

Research on High-quality Coordinated Development of Digital Economy and Manufacturing Industry — Taking 31 Provinces and Cities in China as an Example

Rui Bao

Mercyhurst Preparatory High School, 16504, Pennsylvania, (Erie County)

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Abstract: The high-quality coordinated development of the digital economy and the manufacturing industry is a strategic requirement for building a modern industrial system and enhancing the country's comprehensive competitiveness. By constructing a comprehensive index evaluation system for the digital economy and manufacturing industry, this paper adopts the coupling coordination model to empirically test the high-quality coordinated development level of the digital economy and manufacturing industry in 31 provinces and cities from 2013 to 2020. The study found: (1) From 2013 to 2020, the coordination level of the digital economy and the high-quality development of the manufacturing industry in various regions was low, and the coordination level of most regions was between "moderate imbalance and mild imbalance"; The spatial structure characteristics of "east to west" decreasing in turn. (2) On the whole, the level of high-quality coordinated development of the digital economy and manufacturing in various regions is on the rise, and the regional differences are gradually decreasing.

1. Introduction

With the rapid development of emerging technologies such as artificial intelligence, big data, blockchain, and cloud computing, the digital economy relying on these advanced information technologies has the foundation and potential for rapid development. At the same time, the in-depth integration of the digital economy and manufacturing industry with informatization as the core has become a new driving force for national economic growth. In terms of the relationship and role of the two, the high-quality development of the digital economy promotes the high-quality development of the manufacturing industry, and the high-quality development of the manufacturing industry drives the high-quality development of the digital economy. The two promote each other and develop in concert. The high-quality coordinated development of the digital economy and manufacturing is an inherent requirement for building a modern industrial system and enhancing a country's comprehensive competitiveness, and it is also an inevitable choice for a country's high-quality economic development. Accelerating the high-quality development of the national advanced manufacturing industry and building a national modern industrial system have become the common strategic goals of all countries in the world. Especially since the beginning of the 21st century, the deep integration of the digital economy and manufacturing based on the Internet, big data and artificial intelligence has become a key development path for the country to build a modern industrial system and build a strong manufacturing country, driving the rapid development of the country's economy and has received much attention. Community concerns and discussions.

In 2019, the total value of the global digital economy reached 32 trillion US dollars, an increase of 5.4% year-on-year, accounting for 42.1% of the global GDP; among them, the total value of China's digital economy in 2019 reached 36 trillion yuan, accounting for 36 trillion yuan in the annual GDP. 36.2%, the economic contribution rate is as high as 67.8%, the scale of digital industrialization is 7.1 trillion yuan, and the scale of industrial digitalization is about 28.8 trillion yuan. It can be seen that China, while insisting on focusing on the real economy such as manufacturing, uses digital technology as a means to strengthen deep integration with

manufacturing, promote the transformation and upgrading of traditional manufacturing, build and improve a modern industrial system, and accelerate the promotion of Digital industrialization to promote the digital transformation of manufacturing.

In recent years, many scholars have conducted in-depth research on the connection between the digital economy and manufacturing. It mainly focuses on the promotion of the digital economy to the manufacturing industry [1], social total factor production efficiency [2], the construction of a manufacturing power and a modern industrial system [3-5], the logic of high-quality economic growth [6-7], and other issues, less discussion in the literature The mechanism of coordinated development of digital economy and manufacturing. Theoretically, on the one hand, the coordinated development of the digital economy and the manufacturing industry, on the one hand, promotes the transformation and upgrading of the traditional manufacturing industry and the digital upgrading of the manufacturing industry; business structure, etc. [8], by improving the information infrastructure, expanding new markets that demand digital technology, and driving the high-quality development of the digital economy.

To sum up, the digital economy and manufacturing are two interdependent and mutually promoting systems. Therefore, this paper uses the coupling coordination model to evaluate the level of coupling and coordination between the regional digital economy and manufacturing from the perspective of coordinated development, and analyzes the status quo of coupling and coordination. Development trends, pointing out existing problems and making targeted recommendations.

2. Interaction Mechanism between Digital Economy and Manufacturing

The high-quality development of the digital economy can promote the upgrading and transformation of the manufacturing industry in many ways, and the high-quality development of the manufacturing industry can provide a strong foundation for the high-quality development of the digital economy., making an important contribution to building a modern industrial system and promoting the overall high-quality development of the social economy.

2.1 The development of the digital economy promotes the transformation and upgrading of the manufacturing industry

As an important engine of economic growth, the digital economy is deeply integrated with various fields of the manufacturing industry, generating new development formats and models, and promoting the optimization and upgrading of the manufacturing structure [9]. Among them, the mechanism of the digital economy driving the transformation and upgrading of the manufacturing industry is mainly due to the fact that the digital economy can effectively expand the boundaries of the industrial chain organization and division of labor, reduce transaction costs, improve the value distribution relationship, generate effective demand, etc., and promote the manufacturing industry to a comprehensive digital industrial chain. In transformation [10], we must take the digital empowerment of the manufacturing industry as the transformation entrance, and carry out digital and intelligent transformation of all manufacturing industries in a planned and comprehensive manner [11], digital The economy is conducive to increasing the effective demand of society, promoting high-quality social investment, promoting the transformation of old and new kinetic energy and the upgrading of economic structure; the digital economy is conducive to promoting the innovation and development of the manufacturing industry, increasing the contribution share of scientific and technological innovation in the development of the manufacturing industry, and giving full play to the contribution of innovation to the economy. driving force of development.

2.2 The impact of manufacturing development on the development of digital economy

The development of the digital economy takes the manufacturing industry as the carrier, and relies on the development of the manufacturing industry in all-round operations such as production, research and development, manufacturing, and management. On the one hand, the development of the digital economy requires the integration of digital technologies into products, services and operations, while the development of manufacturing provides infrastructure support for

digital technologies; on the other hand, the digital economy represents an important goal of empowering infrastructure with digital technologies, and these The R&D, manufacturing and upgrading of digital infrastructure all depend on the level of manufacturing development. At the same time, the development level of the manufacturing industry has become the basic condition for the development of the digital economy, such as the level of industrialization and the division of labor in the industrial chain. Therefore, the development of the digital economy is affected by factors such as regional industrialization and economic stage [12]. In addition, the integration of the digital economy and manufacturing has spawned new product and service supply and demand, expanding the space for economic development, while new market demands have put forward new requirements for digital technology and the digital economy, driving digital technology innovation and digital economic development.

3. Research Model Design

3.1 Comprehensive evaluation model of digital economy and manufacturing

The original data needs to be standardized first, and the specific processing formula is as follows:

$$\begin{aligned} y_{ijt} &= \frac{x_{ijt} - m_{jit}}{M_{jit} - m_{jit}}, x_{ijt} \text{ positive indicator} \\ y_{ijt} &= \frac{M_{ijt} - x_{jit}}{M_{jit} - m_{jit}}, x_{ijt} \text{ negative indicator} \end{aligned} \quad (1)$$

In the above formula, x_{ijt} is the raw data of i samples in the j index system in the digital economy (DE) and manufacturing (RE) systems in year t . x_{ijt} is the data sample obtained after standardization; M_{ijt} and m_{jit} represent the maximum and minimum values of the index x_{ijt} , respectively; $i=1,2,\dots,n$; $j=1,2,\dots,m$.

Then this paper uses the entropy method to determine the weight of each index, the specific formula is as follows:

$$\begin{cases} p_{ij} = \frac{y_{ij}}{\sum_{i=1}^m y_{ij}} \\ e_j = \left[-\frac{1}{\ln(m)} \right] \sum_{i=1}^m p_{ij} \ln p_{ij} \\ w_j = \frac{(1 - e_j)}{\sum_{i=1}^m (1 - e_i)} \end{cases} \quad (2)$$

In the above formula, p_{ij} is the ratio of the i -th sample index value under the j -th index, and w_j is the weight of each index. Finally, the comprehensive development level of the digital economic system and the manufacturing system is calculated according to the above measured values. The calculation formula is as follows:

$$\begin{cases} DE_t = \sum_{j=1}^m w_{jt}^a u_{jt}^a & \sum_{j=1}^m w_{jt}^a = 1 \\ RE_t = \sum_{j=1}^m w_{jt}^b u_{jt}^b & \sum_{j=1}^m w_{jt}^b = 1 \end{cases} \quad (3)$$

3.2 Construction of coupling coordination model and division of coordination feature levels

The concept of coupling and coordination comes from the system theory, which mainly describes the coordinated changes between systems. The specific model is constructed as follows:

$$\begin{cases} C = \frac{2\sqrt{DE \times RE}}{(DE + RE)}, & C \in [0,1] \\ T = \alpha DE + \beta RE, & \alpha + \beta = 1 \\ D = \sqrt{C \times T} \end{cases} \quad (4)$$

In the above formula, C is the coupling degree of the system, which takes the value [0, 1]; T is the comprehensive evaluation index of the two systems, reflecting the overall synergistic effect of the two systems, α and β are undetermined coefficients, satisfying $\alpha + \beta = 1$, Referring to previous studies, we set the values of α and β as 0.3 and 0.7, respectively; D is the coupling coordination degree.

In addition, in order to reflect the coupling coordination state and relative development degree between DE and RE, this paper divides the coupling coordination degree and relative development degree between DE and RE into 10 grades. The specific evaluation criteria are shown in table 1.

Table 1 Evaluation criteria for coupling coordination between digital economy development and manufacturing

interval	coordination interval			
Coordination	0.9<D≤1	0.8<D≤0.9	0.7<D≤0.8	0.6<D≤0.7
Coordination level	High-quality coordinated development(IIIX)	Well-coordinated development(IX)	Intermediate Coordinated Development(VIII)	Primary coordinated development(VII)
interval	transition interval			
Coordination	0.5<D≤0.6		0.4<D≤0.5	
Coordination level	Barely coordinated development(VI)		on the verge of dysregulation(V)	
interval	Offset interval			
Coordination	0.3<D≤0.4	0.2<D≤0.3	0.1<D≤0.2	0<D≤0.1
Coordination level	mild dysregulation decline(IV)	Moderately dissonant decline(III)	Severely dysfunctional decline(II)	extremely dysregulated recession(I)

3.3 Construction of an evaluation index system for the development of the digital economy and the development of the manufacturing industry

Since the development level of the digital economy and the development level of the manufacturing industry are a comprehensive and complex economic system, there will be large errors when measured by a single index. Therefore, this paper measures the relationship between the digital economy and the manufacturing industry by building a comprehensive evaluation index system method Comprehensive development level. As shown in table 2.

Table 2 Coupling and Coordination Evaluation Index System of Digital Economy Development and Real Manufacturing Development

economic system	first-level indicator	Secondary indicators	three-level indicator
Comprehensive development of digital economy	Digital economy development	Development level of digital	Total telecom business as a percentage of GDP(%,+)
			Number of mobile phone base stations(万,+)

		industrialization	Internet penetration(%)
			Mobile phone penetration(%,+)
			Proportion of broadband Internet users(%,+)
			Proportion of mobile internet users(%,+)
			Software business revenue as a percentage of GDP(%,+)
		Industrial digital development level	Total output value of electronic equipment manufacturing industry (100 million yuan)
			Proportion of enterprises with e-commerce transactions(%,+)
			Websites per 100 companies (one, +)
			Share of e-commerce retail sales(%,+)
			Industrial added value as a share of GDP(%,+)
	Manufacturing level	Manufacturing Development Foundation	Number of industrial enterprises above designated size(one, +)
			Proportion of new fixed investment in manufacturing(%,+)
			Current ratio of industrial enterprises above designated size(%,+)
		Manufacturing development benefits	Sales profit margin of industrial enterprises(%,+)
			Current ratio of industrial enterprises above designated size(%,+)
		The ratio of property rights of industrial enterprises above designated size(%,-)	

3.4 Evaluation of the effect of high-quality coordinated development of China's regional digital economy and manufacturing

Table 3 reports the calculation results of the high-quality coordinated development of digital economy and manufacturing in 31 provinces and cities in China from 2013 to 2020. From Table 3, it can be seen that from 2013 to 2020, the coordinated development level of digital economy and manufacturing in various regions was low, but the overall development showed a trend of continuous growth. From the perspective of the increase in each region, Guizhou Province and Guangxi Province have the largest increase in the level of coupling coordination, both of which are 7.10%. This is because the rise of the big data industry in Guizhou and Guangxi has led to the rapid development of their digital economy, and also promoted the transformation and upgrading of related manufacturing industries. The level of coupling coordination in Hainan and Qinghai regions also increased significantly, 6.05% and 6.06%, respectively, and the coordination levels were between "moderate disorder → near disorder" and "severe disorder → mild disorder". Due to the developed service industry in Hainan, there is a lack of investment in the construction of the digital economy. The three regions of Shanghai, Beijing and Tianjin have a smaller increase, 2.27%, 3.06% and 3.07% respectively; the coordination status is also in the range of "mild disorder → near disorder", "near disorder → barely coordinated" and "mild disorder". → On the verge of dissonance". The areas with better coordinated development of digital economy and manufacturing development are mainly concentrated in the eastern coastal provinces, while the overall coordination degree of the central, northeastern and western provinces is relatively low; from the perspective of inter-annual changes, the coordination effect of various comprehensive economic zones has gradually increased In terms of spatial structure, the level of coupling coordination shows a gradually decreasing spatial pattern distribution from "east" to "west".

Table 3 Calculation results of high-quality coordinated development effects of digital economy and manufacturing

area	2013	2014	2015	2016	2017	2018	2019	2020	mean	growth rate
Beijing	0.447	0.450	0.462	0.482	0.494	0.517	0.557	0.536	0.476	3.06%

Tianjin	0.365	0.372	0.376	0.390	0.395	0.403	0.414	0.428	0.381	3.07%
Hebei	0.340	0.346	0.359	0.370	0.386	0.399	0.420	0.437	0.371	4.21%
Shandong	0.433	0.469	0.477	0.485	0.502	0.513	0.526	0.510	0.470	3.16%
Shanghai	0.393	0.400	0.420	0.436	0.460	0.470	0.492	0.469	0.430	2.27%
Jiangsu	0.491	0.501	0.516	0.537	0.551	0.566	0.589	0.575	0.521	3.18%
Zhejiang	0.466	0.447	0.473	0.503	0.527	0.549	0.583	0.585	0.497	3.74%
Fujian	0.389	0.392	0.409	0.428	0.446	0.472	0.475	0.503	0.424	3.76%
Guangdong	0.519	0.521	0.538	0.557	0.575	0.608	0.669	0.699	0.563	4.57%
Hainan	0.298	0.316	0.320	0.330	0.327	0.331	0.383	0.410	0.323	6.05%
Liaoning	0.385	0.398	0.405	0.407	0.394	0.406	0.418	0.445	0.391	3.61%
Jilin	0.303	0.311	0.327	0.334	0.342	0.356	0.369	0.378	0.323	5.12%
Heilongjiang	0.293	0.332	0.340	0.339	0.334	0.352	0.360	0.376	0.327	3.85%
Shanxi	0.300	0.302	0.316	0.325	0.334	0.344	0.359	0.372	0.318	4.34%
Inner Mongolia	0.277	0.292	0.304	0.311	0.317	0.325	0.340	0.353	0.302	4.19%
Henan	0.358	0.375	0.394	0.415	0.427	0.447	0.460	0.478	0.400	4.88%
Shanxi	0.328	0.330	0.342	0.355	0.371	0.376	0.425	0.402	0.350	4.57%
Anhui	0.332	0.352	0.373	0.387	0.402	0.417	0.440	0.450	0.375	5.17%
Jiangxi	0.309	0.322	0.336	0.352	0.361	0.382	0.406	0.398	0.341	4.58%
Hubei	0.341	0.360	0.378	0.397	0.409	0.429	0.449	0.464	0.385	4.70%
Hunan	0.333	0.347	0.364	0.377	0.388	0.405	0.455	0.429	0.369	4.57%
Guangxi	0.291	0.309	0.320	0.329	0.336	0.370	0.404	0.469	0.335	7.10%
Chongqing	0.331	0.342	0.356	0.373	0.391	0.400	0.437	0.417	0.362	5.00%
Sichuan	0.360	0.369	0.386	0.404	0.422	0.440	0.484	0.459	0.396	4.33%
Guizhou	0.254	0.275	0.287	0.306	0.327	0.347	0.378	0.398	0.302	7.10%
Yunnan	0.267	0.292	0.306	0.318	0.328	0.344	0.384	0.384	0.311	5.85%
Tibet	0.240	0.267	0.276	0.269	0.289	0.288	0.291	0.295	0.264	4.04%
Gansu	0.292	0.316	0.319	0.331	0.351	0.332	0.346	0.344	0.311	4.87%
Qinghai	0.240	0.261	0.261	0.281	0.286	0.295	0.321	0.330	0.269	6.06%
Ningxia	0.256	0.269	0.275	0.281	0.294	0.305	0.330	0.329	0.276	5.87%
Xinjiang	0.262	0.278	0.281	0.294	0.299	0.298	0.329	0.323	0.284	3.84%

4. Research Conclusions

By constructing a comprehensive index evaluation system for digital economy and manufacturing, this paper adopts a coupled coordination model to measure the high-quality coordinated development level of digital economy and manufacturing in 31 provinces and cities in

China from 2013 to 2020. The study found that from 2013 to 2020, the level of high-quality coordinated development of digital economy and manufacturing in various regions was low, but the overall development showed a trend of continuous growth. In terms of spatial structure, the coordination level of the two shows a spatial distribution characteristic of orderly decreasing from "east to west", and the coordination level of digital economy and manufacturing in the eastern coastal areas is significantly better than that in the central, western and northeastern regions. Due to the layout of the national digital industry policy in Guangxi and Guizhou, the coordinated development level of digital economy and manufacturing has rapidly improved, and regional pillar industries have gradually formed. At the same time, with the development of time, the regional differences in the coordinated development level of the digital economy and manufacturing in various regions have gradually reduced. From the above research, we can find that the industrial structure of the western region is relatively simple, and the integration of the digital economy and the manufacturing industry is limited, which seriously restricts the high-quality coordinated development of the two. Taking the "Calculation" project as an opportunity, accelerate the upgrading and optimization of the industrial structure in the region, and formulate relevant industrial reform policies according to local conditions.

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