DOI: 10.23977/ieim.2024.070306
ISSN 2522-6924 Vol. 7 Num. 3

Exploration of Deep Integration Development Methods between Logistics Industry and Manufacturing Industry in the Digital Economy

Min Feng[1,a,*], Qi Yang[1,b], Xiaohua Cai[1,c], Hongxia Gu[1,d], Meizhen Xie[1,e]

[1]Haojing College, Shaanxi University of Science and Technology, Xi'an, Shaanxi, China
[a]1073922624@qq.com, [b]HJyangqi@hotmail.com, [c]383040125@qq.com, [d]gu_hx@outlook.com, [e]2915254933@qq.com
[*]Corresponding author

Keywords: Logistics Industry, Manufacturing Industry, Integrated Development, Coupling Degree Coordination Model

Abstract: Under the new normal, the integration of logistics and manufacturing has become an inevitable trend in industrial development. The development plan for the two industries was jointly issued by multiple ministries, including the Group Development and Reform Commission, which put forward new demands for deepening reform and opening up. Taking the integrated development of China's "two industries" as an example, an evaluation index system for the integrated development of China's logistics and manufacturing industries is established from six aspects: economic, social, ecological benefits, structural optimization, technological innovation, and open development. Secondly, the entropy method is used to weight each indicator and calculate the comprehensive evaluation indicators of the "two industries", establishing a coupling and synergy model for the degree of integration of the "two industries". Based on the measurement of the degree of integration between the two industries, taking into account the actual situation and historical background of China's economic and social development, this study aims to explore the promotion methods and policy measures for the deep integration of the two industries, with the aim of providing reference for the development of logistics and manufacturing industries in different regions of China.

1. Introduction

The report from the 20th National Congress of the Communist Party of China explicitly emphasized "enhancing the resilience and security of industrial and supply chains" and "focusing on developing the real economy, promoting new industrialization, and accelerating the construction of a strong manufacturing nation." The '14th Five-Year Plan' and the Long-Range Objectives through the Year 2035 emphasize 'promoting the integrated development of productive services,' with a particular focus on 'guiding the high-quality development of manufacturing and advancing productive services towards specialization and the high end of the value chain [1].'

Currently, scholars both domestically and internationally have explored the integration mechanisms and models of logistics and manufacturing industries primarily from the perspectives of social division of labor theory, transaction cost theory, and industrial association theory. In terms of social division of labor theory, He Bo developed a system dynamics model for the linkage mechanism between logistics and manufacturing industries, exploring the key factors affecting the linkage effect between these industries [2]. Regarding industrial association theory, Zhang Jiping identified issues in the collaboration between RRS Logistics and Haier Manufacturing, proposing the use of internet, cloud storage, and other technologies to build an information service platform for the two industries, thereby achieving resource sharing [3].

In terms of measuring the level of coordinated development between these two industries, domestic scholars have made significant contributions by measuring and empirically analyzing the integration level of logistics and manufacturing industries. They have mainly utilized data envelopment models, composite system coordination models, coupling coordination models, and grey relational models. For instance, Yang Yuefeng and others used a data envelopment model from an input-output perspective to empirically analyze the degree of integration between these two industries in the Minnan region, providing suggestions for promoting long-term regional economic integration [4]. Liang Hongyan measured the integration degree of the two industries and evaluated its impact on industry performance [5]. Chen Chunming and others, based on the coupling-coordination theory, analyzed the spatio-temporal differentiation of the coordinated development level between the two industries in China's eight major economic zones [6]. Chu Yanchang used a DEA-GRA two-layer model to measure the total factor productivity of China's logistics and manufacturing industries in recent years, researching the efficiency of their linkages [7].

In summary, while existing research has made valuable explorations into the integration of the logistics and manufacturing industries as their integration level in China continues to increase, further expansion is still needed. Some studies have limitations in the construction of evaluation index systems, such as a narrow scope and single-dimensional indicators, which do not fully align with current economic development needs [8]. Additionally, the evaluation of the development levels of logistics and manufacturing industries is not comprehensive and accurate enough. Based on this, this paper aims to build a more complete evaluation index system and introduce a "coupling coordination" model to provide new insights for the deep development of the two industries [9].

2. Research Methods and Model Introduction

For the integration of the manufacturing and logistics industries, appropriate measurement methods need to be chosen. This paper reviews relevant domestic and international literature and existing measurement methods, compares their characteristics, and selects the most suitable methods for measuring the integration degree of the manufacturing and logistics industries.

Based on the literature review, the research methods in this paper include the Herfindahl index method, the patent coefficient method, the NEGOPY network analysis method, the input-output method, the entropy weight method, and the coupling-coordination model. An empirical study was conducted using these methods. The Herfindahl index method uses relatively simple data, but it focuses on technical integration within industries and lacks sufficient research on the integration between the manufacturing and logistics industries. Similarly, the patent coefficient method focuses on technical calculations based on technological patents within industries. Although patent numbers are relatively simple, the integration of the manufacturing and logistics industries involves multiple aspects, including products, markets, and organizational and managerial levels. Therefore, the patent coefficient and Herfindahl index methods are not suitable for measuring the integration degree of these two industries. The NEGOPY network analysis method, although capable of clearly reflecting changes in industry structure, has a significant drawback: it requires a large and cumbersome amount of data. Therefore, this method is not typically used to calculate the integration degree between production and logistics.

In information theory, the entropy method is a commonly used method for calculating index weights. It is inversely proportional to the amount of information in the system: the more information in the system, the lower the uncertainty value; conversely, the less information in the system, the higher the uncertainty and the entropy value. The entropy method can effectively determine the weight of each indicator in the existing evaluation system, assess its dispersion and difference, and ultimately obtain a composite index. In the field of industrial integration, most domestic scholars have adapted industrial integration algorithms proposed by foreign scholars, considering China's specific circumstances. For example, Zhang Xiaomin and others proposed a coupling-coordination model for the integration of "agriculture-tourism" and "culture-tourism." Zhang Kangjie and others constructed a subsystem for evaluating industrial integration development from the perspective of industrial development and used the coupling coordination degree model to measure relevant indicators, evaluating the integration level of five regions in Shandong Province.

Based on these, this paper explores the integration methods of China's manufacturing and logistics industries using the entropy method and the coupling coordination degree model.

3. Construction of Models for Logistics and Manufacturing Industries

3.1. Selection of Indicator System

Table 1: Evaluation Index System for the Development of China's Logistics Industry

System layer	Dimension layer	Indicator layer	Specific indicators	unit	Indicator attribute
Development indicators of logistics industry	economic benefits	Capital	Fixed assets investment of the whole society in the logistics industry	RMB100mn	just
		Industrial scale	Value added of logistics industry	RMB100mn	just
		labour productivity	Value added of logistics industry/number of logistics industry employees	10000 yuan/person	just
	social benefit	Express Service	Express delivery volume	Ten thousand pieces	just
		Employment contribution	Employment in logistics industry/total employment	%	just
		income distribution	Average salary level in the logistics industry	element	just
	ecological benefit	energy consumption	Total energy consumption of logistics industry/added value of logistics industry	10000 tons of standard coal/100 million yuan	burden
	Structural optimization	urban and rural structure	Rural delivery route length/total delivery route	%	just
		industrial structure	Value added of logistics industry/Value added of tertiary industry	%	just
	technological innovation	Invention Patent	Logistics patent application volume	piece	just
	Development for global progress	Trade dependenc	Total import and export value of goods/regional GDP	%	just

Drawing on relevant domestic and international literature, an evaluation indicator system for the development of the logistics and manufacturing industries is constructed based on six dimensions: economic, social, ecological, structural optimization, technological innovation, and open development (as shown in Table 1).

Economic Benefits: The high-quality development of China's logistics industry faces the dual demands of quality and quantity. It must emphasize overall efficiency while ensuring the continuous growth of scale.

Social Benefits: The fundamental starting point for the high-quality development of logistics is to enhance people's quality of life and create a better living environment. Express delivery services, being closely and directly connected to people's daily lives, not only promote social sharing, expand domestic demand, and drive employment, but also benefit people's livelihood.

Ecological Benefits: For the logistics industry to achieve sustainable development, it must impose constraints on environmental impact.

Structural Optimization: To achieve transformation, upgrading, and high-quality development of the logistics industry, it is crucial to focus on upgrading the industrial structure and coordinating urban and rural development.

Technological Innovation: Technological innovation is the driving force behind the high-quality development of logistics. To break free from dependence on others, it is necessary to increase investment in technological innovation and intensify research and development efforts to truly master core technologies.

Table 2: Evaluation Index System for the Development of China's Manufacturing Industry

System layer	Dimension layer	Indicator layer	Specific indicators	Company	Indicator attributes
Development indicators of logistics industry	economic performance	Contribution to Growth	Total profit of manufacturing enterprises	RMB100mn	just
		labour productivity	Industrial added value/employment of labor force	10000 yuan/person	just
		Asset liability ratio	Total liabilities of manufacturing enterprises/total assets of manufacturing industry	%	just
	social results	income distribution	Average wage level in manufacturing industry	element	just
		Tax contribution	Total tax amount of manufacturing industry/total output value of manufacturing industry	%	just
	ecological benefit	Environmental governance	Industrial pollution control investment/general public budget expenditure of local governments	%	just
	Structural optimization	High end transformation	High end technology industry revenue, industrial revenue	%	just
		Clustering	Number of enterprises in national high-tech zones/total number of enterprises	%	just
	technological innovation	R&D investment	R&D expenses for industrial enterprises above designated size	Ten thousand yuan	just
		Innovation output	Sales revenue from newly developed products in the high-end technology industry	RMB100mn	just
	Development for global progress	Invention Patent	Logistics patent application volume	%	just

Open Development: For the logistics industry to achieve high-quality development, it must establish an open innovation system with a global outlook and engage in open cooperation across broader fields. The China-Europe freight train service has accelerated the integration of the global logistics industry, promoting the "Belt and Road" initiative.

Based on the principles of indicator construction, the evaluation indicator system for the development of China's manufacturing industry is shown in Table 2.

Economic Benefits: In the new normal of the economy, the development of the manufacturing industry needs to focus more on efficiency and quality while maintaining stable economic growth. The economic benefits indicators of manufacturing enterprises should reflect not only the explicit indicator of "quantity" but also the higher intrinsic requirements of "quality."

Social Benefits: For the manufacturing industry to achieve high-quality development, it must create positive social benefits while promoting economic growth. Wages provide basic security for workers, while taxes reflect their contributions to society.

Ecological Benefits: Faced with the dual pressures of resources and the environment, the manufacturing industry must implement the concept of green development to achieve high-quality growth. This involves transitioning away from the traditional manufacturing model characterized by high pollution and high energy consumption and focusing on pollution control.

Structural Optimization: High-quality development in manufacturing cannot only pursue an increase in "quantity" but must also emphasize the improvement of "quality." Structural optimization in manufacturing is primarily reflected in the promotion of high-tech, high-value-added industries toward high-end development and the regional agglomeration of related competitive enterprises.

Technological Innovation: Technological innovation has become an inexhaustible driving force for the transformation, upgrading, and development of China's manufacturing industry. Achieving strategic goals like "intelligent manufacturing" and "Made in China 2025" requires continuous enhancement of independent innovation capabilities and accelerating the process of intelligent manufacturing.

Open Development: Based on the "dual circulation" strategy, the manufacturing industry should actively participate in international competition, adhere to expanding open cooperation, and achieve high-quality development.

3.2. Data Processing and Comprehensive Evaluation Index

"Determine the indicator weights using the entropy method and calculate the comprehensive evaluation index for the logistics and manufacturing industries. Determine the indicators: select m regions, n indicators, and T years to construct the initial evaluation matrix."

$$X = \{x_{ij}^{t}\}_{mT\times n} \tag{1}$$

In the formula, x_{ij}^{t} represents the t indicator of the i province in the j year.

Standardization: Due to differences in dimensions and positive or negative orientations that may affect the indicators, this paper uses the range standardization method to process the data and applies data shifting to eliminate the impact of zero values.

Positive indicators:

$$y_{ij}^{t} = \frac{x_{ij}^{t} - x_{j\min}}{x_{j\max} - x_{j\min}} + 0.0001 \tag{2}$$

Negative indicators:

$$y_{ij}^{t}=\frac{x_{j\max}-x_{ij}^{t}}{x_{j\max}-x_{j\min}}+0.0001 \tag{3}$$

Calculate the proportion of indicator values p_{ij}^{t}:

$$p_{ij}^{t}=\frac{y_{ij}^{t}}{\sum_{t=1}^{T}\sum_{i=1}^{m}y_{ij}^{t}} \tag{4}$$

In the formula:p_{ij}^{t} The proportion of the j-th indicator representing the i-th indicator value in the t-th year.

Calculate the entropy value e_j:

$$e_j=-k\sum_{t=1}^{T}\sum_{i=1}^{m}p_{ij}^{t}\ln p_{ij}^{t}\left(k=\frac{1}{\ln mT}\right) \tag{5}$$

In the formula, the weight of the jth indicator is represented by e_j; Indicates that $0\le e_j\le 1$.

Determine the weight of the indicator w_j:

$$w_j=\frac{(1-e_j)}{\sum_{j=1}^{n}(1-e_j)} \tag{6}$$

In the formula, the weight of the jth indicator is denoted as w_j Representing ,$0\le w_j\le 1, \sum_{j=1}^{n}w_j=1, (1-e_j)$ is often denoted as g_j, For the coefficient of difference, the larger the value of g_j the higher the importance of the indicator.

Calculate the comprehensive evaluation index:

$$S_j=\sum_{j=1}^{n}w_jy_{ij}^{t} \tag{7}$$

4. Measurement and Analysis of the Integration Level between Logistics and Manufacturing Industries

By adopting a coupled coordination model, the logistics industry and manufacturing industry are closely linked, forming a coupled system. The degree of coupling is used to measure the degree of interaction between the two subsystems. Referring to the research of other scholars, calculate using the following formula:

$$C=\sqrt{\frac{U_1U_2}{(\frac{U_1+U_2}{2})^2}}=\frac{2\sqrt{U_1U_2}}{U_1+U_2} \tag{8}$$

In the formula, C represents the coupling degree, U1 represents the comprehensive evaluation index of the logistics industry system, and U2 represents the comprehensive evaluation index of the manufacturing industry system.

This article further cites the coupling coordination degree to explore the mutual promotion effect between the two systems. The calculation formula is:

$$D=\sqrt{C\times T} \tag{9}$$

$$T=\alpha U_1+\beta U_2 \tag{10}$$

In the formula, D represents coupling coordination, T represents coupling coordination index, and is an undetermined coefficient. The logistics industry and manufacturing industry are equally important, with a value of 0.5. The interruption score method and uniform distribution function method are used to classify the coupling degree and coupling coordination degree of the two industries into different levels (as shown in Table 3).

Table 3: Classification of Coupling and Coordination Levels

Standard division		gradation	
Coupling degree division standard	(0-0.3]	Coupling level	Low level coupling stage
	(0.3-0.5]		Antagonistic stage
	(0.5-0.8]		Running in stage
	(0.8-1]		High level coupling stage
Coordination division criteria	(0-0.1]	Coordination level	Extreme imbalance
	(0.1-0.2]		Serious imbalance
	(0.2-0.3]		Moderate imbalance
	(0.3-0.4]		Mild imbalance
	(0.4-0.5]		On the brink of imbalance
	(0.5-0.6]		Barely coordinating
	(0.6-0.7]		Primary Coordination
	(0.7-0.8]		Intermediate coordination
	(0.8-0.9]		Good coordination
	(0.9-1.0]		High quality coordination

5. Strategies and Recommendations for Enhancing the Integration Development of the Logistics and Manufacturing Industries

The coordinated development of the manufacturing and logistics industries is a crucial means to improve the overall performance of China's logistics industry and drive economic growth. To address the issue of enhancing the interaction between these two industries and improving manufacturing performance, this paper proposes the following recommendations based on the development of each industry and the external conditions affecting their interaction:

(1) Chinese manufacturing enterprises should shift from the traditional "large and comprehensive, small and comprehensive" model to outsourcing certain functions to specialized, external firms and forming strategic alliances with them.

(2) Develop and organize demonstration projects and major initiatives to promote the interaction between the two industries, focusing on sectors such as steel, automotive, shipbuilding, petrochemicals, equipment manufacturing, and electronic information. The goal is to enhance the core competitiveness of the manufacturing industry by leveraging information technology to drive interaction between the two industries.

(3) Create a favorable business environment to facilitate the coordinated development of the manufacturing and logistics industries. This can be achieved by simplifying administration and delegating power, optimizing services, minimizing direct government intervention in market activities, and strengthening supervision during and after events. Such measures will create a safer and more convenient institutional environment for cooperation between manufacturing and logistics enterprises.

References

[1] He Dengcai. New Methods and Pathways for Modern Logistics Development—Based on the "14th Five-Year Plan" and the 2035 Long-Term Vision Outline. Journal of Beijing Jiaotong University: Social Sciences Edition, 2022, 21 (1): 6.

[2] He Bo. System Dynamics Analysis of the Mechanism of Interaction between Manufacturing and Logistics Industries. Journal of Chongqing Technology and Business University: Social Sciences Edition, 2016, 33 (2): 9. DOI: 12.3969/j.issn.1672-0598.2016.02.003.

[3] Zhang Jiping. New Model of Manufacturing + Logistics Coordination—Based on the Operational Mechanism of Haier and RRS Logistics. Enterprise Management, 2020 (03): 103-106.

[4] Yang Yuefeng, Lai Yongbo. Research on the Coordinated Development of the Logistics and Manufacturing Industries in the Minnan Region. Journal of Changchun University, 2021, 31 (09): 10-17.

[5] Liang Hongyan. Evolution Characteristics, Performance, and Enhancement Paths of the Integration Development of Logistics and Manufacturing Industries in China. Quantitative Economic and Technical Economic Research, 2021, 38 (10): 24-45.

[6] Chen Chunming, Chen Jiaxin, Gu Jun. Evolutionary Study of the Coordinated Development of Logistics and Manufacturing Industries in China. Journal of Shandong University (Philosophy and Social Sciences Edition), 2020 (02): 73-81.

[7] Chu Yanchang, Lian Wenhao, Yan Zichun. Measurement of the Efficiency of the Coordination between Logistics and Manufacturing Industries Based on DEA-GRA Two-Layer Model. Statistics and Decision, 2021, 37 (01): 182-186.

[8] Zhang Xiaomin, Sun Na, Xue Jingfeng. Study on the Integrated Development of Tourism and Cultural Industries in Shandong Province Based on Coupling Degree Model. China Market, 2019, (20): 58-59.

[9] Zhang Kangjie, Jiang Hui. Study on the Integration Development Level of Primary, Secondary, and Tertiary Industries in Traditional Agricultural Areas—Taking Shandong Province as an Example. Resource Development and Market, 2017, 33 (03): 349-354.