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ИССЛЕДОВАНИЕ РАЗРАБОТКИ ПОЛИТИКИ И ПЕРЕМЕННЫХ ЦИФРОВЫХ ТЕХНОЛОГИЙ ПРОИЗВОДСТВА В КИТАЕ И США

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В данной статье анализируется промышленное экономическое развитие и промышленная структура Китая и США в эпоху Индустрии 4.0, а также кратко излагается политика модернизации производства в этих двух странах. В рамках производственной политики общее экономическое развитие и промышленная структура Китая и США претерпели значительные изменения. С 2015 г. цифровизация производства стала одним из основных направлений экономической работы в странах по всему миру. Политика оцифровки производства, сформулированная Китаем и США, сыграла разные роли и повлияла на нее. В статье проводится углубленное исследование того, как Китай и Соединенные Штаты могут реализовать дальнейшую цифровизацию производства после того, как мир вступит в эпоху Индустрии 4.0. Делается вывод о том, что страна должна опираться на развитие обрабатывающей промышленности и использовать возможности развития цифровой экономики и руководящую роль политики для реализации цифровой трансформации обрабатывающей промышленности.
Ключевые слова: цифровое производство, производство, цифровая экономика, цифровая трансформация, Индустрия 4.0, Сделано в Китае 2025, промышленный Интернет.

RESEARCH ON THE POLICY DEVELOPMENT AND VARIABLES OF THE DIGITALIZATION OF MANUFACTURING IN CHINA AND UNITED STATES

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This paper analyses the industrial economic development and industrial structure of China and United States in the era of Industry 4.0, and summarizes the manufacturing upgrade policies of the two countries. Under the manufacturing policy, the overall economic development and industrial structure of China and United States have undergone significant changes. Since 2015, the digitalization of manufacturing has become one of the focuses of economic work in countries

around the world. The policies formulated by China and United States for the digitalization of manufacturing have played different roles and influences. This article conducts an in-depth study on how China and United States can further realize the digitalization of manufacturing after the world enters the age of Industry 4.0. It is concluded that the country should base itself on the development of the manufacturing industry, and use the development opportunities of the digital economy and the guiding role of policies to realize the digital transformation of the manufacturing industry.
Keywords : manufacturing, Industry 4.0, digital manufacturing, digital economy, digital transformation, industrial Internet, made in China 2025.

1. Introduction

Around 2000, many financial crises broke out around the world, and the economies of all countries were hit hard. After the international financial crisis, all countries in the world have made industrial manufacturing the top priority of economic development. Developed countries such as Germany, the United States, Britain, France and other developed countries have successively issued the "German Industry 4.0 Strategy" and the "National Strategic Plan for Advanced Manufacturing Industries in the United States" "British Industry 2050" and "New Industry France Plan", Russia issued the "National Plan for Industrial Development and Improving Industrial Competitiveness". Among emerging economies, India has introduced "Made in India", and South Korea has formulated "Future Growth Drivers Plan." In May 2015, the State Council of China issued "Made in China 2025", which is the first ten-year action plan for China to implement the strategy of a manufacturing powerhouse. The industrial manufacturing development plans of various countries are collectively referred to as "Industry 4.0" in the study.

A new round of scientific and technological revolution and industrial transformation has given birth to new technologies, new industries, new business forms, and new models. Protectionism, unilateralism, and "anti-globalization" [14] have emerged, and the comparative advantages of countries around the world have continued to change, and other factors have promoted the manufacturing industry. Significant changes have taken place in the global industrial structure. The in-depth advancement of the technological revolution and industrial transformation, the countercurrent of economic globalization, and the impact of the COVID-19 epidemic will further change the global industrial structure of the manufacturing industry. The policies and ideas of Industry 4.0 are located in the internal fields of electrical engineering, business administration, communication science, business and information system engineering, mechanical engineering, and participating disciplines [4]. Industry 4.0 is a major innovation brought about by digital technologies such as the Internet of Things [17], artificial intelligence, cloud computing, and big data. The implementation of Industry 4.0 and Industrial Internet policies has driven the digital development of the manufacturing industry. When the country realizes the digital transformation of the manufacturing industry, it must speed up the formulation of digital manufacturing standards and

promote the construction of new infrastructure. Actively promote the development of the Industrial Internet, accelerate the digital transformation of the manufacturing industry, and effectively promote the high-quality development of the manufacturing industry. After entering the Industry 4.0 era, China and United States, the world's major economies, have formulated different upgrade plans and national policies in the process of achieving manufacturing upgrades and manufacturing digitization. The research method is that we use the information and data of the World Bank and the China International Bureau of Statistics to compare the industrial economic development status and manufacturing upgrade policies of China and United States. The research goal is to study and analyse the advantages and disadvantages of China and United States in achieving manufacturing transformation. The purpose of the research is to analyse the interaction between national policies and the digital transformation of manufacturing.

2. Background Information

2.1. Industry 4.0

After the human society entered the industrial age, it has experienced three industrial revolutions. The first industrial revolution, in the 1860s, was marked by the invention of the steam engine, and mankind entered the age of machines. The second industrial revolution, in the 1860s, mankind entered the era of electrical appliances, and production methods entered automation. The third industrial revolution began in the 1950s, when mankind entered the information age, and the mode of production became electronic. Germany is a world industrial power, with advanced industrial technology and a complete industrial system. The first industrial 4.0 strategic concept put forward has led other countries' industrial manufacturing plans. Therefore, after 2013, the industrial manufacturing industry has entered the era of "Industry 4.0" revolution.

2.2. Made in China 2025

"Made in China 2025"[1] is a strategic document issued by the State Council of China in May 2015 to deploy and comprehensively promote the implementation of a manufacturing powerhouse. It is China's first ten-year action plan for implementing the manufacturing powerhouse strategy. This strategy has three important target nodes: by 2025, China will enter the ranks of manufacturing powers, by 2035, China's manufacturing industry as a whole will reach the mid-level of the world's manufacturing power camp, by the 100th anniversary of the founding of New China, comprehensive strength will enter the world's manufacturing Powerful countries are at the forefront.

[1] Уведомление Государственного совета по печати и распространению "Сделано в Китае 2025" // Государственный совет Китая. – 2015. – 19 мая. – URL: http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm (дата обращения: 11.11.2021).

Made in China 2025 focuses on the transformation of industry and manufacturing itself, with the goal of transforming from an industrial power to an industrial power. Made in China 2025 takes the digital, networked and intelligent manufacturing that embodies the deep integration of information technology and manufacturing technology as its main line, shifts from production factors to innovation-driven, and promotes the deep integration of informatization and industrialization. Compared with the world's advanced manufacturing level, China's manufacturing industry is still large but not strong, there are obvious gaps in independent innovation capability, resource utilization efficiency, industrial structure level, informatization level, quality and efficiency, etc. The task of transformation, upgrading and leapfrog development is urgent and arduous [11]. Made in China 2025 uses two resources and two markets as a whole, implements a more active opening strategy, better integrates bringing in and going out, expands new open areas and spaces, improves the level and level of international cooperation and promotes key industries internationally Layout. The fundamental purpose of Made in China is to enhance comprehensive national strength, ensure national security, and become a manufacturing power in the world.

2.3. National Strategic Plan for Advanced Manufacturing

In order to cope with the development trend of the global advanced manufacturing industry and the challenges faced by the US manufacturing industry, in February 2012, in accordance with the "America COMPETES Reauthorization ACT 2010", the US National Science and Technology Commission (NSTC) formulated and issued the “National Strategic Plan for Advanced Manufacturing Industry” was adopted, and the development of advanced manufacturing was raised to the level of US national strategy. After the U.S. government issued the "Rejuvenation of U.S. Manufacturing Policy" and "Advanced Manufacturing Partnership (AMP) Program" policies, it put forward specific recommendations and measures to accelerate innovation and promote the development of U.S. advanced manufacturing in accordance with the national strategy.

The "National Strategic Plan for Advanced Manufacturing Industries" clarified three principles: perfecting advanced manufacturing policies, strengthening the construction of "industrial commons", and increasing and optimizing government investment. The report puts forward five goals: increase investment in small and medium-sized enterprises, increase labour skills, establish and improve partnerships, adjust and optimize government investment, and increase R&D investment.

2.4. Comparison of "Made in China 2025" and "National Strategic Plan for Advanced Manufacturing"

Table 1 provides a comparison between the "National Strategic Plan for Advanced Manufacturing Industry" and "Made in China 2025".

The promulgation and implementation of these two policies are in 2012 and 2015. The goal of the Advanced Manufacturing National Strategic Plan is to reshape the competitiveness of the United States in advanced manufacturing, while the goal of Made in China 2025 is to build China into a manufacturing powerhouse. According to data from the World Bank, the GDP of the United States in 2015 was 18.24 trillion U.S. dollars, and China's GDP was 11.06 trillion U.S. dollars. The GDP of the United States is far ahead of the rest of the world. In 2015, the proportion of China's industrial added value to GDP was 2.2 times that of the United States. In 2015, the world's average industrial added value accounted for 25.53% of GDP. In 2015, China's industrial added value was US$4.52 trillion, and the US's industrial added value was US$3.38 trillion. The scale of China's industrial added value is the largest in the world, indicating that China is the world's largest industrial country. The growth rate of US GDP from 2015 to 2020 is 14.8%, and the growth rate of China's GDP from 2015 to 2020 is 33%. The proportion of industrial added value in GDP and the growth rate of industrial added value of China and United States have declined to a certain extent from 2015 to 2019.

Table 1

Industrial policy goals of China and the U.S.*

	United States	China
Promulgation and implementation time	February 2012	May 2015
Goal	Reshaping the U.S.'s competitiveness in advanced manufacturing	Realize the transformation of a manufacturing country into a manufacturing powerhouse
GDP (2015)	18.24 trillion U.S. dollars	11.06 trillion U.S. dollars
GDP (2020)	20.94 trillion U.S. dollars	14.72 trillion U.S. dollars
Industrial added value as a proportion of GDP (2015)	18.54%	40.84%
Industrial added value as a proportion of GDP (2019)	18.16%	38.59%
Industrial value added growth rate (2015)	2.59%	5.93%
Industrial value added growth rate (2019)	2.29%	4.87%
Implementation time	Unclear	10 years; extended to 2049
Implementation phase	4 years in a phase	Three phases (2025–2049)

* *Source*: World Bank Data. – 2021.

3. Digitalization of Manufacturing

3.1. Evolution of U.S. Manufacturing Digital Policy

With the development of Industry 4.0 and the Industrial Internet, data has become a new key production factor in the manufacturing industry [9], and digital transformation has become one of the important trends in global industrial development and trade innovation [3]. The United States is the first country in the world to deploy digital transformation. It has been paying attention to the development and influence of new generation information technology for many years, and has established its leading position in digital transformation. Industrial digital transformation is considered to provide a good opportunity to solve the sustainability problem of industrial operations [8]. Continuous digital transformation improves working conditions, creates job opportunities, enhances customer experience [2] and promotes sustainable social development.

In 2014, five giant companies, General Electric (GE), AT&T, Cisco, IBM, and Intel, announced the establishment of the Industrial Internet Consortium IIC in the United States, and the Industrial Internet of Things was officially proposed for the first time. Industrial Internet (Industrial Internet) is a new type of infrastructure, application model and industrial ecology that deeply integrates the new generation of information and communication technology and industrial economy, and is a further expansion of Industry 4.0. Through the comprehensive connection of people, machines, things, systems, etc., the Industrial Internet builds a new manufacturing and service system covering the entire industry chain [13] and the entire value chain [15], enabling the industry to achieve digitalization, networked and Intelligent.

In recent years, the United States has further focused on cutting-edge technology fields such as big data and artificial intelligence, and successively released the "Federal Big Data R&D Strategic Plan", "National Artificial Intelligence Research and Development Strategic Plan", "Prepare for the Future of Artificial Intelligence", and "U.S. Machine Intelligence The National Strategy has established a policy system based on open innovation and focused on promoting the transformation of traditional industries, effectively promoting the development process of digital transformation. In order to guide the recovery of the real economy, the United States reindustrialized after the financial crisis, successively released the "Intelligent Manufacturing Revitalization Plan" and " Strategy for American Leadership in Advanced Manufacturing"[1], relying on the new generation of information technology to accelerate the development of technology-intensive advanced manufacturing, and develop advanced manufacturing Industry, making it an engine of

[1] Стратегия американского лидерства в передовом производстве // Национальный совет по науке и технологиям. – 2018. – Октябрь.

American economic power and a pillar of national security. In July 2020, in order to further clarify the methods and processes of industrial digital transformation, so as to provide a reference for enterprises' digital transformation decision-making, the Industrial Internet Alliance of the United States released the "White paper on digital transformation in industry" (Table 2).

Table 2

Major Policies of U.S. Industrial Digitalization*

Main Policies of U.S. Industrial Digitalization	
2014	Revitalizing the American Manufacturing and Innovation (RAMI)
2015	American Innovation Strategy 2015
12/2016	American Innovation and Competitiveness Act
12/2017	Tax Cuts and Jobs Act of 2017
10/2018	Strategy for American Leadership in Advanced Manufacturing
2020	Intensify efforts to promote future industrial development
07/2020	White paper on digital transformation in industry

3.2. Promotion of China's manufacturing digitalization policy

Since China put forward the “National Big Data Strategy” in 2015, the policy of advancing the development of digital economy and digital transformation has been deepened and implemented. Since 2017, the “digital economy” has been included in the government work report for four consecutive years. Government work in 2020 The report clearly pointed out that it is necessary to continue to introduce support policies, comprehensively promote the "Internet +", and create new advantages in the digital economy.

In May 2016, the State Council of China issued the "Guiding Opinions on Deepening the Integrated Development of Manufacturing and the Internet", which is an upgraded version of "Made in China 2025". From 2018 to 2020, the Ministry of Industry and Information Technology of China issued the "Industrial Internet Development Action Plan (2018-2020)", "Industrial Internet Special Working Group 2018 Work Plan", and "Industrial Internet Network Construction and Promotion Guidelines", "Implementation Opinions on Promoting the Deeply Integrated Development of Advanced Manufacturing and Modern Service Industries" and "Notice on Promoting the Accelerated Development of Industrial Internet"(Table 3). These policies require the establishment of an industrial Internet infrastructure and industrial system, continuous promotion of the development of the industrial Internet, and realization of the digital development of the manufacturing industry. In January 2021, the Ministry of Industry and Information Technology of

China issued the "Industrial Internet Innovation and Development Action Plan (2021–2023)". This plan is a further deepening of the "Opinions on Deepening the Development of 'Internet + Advanced Manufacturing' and Industrial Internet" released in 2017.

Table 3

Main Policies of China's Industrial Digitalization

Main Policies of China Industrial Digitalization	
2016	Guiding Opinions on Deepening the Integrated Development of Manufacturing and the Internet
2017	Guiding Opinions on Deepening "Internet + Advanced Manufacturing" and Developing Industrial Internet
2018	Industrial Internet Development Plan (2018-2020)
01/2019	Industrial Internet Construction and Promotion Guide
11/2019	Implementation Opinions on Promoting the Deeply Integrated Development of Advanced Manufacturing Industry and Modern Service Industry
2020	Notice to Promote the Accelerated Development of Industrial Internet
2021	Industrial Internet Innovation and Development Action Plan (2021-2023)

4. Research result

4.1. Data

We use World Bank data (updated on July 30, 2021) and data and information from the National Bureau of Statistics of China to analyse the process of change from "Made in China" to China's industrial Internet economy [1]. Table 4 shows the data and data sources used in this study. According to the attributes of the data, we define the variables of the digital development of the manufacturing industry as: manufacturing capacity, R&D, and human capital.

Manufacturing capacity includes four items: GDP, the proportion of industrial added value in GDP, the growth rate of industrial added value, and the proportion of high-tech exports in manufacturing. R&D includes two items: the percentage of information and communication technology (ICT) product exports to the total product exports, the receipt and use of intellectual property rights, and the use of intellectual property expenditures. Human capital includes five items: the number of ordinary undergraduate/academy graduates, educational funding, research and experimental development personnel of scientific research and development institutions, research and experimental development expenditures of scientific research and development institutions, and overseas/returning overseas students.

Table 4

Data from China and United States from 2015 to 2020*

Indicator Name	Country	2015	2016	2017	2018	2019	2020	2016	2017	2018	2019	2020
GDP (billions of U.S. dollars)	China	11 061.55	11 233.28	12 310.41	13 894.82	14 279.94	14 722.73	1.55%	11.29%	25.61%	29.10%	33.10%
	U.S.	18 238.3	18 745.08	19 542.98	20 611.86	21 433.22	20 936.60	2.78%	7.15%	13.01%	17.52%	14.79%
Industry (including construction), value added (% of GDP)	China	40.84	39.58	39.85	39.69	38.59	–	–3.09%	–2.42%	–2.83%	**–5.52%**	_
	U.S.	18.54	17.97	18.25	18.53	18.16	–	–3.12%	–1.58%	–0.09%	**–2.09%**	_
Industry (including construction), value added (annual % growth)	China	5.93	6.03	5.87	5.79	4.87	–	1.77%	–0.99%	–2.27%	**–17.75%**	_
	U.S.	2.59	0.30	2.45	3.73	2.29	–	–88.62%	–5.41%	43.97%	**–11.64%**	_
High-tech exports (millions of dollars)	China	652 237.38	594551.85	654187.61	731890.59	715843.47	–	–8.84%	0.30%	12.21%	9.75%	_
	U.S.	178 349.53	176 346.13	156 640.13	156 037.13	156 074.13	–	–1.12%	–12.17%	–12.51%	**–12.49%**	_
Commodity exports (millions of dollars)	China	2 273 468	2 097 632	2 263 346	2 486 695	2 499 457	2 591 121	–7.73%	–0.45%	9.38%	9.94%	13.97%
	U.S.	1 502 572	1 451 011	1 546 273	1 663 982	1 643 161	1 431 638	–3.43%	2.91%	10.74%	9.36%	**–4.72%**
High-tech exports (% of manufactured exports)	China	30.42	30.24	30.91	31.47	30.79	–	–0.59%	1.60%	3.44%	1.19%	–
	U.S.	21.76	22.72	19.52	18.74	18.93	–	4.43%	–10.29%	–13.87%	**–12.99%**	–
ICT product exports (% of total product exports)	China	26.56	26.50	27.07	27.31	26.50	–	–0.25%	1.90%	2.81%	**–0.23%**	–
	U.S.	9.44	9.65	9.48	8.90	8.74	–	2.21%	0.39%	–5.74%	**–7.38%**	–
Intellectual property usage fee, Received (million dollars)	China	1 085	1 161	4 803	5 561	6 605	8 554	7.00%	342.67%	412.53%	508.76%	***688.39%***
	U.S.	111 151	112 981	118 147	118 874	117 401	114 045	1.65%	6.29%	6.95%	5.62%	2.60%
Intellectual property usage fee, Paid (millions of dollars)	China	22 022	23 980	28 746	35 783	34 370	37 782	8.89%	30.53%	62.49%	56.07%	71.56%
	U.S.	35 178	41 974	44 406	43 932	42 732	40 682	19.32%	26.23%	24.88%	21.47%	15.65%

* *Source*: World Bank Data. – 2021.

4.2. Manufacturing capabilities

GDP is an important indicator to measure the economic status and development level of a country or region[1]. China's GDP ranked second in the world in 2009, becoming the world's second largest economy, and the world's digital economy presents a pattern of two powers coexisting[2]. At the beginning of the 21st century, advanced industrialized countries began to adjust the proportion of labor-intensive, low-value-added, and low-profit industries in the domestic manufacturing industry, focusing on high-tech products and technology industries. Then, the manufacturing center moved from the advanced industrialized countries in North America and Europe to Asian countries and South American countries represented by China. During this period, China became the world's major industrial production base, one of the major producers and exporters of industrial products, and was called the new "World factory" [7].

The China-US GDP (Table 4) shows that from 2015 to 2019, China's GDP growth rate was relatively high. In 2020, the world economy totaled 84505.426 billion US dollars, and the GDP growth rate was –3.6%. The GDP growth rate of the United States in 2020 is –3.5%, which is the first time since 2009 to record a negative value, and hit a new low since 1946. China's GDP growth rate in 2020 is 2.3%, making it the only major economy in the world to achieve positive economic growth. The overall change in China's industrial added value from 2015 to 2019 (Figure 1) showed a steady trend, with a slight decline.

The value added of industry in the United States dropped sharply in 2016 and rose sharply in 2018. The proportion of the industrial added value of China and United States in GDP has maintained a steady development trend. U.S. high-tech exports (as a percentage of manufactured goods exports) in 2016 increased by 4.4% compared to 2015, and the overall changes in China’s

[1] Предварительный учет ВВП Китая (валового внутреннего продукта) в первом квартале 2015 // Национальная статистика Китайской Народной Республики. – 2016. – 16 апреля. – URL: http://www.stats.gov.cn/tjsj/zxfb/201504/t20150416_713042.htm (дата обращения: 13.11.2021).

[2] Доклад о цифровой экономике 2019. Создание и захват стоимости: последствия для развивающихся стран // Организация Объединенных Наций. – Женева, 2019.

high-tech exports (as a percentage of manufactured goods exports) showed a steady trend.

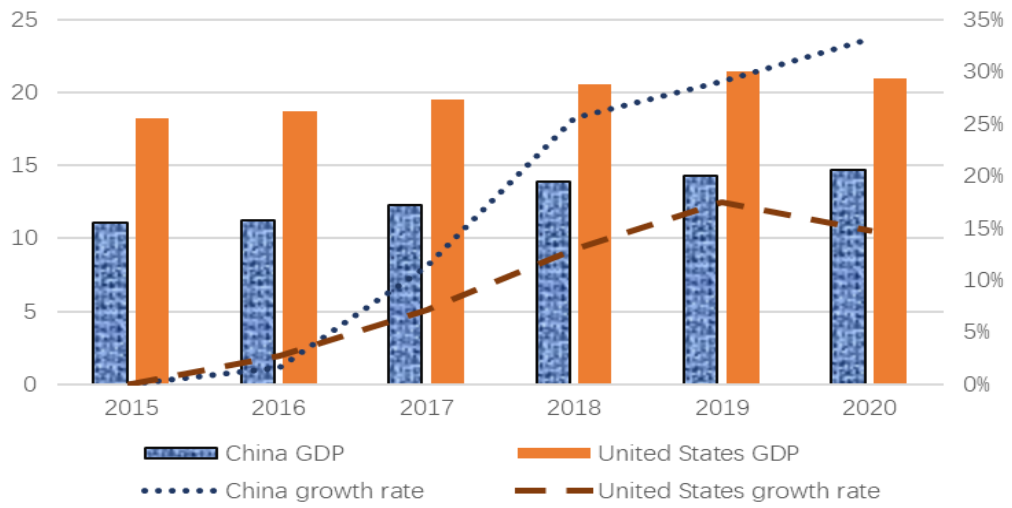

Figure 1. The GDP and growth rate of China and United States[1]

4.3. R&D capabilities

Digital technology can better understand industry changes and customer needs [16]. The development of digital technology requires continuous, high-quality, and high-intensity R&D investment. According to China's "Statistical Bulletin of National Science and Technology Expenditures", China's total R&D investment reached 2.23 trillion yuan in 2019, an increase of 810 billion yuan from 1.42 trillion yuan in 2015. Since China's total R&D investment has surpassed Japan in 2013, it has ranked second in the world. China's R&D investment intensity has exceeded the average level of 2.13% of the 15 EU countries, not far from the average level of 2.37% of the OECD countries.

R&D investment enhances independent innovation capabilities, thereby reducing production costs, generating new social needs, and promoting the rationalization of industrial structure [10]. The purpose of scientific research is to generate scientific and technological achievements [5]. The transformation of scientific and technological achievements is a complex system engineering. It is also a risky business. Intellectual property is the bridge and tie for the

[1] *Source Figure 1, 2*: World Bank Data. – 2021.

transformation of scientific research results into actual productivity. At the same time, the revenue of intellectual property can stimulate more scientific research and innovation, and it is also the driving force and basic guarantee for stimulating scientific research and innovation. From 2015 to 2020, China's payment of intellectual property royalties gradually tends to be the same from a certain gap. Although China has a higher growth trend in income from intellectual property fees, the United States has a greater advantage in income from intellectual property fees (Figure 2).

From 2015 to 2020, the proportion of US intellectual property fee income to world intellectual property fee income is 33.59%, 33.90%, 32.48%, 29.87%, 29.52%, and 30.88%. From 2015 to 2019, the overall changes in China and United States' ICT product exports (as a percentage of total product exports) showed a steady trend.

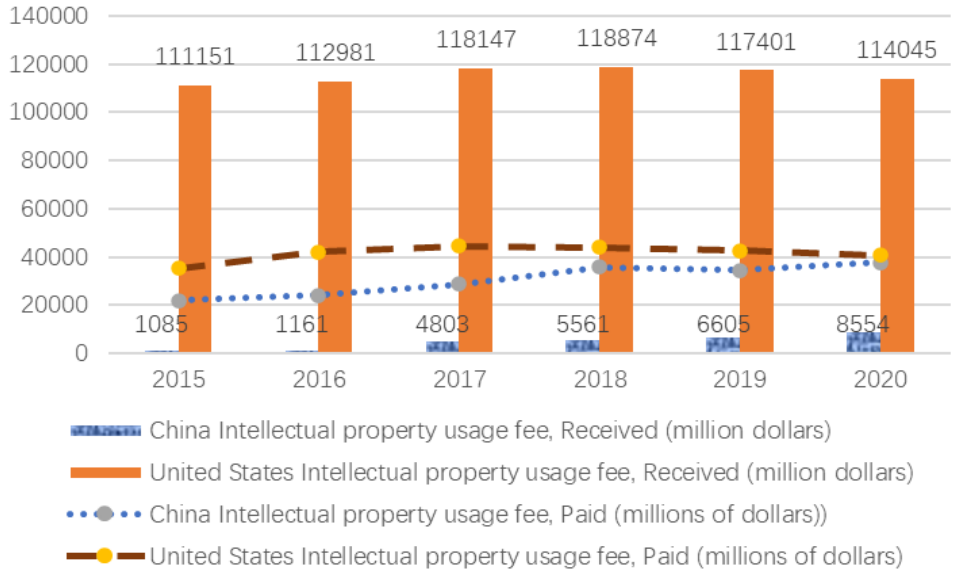

Figure 2. Intellectual property royalties, Received/Paid: China and United States

4.4. Human capital

A country's human capital is an important engine for the country's economic growth, and it is the personification of technology and knowledge. The higher the quality of human capital, the more conducive to promoting technological progress, increasing the level of marginal productivity of factors, realizing economic policies, and improving the level of economic

development. The human capital of an enterprise has a significant decisive role in the possibility of enterprise product innovation. The industry 4.0 era has greatly increased in labour costs, and the requirements for manufacturing skills are getting higher and higher. In the future, large-scale mass production will accelerate, and production will often rely on customized high-skills. Among them, the proportion of low-cost labor is getting lower and lower, and the maintenance requirements of the manufacturing industry are getting higher and higher.

The number of undergraduate and academy graduates in China (Table 5) in 2020 has increased by 50% and 15% respectively compared to 2011. Education funding has increased by 110% from 2011 to 2019, and the expenditure on research and experimental development of scientific research and development institutions has increased by 136% from 2011 to 2019, which has led to the increase of research and experimental development personnel in scientific research and development institutions. The promotion and transformation of China's industrial manufacturing provides a strong guarantee for talents.

The sustained growth of China's economy in 2020 has become the hope of global economic recovery, and it is the first element for more and more international students to choose to return to China for development. The severity of the COVID-19 epidemic abroad has aggravated many international students returning to the country for employment, and even some international students have returned to China early without completing their studies. In addition, emotional and cultural factors, policies for attracting talents to study abroad, and personal development opportunities are all important factors that affect the employment of overseas students. From 2011 to 2019, the number of Chinese students studying abroad and the number of returning students have increased significantly. In 9 years, the number of students studying abroad has increased by 107%, and the number of returning students has increased by 212%.

According to the above data, talents are the most active and active element in innovation activities. Talent advantages reshape industrial advantages, and play an important role in pioneering and innovative advantages and technological advantages. There are more than 170 million people with higher education or various professional skills in China, and a large-scale human resource team plays a unique and irreplaceable role in economic and social development.

Table 5

Human capital in China*

Indicator Name	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Number of general undergraduate graduates (10,000 people)	420.5	394.7	386.8	384.2	374.4	358.6	341.4	320.0	303.8	279.6
Number of general academy graduates (10,000 people)	376.7	363.8	366.5	351.6	329.8	322.3	318.0	318.7	320.9	328.5
Education funding (million yuan)	–	5 017 812	4 614 300	4 256 201	3 888 839	3 612 919	3 280 646	3 036 472	2 865 531	2 386 929
Research and experimental development personnel in scientific research and development institutions (10,000 people)	–	48.53	46.43	46.22	44.99	43.63	42.3	40.9	38.82	36.21
Research and experimental development expenditures of scientific research and development institutions (billion yuan)	–	308.08	269.17	243.57	226.02	213.65	192.62	178.14	154.89	130.67
Number of students studying abroad (10,000 people)	–	70.35	66.21	60.84	54.45	52.37	45.98	41.39	39.96	33.97
Number of returnees from studying abroad (10,000 people)	–	58.03	51.94	48.09	43.25	40.91	36.48	35.35	27.29	18.62

* *Source:* Ministry of Education of China; National Bureau of Statistics of China.

5. Discussion

The manufacturing industry is the foundation of a country's industrial modernization and the foundation of a strong country [12]. The digital economy has an increasing influence on social development and production methods [6]. Therefore, the digitalization of the manufacturing industry is the development trend of the world economy. With the development of China's manufacturing industry and the improvement of its scientific and technological strength, China already has a certain basis for manufacturing digitization. The first is the huge talent (user) advantage. The current quantitative advantage of the Chinese population is gradually transforming into a quality advantage. While providing a large-scale consumer market and application users, it also provides labour resources with huge innovation potential. The second is rich experience in systematic engineering construction. China's successful experience in major engineering fields such as communications standards, high-speed rail, and aerospace has laid a solid foundation for the centralized resource system to promote the "Internet + advanced manufacturing" with Chinese characteristics. The third is a complete industrial system. China is a large industrial country with a complete industrial system, complete industrial supporting facilities and multi-level industrial clusters. The fourth is good infrastructure conditions. China not only has a strong transportation and energy infrastructure, but also has a wide coverage of broadband networks, mobile Internet, satellite navigation, cloud computing and other new infrastructure construction is also accelerating. The fifth is a complete Internet ecosystem. China's Internet industry is active in innovation. A group of internationally competitive Internet companies represented by Huawei have risen rapidly. New technologies such as artificial intelligence and quantum computing have continued to emerge. New models and formats of digital manufacturing are emerging endlessly.

At present, the United States has proposed and implemented a "re-industrialization" plan, which is mainly aimed at the reality of the excessive virtual economy, the decline of the real economy, and the imbalance of the industrial structure in the economy. However, the United States is a powerful and innovative industrial country in the world. The industrial foundation of intelligent manufacturing is solid, and most of the core technologies and components can be independently developed and manufactured. As an important part of advanced manufacturing, intelligent manufacturing has received great attention from the US government and enterprises at all levels. The US government has initiated a series of plans and projects to systematically support the development of key elements of intelligent manufacturing such as model-based enterprises, cyber-physical systems (CPS), industrial robots, advanced measurement and analysis, and intelligent manufacturing system integration. An important shortcoming in the development of digital manufacturing in the United States is the unbalanced distribution of industrial production. After the information revolution, the United States continues to carry out industrial replacement from traditional

manufacturing to high-end manufacturing, and from manufacturing to service industries; within specific industrial sectors, the United States continues to use the internationalization of the industrial chain to break away from production, outsource factories, and retain only in the United States R&D and operations talents. In addition, competition among companies in other countries in the world is still intensifying, and manufacturing factories continue to flee the United States with the globalization of the industrial chain.

6. Conclusion

In this study, we compared the evolution of manufacturing policies in China and United States, and analysed the development of manufacturing under the influence of manufacturing policies in China and United States.

The world is transitioning from an industrial economy to a digital economy. The manufacturing industry has entered the historical stage of digital transformation and development, and will continue to leap forward along the digital, networked, and intelligent stages. The main mission of the digitization stage is the digitalization and software transformation of manufacturing infrastructure and behavioural activities, and the rules of manufacturing resource allocation may not necessarily undergo fundamental changes; the main mission of the network stage is to socialize a large-scale dynamic allocation of manufacturing resources on demand, The main mission of the intelligent phase is to dig deep and socially accurately configure manufacturing resources according to individual needs. Therefore, the network and intelligent phase will be an era of disruptive innovation and subversive changes in the rules of manufacturing resource allocation. At present, the manufacturing industry is in a critical period of accelerating from the digital stage to the network stage. The development theory, method tools, solutions and value models of the manufacturing industry are about to undergo systematic and systematic changes, and the digital transformation of the manufacturing industry is facing important opportunities and challenges.

Through analysis, China has clear goals, accurate implementation time control, and continued policies and regulations in the digital upgrade process of the manufacturing industry. China's advantages in the three modules of manufacturing capacity, R&D and human capital are the key competitiveness that determines China's manufacturing transformation. It can be concluded that advanced manufacturing is the main factor affecting the long-term rapid development of China's manufacturing industry in the future.

Manufacturing has always been the focus of US national policy. The US government implemented the "Advanced Technology Program", "Manufacturing Cooperative Development Program" and "Next Generation Manufacturing Action Framework" in 1990, 1993 and 1997, respectively, to promote the further development of American manufacturing. The study concluded that the United States is still a strong country in manufacturing, has a global manufacturing industry chain, and occupies the high end of the global manufacturing industry chain. The U.S. manufacturing policy has played a

key role in realizing advanced manufacturing, providing innovative power and institutional guarantees for the development of advanced manufacturing.

Digital transformation will redefine the global division of labour. The digital transformation of manufacturing has become an important engine leading the global economic and social transformation. Both the Chinese and American governments attach great importance to the manufacturing industry, and both governments have stated in their policy documents to welcome the advent of a new wave of technological revolution. These policy visions outline the blueprint for the future development of manufacturing industries in China and United States. In the future, to promote the development of manufacturing in the direction of digitization and intelligence, the in-depth integration of digital technology and manufacturing will become a key factor in reshaping the competitiveness of manufacturing.

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