. Russia is interested in increasing supply and developing new products, while China has corresponding manufacturing industries and sufficiently high potential for technological cooperation. Trade between the two countries has grown significantly in the past few years [Баринова и др. 2024]. From the analysis of China's export commodity data in the past 20 years, the percentage of finished goods exports has been above 90%, reflecting that China has a complete supply chain system and occupies a key position in the global industrial chain. The high proportion of finished goods exports is an important support for China to maintain a long-term trade surplus and enhance its influence in international trade. Although Russia has strong technological sovereignty in some high-end manufacturing sectors, such as aerospace and military equipment, its overall manufacturing exports account for a lower proportion than the world average, and its technological sovereignty in large-scale consumer manufacturing is relatively weak (as shown in Figure 1).
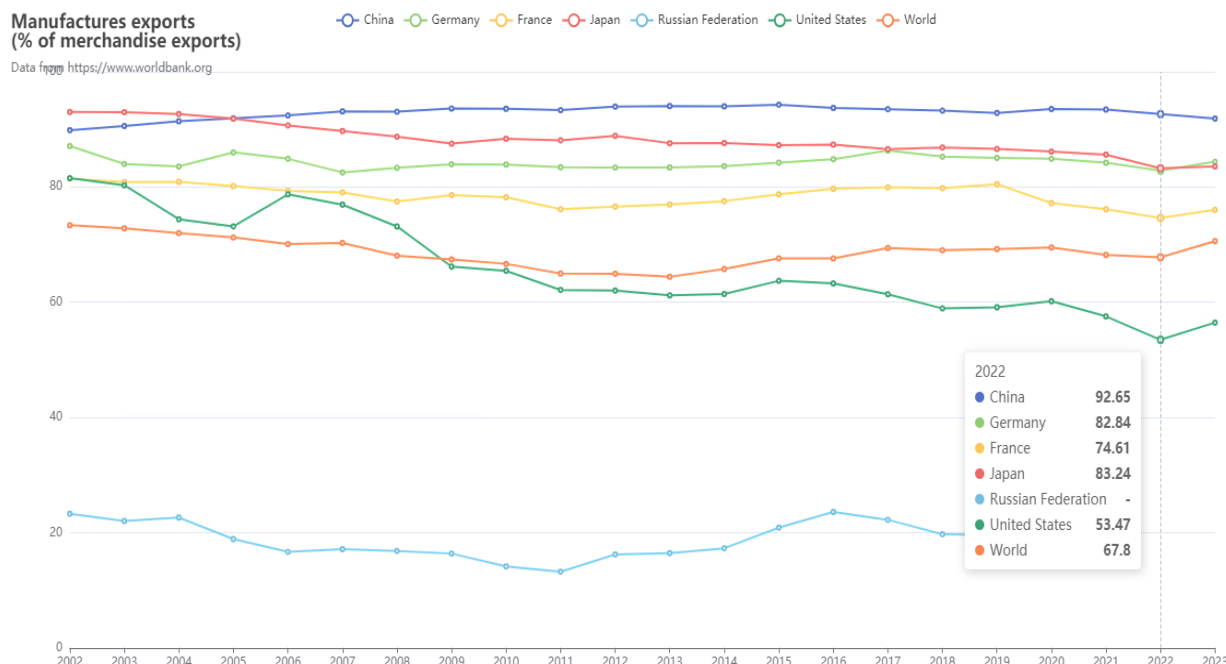
Figure 1. Finished goods exports of major countries from 2002 to 2023 (percentage of commodity exports)[4]

As shown in Figure 2, in the past 10 years, China's industrial added value has accounted for more than 30% of the entire economic system. In 2022, the industrial added value reached 39.91 trillion yuan, accounting for 31.66% of GDP, indicating that industry is the leading industry of the national economy. It is a key force in promoting economic growth and an important foundation for supporting the development of the national economy. China's industrial structure is still in the stage of industry as the center of gravity, and industry is an important field of technological innovation.
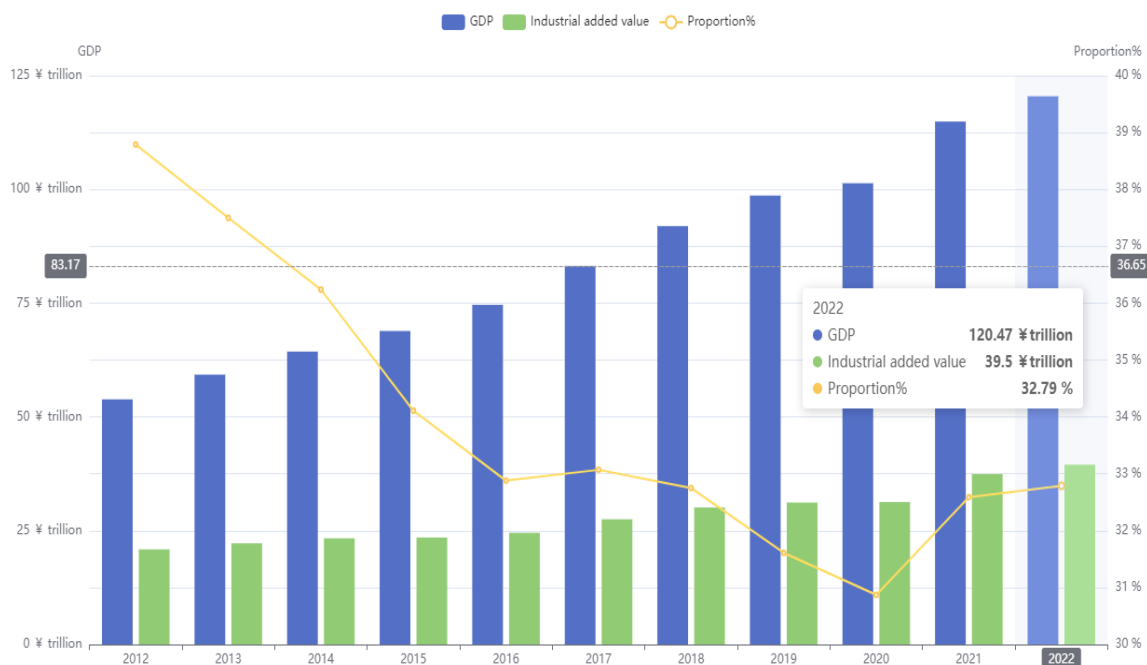
Figure 2. Trend chart of China's GDP, industrial value added, and proportion % from 2012 to 2022[5]

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[4] Compiled by the author based on: Manufactures exports (% of merchandise exports) // World Bank Group [Electronic resource]. URL: https://data.worldbank.org/indicator/TX.VAL.MANF.ZS.UN?view=chart (accessed: 25.01.2025).
[5] Compiled by the author based on data from National Bureau of Statistics [Electronic resource]. URL: https://data.stats.gov.cn/easyquery.htm?cn=C01&zb=A0204&sj=2023 (accessed: 25.01.2025).

The Chinese government has issued the "Guiding Opinions on Accelerating the Transformation and Upgrading of Traditional Manufacturing Industry", which clarifies a series of measures from the aspects of "adhering to innovation driven development, accelerating the transition to the mid to high end of the value chain" and "accelerating digital technology empowerment, comprehensively promoting intelligent manufacturing". By 2027, the level of high-end, intelligent, green, and integrated development in traditional manufacturing will significantly improve, with the penetration rate of digital R&D design tools and the CNC (computer numerical control) rate of key processes in industrial enterprises exceeding 90% and 70%, respectively.

At the same time, the Strategic Development and National Special Planning Committee of the President of the Russian Federation approved "The National Special Plan for the Digital Economy". The special plan for the digital economy consists of seven sub plans (federal plans), including seven directions: information infrastructure, digital technology, digital national management, digital economic talent, information security, digital environment regulation construction, and artificial intelligence. The Russian government has released a list of technologies applicable to experimental legal systems in the field of digital innovation, including neural technology and artificial intelligence, Big Data technology, quantum technology, manufacturing technology, robotics and sensing technology, distributed billing, wireless communication, virtual and augmented reality, the Internet of Things, industry digital technology, etc.

The digital transformation of intelligent manufacturing refers to the use of advanced technologies such as digital technology, the Internet of Things, and Big Data analysis in the manufacturing industry to achieve intelligent, automated, and optimized production processes, in order to improve production efficiency, quality, and flexibility [Чжан 2023]. Information technology (IT) is one of the most important driving forces for innovation in production and automation [Waidner, Kasper 2016]:

1. Virtual simulation and digital twin realize the digitization of product design, manufacturing planning, and production simulation, optimize design solutions to discover and solve problems in advance, and improve product quality and production efficiency.

2. Digital technology has given rise to digital production and control systems, which can achieve automation and integration of production equipment, processes, and manufacturing processes. Digital control systems enable precise settings and real-time monitoring, improving production efficiency and quality while reducing production costs.

3. The Internet of Things and sensor technology collect and analyze time-series data, real-time collection of production, process execution time, equipment status and other time-series data, establish equipment health models and conduct Big Data analysis to achieve predictive maintenance. It can obtain key indicators and monitoring of production processes (temperature, pressure, weight, etc.) and product quality, and comprehensively evaluate equipment performance.

4. Artificial intelligence and machine learning algorithms predict, optimize, and make autonomous decisions for manufacturing processes and equipment. Algorithms can analyze large amounts of data in the manufacturing process to optimize production processes and predict potential defects in products. By modeling and analyzing the relationship between production process parameters and energy consumption, find the optimal operating parameters to reduce energy consumption.

5. Intelligent warehousing adopts high-tech automation technologies such as vertical stacker crane system (AS/RS), cargo to person system, cross belt sorting system, AGV intelligent handling robot, and automatic shelving system. With the help of the Internet of Things and data analysis, real-time tracking, optimization, and scheduling of logistics and supply chain are achieved, improving the reliability, flexibility, and efficiency of the supply chain. Agile supply chain management improves the on-time delivery rate of goods.

Figure 3 shows the application areas of digital technology in China's manufacturing industry.
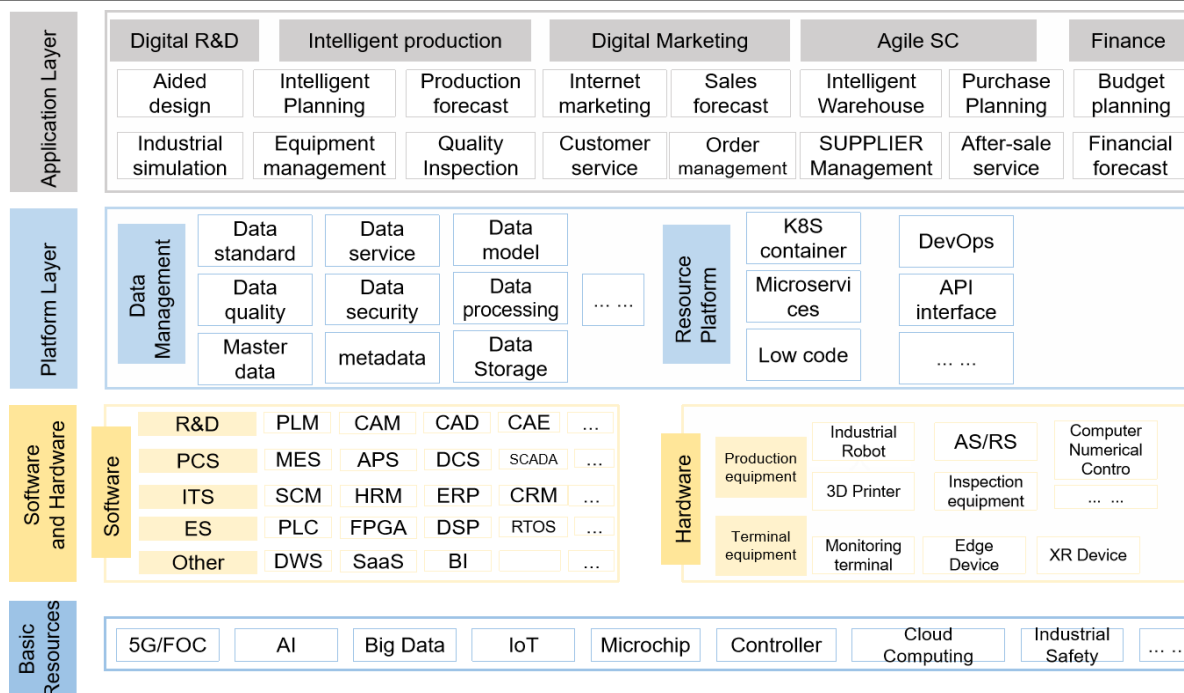
Application Layer

Digital R&D	Intelligent production		Digital Marketing		Agile SC		Finance
Aided design	Intelligent Planning	Production forecast	Internet marketing	Sales forecast	Intelligent Warehouse	Purchase Planning	Budget planning
Industrial simulation	Equipment management	Quality Inspection	Customer service	Order management	SUPPLIER Management	After-sale service	Financial forecast

Platform Layer

Data Management:
Data standard	Data service	Data model		
Data quality	Data security	Data processing	... ...
Master data	metadata	Data Storage	

Resource Platform:
K8S container	DevOps
Microservices	API interface
Low code	... ...

Software and Hardware

Software:
R&D	PLM	CAM	CAD	CAE	...
PCS	MES	APS	DCS	SCADA	...
ITS	SCM	HRM	ERP	CRM	...
ES	PLC	FPGA	DSP	RTOS	...
Other	DWS	SaaS	BI		...

Hardware:
Production equipment	Industrial Robot	AS/RS	Computer Numerical Contro
	3D Printer	Inspection equipment	... ...
Terminal equipment	Monitoring terminal	Edge Device	XR Device

Basic Resources

| 5G/FOC | AI | Big Data | IoT | Microchip | Controller | Cloud Computing | Industrial Safety | ... .. |

Figure 3. Application of digital technology in the digital transformation of China's manufacturing industry[6]

As shown in the Figure, the application layer consists of digital business functional modules and business scenarios for the manufacturing industry; the platform layer mainly serves as a technical resource platform for data asset management and services; the hardware and software layers provide on-site production and management equipment and software tools; the basic layer provides underlying technical support for emerging industrial technologies and guarantee factors; as a major economic form following agricultural and industrial economies, the key element of the digital economy lies in data resources, and the main carrier is modern information networks. The integration and application of information and communication technology as well as the digital transformation of all factors are important driving forces for its development.

Data is a key resource driving the digital transformation of the manufacturing industry. By collecting, analyzing, and applying data, the manufacturing industry can identify problems in the production process, optimize the process, and improve product quality. At the same time, data helps companies gain in-depth insights into market demand, and based on this, develop marketing strategies to enhance user experience. Therefore, it is necessary for the manufacturing industry to establish a comprehensive data management system to ensure the accuracy, security, and availability of data. Simultaneously emphasizing information security will lead to protecting privacy, integrity, and availability [Михалевич, Рыжов 2018].

Data, as a new means of production, should be integrated into the entire production and operation lifecycle of the manufacturing industry. Data has become an indispensable and important component of products and services, and the operational needs of data must be fully considered when designing products. By collecting and integrating production process data, it is possible to optimize the production process, improve production efficiency and product quality. Mastering real-time data from various stages of manufacturing production scenarios and coordinating management can improve the performance of data transmission, analysis, and protection applications in the production process, achieving efficient integration of intelligent production processes.

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[6]Compiled by the author.

After the manufacturing industry obtains massive data from the market and production processes, its innovation approach will undergo a fundamental transformation, and open innovation will gradually become the dominant mode of manufacturing innovation. Due to the existence of data, the process of data circulation has undergone revolutionary changes, with the emergence of online and offline integration as well as the integration of customers and enterprises. This has led to changes in the market mechanism, thereby promoting corresponding changes in the way enterprises promote and compete in the market.

Analysis of the current situation, development suggestions, and future prospects of digital transformation in the manufacturing industry

The digital transformation of the manufacturing industry belongs to systematic engineering, which requires the joint participation and collaborative efforts of the government, enterprises, and all sectors of society. Presidential Decree No. 83, signed by President Putin, "On Measures to Ensure the Accelerated Development of the Information Technology Industry in the Russian Federation" provides credit incentives for IT experts, the cultivation of digital talents, and digital transformation in the field of education. Publish policies are defined by "The Basic Principles of National Policies for the Protection of Critical Information Infrastructure" [Yu Nanping, Zhang Yiran 2022]. "The National Special Plan for Digital Economy" promotes the structural transformation of the Russian economy, cultivates new growth points, enhances the competitiveness of traditional industries, strengthens the country's digital competitiveness, including talent and infrastructure construction, and safeguards national security and sovereignty. "The List of Applicable Technologies for Experimental Legal Systems in the Field of Digital Innovation" promotes the exploration and transformation of digital innovation technologies, fills legal gaps, and guides the improvement of legal systems, creating a favorable legal environment for digital innovation [寇佳丽 2020]. The Law of the Russian Federation "On Experimental Legal Mechanisms in the Field of Digital Innovation" declares that Russia has introduced special support policies for innovative small and micro enterprises, domestic digital solution pilot projects, domestic IT solution projects, domestic software development, industrial research and development, etc. Relevant enterprises can apply for subsidies and preferential loans.

The Chinese government has formulated policies specifically to support the digital transformation of the manufacturing industry, providing a certain proportion of funding subsidies for key smart factory demonstration projects, such as providing financial subsidies, tax incentives, etc. in order to reduce the transformation costs of enterprises. At the same time, the government should provide support and encouragement for enterprises to carry out digital technology transformation through various methods such as technology transformation loan interest subsidies, accelerated depreciation, and industry guidance fund investment.

In order to promote the intelligent transformation of the manufacturing industry, governments across China have introduced a series of subsidy policies to encourage enterprises to increase investment in the construction of smart factories and digital workshops. As recognized by Heilongjiang Province, digital workshops (production lines) and smart factories will receive a one-time subsidy of 10% of the project contract amount, with a maximum subsidy of 10 million yuan for smart factories. Suzhou City provides a 20% purchase subsidy to enterprises for purchasing hardware facilities that meet the requirements, such as intelligent production equipment and automated testing equipment. For example, if a company purchases a smart device worth 5 million yuan, it can receive a subsidy of 1 million yuan. The city provides also a 30% subsidy to enterprises for adopting advanced digital systems such as production management software and industrial control software. The enterprise will receive a reward of 500000 yuan for being recognized as a city level demonstration enterprise, 1 million yuan for being recognized as a provincial-

level demonstration enterprise, and 2 million yuan for being recognized as a national level demonstration enterprise. The policy covers multiple aspects such as equipment purchase subsidies, software system subsidies, project construction subsidies, and incentives for demonstration enterprises.

The Chinese government has strengthened the construction of information infrastructure. The new generation of information technology represented by the Internet of Things, Industrial Internet, 5G, and Satellite Internet has evolved into communication network infrastructure, new technology infrastructure represented by cloud computing, artificial intelligence, blockchain, and computing infrastructure represented by data centers and intelligent computing centers. At the same time, this infrastructure system is driven by technological innovation, with information networks as the foundation, in order to meet the needs of high-quality development and provide services such as digital transformation, intelligent upgrading, and integrated innovation. Reasonable layout of digital infrastructure construction by the government and enterprises, and strengthening cooperation and collaboration between upstream and downstream enterprises in the industrial chain, will effectively promote the digital transformation of the entire industrial chain, improve the overall efficiency and competitiveness of the manufacturing industry, and occupy a favorable position in the global digital economy competition.

As shown in Figure 4, according to the data, the export value of high-tech products in China accounts for about 30% of China's total export trade and industrial manufactured goods, and only 23.12% in 2022. The long-term high dependence on foreign technology has made it difficult for Chinese enterprises to compete with other developed countries in the international market due to the lack of sufficient independent innovation capabilities and independent innovation brands. The Group of Seven (G7) has a significant monopoly advantage in the global market, especially in high-tech industries, and this technology introduction has kept China in a passive position for innovation and development. Due to developed countries possessing advanced technology, key core technologies, and technological advantages such as patents. Developed countries have strong technological moats and industrial alliance ecosystems (such as Wintel Alliance and ASML technology ecosystem), and they still have strong competitiveness in the high-tech field.
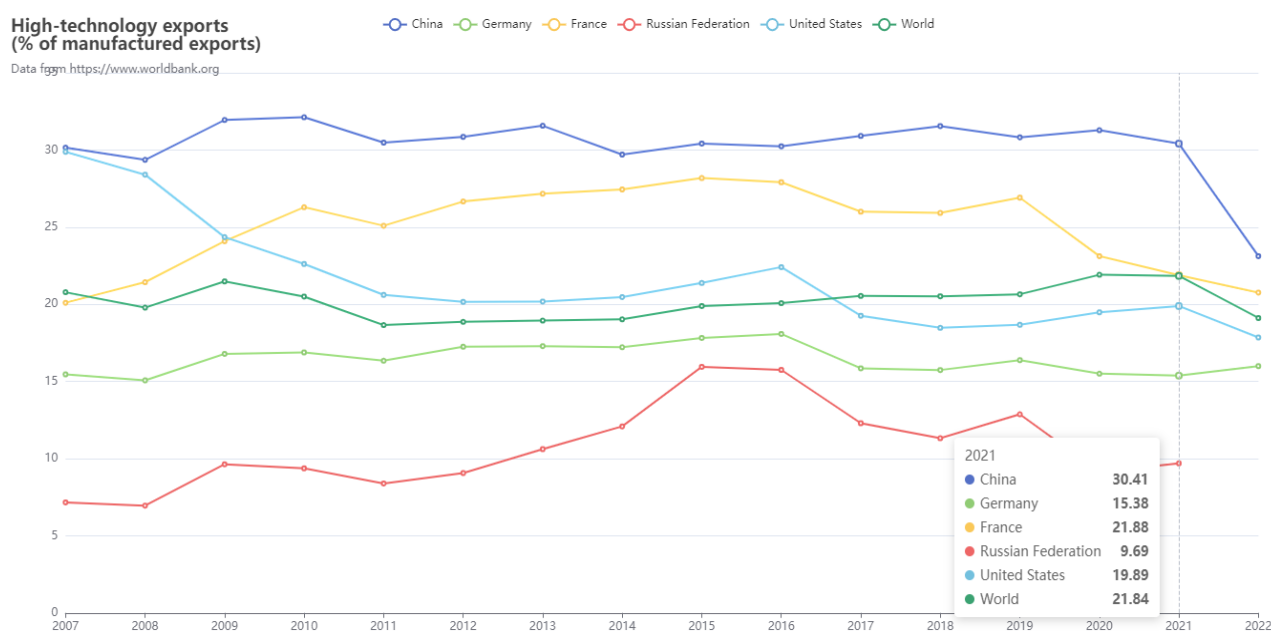
**Figure 4. High tech exports of major countries from 2007 to 2022
(percentage of manufactured goods exports)[7]**

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[7] Compiled by the author based on: High-technology exports (% of manufactured exports) // World Bank Group [Electronic resource]. URL: https://data.worldbank.org/indicator/TX.VAL.TECH.MF.ZS?view=chart (accessed: 25.01.2025).

The deep integration of artificial intelligence and manufacturing is a trend in the development of the integration of digital economy and real economy. When artificial intelligence technology is introduced into the manufacturing industry, it endows the entire lifecycle of the manufacturing industry with new vitality. Based on data, artificial intelligence technology promotes the intelligent transformation of the entire industry chain, including product design, manufacturing, equipment maintenance, intelligent supply chain, sales, product use, and safety management. This transformation will inject stronger vitality into the manufacturing industry, enabling it to adapt and thrive in the context of the integration of the digital economy and the real economy.

Digital transformation relies on various digital technologies, such as operating systems, Big Data, artificial intelligence, industrial software, etc. National technological sovereignty means effectively resisting the risks of supply and service interruptions caused by sanctions, being able to independently control the research and development of these technologies, and prompting enterprises and countries to increase investment in technological research and development, thereby enhancing technological sovereignty. China and Russia are taking active actions on technological sovereignty. For example:

1. In terms of operating system, it is based on the Linux kernel, with the Russian self-developed mobile OS system Aurora and the military's Astra operating system. In terms of cloud computing, the Russian government has taken the lead in building the National Unified Cloud Platform (Gosoblako). Chinese Kirin operating systems such as Kylin and Unisoc UOS have achieved localization substitution, while Huawei has developed HarmonyOS and Euler operating systems. These basic platforms will focus on building a software and hardware ecosystem for operating systems in the future.

2. In terms of industrial software, the PLM complex of ASCON and "RazvITie" consortium in Russia provides an alternative to foreign CAD and PLM solutions in the key process of creating complex technological products. The United States has implemented restrictions on the use of MATLAB in China, and Baltamatica and MWorks from Tongyuan Soft Control have provided new options for Chinese enterprises and research institutions.

China and Russia have a 70-year history of cooperation in the manufacturing field [张永康 2024]. Based on the complementary advantages of both sides, they have strengthened cooperation in manufacturing industries such as automobiles, communications, and aviation. For example, Haval Automotive has established an automotive automation production base in Russia, and Huawei Research Institute has cooperated with Russian communication companies or research institutions for technology development and patent sharing. Haier has established a home appliance production base in Kaluga, Russia with an annual output of over 1 million units, enjoying tax exemptions and land leasing preferential policies from the Russian government. The factory's products can easily radiate to the Eurasian region and Eastern European countries, enhancing brand awareness. In the field of high-end chip manufacturing in China, strengthening international cooperation, actively attracting European and American talents and introducing relevant technologies, while promoting domestic high-end talents to stay in the country for development, digital talents are the driving force for building the digital competitive advantage of the manufacturing industry. This will help China's chip manufacturing move towards advanced processes such as 7-nanometer and 5-nanometer, achieve technological autonomy and controllability, and promote Chinese chip manufacturing enterprises to accelerate their integration into the global chip industry chain.

The BRICS Summit was held in Kazan, Russia on October 22, 2024, and the digital economy was listed as one of the three key areas of cooperation in the BRICS Economic Partnership Strategy 2025. From holding the BRICS Industrial Internet and Digital Manufacturing Development Forum and the International Forum on Big Data for Sustainable Development to reaching the BRICS Digital Economic Partnership Framework and releasing the BRICS Digital Transformation Cooperation Initiative for Manufacturing Industry, China,

Russia, and BRICS countries are actively building a digital cooperation platform to stimulate the potential and vitality of digital economic development. Therefore, the unified payment system of BRICS countries enhances regional economic cooperation and financial autonomy through local currency settlement and advanced payment technology BRICS Pay, which is an important innovative tool for promoting financial multipolarity and global economic stability.

Therefore, in the era of digital economy, digital technology is an opportunity for the world's technological revolution and industrial transformation. The manufacturing industries of China and Russia are facing challenges such as brand awareness, tariff barriers, intellectual property protection, geopolitics, and technological standards. In this regard we propose the following suggestions:

— strengthen technological cooperation and digital transformation talent training between China and Russia, achieve independent and controllable technology, and protect intellectual property rights;

— drawing on the successful experiences of both countries, promote deep cooperation between China and Russia in key industrial chains such as automobile manufacturing, energy equipment, aerospace, and R&D centers for information technology, intelligent manufacturing, and other enterprises;

— strengthen communication and cooperation with organizations such as the Shanghai Cooperation Organization and BRICS, actively participate in the formulation of international technical standards, and jointly explore overseas markets such as Eurasia.

— deepen financial cooperation between the two countries, promote local currency settlement in bilateral trade between China and Russia, and achieve normal trade through a unified payment platform;

— on the basis of strategic cooperation between the two governments, the economic and trade conferences and forums between China and Russia can promote experience exchange and drive the continuous deepening of bilateral relations.

Conclusion

The digital economy has become a new battlefield for international competition and confrontation, and developed countries continue to use digital hegemony to suppress and contain the development momentum of competitors. Developing the digital economy will become a major development strategy for technologically innovative countries. The digital economy era has brought unprecedented opportunities and challenges to the manufacturing industry in China and Russia, and the digital transformation of the manufacturing industry is of great significance to the economic development of China and Russia. Therefore, both Russia and China need to pay more attention to the development of the digital economy, consolidate new infrastructure, establish awareness of digital security, and safeguard digital sovereignty and financial independence.

The BRICS International Payment System (BRICS PAY) for emerging economies in the global economic landscape addresses cross-border payment issues under financial sanctions, and local currency settlement promotes the establishment of a fair, diverse, and inclusive international financial and trade order. It will enhance regional economic cooperation, financial sovereignty, and investment settlement, and be conducive to the common development of China and Russia in the manufacturing industry chain in the future.

Data management and information security are crucial, from software operating systems to industrial software and other technological sovereignty, establishing a complete ecosystem. The country

independently controls the core technology of these software to prevent software vulnerabilities or backdoors from conducting network attacks, power outages, and sanctions that threaten national security.

The digital transformation of the manufacturing industry is not only an inevitable choice to adapt to the development of the times, but also to enhance its competitiveness in international trade and provide strong support for the stable economic growth of the two countries.

Government policy guidance plays a positive role in promoting digital transformation, clarifying the direction and goals of development.

Technological innovation is the core driving force of digital transformation, fully empowered by intelligent manufacturing technology, and data has become a key element of innovation.

Therefore, the digital transformation of manufacturing industry in the era of digital economy is a systematic and complex project, involving multiple aspects such as policy guidance, technological innovation, data management, and information security. Only by comprehensively grasping these key factors and constantly exploring innovation can the manufacturing industry achieve successful transformation in the wave of digital economy, enhance global competitiveness, and move towards a new stage of high-quality development.

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