

Research on the Integration and Innovative Development of Logistics Industry and Manufacturing Industry in Anhui Province

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Abstract: The integration and innovative development of logistics industry and manufacturing industry (LMIID) can promote the high-quality development of economy. Based on the actual development of Anhui Province, the article constructs the evaluation index system of the LMIID, takes the development data of Anhui Province from 2013 to 2022 as the support, utilizes the entropy value method and the coupling coordination degree model to measure the coupling degree and the coupling coordination degree of the two industries in Anhui Province, and then utilizes the linear regression model to explore the influencing factors of the LMIID. The results found that the coupling coordination degree of logistics industry and manufacturing industry in Anhui Province is on the rise as a whole, but there are large fluctuations. Its influencing factors are mainly: development environment, science and technology innovation level, economic development level and labor force level. On this basis, suggestions are put forward to promote the LMIID, with a view to promoting the in-depth integration of the two industries in Anhui Province and promoting the development of the economy in the direction of high quality.

Keywords: Logistics Industry; Manufacturing Industry; Integration and Innovation; Coupling and Coordination

1. Introduction

China's reform and opening up as a new starting point, the rapid development of the economy, the continuous innovation and application of the Internet and information technology have supported the rise of the logistics industry (LI) from a subsidiary industry to a modernized and comprehensive pioneer industry that guides

production and promotes consumption[1]. At the same time, the supply-side reform, the integrated development of the Yangtze River, the innovation of Internet technology and other comprehensive advancement will surely promote the development speed and mode innovation of China's LI. Manufacturing industry (MI) is an important embodiment of the country's comprehensive strength and international competitiveness[2]. China's MI promotes the rise of China's economy, while China's MI supports China to become the second largest economic entity in the world. The introduction of the "Made in China 2025" strategic plan has put forward new requirements for China's MI. In addition, with the Internet of Things, big data, cloud computing and blockchain and other new generation of information and communication technology applications, will certainly promote a new round of industrial revolution, the new industrial revolution will certainly subvert the mode of production, but also inevitably lead to the birth of a new manufacturing model[3]. The rapid development of information and Internet technology makes it possible for different industries to cross, penetrate and gradually integrate with each other, and the development of industrial integration will become a major trend in the optimization and adjustment of industrial structure in the future [4]. The development of industrial integration will become a major trend in the optimization and adjustment of industrial structure in the future. In this context, the integration development of LI and MI has become a reality.

2. Literature Review

At present, there are many studies on the LI and MI, and this paper focuses on the relationship between the LI and MI, the conditions, level and significance of the integration development of

the two industries. Among them, Liang [5] studies the characteristics, performance and enhancement strategies of the integrated development of China's LI and MI to provide practical evidence to support the integrated development of the two industries. Jonas Lind [6] argues that the clear boundaries between the LI and MI are gradually breaking down, and that the integration of the two industries will be the highest form of development. Khan SAR et al. [7] show the necessity of linkage development between LI and MI and explore the mechanism of the two industries' integration development. Chen et al. [8] measured the coupling level of the LI and MI by using the coupling coordination model based on the economic data of eight regions, and found that the coordination level of the two industries is on a growing trend, but there is a large gap in the development of the coupling coordination of the two industries between the various economic regions. Chen and Wang [9] utilize the coupling coordination model to measure the level of LMIID, which shows that the level of integration and development of China's LI and MI is on the rise, but the overall level is still low, there is significant divergence between regions. Su et al. [10] concluded that the integrated development of the LI and MI is conducive to the LI's reduction of circulation costs and improvement of the matching degree of supply and demand on the one hand, and the promotion of the high-quality development of the MI on the other hand, which has important practical significance. Yan and Wang [11] explored the relationship between specialized agglomeration and synergistic agglomeration of LI and MI and regional economic growth, which provides a new perspective for regional economic development.

By combing the relevant literature on the LMIID, the two industries have the conditions to realize the integration development, and there are differences in the level of the integration development of the two industries between

different regions. However, there are fewer studies on the coordination of the two industries at the local level, and there is insufficient research on the direction of the LMIID. Anhui Province has a favorable geographical location, is an important member of the Yangtze River Delta Economic Development Zone, and has great development potential. Therefore, it is of good research value to take Anhui Province as the research object. Therefore, the research of this paper, on the one hand, is conducive to expanding the relevant theoretical research, on the other hand, is conducive to promoting the industrial transformation and upgrading of Anhui Province, and promoting the development of the economy of Anhui Province in the direction of high quality.

3. Evaluation Indicator System

3.1 Evaluation Index System for the LMIID in Anhui Province

When measuring the level of LMIID, it draws on Gong et al.'s [12] system for measuring the coordination level of the two industries, which can not only highlight the level of LMIID, but also reflect the degree of integrated innovation development. Therefore, the evaluation index system is constructed from four aspects: industrial scale, development efficiency, technology level and growth potential. The industrial scale reflects the state of industrial scale and the level of investment in fixed assets; the development efficiency reflects the level of development at the present stage; the technology level reflects the level of innovation and the driving force for the integration of the two industries; and the growth potential reflects the potential for the future development of the two industries. The data sources for the indicators in this study are Anhui Statistical Yearbook 2013-2022 and China Key Industry Patent Information Service Platform. Specific indicators are shown in Table 1:

Table 1. Evaluation Index System of LMIID

sector	Level 1 indicators	Secondary indicators	Unit
logistics industry	Industrial scale	Value added of the LI	billions
		Number of employees in the LI	man
		Freight volume	tons
	Development effectiveness	Cargo turnover	Ton-kilometer
	Technical level	Patent Scale of LI	items
		Logistics Patent Quality	%

service industry	Growth potential	Growth rate of value added in the LI	%
		Freight volume growth rate	%
	Industrial scale	Investment in fixed assets in the manufacturing sector	billions
		Manufacturing value added	billions
		Number of people employed in manufacturing	man
	Development effectiveness	Total profit as a percentage of main business income	%
	Technical level	Number of active patents	items
		Level of innovation inputs	%
		Level of innovation output	%
	Growth potential	Growth rate of investment in fixed assets	%
		Growth rate of manufacturing value added	%

3.2 Influencing Factors of the LMIID in Anhui Province

In the context of China's market economic environment, according to the actual development of the LI and MI in Anhui Province, the level of economic development, the level of labor force and the level of social consumption are chosen as the influencing factors for the LMIID in Anhui Province. The measurement of economic development level is GDP per capita, which can reflect the macroeconomic situation of Anhui Province; the labor force level can reflect the employment situation of the LI and MI in the region, which can be measured by the number of employed people; the social consumption level can reflect the situation of material and cultural level of the residents in the region in a certain period of time, and the demand for products produced by the LI and MI, which can be measured by the ratio of the total retail sales of consumer goods to the regional GDP. Social consumption level can reflect the material and cultural level of regional residents in a certain period of time, the demand for products produced by the LI and MI, measured by the ratio of total retail sales to regional GDP. The construction of the indicator system of specific influencing factors is shown in Table 2.

Table 2. Indicator System of Influencing Factors for the LMIID in Anhui Province

Norm	Measurement
Economic development level	GDP per capita
Labor force level	The number of employed persons(natural logarithm)
Social consumption level	Total retail sales of consumer goods/GDP

4. Research Methodology and Modeling

4.1 Entropy Value Method

Before measuring the level of LMIID in Anhui Province, it is necessary to select a suitable evaluation method. Referring to the methods used in the existing literature, and then combining the data of the multi-indicator system related to the two industries in Anhui Province, the entropy value method is utilized to determine the weights of each indicator, to reduce the uncertainty brought by the indicators due to the differences in positive and negative attributes, and to lay the foundation for the later coupling coordination degree model calculation.

In the indicator system, due to the different types of indicators, the unit of each indicator is also different, so it is necessary to carry out the quantitative processing of all the indicators first. The main steps are as follows:

(1) Data standardization: For the positive and negative indicators, the method of standardization is as follows:

For positive effect indicators:

$$X_{ij}' = \frac{X_{ij} - \min X_j}{\max X_j - \min X_j} \quad (1)$$

For negative effect indicators:

$$X_{ij}' = \frac{\max X_j - X_{ij}}{\max X_j - \min X_j} \quad (2)$$

(2) Calculation of the jth indicator weight of the ith year:

$$Y_{ij} = \frac{X_{ij}}{\sum_{i=1}^m X_{ij}} \quad (3)$$

(3) Perform the information entropy calculation of the indicator:

$$e_j = -k \sum_{i=1}^m (Y_{ij} \times \ln Y_{ij})$$

$$k = \frac{1}{\ln m}, 0 \leq e_j \leq 1, \text{ and when } Y_{ij} = 0, \text{ let } Y_{ij} \times \ln Y_{ij} = 0 \quad (4)$$

(4) Calculation of information entropy redundancy:

$$d_j = 1 - e_j \quad (5)$$

(5) Calculation of indicator weights:

$$w_j = \frac{d_j}{\sum_{j=1}^n d_j} \quad (6)$$

(6) Calculate the composite assessment value:

$$U = \sum_{j=1}^m X_{ij} W_j \quad (7)$$

4.2 Coupled Coordination Degree Model

Since there is an interaction and mutual influence between the LI and MI, it can be assessed using a coupled coordination degree model.

(1) Calculate the value of coupling C between the LI and MI as follows:

$$C = \frac{2\sqrt{U_1 \times U_2}}{U_1 + U_2} \quad (8)$$

In the above equation, U stands for the composite evaluation index, the U_1 and U_2 respectively, represent the comprehensive evaluation index of LI and MI in Anhui Province. The result of C is positively proportional to the degree of association between LI and MI.

(2) Calculation of the coupling coordination degree D of the LI and MI:

$$T = w_1 U_1 + w_2 U_2 \quad (9)$$

$$D = \sqrt{C \times T} \quad (10)$$

Where T denotes the coordination index of the LI and MI. D denotes the value of the coupled coordination degree of the two systems. Drawing on the division standard of Sun et al. [13], this paper divides the coupling coordination degree D of LI and MI into 10 levels, as shown in Table 3:

Table 3. Classification of Coupling Coordination Degree

D-values of coupling coordination	Coordination level	Degree of coupling coordination
[0.0, 0.1)	1	Extreme disorder
[0.1, 0.2)	2	Severe disorder
[0.2, 0.3)	3	Moderate disorder
[0.3, 0.4)	4	Mild disorder

Table 4. Indicator Weights for Each Level of the LI

Sector	Level 1 indicators	Secondary indicators	Unit	Properties	Weights
LI	Industrial scale	LI value added	billions	+	0.1572
		LI number of employees	man	+	0.1052
		Volume of freight	tons	+	0.0758
	Development effectiveness	Cargo turnover	Ton-kilometer	+	0.1291
	Technical level	Patent Scale of LI	item	+	0.0733
		Logistics Patent Quality	%	+	0.1279
	Growth potential	Growth rate of value added in the LI	%	+	0.2837
		Freight volume growth rate	%	+	0.0477

[0.4, 0.5)	5	On the verge of dysfunctional
[0.5, 0.6)	6	Sue for harmonization
[0.6, 0.7)	7	Primary coordination
[0.7, 0.8)	8	Intermediate level coordination
[0.8, 0.9)	9	Good coordination
[0.9, 1.0]	10	Quality coordination

5. Empirical Analysis

5.1 Measurement Results of the LMIID

According to Table 4 and Table 5, the weight of the LI value added accounts for a larger proportion in the scale indicator system of the LI, and the weight of the value added growth rate of the LI accounts for the largest proportion in the growth potential indicator, which indicates that the development potential of the LI is good. However, the weight of the technical level indicators of the LI is on the low side, which restricts the possibility of further integration and innovative development of the two industries. The industrial scale of MI accounts for a relatively large number, of which MI employees ranked first, and fixed asset investment ranked second. Secondly, in the technology level index system of MI, the level of innovation investment is higher, which is conducive to continuously stimulate the innovation vitality of the industry and promote the LMIID. In order to better realize the LMIID, it is necessary to stabilize the amount of fixed industrial investment, continue to promote scientific and technological innovation investment, expand the scale of logistics patents and improve the quality of logistics patents.

Table 5. Indicator Weights at Various Levels for the MI

Sector	Level 1 indicators	Secondary indicators	Unit	Properties	weights
MI	Industrial scale	Investment in fixed assets in the MI	billions	+	0.1102
		Manufacturing value added	billions	+	0.0794
		Number of people employed of MI	man	+	0.1731
	Development Effectiveness	Total profit as a percentage of main business income	%	+	0.1500
	Technical level	Number of active patents	item	+	0.0897
		Level of innovation inputs	%	+	0.1981
		Level of innovation output	%	+	0.0511
	Growth potential	Growth rate of investment in fixed assets	%	+	0.0539
		Growth rate of manufacturing value added	%	+	0.0944

Table 6. Calculation Results of Coupling Coordination Degree

Year	C-value	T-value	D-value	Coordination level	Degree of coupling coordination
2013	0.9746	0.1795	0.4183	5	on the verge of dysfunctional
2014	0.9389	0.2604	0.4944	5	on the verge of dysfunctional
2015	0.9919	0.1424	0.3758	4	mild disorder
2016	0.9841	0.2638	0.5095	6	sue for harmonization
2017	0.9890	0.3524	0.5904	6	sue for harmonization
2018	0.9804	0.5927	0.7622	8	Intermediate level coordination
2019	0.9987	0.5587	0.7469	8	Intermediate level coordination
2020	0.9443	0.4454	0.6485	7	Primary coordination
2021	0.9502	0.4829	0.6774	7	Primary coordination
2022	0.9581	0.6251	0.7739	8	Intermediate level coordination

From Table 6, the coupling degree of the two industries in Anhui Province is at a high level, stabilized above 0.9, indicating that Anhui Province has a high degree of interaction between the two industries and promotes each other's development from 2013-2022. From 2018-2022, the coupling and coordination levels of the LI and the MI in Anhui Province are all stabilized at the intermediate level of coordination, with the highest coupling and coordination degree of 0.774, which indicates that the development of the LI and MI in Anhui Province has a high degree of coupling coordination. From the change trend, the value of the coupling coordination degree from 2015-2016 was from 0.376 to 0.510, showing a large increase. In 2014, our government promulgated the Medium and Long-term Plan for the Development of the LI (2014-2020), which aims to innovate the logistics management mode, promote the synergistic development of the LI and MI and other fields, and to form a new competitive advantage. It is worth noting that the coupling coordination

degree of the LI and MI in Anhui Province shows a downward trend in 2018-2020, from 0.762 in 2018 to 0.649 in 2020, and this stage is affected by the national development environment, which greatly affects the industry development, resulting in the reduction of the level of integration and innovative development of the two industries. After 2020, the coupling and coordination degree of the two industries has rebounded. In 2021, the state put forward the 14th Five-Year Development Plan about the two industries, and the integration and development of the LI and MI has been further enhanced.

Overall, from 2013 to 2022, the level of coupling coordination between the LI and MI in Anhui Province shows an overall upward trend, and from the perspective of time span, the coordination level has roughly gone through the verge of dysfunction, barely and intermediate coordination, and the degree of development has been developing from poor to better.

5.2 Measurement Results of Influencing Factors of the LMIID

According to the statistically data, using SPSS software, the processed data were organized as

Table 7. Summary of Models

Model	R	R-square	Adjusted R-square	Errors in standardized estimates	Durbin Watson
1	.974 _a	.950	.924	.0399	3.156
a. Predictor variables: (constants), level of social consumption, level of labor force, level of economic development					
b. Dependent variable: D-value of coupling harmonization					

Table 8. ANOVA

Model	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Regression	.180	3	.060	37.624	<.001 ^b
Residual	.010	6	.002		
Total	.189	9			
a. Dependent variable: D-value of coupling harmonization					
b. Predictor variables: (constants), level of social consumption, level of labor force, level of economic development					

Table 9. Linear Regression Results

Model	Unstandardized Coefficient		Standardized Coefficient Beta	t	Significance	Covariance Statistics	
	B	Standard Error				Tolerance	VIF
Constant	-5.791	1.316		-4.402	.005		
Economic development level	1.786E-5	.000	1.688	8.134	<.001	.195	5.121
labor force level	.709	.155	.717	4.561	.004	.340	2.938
Social consumption level	-.925	.358	-.368	-2.586	.041	.416	2.403
a. Dependent variable: D-value of coupling harmonization							

According to Table 7, the adjusted R^2 value is

shown in Table 7, Table 8 and Table 9 respectively:

0.924, reflecting that 92.4% of the changes in the degree of synergistic development of LI and MI in Anhui Province are influenced by the three factors selected, indicating that the established regression model has a better simulation effect. As can be seen from Table 8, the significance of the regression equation model is less than 0.001, which passes the F test, indicating that the established regression model is effective. As can be seen through Table 9, the significance of the level of economic development and the level of labor force is less than 0.05, indicating that these two factors have a significant relationship with the coupling coordination index. The standardized coefficient of the economic development level is positive, indicating that the economic development level has a significant positive relationship with the coupling coordination index, and the higher the economic development level is, the more investment and resources it is conducive to attracting, and the more promotion of the LMIID. The standardized coefficient of labor force level is positive, showing a significant positive correlation with the coupling coordination index, indicating that the close integration of the two industries will lead to the development of related industries and create more employment opportunities, and at the same time, the higher the related labor force level, it will also transport more talents for the two industries, help the two industries to improve their production efficiency and economic benefits, and promote the LMIID and innovative development. The standardized coefficient of social consumption level is negative, indicating that it shows a significant negative correlation with the coupling coordination index, which is mainly due to the stage of economic development in Anhui Province. In different stages of economic development, the structure of consumption and production will change. Anhui Province in this decade to experience the adjustment of industrial structure and the development of the environment, the level of social consumption will also be affected by the corresponding impact, the level of consumption has been improved, but the coupling of the two industries, the integration of innovation and development may not have played a positive role in promoting the development of the two industries.

5.3 Proposals for Anhui Province LMIID

Based on the above analysis, combined with the actual development needs of Anhui Province on the LI and MI, in order to deeply promote the LMIID, Some development suggestions on the LMIID are put forward.

5.3.1. Optimizing the policy environment for integration and development

As shown in Table 6, the coupling coordination value of the two industries in Anhui Province in 2015-2016, from 0.376 in 2015 to 0.510 in 2016; 0.762 in 2018 to 0.649 in 2020; and the coupling coordination degree has been recovered faster after 2021. At the above stage, the Chinese government issued the Medium and Long-term Plan for the LI Development (2014-2020), which was influenced by the development environment, and Anhui Province issued the "14th Five-Year" development plan policy on the two industries. It can be seen that the LMIID is affected by the national policy and the development environment. Therefore, local governments can respond to the national policy and, at the same time, "adapt to local conditions", introduce and improve relevant policies conducive to promoting the LMIID, and build a legal environment conducive to the LMIID, so as to minimize the policy risks and uncertainties, and better cope with the instability of the development environment.

5.3.2. Focus on enhancing innovative development capacity

As can be seen from Table 4 and Table 5, the weight of the technology level indicator of the LI is low, the weight value of the patent scale of the LI is low, and the LI patents quality level is not high, compared with the higher weight of the technology level of the MI, in which the level of innovation investment accounts for the highest proportion. Therefore, the two under the indicator of technology level, the integration of innovation development is not coordinated. Because patents can reflect the strength of innovation, so the Anhui provincial government should focus on improving innovation and development capacity. Focus on the key core technology areas, with patents as the entry point, increase the protection of patents and support, expanding the scale of the LI patents, looking for Anhui province LI and MI in the direction of the integration of innovation and development of patented technology; Steadily enhance the MI's level of investment in innovation, and promote

the MI towards high-quality development; The government should do a good job of technological upgrading work, in order to provide more innovative resources and services and create a good atmosphere for the two industries to realize the LMIID.

5.3.3. Building the talent pool

As can be seen from Table 5, the number of people employed in the MI has a larger weight in the industrial scale index system of Anhui Province, indicating that the number of labor force in the MI is higher. When exploring the factors affecting the LMIID, the level of labor force selects the number of employed people in Anhui Province, and the GDP per capita of the employed people number reflects the economic development level in the region, while the economic development level and the labor force level is significant to the coupling level of the two industries. Therefore, on the one hand, the provincial government should steadily expand the employment opportunities in the two industries and expand the labor force number, thus enhancing the economic development level in the region. On the other hand, because the labor force number is directly related to the quality of labor force, the collection of talents is crucial for the two industries in Anhui Province to realize the integration and innovative development, so the Anhui provincial government should do a good job on the construction of the talent team of the two industries, in order to promote the LMIID to reserve talent resources. Specifically from the independent cultivation of talents and the introduction of talents in these two aspects. The government should make every effort to promote the cooperation between enterprises and universities. Universities should cooperate with the government to offer relevant courses, establish talent training bases, and improve the practical operation ability of the labor force.

6. Conclusions

This study uses entropy value method and coupling coordination degree model to measure and evaluate the LMIID in Anhui Province from 2013 to 2022, and analyzes the influencing factors of it by using multiple linear regression model. It is found that the coordinated development level of the LI and MI in Anhui Province shows an overall upward trend, but there are also large fluctuations, it is influenced by the policy environment, innovation and

development ability, economic development level and labor force level. Among them, the social consumption level has the possibility of restricting the LMIID. In this regard, there are three suggestions: optimize the integration and development policy environment, focus on improving the innovation and development capacity and do a good job in building the talent team. The research explores the new direction of the LMIID in Anhui Province, and it is of great significance to promote the high-quality development of the economy of Anhui Province. However, due to the limited statistics of the existing information, the data is incomplete, the indicator system also needs to be further explored, and about the use of research tools is limited to the perspective of time, which are the shortcomings of the research in this paper, follow-up studies are expected to overcome these shortcomings.

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