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Measuring the Position of China, Japan, and South Korea in the Global Value Chain of Digital Product Manufacturing and a Comparative Analysis of Their Competitiveness

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Abstract

The rise of the digital economy has injected new momentum into global economic integration and is profoundly reshaping the landscape of the international division of labor. Although China has developed a substantial market scale and holds a considerable share in the digital product manufacturing industry, its development remains large in scale while lacking sophistication. A thorough investigation into the international division of labor position and competitive advantages of China, Japan, and South Korea in digital product manufacturing and its sub-sectors is of enormous significance for advancing the high-quality transformation of China's manufacturing sector and fostering the leapfrog development of the digital economy. In the existing literature, few scholars have conducted systematic measurements and analysis of the global value chain (GVC) in the sub-sectors of digital product manufacturing. This paper addresses this gap by utilizing trade data at the HS 6-digit level from the UN Comtrade database, covering the period 2018-2022, for China, Japan, and South Korea. We calculate the trade performance of sub-sectors within the digital product manufacturing industry for the three countries and construct GVC position indices to evaluate their respective roles in the international division of labor. A comparative analysis is then undertaken to assess China's position relative to Japan and South Korea. In addition, the study incorporates a set of international competitiveness indicators—namely the Market Share Index (MS), the Revealed Comparative Advantage Index (RCA), and the Trade Competitiveness Index (TC)—to further measure and compare the international competitiveness of the three economies. The findings can be summarized as follows: First, although China's GVC position in digital product manufacturing is lower than that of Japan and South Korea, it has consistently maintained the world's largest trade scale in this sector, demonstrating a strong comparative advantage and considerable international competitiveness. Second, from a subsectors perspective, Japan exhibits a well-developed R&D and innovation system in smart device manufacturing, granting it a distinct competitive edge that offers valuable lessons for China. Meanwhile, South Korea demonstrates strong industrial advantages in electronic component manufacturing, where it has established a complete domestic value chain and robust industrial clusters—an experience also worthy of reference for China.

Keywords

China-Japan-South Korea, Digital Product Manufacturing, Position in the Global Value Chain, Competitiveness

1. Introduction

The wave of technological revolution has driven the rapid rise of the digital economy. Since the beginning of the twenty-first century, with the accelerated advancement of information technology, the potential of the digital economy has been further unleashed, becoming a core force in driving global economic transformation and upgrading. Against the backdrop of an increasingly complex global trade environment, countries around the world regard the digital economy as a key factor in gaining international competitive advantage. Manufacturing, as the foundation of national economic development and the engine of technological progress, has increasingly been assessed through its integration with digital technologies—now widely recognized as a crucial indicator of national competitiveness. China, Japan and South Korea all stand as major players in the digital economy. China, supported by a strong manufacturing base, has elevated the development of the digital economy to the level of national strategy, fostering an ecosystem that accelerates the integration of the digital and real economies. Japan has promoted economic growth and addressed societal challenges through the high-level integration of cyber and physical systems, while also introducing its national data strategy. South Korea, for its part, has launched the *Semiconductor Powerhouse Strategy*, which significantly improves tax policies, emphasizes talent cultivation and strengthens investment to consolidate its leading position in the global semiconductor industry.

To accurately assess the development of the digital economy, China's National Bureau of Statistics released the *Statistical Classification of the Digital Economy and Its Core Industries* (2021), in which digital product manufacturing is identified as a core component. In 2022, the scale of China's digital economy reached USD 6.97 trillion, representing a nominal year-on-year growth of 10.3%, the largest in the world. As leading digital economies, China, Japan, and South Korea each demonstrate distinct competitive advantages in different domains. This paper aims to measure and analyze the import and export scale and structure of digital product manufacturing in the three countries and to evaluate the global value chain (GVC) positions of their respective sub-sectors. By conducting a comparative analysis of China's advantages and disadvantages relative to Japan and South Korea, this study provides essential empirical evidence to support the further development of China's digital economy and digital product manufacturing industry.

2. Literature Review

The measurement of global value chains (GVCs) has primarily relied on several approaches. First, focus on the measurement of export complexity indices and export product price indices. Michaely (1984) introduced the concept of export complexity, examining the interaction between the technological sophistication of specific export products and a country's per capita income. The uniqueness of this approach lies in its ability to evaluate the technological content of export goods using per capita income levels, even in the absence of industry-specific information on technology and R&D investment. Building on this idea, Hausmann et al. (2007) developed the Export Complexity Index (ECI), which operates at the product, industry, and national levels to assess a country's position in the GVC. A higher ECI indicates that a product possesses stronger competitiveness and generates greater trade value added, thereby reflecting a higher position in the GVC. However, with the deepening of economic globalization, traditional economic analysis has shown limitations. These methods do not adequately account for a country's role in GVC division of labor, nor do they consider the value added from imports. As a result, they may not fully capture the actual situation of an economy, and can lead to "statistical illusions".

In terms of applying export product price indices, Schott (2008) was among the first to use export prices to measure a country's position within the GVC. Building on this, Shi (2010) introduced both the export price index and the price fluctuation index, which reflect price changes of a country's exports over different time periods. This approach emphasizes product-level analysis by converting differences among varieties into price differentials. Although this method is relatively straightforward, its computational rigor is limited, and the conclusions derived may be subject to bias.

Second, Hummels et al. (2001) proposed the Vertical Specialization Index (VSI) to measure a country's position in the global value chain of its export products. This index evaluates the extent of a country's participation in international production by quantifying the contribution of imported intermediate inputs in its exports. The VSI captures the link between imports and exports: a higher share of imported inputs in a country's exports indicates deeper integration into the global division of labor. However, this method relies on stringent assumptions. First, it requires that a country's exported goods and final consumption products share common intermediate inputs in the production process. Second, it assumes that the intermediate inputs are primarily composed of foreign value added. In practice, these conditions are difficult to satisfy, which limits the applicability and accuracy of this measurement approach.

Third, the measurement of trade in value added has been developed to capture the characteristics of globalized trade better. Traditional trade statistics fail to accurately reflect the true contribution of countries within global production networks as economic globalization deepens. In response, the World Trade Organization (WTO) and the Organization for Economic Co-Operation and Development (OECD) formally introduced the concept of value-added trade in 2011, defining it as the value added from a country that is directly or indirectly embodied in the final consumption of another country. Daudin et al. (2011) further distinguished the value added in final products by their sources, quantifying the share of imported inputs in total exports, the portion re-exported back to the origin country after processing, and the share exported to third countries after further processing. The introduction of TiVA has spurred the development of numerous related indicators aimed at capturing a country's position in the global economy. To clarify the relationships among these indicators, Koopman et al. (2014) proposed an integrated approach, establishing the well-known KPWW framework. This framework begins with a detailed decomposition of total exports, separately considering domestic value added, foreign transactions, and the value added from domestic intermediates that are re-exported. Subsequently, it allows for finer disaggregation of domestic value added by sector. Building on the KPWW methodology, Wang et al. (2013) introduced an extended model to calculate value added at the bilateral, sectoral, and bilateral-sectoral levels. Despite its advantages, TiVA-based assessments also have limitations. Specifically, while this method measures the value added obtained by a country through exports, it cannot fully reveal the precise origins of that value added within global production networks.

Last, the measurement of the Global Value Chain (GVC) position index has been developed to assess a country's role within international production networks. Koopman et al. (2011), building on the KPWW methodology for measuring trade in value added, introduced the GVC position index, which evaluates a country's status in the global value chain by comparing the exports of intermediate goods. Countries positioned at the high end of the value chain tend to supply more intermediate products, whereas those at the lower end typically rely heavily on importing intermediates from other countries. A notable limitation of the GVC position index is that it overlooks downstream stages, which may result in measurement errors.

Subsequently, Lin and He (2015) extended this approach by using the relative unit price of exported intermediates to construct a GVC position index, analyzing the international division of labor and evolutionary path of China's equipment manufacturing industry. Building on Lin's innovation, Han and Zhang (2020) further refined the methodology at the product level, developing a novel calculation method for the GVC position index based on HS-coded classifications. Given that the calculation of the Global Value Chain (GVC) index for the digital product manufacturing industry involves multiple HS six-digit intermediate goods codes, this study adopts the methodology proposed by Lin and He (2015) and Han and Zhang (2020) to measure the GVC indices of the digital product manufacturing industries in China, Japan, and South Korea.

3. Trade Performance of Digital Product Manufacturing in China, Japan, and South Korea

3.1. Trade Performance of China's Digital Product Manufacturing Industry

In 2021, China's digital economy achieved remarkable progress, with its overall scale exceeding USD 7.06 trillion and accounting for 39.6% of GDP. It has thus become a core driver of the national economy, exerting growing influence across sectors. The country's comparative advantage in ICT services has become increasingly prominent, while both the software industry and the internet sector have also made notable advances. Furthermore, significant progress has been observed in industrial digitalization: official data indicate that its scale surpassed USD 5.77 trillion in 2021, marking a substantial enhancement in the digital transformation of Chinese industries.

3.1.1. Import and Export Trade of China's Digital Product Manufacturing Industry

In terms of the overall scale of imports and exports in the digital product manufacturing industry, China's trade volume reached USD 6.3096 trillion in 2022, with digital product manufacturing accounting for 22.49% of the country's total trade and registering a pronounced trade surplus. From 2018 to 2022, the trade volume of China's digital product manufacturing industry exhibited a fluctuating yet upward trajectory. In 2019, the total trade volume declined slightly as a result of the trade war, but it rebounded rapidly in 2020, surpassing the level of 2018. In 2021, the industry's total import and export volume recorded a strong growth rate of 23.28%, the highest within the five-year period under review. Although the trade volume moderated to some extent in 2022, the growth rate of China's digital product manufacturing industry still reached 50.16%, considerably exceeding the contemporaneous global average growth rate of 28.97%.

3.1.2. Export Scale and Structure of China's Digital Product Manufacturing Industry

From 2018 to 2022, China's exports of digital product manufacturing demonstrated a fluctuating yet upward trend. Examining its share in China's overall export trade, the proportion rose modestly from 29.09% to 30.2%, reflecting a gradual increase over the five-year period. Nevertheless, given China's substantial trade volume, even a 1% rise signifies a considerable expansion in trade for the digital product manufacturing sector. In China, the industry is advancing steadily, and its role in international trade is becoming increasingly prominent. Despite the challenges brought about by shifts in the global landscape, neither China's total trade scale nor the trade volume of its digital product manufacturing industry has been significantly affected—thanks to its large transaction scale, well-developed industrial chain, and diversified product portfolio.

The export structure of China's digital product manufacturing industry is presented in Table 1. From 2018 to 2022, exports were primarily driven by computer manufacturing, which consistently accounted for around 40% of total exports over the five-year period and further rose to 44.92% in 2022. The second-largest contributors were electronic components and equipment manufacturing, and telecommunications and radar equipment manufacturing. In contrast, the share of telecommunications and radar equipment manufacturing showed a steady decline year by year, while the share of electronic components and equipment manufacturing increased continuously, reaching 38.35% in 2022. This trend indicates that China's export competitiveness in this field has been strengthening, reflecting a positive trajectory in the industry's development.

Table 1. The export structure of China's digital product manufacturing industry*. (Unit: USD 100 million)

Sub-sectors	2018		2019		2020		2021		2022	
	EV**	ES**	EV**	ES**	EV**	ES**	EV**	ES**	EV**	ES**
CM	2877.2	39.12%	2736.7	37.74%	2969.4	38.04%	3503.3	36.26%	3431.7	44.92%
CREDM	1589.9	21.61%	1435.0	19.79%	1451.0	18.59%	1702.4	17.62%	206.6	2.70%
DMEM	547.7	7.45%	496.5	6.85%	531.8	6.81%	602.0	6.23%	427.0	5.59%
SDM	246.5	3.35%	258.9	3.57%	272.8	3.50%	343.3	3.55%	140.2	1.84%
ECEM	1750.1	23.79%	2001.4	27.60%	2247.7	28.80%	3065.6	31.73%	2929.9	38.35%
ODPM	344.1	4.68%	322.7	4.45%	332.2	4.26%	445.0	4.61%	503.5	6.59%
DPMI	7355.5	100%	7251.2	100%	7805.0	100%	9661.5	100%	7638.9	100%

Note: *Digital Product Manufacturing Industry (DPMI) includes six sub-sectors: Computer Manufacturing (CM), Communication and Radar Equipment Manufacturing (CREDM), Digital Media Equipment Manufacturing (DMEM), Smart Device Manufacturing (SDM), Electronic Components and Element Manufacturing (ECEM), and Other Digital Product Manufacturing (ODPM). **EV represents the export value of the DPMI sub-sectors, and **ES represents the share of each sub-sectors' exports in the total exports of the DPMI. **Data Source:** compiled, categorized, and calculated by the author based on primary data from the UN Comtrade Database.

3.1.3. Import Scale and Structure of China's Digital Product Manufacturing Industry

Between 2018 and 2022, China's imports of digital product manufacturing exhibited a fluctuating upward trend, with overall imports increasing by approximately 21.17% during this period. Notably, between 2019 and 2021, imports grew significantly, registering a cumulative increase of 35.80%. It is particularly worth highlighting that in 2020, despite the global downturn in import volumes, China's imports of digital product manufacturing still achieved a 10.80% counter-cyclical increase. This phenomenon suggests that, although China demonstrates strong performance in digital product exports, its role as a major global consumer market has created a substantial domestic demand gap for high-tech digital products, resulting in a high degree of reliance on imports. On the other hand, the added value of China's domestically produced digital products may not be sufficiently competitive, revealing a certain disadvantage in the international market structure.

From **Table 2**, it can be observed that within China's digital product manufacturing imports, the electronic components and equipment manufacturing sector dominates, accounting for more than 70% of total imports. This is followed by the computer manufacturing sector, which represents approximately 15%. In comparison with China's export data, electronic components and equipment manufacturing account for only about one-quarter of exports, whereas the import share reaches as high as 70%. This contrast highlights the fact that China relies heavily on imported electronic components to meet domestic market demand. In summary, China's electronic components and equipment manufacturing has long been influenced by external supply chains from countries such as Japan and South Korea. Due to insufficient domestic industrial development, the sector remains highly dependent on foreign sources.

Table 2. China's digital product manufacturing industry import structure. (Unit: USD 100 million)

Sub-sectors	2018		2019		2020		2021		2022	
	IV***	IS***	IV***	IS***	IV***	IS***	IV***	IS***	IV***	IS***
CM	855.5	15.82%	861.1	16.48%	910.4	15.72%	1118.9	15.77%	1011.8	15.44%
CREDM	131.3	2.43%	131.1	2.51%	158.5	2.74%	207.1	2.92%	201.6	3.08%
DMEM	103.4	1.91%	90.5	1.73%	74.4	1.28%	67.0	0.94%	33.1	0.51%
SDM	52.0	0.96%	50.6	0.97%	45.6	0.79%	54.6	0.77%	42.8	0.65%
ECEM	4103.1	75.88%	3934.0	75.28%	4437.0	76.63%	5461.7	76.96%	5088.7	77.67%
ODPM	161.6	3.00%	158.5	3.03%	164.1	2.83%	187.5	2.64%	173.9	2.65%
DPMI	5406.9	100%	5225.8	100%	5790.0	100%	7096.8	100%	6551.9	100%

Note:* IV indicates the import value of sub-sectors within the digital product manufacturing industry; ***IS refers to the share of each sub-sectors' import value in the total imports of the digital product manufacturing industry. **Source:** Author's calculation and classification based on raw data from the UN Comtrade Database.

Although China's digital product manufacturing industry has not yet developed into a pillar industry, it continues to maintain an overall trade surplus. Notably, the foreign trade performance of the electronic components and equipment manufacturing sector has persistently shown a deficit, with the gap widening year by year. By 2020, the trade deficit in this sector had reached as high as USD 213.13 billion, making it the largest deficit segment within the digital product manufacturing industry. The large-scale imports of electronic components and equipment highlight China's lack of competitiveness in this area. While imports may, to some extent, foster domestic development in related industries through technology spillover effects, the negative consequences of intensified market competition deserve greater attention. Given the dominant positions of Japan and South Korea in this field, the future development prospects of China's electronic components and equipment manufacturing sector appear rather uncertain. Considering China's enormous domestic demand, it is imperative to strategically prioritize the development of this sector and foster indigenous innovation as a policy imperative in order to gradually reduce reliance on imports (see Table 2).

3.2. Japan's Digital Product Manufacturing Trade Level

In 2021, Japan's digital economy ranked fourth globally, behind only the United States, China, and Germany, with a total scale reaching an impressive USD 2.5691 trillion. The share of the digital economy in Japan's GDP rose to 51.33%. Since 2017, Japan's digital economy has achieved significant growth, playing an essential role in maintaining national economic stability.

3.2.1. Import and Export Trade of Japan's Digital Product Manufacturing Industry

In 2022, the import and export trade volume of Japan's digital product manufacturing industry accounted for 13.87% of its total trade. Between 2018 and 2020, both imports and the overall trade volume of Japan's digital product manufacturing industry showed a downward trend. However, in 2019, exports increased by USD 1.94 billion, though the growth was not substantial. In 2021, both imports and exports of digital product manufacturing experienced rapid growth, with the export growth rate reaching 19.23%. In the same year, Japan's total export growth rate was 18.05%. In 2020, although Japan's foreign trade volume fell sharply due to the global COVID-19 pandemic, the exports of digital product manufacturing achieved a notable increase, and its share of total exports also rose.

3.2.2. Export Scale and Structure of Japan's Digital Product Manufacturing Industry

In 2022, Japan's top ten export products included semiconductor devices, machinery, instruments, and related equipment. Japan is home to four of the world's top ten semiconductor equipment manufacturers—Tokyo Electron, Disco, Advantest, and Hitachi High-Tech. Among nineteen critical semiconductor materials, Japan produces fourteen, accounting for more than half of the global market share. Clearly, digital product manufacturing occupies a central position in Japan's export strategy, with a pronounced comparative advantage. In recent years, Japan has regarded the semiconductor industry as a core sector with profound implications for national strength, intensifying policy support and industrial promotion efforts through multiple channels.

From the perspective of export scale and structure, Japan's digital product manufacturing exports followed a trajectory of initial decline and subsequent recovery between 2019 and 2021, achieving a growth rate of 21.27%. The total export value rose from USD 112.88 billion to USD 136.88 billion during this period. The share of digital product manufacturing in Japan's overall exports steadily increased, from 16.26% in 2018 to 18.14% in 2022. This indicates Japan's ongoing efforts to strengthen the competitiveness of its digital product manufacturing sector. Over the past five years, the development of Japan's digital product manufacturing exports has remained largely unaffected by shifts in the international environment, such as the rise of trade protectionism, trade conflicts, and the global pandemic. In 2020, although Japan's overall foreign trade volume declined significantly due to the COVID-19 shock, the trade volume of digital product manufacturing maintained steady growth, and its share of exports further increased. This demonstrates the pivotal role of digital product manufacturing in sustaining Japan's export performance.

As shown in **Table 3**, in 2022 the export share of Japan's electronic components and equipment manufacturing sector reached a historical high of 69.77%, marking a new peak in recent years. However, in other subsectors such as communications, radar, smart devices, and digital media, export volumes remain relatively small and have shown a gradual decline. This highly concentrated development model—anchored in a single dominant industry—has enabled Japan to achieve rapid progress and secure a leading global position in the sector. The focus on one core industry also facilitates the effective integration of domestic resources, allowing Japan to strengthen its competitive edge in this field. Nevertheless, this over-concentration has simultaneously constrained the broader growth potential of Japan's digital product manufacturing industry, leaving high-tech sectors such as smart device manufacturing underdeveloped and insufficiently cultivated. To address this imbalance, Japan has been implementing a series of measures, including subsidy policies to bolster the semiconductor industry and significant increases in R&D investment, in an effort to consolidate its industrial advantages while promoting more diversified technological development.

Table 3. Export structure of Japan's digital product manufacturing industry. (Unit: USD 100 million)

Sub-sectors	2018		2019		2020		2021		2022	
	EV	ES	EV	ES	EV	ES	EV	ES	EV	ES
CM	189.8	15.86%	176.4	15.63%	174.2	15.17%	198.0	14.47%	189.3	15.30%
CREDM	37.5	3.14%	33.8	2.99%	27.4	2.38%	32.4	2.37%	24.2	1.95%
DMEM	40.9	3.41%	34.3	3.04%	29.2	2.54%	31.7	2.31%	4.9	0.40%
SDM	47.9	4.01%	43.4	3.84%	41.6	3.62%	50.1	3.66%	46.1	3.72%
ECEM	773.6	64.65%	741.2	65.66%	771.1	67.16%	937.6	68.50%	863.2	69.77%
ODPM	106.9	8.94%	99.7	8.84%	104.8	9.13%	119.0	8.69%	109.5	8.85%
DPMI	1196.6	100%	1128.8	100%	1148.2	100%	1368.8	100%	1237.2	100%

Data Source: Compiled and calculated by the author based on raw data from the UN Comtrade Database.

3.2.3. Import Scale and Structure of Japan's Digital Product Manufacturing Industry

As discussed above, Japan's digital product manufacturing exports are heavily concentrated in the electronic components and equipment sector, while other subsectors have shown little growth momentum, with some even experiencing stagnation or gradual decline. This concentration inevitably poses challenges for the industry's overall expansion potential. Against this backdrop, it is necessary to examine the scale and structure of Japan's imports to gain a more comprehensive understanding of its position within the global trade landscape.

An analysis of the period from 2018 to 2022 reveals that Japan's imports in this sector have remained relatively stable. Notably, in 2020, when global import volumes fell sharply by 11.88%, Japan's imports of digital product manufacturing goods maintained their stability. Japan consistently ranks among the world's top importers and exporters in this industry. Its imports and exports have demonstrated resilience in the face of market fluctuations, with a sustained trade surplus that shows signs of gradual expansion.

Turning to the import structure, the annual data presented in Table 4 highlight striking differences compared with the export profile. While exports are overwhelmingly dominated by electronic components and equipment—accounting for nearly 70%—Japan's imports display a more diversified and balanced pattern. In particular, computer manufacturing and electronic components and equipment together account for nearly 80% of imports, and this share has shown a rising trend over time. By contrast, imports of communications and radar equipment have dropped significantly, falling from 20.14% of total imports in 2018 to just 4.13% in 2022. Although global trade conditions have exerted volatility on Japan's overall imports, the digital product manufacturing industry has remained relatively stable. This suggests that Japan does not rely exclusively on imports to sustain the development of its digital product manufacturing sector; rather, its inherent production capacity and adaptive industrial restructuring strategies have played a critical role in maintaining stability.

Table 4. Import structure of Japan's digital product manufacturing industry. (Unit: USD 100 million)

Sub-sectors	2018		2019		2020		2021		2022	
	IV	IS	IV	IS	IV	IS	IV	IS	IV	IS
CM	349.3	30.88%	377.6	34.05%	393.7	35.43%	397.4	32.11%	392.2	37.52%
CREDM	227.8	20.14%	207.9	18.75%	202.2	18.20%	234.4	18.94%	43.1	4.13%
DMEM	80.1	7.08%	89.3	8.05%	87.7	7.89%	91.4	7.38%	57.6	5.51%
SDM	30.2	2.67%	31.5	2.84%	25.8	2.32%	27.6	2.23%	23.0	2.20%
ECEM	388.0	34.30%	349.4	31.51%	350.0	31.50%	431.2	34.84%	471.6	45.11%
ODPM	55.7	4.93%	53.1	4.79%	51.7	4.65%	55.6	4.50%	57.9	5.54%
DPMI	1131.1	100%	1108.8	100%	1111.1	100%	1237.6	100%	1045.4	100%

Data Source: Author's compilation, categorization, and calculation based on primary data from the UN Comtrade Database.

A detailed examination of the data indicates that Japan's digital product manufacturing industry is heavily concentrated in the production and trade of electronic components and devices, with the semiconductor sector being particularly prominent. Approximately 70% of Japan's exports and about 45% of its imports in this domain are attributed to electronic components and devices, underscoring their dominant position. Japan imports a significant volume of semi-finished electronic components, undertakes domestic processing, and subsequently re-exports a considerable share. The semiconductor industry, in particular, occupies a pivotal position within Japan's overall export structure, further consolidating the role of electronic components and device manufacturing as the core of Japan's digital product trade.

3.3. The Trade Performance of South Korea's Digital Product Manufacturing Industry

In 2021, the total value of South Korea's digital economy reached USD 963.1 billion, positioning the country seventh among the world's leading digital economies. With the digital economy's share in GDP continuously expanding, its contribution to national economic growth has become increasingly pronounced, further reinforcing its driving role. In that year, South Korea's digital economy grew at a rate of 10.6%, accounting for 52.96% of GDP, thereby indicating substantial potential for further development. From 2018 to 2022, the trade volume of South Korea's digital product manufacturing industry demonstrated an overall upward trajectory. Following an initial decline in 2018, trade activities recovered and expanded steadily, ultimately peaking in 2021.

3.3.1. The Export Scale and Structure of South Korea's Digital Product Manufacturing Industry

Within South Korea's total exports, the digital product manufacturing industry has consistently accounted for a substantial share. Semiconductors, flat-panel displays and sensors, wireless communication equipment, and computers ranked among South Korea's top ten export products in 2021, together comprising 29.7% of the country's total exports. This highlights the critical role of the digital product manufacturing industry in South Korea's foreign trade. South Korea has long maintained a leading position in the international market in this sector, with the industry's share of total exports exceeding 30% in 2018, 2020, and 2021. Although South Korea's overall trade volume declined significantly in 2020 due to the prolonged impact of the COVID-19 pandemic, the expansion of digital technologies facilitated a gradual recovery. In 2021, as foreign trade rebounded, exports of digital product manufacturing increased by USD 39.21 billion, representing a growth rate of 24.99%—the highest in five years.

Data presented in Table 5 clearly reveal that South Korea's digital product manufacturing exports are concentrated in electronic components and device manufacturing. The country's pillar industries, such as semiconductors, fall under this category. In 2022, the share of electronic components and devices rose to 74.89%, establishing this sector as the absolute core of South Korea's digital product manufacturing industry. Meanwhile, computer manufacturing exhibited steady growth, accounting for 18.04% of exports in 2022—nearly four percentage points higher than in 2018. By contrast, exports from sub-industries such as communication and radar equipment, digital media devices, and smart devices have consistently remained below 10% and continue to show a declining trend.

Table 5. Export structure of South Korea's digital product manufacturing industry. (Unit: USD 100 million)

Sub-sector	2018		2019		2020		2021		2022	
	EV	ES	EV	ES	EV	ES	EV	ES	EV	ES
CM	270.8	14.57%	233.8	15.54%	298.7	19.02%	352.9	17.98%	335.4	18.04%
CREDM	142.3	7.65%	154.5	10.27%	123.5	7.86%	131.9	6.72%	70.6	3.80%
DMEM	24.1	1.30%	21.0	1.39%	17.6	1.12%	44.1	2.25%	10.4	0.56%
SDM	22.0	1.18%	18.7	1.26 %	15.9	1.01%	17.0	0.87%	15.6	0.84%
ECEM	1368.4	73.61%	1046.2	69.57%	1086.5	69.17%	1383.8	70.50%	1391.9	74.89%
ODPM	31.4	1.69%	29.7	1.97%	28.5	1.81%	33.1	1.68%	34.8	1.87%
DPMI	1859.0	100%	1503.9	100%	1570.7	100%	1962.8	100%	1858.7	100%

Data Source: Compiled and calculated by the author based on raw data identified and categorized from the UN Comtrade Database.

3.3.2. The Import Scale and Structure of South Korea's Digital Product Manufacturing Industry

In terms of imports, compared with the overall industry, which declined in 2019 and 2020 due to the global trade environment, South Korea's digital product manufacturing imports continued to increase. Notably, in 2020, despite a contraction of USD 35.672 billion in South Korea's total trade imports caused by the COVID-19 pandemic, imports in the digital product manufacturing industry still maintained a growth rate of 11.12%.

Table 6. Import Structure of South Korea's digital product manufacturing industry. Unit: USD 100 million

Sub-sectors	2018		2019		2020		2021		2022	
	IV	IS	IV	IS	IV	IS	IV	IS	IV	IS
CM	227.9	22.73%	234.8	24.12%	243.5	22.50%	286.2	21.17%	305.8	22.20%
CREDM	73.1	7.29%	100.7	10.34%	89.7	8.29%	96.5	7.14%	27.8	2.02%
DMEM	29.8	2.97%	28.4	2.92%	28.7	2.65%	35.8	2.65%	25.1	1.82%
SDM	13.7	1.37%	13.4	1.37%	12.7	1.18%	13.7	1.01%	11.5	0.83%
ECEM	617.9	61.64%	557.2	57.22%	667.9	61.73%	873.7	64.61%	960.1	69.70%
ODPM	40.1	4.00%	39.2	4.02%	39.5	3.65%	46.4	3.43%	47.2	3.42%
DPMI	1002.5	100%	973.7	100%	1082.0	100%	1352.3	100%	1377.5	100%

Data Source: Compiled and calculated by the author based on raw data identified and categorized from the UN Comtrade Database.

As shown in Table 6, in terms of import structure, two sub-sectors—electronic components and equipment manufacturing and computer manufacturing—accounted for 90% of South Korea's total digital product manufacturing imports. Other sub-sectors, similar to exports, held only a small share and showed a downward trend. This phenomenon, whereby a large proportion of imports and exports is concentrated in a single sub-sector, can be attributed to various factors, such as diversified consumer demand and the integration of global value chains. Further explanation will be provided in the subsequent calculation of the Global Value Chain Position Index.

From a global perspective, between 2018 and 2022, the total trade volume of the digital product manufacturing industry demonstrated a fluctuating upward trend. The year 2018 marked the beginning of the U.S.–China trade frictions, whose impact became evident in 2019, when many countries experienced a decline in foreign trade compared with 2018. Following successive shocks—including the U.S.–China trade dispute, the COVID-19 pandemic, and the Russia–Ukraine conflict—many countries witnessed a contraction in foreign trade in 2020, a strong rebound in 2021, and then a significant slowdown in trade growth in 2022. By comparing the policy environments, strategic orientations, and trade performance of China, Japan, and South Korea in the field of the digital economy, several findings emerge:

China, Japan, and South Korea have long maintained leading positions in the global development of the digital economy. Japan and South Korea already possess technological, industrial, and human capital advantages in advancing the digital economy, particularly in technology-intensive sectors such as semiconductor chips and integrated circuits. Although China started relatively late, it benefits from a vast consumer market and a complete industrial system, giving it substantial development potential at the current stage.

From the perspective of policy background and strategic orientation, Japan has leveraged its technological advantages and long-standing policy accumulation to establish a relatively comprehensive policy framework for strategic scientific research, high-level talent cultivation, and monopolization of high-end manufacturing. South Korea, on the other hand, has consolidated its leading edge by maintaining trade and technological restrictions on China. In recent years, China has continuously advanced its digital economy strategy, achieved breakthroughs in next-generation information technology and intelligent manufacturing, and secured an early-mover advantage in the ongoing wave of the Fourth Industrial Revolution.

From the perspective of both the overall trade level of the digital product manufacturing industry and the trade performance of its sub-sectors, China has grown into the world's largest trading nation in digital product manufacturing. Its trade scale is far greater than that of Japan and South Korea and continues to show an upward trend while maintaining a long-term trade surplus. In particular, China holds a dominant position in trade scale across five sub-sectors, including computer manufacturing, and has consistently maintained trade surpluses in these areas. The only exception lies in the electronic components and equipment manufacturing sector, where China experiences a substantial trade deficit. By contrast, Japan and South Korea demonstrate large trade volumes and long-term balance in both imports and exports within the electronic components and equipment sector. This indicates that China remains highly dependent on imports in this domain, with its research, development, and production capabilities still lagging significantly behind those of Japan and South Korea.

4. Comparison of the GVC Position of China, Japan, and South Korea in Digital Product Manufacturing

This paper draws on the calculation method for the global value chain (GVC) position in the equipment manufacturing industry proposed by Lin and He (2015), as well as the accounting framework for the GVC position of China and Japan developed by Han and Zhang (2020), to construct the GVC position index for the sub-industries of China's digital product manufacturing sector. The calculation formula is as follows:

$$\text{GVC Index} = \sum_{j=1}^{k} \frac{X_t^{ij} / Q_t^{ij}}{X_t^{wj} / Q_t^{wj}} \cdot \frac{X_t^{ij}}{X_t^{iT}}$$

In the formula, represents the total number of intermediate product types involved in the i-th industry ($i = 1, 2, 3, \ldots, 6i$) within a country's digital products manufacturing sector, while j denotes the j-th intermediate product ($j = 1, 2, \ldots, k$). At time t, the export value of the j-th intermediate product in the i-th industry of a given country is denoted as X_t^{ij} and its export quantity is denoted as Q_t^{ij}. Correspondingly, the total global export value and export quantity of the j-th intermediate product in the i-th industry are represented by x_t^{wj}, Q_t^{wj}. Finally, X_t^{iT} denotes the total export value of all intermediate products in the i-th industry of the country at time t.

This study first identifies the specific product types of the digital products manufacturing sector and its sub-industries according to the correspondence between the 2012 HS 6-digit classification codes and the BEC product categories. Based on the HS 6-digit code data extracted and screened from the UN Comtrade database, we analyze the export prices of intermediate products in China, Japan, and South Korea relative to the global levels in the digital products manufacturing sector. Finally, using the HS6-classified export data for the respective sub-products of China, Japan, and South Korea, the Global Value Chain (GVC) position indices of the digital products manufacturing sector are calculated, allowing for an analysis of the dynamic evolution and comparative positioning of China, Japan, and South Korea in the global value chain of digital products manufacturing during 2018-2022.

4.1. Comparison of the Global Value Chain Positions of China and Japan in the Digital Products Manufacturing Sector

Based on the calculation results, although, as noted earlier, China's total exports in the digital products manufacturing sector are more than ten times higher than Japan's, the calculated GVC indices reveal that China's intermediate products generally have relatively low unit values. In other words, China competes primarily through volume rather than value, offering the same products at lower prices and with lower added value. According to theories such as the comparative advantage trap (an economic predicament in which developing countries become overly dependent on factors such as cheap labor or resource exports, leading to rigid industrial structures and difficulty in upgrading, thereby locking them into the low end of the international division of labor) and Schumpeter's innovation model, this is not conducive to China's further development.

During the GVC calculation process for both China and Japan, a small number of HS6 codes lacked QTY (quantity) data. In these cases, Net Weight was used as a substitute to calculate the relative unit price of the product, while the corresponding world relative unit price was computed without using QTY. Since both countries employed Net Weight rather than Quantity for the same HS 6-digit intermediate goods, the substitution does not affect the validity of the comparative analysis. For countries with available Net Weight statistics, the global relative unit price was aggregated based on Net Weight. Although this approach required a substantial amount of manual calculation, it maximized data completeness and produced more accurate GVC index results.

Table 7. Comparative Global Value Chain (GVC) position indices of digital products manufacturing sub-industries: China vs. Japan.

Sub-sectors	Countries	2018	2019	2020	2021	2022
CM	China	0.67037	0.51310	0.47945	0.46433	0.42683
	Japan	1.95039	1.89887	2.13192	1.95418	1.42265
CREDM	China	0.47559	0.48592	0.46354	0.49226	0.42781
	Japan	3.05002	2.29759	1.86013	2.30380	3.11159
DMEM	China	0.46881	0.38977	0.42977	0.49095	0.39835
	Japan	2.57907	2.43406	2.52637	2.24356	2.05121
SDM	China	0.64745	0.67116	0.74560	0.76051	0.54438
	Japan	2.62703	2.78910	3.41158	3.36299	3.07658
ECEM	China	0.52026	0.65249	0.71938	0.64959	0.63529
	Japan	1.42453	1.29173	1.34683	1.21235	1.02875
ODPM	China	0.41854	0.39658	0.44720	0.49173	0.51384
	Japan	3.10677	3.05952	3.11567	2.85219	2.39940

Note: GVC stands for Global Value Chain. **Data Source:** The data are compiled, classified, and calculated by the author based on raw data extracted from the UN Comtrade Database.

As shown in Table 7, from 2018 to 2022, the GVC indices of China's sub-industries in the digital products manufacturing sector were generally below 1. This indicates that, in terms of export unit prices of intermediate products, China mainly occupies the lower segments of the global value chain, producing mostly low-value-added products and remaining below the global average. By contrast, Japan presents a markedly different pattern. Its sub-industries consistently maintain GVC indices significantly above 1. In particular, in the manufacturing of digital media equipment and smart devices, Japan's role in the international division of labor clearly surpasses the global average, demonstrating strong competitive advantages. However, Japan's GVC indices in the electronic components and equipment manufacturing sub-sectors are noticeably lower than those of its other sub-industries.

Observing the trends in China's GVC position indices from 2018 to 2022 in sectors such as computer manufacturing, communications and radar equipment manufacturing, and digital media equipment manufacturing, we can see that in the digital media equipment and smart device manufacturing sectors, the decline in 2022 offset the growth observed in 2019-2021, resulting in a GVC position lower than the 2019 level. In contrast, China's GVC indices in the electronic components and equipment manufacturing sector and other digital products manufacturing sectors showed an upward trend. Regarding sub-industry trends in Japan, the GVC position in computer manufacturing shifted slightly downstream along the value chain, yet remained above 1 overall, indicating that Japan still occupies the upper-middle segment of the global value chain. In the communications and radar equipment manufacturing sector, the GVC exhibited a U-shaped pattern, essentially returning to its 2018 international division of labor position by 2022. In the digital media equipment manufacturing sector, Japan did not consistently maintain a long-term high-end position in the value chain; in recent years, its GVC position declined slightly, yet it remained above 2, indicating that this sub-industry is still positioned far above the global average. Smart device manufacturing stands out as Japan's strongest-performing sector. While many Japanese sub-industries experienced slight downstream movements in their international division of labor positions, the GVC index for smart device manufacturing continued to grow from a high level above 2.5 in 2018 and remained above 3 in the past two years. Although smart device manufacturing is not Japan's main export-import advantage within digital manufacturing, it clearly occupies a high-end position in the global value chain. In contrast, the GVC position of Japan's otherwise highly traded electronic components and equipment manufacturing sector has slightly declined over the years. Meanwhile, China's international division of labor position in electronic components and equipment manufacturing is rising, indicating a gradual erosion of Japan's relative advantage in this sub-industry.

In summary, the GVC indices of all sub-industries in Japan's digital products manufacturing sector are higher than those of China. This indicates that Japan overall occupies the high end of the global value chain in digital products manufacturing, engaging in the production of high-value-added products and demonstrating clear advantages in product competitiveness, industrial upgrading, and research and development. In contrast, China's GVC indices have remained below 1 for an extended period, indicating a persistent focus on low-value-added production. Moreover, the temporal trends of most Chinese sub-industries' GVC indices are not encouraging. China's digital products manufacturing sector urgently needs to break the "low-end lock-in". Although China's trade data, as noted earlier, show export volumes many times higher than Japan's, long-term engagement in low-end, low-value-added production risks falling into the comparative advantage trap, thereby missing the optimal window for upgrading its position in the international division of labor.

4.2. Comparison of the Global Value Chain Positions of China and South Korea in the Digital Products Manufacturing Sector

Overall, except for other digital products manufacturing, the GVC indices of all sub-industries in South Korea's digital products manufacturing sector are significantly above 1. This indicates that South Korea occupies an upper-middle position in the value chain, engaging in the production of high-value-added products. Notably, in the computer manufacturing sector, the GVC index has consistently exceeded 10, demonstrating that South Korea occupies a high-end position in the global value chain for this industry. The products exhibit extremely strong competitiveness, and the sector possesses high industrial production and technological R&D capabilities, enabling participation in rule-making and conferring substantial influence within the industry. Comparing this with China, it is evident that there is a notable gap between the two countries in the global value chain positions of digital products manufacturing. China will need to achieve breakthroughs in technological research and development and the establishment of industrial clusters to close this gap.

As shown in Table 8, from 2018 to 2022, South Korea maintained stable growth in computer manufacturing, communications and radar equipment manufacturing, and other digital products manufacturing, with the computer manufacturing sector showing continued growth despite already having extremely high GVC indices. This indicates that South Korea possesses core technological advantages and strong competitiveness in this sub-industry, with its position in the international division of labor continuously strengthening. In the digital media equipment, smart device, and electronic components and equipment manufacturing sectors, GVC indices exhibited fluctuating declines, though the decreases were relatively modest. This suggests that South Korea's global value chain positions in these areas have not improved significantly in recent years. Combining this with previous analyses of trade levels in the digital products manufacturing sector, South Korea's electronic components and equipment manufacturing maintains an absolute share of exports and imports in the sector, with its share continuing to grow annually, and demonstrates a substantial trade surplus. However, the GVC index of this sub-industry has fluctuated in recent years and fell below its 2018 level by 2022, showing an overall downward trend. This allows a reasonable inference that

South Korea's large-scale imports and exports may involve low-end import processing followed by high-end exports, generating the significant trade surplus observed.

Table 8. Comparative Global Value Chain (GVC) position indices of digital products manufacturing sub-industries: China vs. South Korea.

Sub-sectors	Countries	2018	2019	2020	2021	2022
CM	China	0.67037	0.51310	0.47945	0.46433	0.42683
	South Korea	14.15589	11.21182	12.57527	10.19918	19.11124
CREDM	China	0.47559	0.48592	0.46354	0.49226	0.42781
	South Korea	1.19576	1.10015	1.43756	1.52805	2.25685
DMEM	China	0.46881	0.38977	0.42977	0.49095	0.39835
	South Korea	2.68181	2.01520	2.23062	2.05467	2.19074
SDM	China	0.64745	0.67116	0.74560	0.76051	0.54438
	South Korea	1.50687	1.44825	1.35700	1.37294	1.14505
ECEM	China	0.52026	0.65249	0.71938	0.64959	0.63529
	South Korea	3.13247	2.04795	5.76568	2.17559	2.43002
ODPM	China	0.41854	0.39658	0.44720	0.49173	0.51384
	South Korea	0.87884	0.92279	0.99061	1.03639	1.01415

Data Source: The data are compiled, classified, and calculated by the author based on raw data extracted from the UN Comtrade Database.

Comparing China and South Korea, China's digital products manufacturing sub-industries exhibit GVC indices lower than those of South Korea. This indicates that South Korea occupies a leading position in the global value chain, whereas China remains positioned at the lower end, with slower upgrading processes and relatively low value-added exports. South Korea's digital products manufacturing, characterized by higher technological content, is mainly concentrated in mid- to high-level segments of the value chain, thereby establishing a distinctive global competitive advantage. In electronic components and equipment manufacturing, China's GVC index shows an upward fluctuation trend, whereas South Korea's GVC index exhibits a fluctuating decline. Therefore, to achieve breakthroughs in the digital manufacturing sector in the future, China must focus on enhancing product quality and technological content, strengthening the development and competitiveness of core technologies, and striving to transition toward the high end of the value chain.

Through a comparative analysis of the GVC position indices of China, Japan, and South Korea, it is evident that China's digital manufacturing sector occupies a relatively low position in the global value chain. This reflects China's reliance on exporting intermediate products at low prices and with relatively low technological content. In contrast, Japan and South Korea have demonstrated outstanding performance, particularly in the electronic components and equipment manufacturing sector, setting global benchmarks and providing valuable reference points for China. Notably, South Korea maintains a GVC position in this sector more than eight times higher than China, highlighting its significant advantage and deep participation in the international division of labor. Encouragingly, although China's overall GVC indices remain lower than those of Japan and South Korea, the indices in electronic components and equipment manufacturing, as well as in other digital products manufacturing sectors, exhibit an upward trend. Combined with the export scale and structure, this indicates substantial growth potential in these sub-industries.

From an industrial positioning perspective, China's digital products manufacturing primarily occupies the low end of the "smiling curve," with limited value-added and narrow profit margins. In contrast, South Korea and Japan maintain advantageous positions within the global value chain, with GVC indices generally well above 1. This indicates their long-term dominance in the production of high-value-added and technologically sophisticated products, yielding substantial profits. To achieve sustainable development, China must focus on enhancing its capabilities in high-end and mid-to-high-end digital manufacturing, thereby strengthening its position in the global value chain. By increasing value-added and expanding international influence and bargaining power in the digital manufacturing sector, China can pursue a strategic objective essential to its digitalization process.

In recent years, China's digital products manufacturing has faced subtle changes. Influenced by trends of "de-globalization" and reindustrialization strategies in developed countries, some of China's manufacturing bases have shown signs of relocation overseas, posing certain challenges. Meanwhile, although Japan and South Korea have experienced slight declines in their GVC positions in digital media equipment manufacturing and certain other digital products sectors, the trade volume in these areas is relatively small and does not constitute their core competitiveness, thus having a limited impact on their overall trade competitiveness. Leveraging early advantages in capital, technology, and talent, South Korea has maintained high-end positions in the global value chain for electronic components and equipment manufacturing, including semiconductors, integrated circuits, and optoelectronic devices. China can draw lessons from this experience, tailoring strategies to its own developmental stage, continuously improving its electronic components and equipment manufacturing, vigorously promoting R&D, and establishing industrial clusters. At the same time, it is essential to balance current trade levels, gradually upgrade, and transition toward higher value-added segments of the global value chain.

5. Comparison of the International Competitiveness of China, Japan, and South Korea in the Digital Products Manufacturing Sector

This study relies on the UN Comtrade Database, selecting the import and export trade values of HS 6-digit coded products in the digital products manufacturing sectors of China, Japan, and South Korea, along with corresponding global data. The time series covers the period from 2018 to 2022.

5.1. Comparison of International Market Share (MS) Indices of China, Japan, and South Korea

The international market share (MS) index measures the proportion of a country's exports in a specific industry relative to the total global exports of the same industry. The specific calculation formula is as follows:

$$\mathrm{MS}_{ij} = \frac{X_{ij}}{X_{wj}}$$

In the formula, X_{ij} represents the exports of the *j*-th industry in the digital products manufacturing sector of country *i*, while X_{wj} denotes the global exports of the same industry. The MS index ranges from 0 to 1. A higher MS value approaching 1 indicates a more significant competitive advantage in the international market, as it reflects that the country's exports of this product account for a substantial share of the total global exports of similar products. Conversely, an MS value approaching 0 indicates a relatively small international market share, implying weaker competitiveness in the global market.

Table 9. Market Share (MS Index) of sub-sectors in the digital product manufacturing industry of China, Japan, and South Korea.

Sub-sectors	Country	2018	2019	2020	2021	2022
CM	China	0.30251	0.29590	0.30663	0.30986	0.30240
	Japan	0.01995	0.01907	0.01798	0.01751	0.01624
	South Korea	0.02847	0.02527	0.03084	0.03122	0.02877
CREDM	China	0.43430	0.40441	0.42741	0.43420	0.44504
	Japan	0.01025	0.00952	0.00806	0.00827	0.00864
	South Korea	0.03886	0.04354	0.03637	0.03364	0.03374
DMEM	China	0.32191	0.30411	0.33072	0.32311	0.33268
	Japan	0.02401	0.02102	0.01816	0.01700	0.01831
	South Korea	0.01418	0.01284	0.01094	0.02369	0.00811
SDM	China	0.24423	0.25733	0.30260	0.31678	0.31870
	Japan	0.04750	0.04313	0.04613	0.04624	0.04871
	South Korea	0.02181	0.01860	0.01768	0.01568	0.01990
ECEM	China	0.15423	0.17810	0.18311	0.19440	0.18188
	Japan	0.06817	0.06596	0.06282	0.05946	0.05759
	South Korea	0.12060	0.09309	0.08851	0.08775	0.08641
ODPM	China	0.18794	0.18389	0.19767	0.18546	0.18700
	Japan	0.05840	0.05684	0.06235	0.06030	0.05374
	South Korea	0.01713	0.01690	0.01695	0.01675	0.01709

Data Source: The data are compiled, classified, and calculated by the author based on raw data extracted from the UN Comtrade Database.

As shown in Table 9, China's digital products manufacturing sector has surpassed both Japan and South Korea in terms of global market share. Notably, the communications and radar equipment manufacturing sector has consistently maintained a global share above 40%, with China's share reaching 44.5% in 2022. The computer manufacturing and digital media equipment manufacturing sectors have demonstrated stable performance, with MS indices remaining around 30% throughout 2018-2022. In the smart device manufacturing sector, the MS index reached 30% in 2022, marking significant progress. However, the electronic components and equipment manufacturing sector showed no significant increase over the same period. In contrast, Japan's performance across all sub-industries appears relatively weak. Its digital products manufacturing sector has experienced a general decline in global market share, with all sub-industries accounting for less than 10% of the global market. Even previously strong sectors, such as electronic components and equipment manufacturing, are not exceptions to this trend.

5.2. Comparison of Revealed Comparative Advantage (RCA) Indices of China, Japan, and South Korea

The revealed comparative advantage (RCA) index is used to evaluate a country's international competitiveness in a specific industry. This index reflects the ratio of the share of a country's exports of a given industry in its total exports to the share of global exports of the same industry in total world exports. The calculation formula can be expressed as follows:

$$\mathrm{RCA}_{ij} = \frac{X_{ij} / X_{it}}{X_{wj} / X_{wt}}$$

In the formula, X_{ij} represents the exports of the *j*-th industry in the digital products manufacturing sector of country *i*, X_{it} denotes the total exports of the digital products manufacturing sector of country *i*, X_{wj} represents the global exports of the same industry, and X_{wt} denotes the total global exports of the digital products manufacturing sector. When the RCA index approaches 1, it indicates that the product's relative comparative advantage in global trade is neutral, meaning the product has neither a significant competitive advantage nor a significant disadvantage in the international market. An RCA index greater than 1 suggests that the country's export share of the product exceeds the global average, indicating a comparative advantage and a certain level of international competitiveness. Conversely, an RCA index below 1 indicates that the domestic export share of the product is lower than the world average, implying a comparative disadvantage and weaker competitiveness in the international market.

Generally, the interpretation of RCA values is as follows:

- $\mathrm{RCA} > 2.5$: the country has a very strong export comparative advantage in the industry;
- $1.25 < \mathrm{RCA} \le 2.5$: the country has a strong export comparative advantage;
- $0.8 < \mathrm{RCA} \le 1.25$: the country has a moderate export comparative advantage;
- $\mathrm{RCA} \le 0.8$: the country has a weak export comparative advantage.

From the perspective of the sub-sectors, it can be observed from **Table 10** that the RCA indices of China's digital product manufacturing industry across sub-sectors are generally above 1.25, with the revealed comparative advantage (RCA) index of each sub-sector higher than those of Japan and South Korea. Among them, the RCA index of communications and radar equipment manufacturing is the highest, consistently staying above 2.5, indicating a strong international competitiveness. However, this index has shown a declining trend in the past five years. The RCA indices of computer manufacturing (CM) and digital media equipment manufacturing (DMEM) have remained above 1.25 for an extended period, signifying their strong international competitiveness. In addition, the revealed comparative advantage index of smart device manufacturing saw a significant increase in 2020. Japan has maintained a revealed comparative advantage index above 1.25 in the field of electronic components and equipment manufacturing for a long time, demonstrating a strong comparative advantage, making it the best-performing industry in Japan's exports. South Korea's revealed comparative advantage index in electronic components and equipment manufacturing has consistently been above 2.5, exhibiting a very strong competitive advantage, although this index has shown a declining trend in the past five years.

Table 10. Revealed Comparative Advantage (RCA) index of sub-sectors in the digital product manufacturing industry of China, Japan, and South Korea.

Sub-sectors	Country	2018	2019	2020	2021	2022
CM	China	2.30774	2.18202	2.03569	2.02437	1.88158
	Japan	0.51262	0.49816	0.48201	0.50115	0.49952
	South Korea	0.89293	0.85910	1.03468	1.04949	0.96667
CREDM	China	3.31312	2.98222	2.83756	2.83665	2.56610
	Japan	0.26339	0.24859	0.21604	0.23652	0.28106
	South Korea	1.21870	1.48011	1.22012	1.13112	1.31367
DMEM	China	2.45572	2.24254	2.19564	2.11092	2.12624
	Japan	0.61707	0.54888	0.48688	0.48645	0.48786
	South Korea	0.44457	0.43638	0.36709	0.79644	0.27263
SDM	China	1.86316	1.89762	2.00897	2.06956	2.04209
	Japan	1.22065	1.12634	1.23655	1.32319	1.30593
	South Korea	0.68389	0.63216	0.59312	0.52713	0.66866
ECEM	China	1.17660	1.31335	1.21569	1.27006	1.16242
	Japan	1.75177	1.72264	1.68371	1.70139	1.64829
	South Korea	3.78221	3.16449	2.96907	2.95033	2.90327
ODPM	China	1.43373	1.35604	1.31234	1.47297	1.57868
	Japan	1.50065	1.48458	1.67120	1.72553	1.65314
	South Korea	0.53724	0.57440	0.56846	0.56302	0.57411

Data Source: The data are compiled, classified, and calculated by the author based on raw data extracted from the UN Comtrade Database.

5.3. Comparison of Trade Competitiveness (TC) Indices of China, Japan, and South Korea

The trade competitiveness (TC) index is used to analyze the international competitiveness of a country's products in a specific industry. The TC index is calculated as follows:

$$\text{TC} = \frac{X_{ij} - M_{ij}}{X_{ij} + M_{ij}}$$

In the formula, X_{ij} denotes the exports of sub-industry j in the digital products manufacturing sector of country *i*, while M_{ij} represents the corresponding imports. The trade competitiveness (TC) index ranges between −1 and 1. A positive TC value indicates that the product possesses a certain degree of international competitiveness, with values closer to 1 reflecting stronger competitiveness. Specifically, when the TC value lies within the interval (0, 0.3), the product demonstrates a slight competitive advantage; within (0.3, 0.6), the advantage becomes more evident; and within (0.6, 1), the product exhibits a strong competitive edge in the global market.

Table 11. Trade Competitiveness (TC) index of sub-sectors in the digital product manufacturing industry of China, Japan, and South Korea.

Sub-sectors	Country	2018	2019	2020	2021	2022
CM	China	0.54160	0.52133	0.53071	0.51586	0.54461
	Japan	−0.29603	−0.36308	−0.38662	−0.33488	−0.34894
	South Korea	0.08604	−0.00229	0.10192	0.10437	0.04603
CREDM	China	0.84739	0.83261	0.80306	0.78313	0.76216
	Japan	−0.71717	−0.72053	−0.76159	−0.75707	−0.78218
	South Korea	0.32110	0.21072	0.15828	0.15504	0.13492
DMEM	China	0.68230	0.69154	0.75461	0.79979	0.85611
	Japan	−0.32449	−0.44469	−0.50028	−0.48517	−0.44258
	South Korea	−0.10450	−0.15067	−0.13918	−0.10379	−0.11384
SDM	China	0.65137	0.67285	0.71345	0.72538	0.64260
	Japan	0.22729	0.15894	0.23470	0.29044	0.33346
	South Korea	0.23260	0.16597	0.11263	0.10710	0.15182
ECEM	China	−0.40200	−0.32560	−0.32750	−0.28100	−0.26923
	Japan	0.33198	0.35924	0.37564	0.36999	0.29342
	South Korea	0.37783	0.30498	0.23857	0.22596	0.18359
ODPM	China	0.36099	0.34107	0.33865	0.40705	0.41652
	Japan	0.31478	0.30522	0.33920	0.36283	0.30810
	South Korea	−0.12259	−0.13834	−0.16152	−0.16770	−0.15055

Data Source: Calculated and organized by the author based on raw data from the UN Comtrade Database.

Conversely, a negative TC value suggests that the product lacks international competitiveness, with values closer to −1 signifying a more severe disadvantage. More precisely, a TC value in the range of (−0.3, 0) reflects a slight disadvantage; in (−0.6, −0.3), a moderate disadvantage; and in (−1, −0.6), a pronounced competitive disadvantage.

As shown in **Table 11**, from the perspective of sub-industries within the digital products manufacturing sector, China's TC indices for five categories—excluding electronic components and equipment manufacturing—are all positive, exhibiting little fluctuation over the past five years and consistently remaining above the levels of Japan and South Korea. This leading advantage is most evident in communications and radar equipment manufacturing, digital media equipment manufacturing, and smart device manufacturing. By contrast, China's TC index for electronic components and equipment manufacturing is the only negative value, indicating a lack of competitiveness in this field. In comparison, both Japan and South Korea, although registering lower competitiveness indices than China in five sub-industries such as computer manufacturing, have maintained TC values consistently above 0.3 in electronic components and equipment manufacturing. This highlights their substantial competitive edge and further demonstrates that their positions at the higher end of the global value chain, specializing in the production of high-value-added products, translate into absolute competitive advantages. For China, however, the weakness in electronic components and equipment manufacturing underscores significant shortcomings and persistent "bottleneck" technologies.

By measuring the competitiveness indices of the digital product manufacturing sub-industries in China, Japan, and South Korea, and combining this with the preceding analysis of comparative advantages, several findings emerge. In the field of computer manufacturing, China's market share has remained around 30% with relatively stable fluctuations, changing by no more than 2% between 2018 and 2022. The long-term TC index above 0.5 further indicates that China holds a significant competitive advantage in this industry. However, although the RCA index has consistently remained above 2, it shows a clear downward trend. This implies that despite China's export share being much higher than the world average, the gradual decline suggests a weakening export advantage in the computer manufacturing sector, which warrants attention. A similar situation is observed in communications and radar equipment manufacturing, where China's market share has hovered around 49% and its TC index has reached 0.8, underscoring its strong competitiveness. Yet, the gradually declining RCA index indicates that China's export advantage in this industry is also weakening. In digital media manufacturing and smart device manufacturing, both the TC index and market share have shown upward trends, with market shares consistently above 25%. This demonstrates that China enjoys clear comparative advantages in these two industries. In contrast, for electronic components and equipment manufacturing, China's RCA index has remained above 1 over the long term, but its TC index has consistently been below −0.2. This indicates that although China's export share is higher than the world average, the country remains heavily reliant on imports to meet domestic demand in this industry.

Japan's export share in computer manufacturing, communications and radar equipment, and digital media manufacturing has consistently remained below 0.5, far lower than the world average. Moreover, the TC index for these three sub-industries has long been negative, indicating that Japan's exports account for only a small proportion of the global total and that it remains heavily dependent on foreign imports. In contrast, in the fields of smart device manufacturing and electronic components and equipment manufacturing, the RCA index has remained above 1 with a clear upward trajectory, while the TC index has consistently been above 0.2 and shows a steady increase. Similarly, the MS index has also risen, suggesting that Japan's trade competitiveness in these two industries has been strengthening over time, with exports becoming increasingly advantageous and its comparative advantage more evident.

For South Korea, the trade competitiveness index in digital media manufacturing has been negative in most years, and its RCA index has long remained below 0.5. This indicates that South Korea's export share in this industry has been significantly lower than the global average, leaving it highly dependent on imports. Combined with the GVC index analysis, which has consistently exceeded 2 and ranked second among South Korea's digital product manufacturing sub-industries, this suggests that South Korea primarily engages in the production of high-value-added products in this sector. However, the relatively small share of exports prevents it from achieving a clear export advantage, and large-scale imports remain necessary to meet domestic demand. In contrast, South Korea's leading export-oriented industry—electronic components and equipment manufacturing—shows an RCA index consistently around 3, a TC index above 0.2, and a market share of approximately 10%. These figures highlight South Korea's strong export advantage in this sector, as well as its ability to produce high-value-added products with core competitiveness. Therefore, it can be concluded that South Korea holds a significant comparative advantage in this sub-industry of digital product manufacturing.

6. Conclusion

From the perspective of the division of labor in digital product manufacturing, China occupies a relatively lower position in the global value chain (GVC) compared with Japan and South Korea. Nevertheless, when international market share is taken into account, China's high value-added products hold a substantial proportion of the global market, which generally indicates significant influence and discourse power in this sector. This advantage can be largely attributed to China's comprehensive industrial chain in digital product manufacturing and its economies of scale, which together enhance its overall competitiveness in global production networks. The overall market share of China's digital product manufacturing industry significantly surpasses that of Japan and South Korea, further underscoring China's dominant position in the global market. In particular, China's sub-industries in digital product manufacturing lead the world in terms of market share, with export volumes exceeding the global average by a wide margin. With regard to revealed comparative advantage (RCA), China's performance across the various segments of digital product manufacturing is consistently above the benchmark level. Of particular note is that China's RCA values in five sub-industries all exceed 2, indicating export shares far above the global average. This not only highlights the strategic importance of the digital manufacturing sector in China's domestic economy but also reflects the industry's rapid development and the strong support it has received from national-level policies. In terms of international trade competitiveness, China's trade competitiveness index (TC) overall outperforms those of Japan and South Korea, both of which are traditionally recognized as strong players in the digital economy. This indicates that China enjoys a distinct international competitive advantage in this domain.

Specifically, China has demonstrated pronounced export advantages in computer manufacturing, digital media equipment manufacturing, and communications and radar equipment manufacturing. In these three sub-industries, China's global market share is exceptionally large, and its products exhibit significant international competitiveness. In global competition, China holds an overwhelming advantage in these sectors, with export volumes substantially exceeding the average levels of other countries.

Japan's digital product manufacturing industry is heavily concentrated in electronic components and equipment, with semiconductors forming its core. Japan's GVC index in this sector exceeds both its other subsectors and China's, yet it has shown a downward trajectory, while China's index has risen, gradually closing the gap. By contrast, smart device manufacturing remains Japan's most competitive subsector, where its GVC position continues to improve despite the general trend of movement toward the downstream of the value chain. This trajectory offers important lessons for China.

South Korea demonstrates particular strength in computer equipment and electronic component manufacturing. Its GVC index in computer equipment manufacturing far surpasses that of Japan, while in electronic components it is several times higher than China's. Combined with RCA results, this indicates not only strong export competitiveness but also dominance in high-end product production. South Korea's early and systematic development of the semiconductor industry has fostered a mature industrial cluster and provides valuable experience for China's industrial upgrading.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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