



# Comparative Analysis on Development and Policy in Intelligent Manufacturing Industry Among China, the United States, Japan and Germany

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## ABSTRACT

With the rapid evolution of digitalization, intellectualization and networking, intelligent manufacturing has become an important direction of global manufacturing reform. Countries around the world have continuously issued a number of policies to provide strategic support and cultivate their own international competitive advantages. Compared with the United States, Japan and Germany, China's manufacturing industry shows the characteristics of "premature and rapid" decline, uneven development level of intelligence in various industries, and China is still lacking in core technology in smart manufacturing industry. In the future, China should learn from the experiences of advanced countries in the development of intelligent manufacturing, accelerate the technological research and development of local intelligent manufacturing industry, and improve the industrial policy support system.

**Keywords:** *Intelligent Manufacturing; Industrial Policy; International Comparison*

## 1. INTRODUCTION

Manufacturing industry is the main component and the anchor of the national economy. With the rapid evolution of digitalization, intellectualization and networking, intelligent manufacturing has become an important direction of global manufacturing reform, and industrial intelligence has also become the main subject of the new round of international competition in the world (Qiu Ying et al., 2021; Liu Jun et al., 2021) [1-2]. In May 2018, at the 19th academician conference of the Chinese Academy of Sciences and the 14th academician conference of the Chinese Academy of engineering, General secretary Xi Jinping stressed that intelligent manufacturing should be taken as the main direction to promote industrial technology reform, optimization and upgrading, and promote China's industry to move towards the middle and high end of the global value chain. On December 28, 2021, the Ministry of Industry and Information technology officially released the "14th Five year plan" for intelligent manufacturing development, which detailed the specific goals to be achieved by manufacturing enterprises in 2025 and 2035 to fully popularize digital networking, highlighting the

importance and support of national policies for intelligent manufacturing. Thus the global industrialization process has put forward new requirements for the development of intelligent manufacturing industry. China urgently needs to break through core technologies and cultivate international competitive advantages.

## 2. DEVELOPMENT STATUS OF INTELLIGENT MANUFACTURING INDUSTRY IN CHINA, THE UNITED STATES, JAPAN AND GERMANY

### ***2.1. The proportion of China's manufacturing industry dropped "prematurely and rapidly", while the United States, Japan and Germany dropped firstly and then stabilized***

Compared with the United States, Japan and Germany, China's manufacturing industry shows the characteristics of "premature and rapid" decline. Comparing the change trend of manufacturing added value in GDP in major countries, it can be found that, on the one hand, although the proportion of manufacturing industry in the United States, Japan and Germany has

decreased, it has stabilized. In China, the downward trend is still continuing. As shown in Figure 1, the United States, Japan and Germany have gradually stabilized after experiencing a small decline in the proportion of manufacturing added value to GDP. Specifically, the proportion of the United States dropped from 16.09% in 1997 to 10.93% in 2019, the proportion of Japan dropped from 23.47% in 1994 to 20.31% in 2019, and that of Germany dropped from 24.85% in 1991 to 18.17% in 2020. It means that although the service industry has a certain crowding out effect on the real sector, adhering to the foundation of the manufacturing industry plays an irreplaceable role in maintaining sustainable economic growth. China's proportion is still in a declining trend. The proportion fell from 32.45% in 2006 to 26.18% in 2020, higher than that of other countries. From the perspective of decline, since 2000 (except for the financial crisis), the proportion of manufacturing added value in GDP of Japan and Germany has remained at about 20%. However, China has seen a sharp decline

since 2012, and the decline has been significantly higher than that of other countries.

On the other hand, the decline in the proportion of manufacturing industry in the United States, Japan and Germany is based on the high income level. Compared with this, China has shown the characteristics of "de industrialization" too early (Cai Fang, 2021) [3]. From the manufacturing peak and per capita GDP of each country in Table 1, the proportion of manufacturing added value in GDP of the United States, Japan and Germany reached the peak in 1953, 1970 and 1969, and the per capita GDP was US \$16400, US \$18700 and US \$19700, both higher than the high-income national standard in 2010. The peak value-added ratio of China's manufacturing industry to GDP was 36.30% in 2006, but the per capita GDP was only US \$3063, far lower than the level of high-income countries, indicating that China's manufacturing industry fell "prematurely".

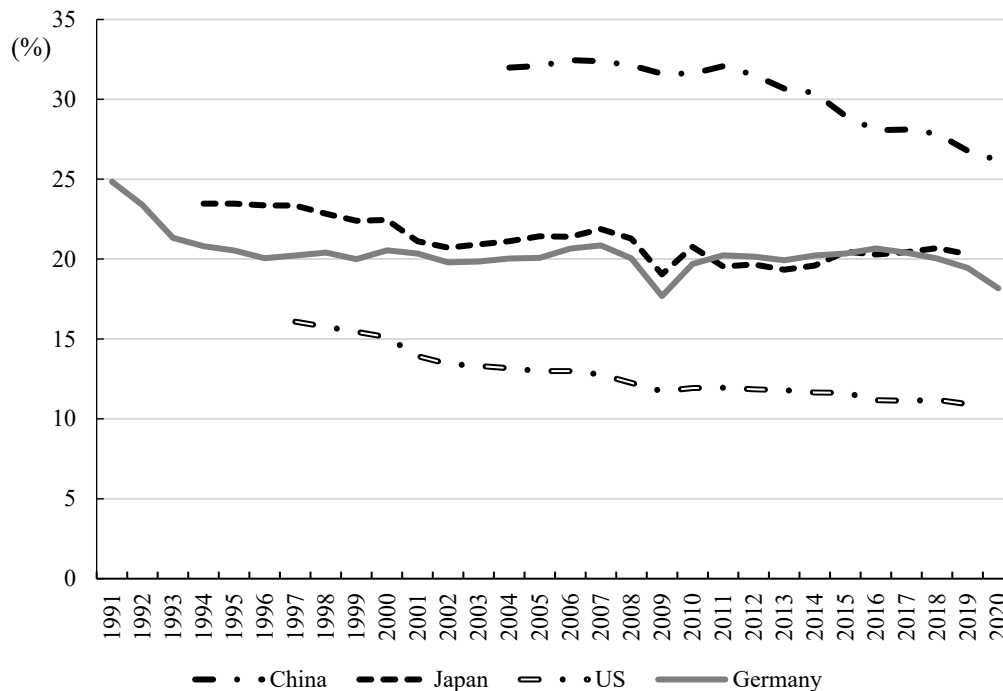


Figure 1. Proportion of manufacturing added value in GDP of major countries  
Data Source: World Bank.

Table 1. Peak Proportion of Manufacturing Industry and Per Capita GDP in Major Countries

Country	Year	Peak value added of manufacturing industry in GDP (%)	Per capita GDP(2010 USD)
China	2006	36.30	3063
U.S.A	1953	26.80	16443
Japan	1970	34.10	18700
Germany	1969	36.90	19681

Note: Peak Proportion is the highest value of data recorded. Data Source: World Bank.

## 2.2 American technology enterprises lead the world, and China, Japan and Germany have their own advantages

Advanced science and technology is the lifeblood of a country's economy. In terms of the industry in which the international leading enterprises are located, as of December 2021, 8 of the top 10 enterprises in the global market value are science and technology enterprises. Moreover, the United States is far ahead of other countries in this field. By country, the top 20 enterprises in the U.S. capital market are mainly distributed in the fields of internet technology, medicine, semiconductors, such as Apple, Microsoft, Google, Amazon and other technology companies, Johnson & Johnson, Pfizer and other pharmaceutical companies, as well as NVIDIA, Broadcom and other semiconductor companies. Among them, Apple, Microsoft, Google and Amazon all rank among the top five in the world. Japanese enterprises with high market value are more concentrated in the automobile, electromechanical equipment and other industries, while German competitive enterprises are mainly concentrated in the pharmaceutical and automotive industries. The number of China's top 100 enterprises in the global market value ranking is less than that of the United States. The top 20 enterprises in the market value are mainly concentrated in the financial industry, technology, food, energy and other industries. As the core driving force of intelligent manufacturing, information technology is an important aspect that China's manufacturing industry and the overall economic development need to catch up with.

## 2.3. Japan and Germany have a high level of manufacturing intelligence, and China has obvious scale advantages

The core of intelligent manufacturing is the deep integration of information and communication technology and manufacturing industry (Li Jianxuan, 2020) [4]. In terms of measuring the intelligent level of a country's manufacturing industry, the number and application of industrial robots are commonly used indicators (Meng Fansheng and Cui Jingwen, 2022) [5]. At present, China has no obvious advantages in the pace and development degree in this field, but the development speed is very fast. According to the statistics of the International Federation of Robotics (IFR), China continued to rank first in the global industrial robot market from 2013 to 2020. In 2020, China installed 168,400 sets of industrial robots, breaking the world record. Compared with robot density, in 2020, the world average was 126 robots /10000 persons, China ranked ninth with 246 robots / 10000 persons.

On the other hand, there are technical weaknesses in China's intelligent development, and the development level of various industries is uneven (Zhou Yong et al., 2022) [6]. China's intelligent manufacturing has shortcomings in some key technologies. Taking reducer, servo system and controller as examples, China's import proportions in the core parts of the three industrial robots are more than 70% (Yang Qianhe, 2021) [7]. In terms of industries, the development levels of intelligence in various industries in China are uneven. Only the development levels of computers, electronic, optical products and mechanical equipment are at a high level (Wang Yuanyuan and zhang Huarong, 2020) [8].

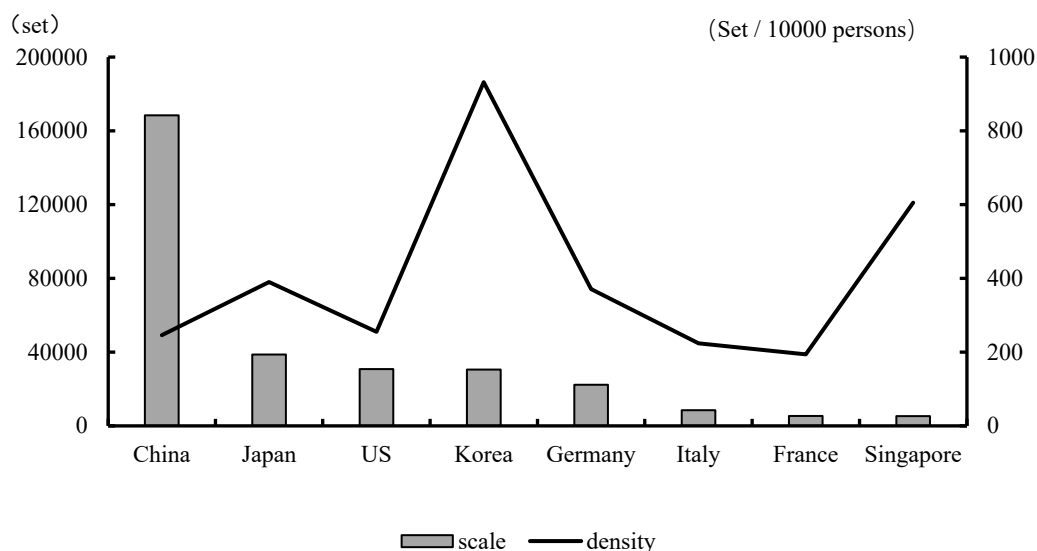


Figure 2. Development of Robots around the World in 2020

Data Source: International Federation of Robotics.

### 3. ANALYSIS ON INTELLIGENT MANUFACTURING POLICIES OF CHINA, THE UNITED STATES, JAPAN AND GERMANY

#### *3.1. China's industrial policies are gradually improving, and the level of manufacturing intelligence needs to be improved*

After years of development, China's industrial policy system has been gradually improved, and the competitiveness of the manufacturing industry has been significantly improved. However, there are still some weaknesses in China's manufacturing industry, for which China has timely adjusted corresponding policies to guide enterprises to adapt to the pace of international development. First, in view of the premature decline in the proportion of China's manufacturing output value in recent years, the outline of the "fourteenth five year plan" emphasizes the need to maintain the proportion of manufacturing industry at a basically stable level. Second, China's manufacturing industry still has obvious weaknesses in key technology areas, and there is a large gap with other countries. In this regard, China has timely adjusted its industrial policies to promote the upgrading of the manufacturing industry to the medium and high-end. In 2015, China put forward "made in China 2025", which requires that the core strategic goal is to achieve a strong manufacturing country, and has defined several main attack directions, such as improving the innovation ability of the manufacturing industry. From 2015 to 2018, China successively implemented 305 intelligent manufacturing pilot demonstration projects and achieved important results. According to the statistics of the Ministry of industry and information technology, the production efficiency of the pilot projects has been improved by 37.6% on average, the operating cost has been reduced by 21.2% and the product development cycle has been shortened by 30.8% on average, forming a good demonstration effect for other enterprises. Third, China should formulate policies to improve the depth and breadth of the development of intelligent manufacturing industry. With the encouragement and support of a series of policies, the added value of China's intelligent manufacturing industry is rising rapidly. The penetration rate of Intelligent Manufacturing in downstream industries continues to increase. According to the data of prospective industry research institute, from 2010 to 2020, the output value of China's intelligent manufacturing industry has increased year by year. In 2020, the output value of China's intelligent manufacturing industry was 2505.6 billion yuan, with a year-on-year increase of 18.85%.

#### *3.2. US industrial policy has been accumulating for a long time and its technical level is leading the world*

The "Reindustrialization" plan is an important strategic choice for the United States to revitalize its economy, and also an important guide for the United States to actively seize the global high-end manufacturing market. On the one hand, the increase of tariffs and the reduction of enterprise tax rates have attracted the return of traditional industries such as steel, aluminum and automobiles, realizing the revitalization and protection of domestic industries. On the other hand, the introduction of the macro level bill planning provides important strategic support for the intelligent upgrading of the US manufacturing industry (Sun yi and Luo Muxiong, 2021) [9]. Specifically, the United States first put forward the concept of industrial Internet in 2012, released and upgraded the industrial Internet reference architecture for many times in recent years, and built an important carrier for the intelligent transformation of manufacturing industry. Under the guidance of relevant policies, the United States continues to lead the world's technological frontier, occupies a core position in semiconductors, software, the Internet, and owns many of the world's top Internet companies, such as Apple, Microsoft, Amazon, etc.

#### *3.3. Japan's industrial policies are highly targeted and the international competitiveness of industrial robots is strong*

Japan's industrial robot industry started early. On the one hand, it is in line with the rapid development process of domestic technology intensive industries. On the other hand, it is also an effective response to the premature aging of the population. As early as 2012, the density of industrial robots in Japan reached 332 sets /10000 persons, ranking first in the world. In order to meet the needs of global industrial transformation, the Japanese government put forward the "new robot strategy" in 2015, aiming to constantly break through existing technologies, expand robot application fields, and move towards a new era of world leading robots. At the same time, the Japanese government has also provided comprehensive financial support in terms of taxation and financing. At present, Japan has strong international competitiveness in automobile, electronics, high-end materials, intelligent robots and so on. It has two international industrial robot giants, FANUC and Yaskawa electric. Moreover, Japan occupies an important position in the upstream of the intelligent manufacturing industry chain, and has a number of global leading technologies, such as sensors, controllers, reducers, etc.

### ***3.4. Germany's industrial policy concept is faster than that of the world, and its traditional industrial strength is strong***

Germany took the lead in putting forward the concept of "industry 4.0" and incorporated it into the national high-tech strategic framework, promoting a new round of scientific and technological revolution and industrial transformation in the world. First, in 2014, the German government issued and implemented the new high technology strategy: Innovation for Germany. In 2018, it further issued the high technology strategy 2025, which defined the strategic objectives to be achieved in various fields at different stages. It is proposed that the proportion of R&D investment in GDP will reach 3.5% by 2025. Second, the German government attaches great importance to the interaction between the government, academia and enterprises. Thanks to the strong promotion and implementation of relevant policies, Germany 4.0 has achieved certain results. Germany still maintains strong international competitiveness in automobile, mechanical equipment, chemical industry, etc.

## **4. ENLIGHTENMENT TO THE INTELLIGENT DEVELOPMENT OF CHINA'S MANUFACTURING INDUSTRY**

### ***4.1. Accelerate technology research and development of intelligent manufacturing industry***

In the upstream field of intelligent manufacturing, China still has some shortcomings. Therefore, first, both the government and enterprises should put the improvement of scientific and technological innovation at the core position, continuously strengthen the technological research and development, actively intervene in the "neck" technology field, and cultivate the domestic core competitiveness. Second, China should make effective use of the advantages of China's entire industrial chain. In addition, while strengthening independent innovation, enterprises can also cooperate with international advanced enterprises in this field by means of joint venture, acquisition of equity, establishment of overseas R&D and innovation centers. Therefore, domestic enterprises and international advanced enterprises can share knowledge and technical resources to achieve leapfrog development.

### ***4.2. Pay attention to the intelligent upgrading of traditional manufacturing industry***

At present, the traditional manufacturing industry is still the main body of China's manufacturing industry and an important channel to solve employment, stabilize society and maintain economic development. The United

States and Japan have proposed "Reindustrialization" and other policies to promote the return of manufacturing industry, and actively promote transformation and upgrading (Luo Xubin, 2021) [10]. In the future, China should continue to promote the coordinated development of traditional manufacturing and high-tech industries, upgrade and transform traditional industries by expanding the application of advanced technologies.

### ***4.3. Improve the industrial policy support system***

Compared with foreign countries, the pertinence and effectiveness of China's industrial policies need to be improved. In the future, China should learn more from the experiences of the United States, Japan and Germany, pay attention to the balance of policy resources between traditional manufacturing and high-end manufacturing, and promote in-depth cooperation and cooperation among the government, academia and enterprises. In addition, China can also refine support policies in different aspects such as R&D, production, application and promotion, clarify development goals, and improve financial support.

## **5. CONCLUSIONS**

This paper compares the intelligent manufacturing development in China, the United States, Japan and Germany, and analyzes the industrial policies of various countries, so as to help us realize the shortcomings of China's intelligent manufacturing. In the future, China should actively learn from the experience of the United States, Japan and Germany, and make breakthroughs in key areas based on its own development characteristics to accelerate the development process of intelligent manufacturing.

## **AUTHORS' CONTRIBUTIONS**

Lina Wang contributed to the conception of the study and the revision of the manuscript;

Hengyuan Zhao performed the data analyses and wrote the manuscript.

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