Coupling Degree of Logistics and Retail Industry Development in the Beijing–Tianjin–Hebei Region

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Abstract. The development of retail and logistics has an interactive effect. Exploring the coupling degree of retail and logistics development in the Beijing–Tianjin–Hebei region can provide insights for advancing coordinated development. This study constructs a gray relational coupling model to examine the time series of retail and logistics development, applying Kaiser–Meyer–Olkin test statistics and a reflection image correlation matrix to test the reliability and validity of the index. Investigating logistics and retail industry development in Beijing, Tianjin, and Hebei from 2010 to 2021 reveals that retail industry scale has a considerable influence on logistics industry development, railway and highway transportation development has a substantial influence on retail industry development, and the coupling degree between logistics and retail industries fluctuates.

Keywords: Beijing–Tianjin–Hebei Region, Logistics industry, Retail industry, coupling factor

1 Introduction

Beijing is a central city of national consumption in China, and the coordinated development of the Beijing–Tianjin–Hebei region is a vital national strategy. The retail industry is a significant aspect of China's real economy for meeting people's daily needs. Retail strives to reduce costs by choosing appropriate transportation modes and also relies on logistics platforms produced by third-party logistics enterprises to maintain operations. Retail industry logistics demand for purchasing and sales stages is also a significant aspect of the logistics demand market. Therefore, the retail and logistics industries share a complementary development process.

In recent years, many studies have examined the interaction between the development of logistics and other industries, among which methods for measuring the degree of coupling are common, including Hu, B.Q. (2017)[1], Liang, W.(2019)[2], Liang, W.(2020)[3], Li, X.R.(2020)[4], Tian, Q.(2021)[5] , Yang, H. et al. (2020)[6], Yeung, H.W.C.(2020)[7], Aziz, A.(2020)[8], Gao, Y.P.(2018)[9], and Wang, Y.J.(2021)[10]. Many studies examined the selection of logistics system indicators, such as Hu, B.Q. (2017)[1] and Wei, X.J.(2008)[11] research on the comprehensive level of regional logistics development. However, limited studies have investigated indicators of retail

A. Rauf et al. (eds.), *Proceedings of the 3rd International Conference on Management Science and Software Engineering (ICMSSE 2023)*, Atlantis Highlights in Engineering 20,
https://doi.org/10.2991/978-94-6463-262-0_28

development. Chen, H.H. et al.(2020)[12] examined evaluation indicators based on rates of information contribution. Chen, H.H.(2021)[13] introduced an evaluation index screening method reflecting the image correlation matrix, Kaiser–Meyer–Olkin (KMO) test statistics, measurement system analysis value, and a partial correlation coefficient in the image correlation matrix.

This study examines the development of the logistics and retail industries in the Beijing–Tianjin–Hebei region from 2010 to 2021 and investigates the development correlation and time–space coupling of the industries.

2 Theory and method

2.1 Gray relational coupling degree model

The gray relational coupling model is one of many coupling degree calculation models. The model is divided into the following steps:

First, determine the reference and comparison series. Suppose the reference series is $Y_j(t)(j = 1, 2, 3, 4\ldots m)$; Let the comparison series be $X_i(t)(i = 1, 2, 3, 4\ldots n)$.

Second, construct dimensionless data. Eliminating the influence of each index dimension and unit by range standardization method. The calculation formula for processing is as follows:

$$X_i(t)' = \frac{X_i(t)-\min(X_i)}{\max(X_i)-\min(X_i)},\ Y_j(t)' = \frac{Y_j(t)-\min(Y_j)}{\max(Y_j)-\min(Y_j)} \quad (1)$$

where t represents the year, and the index represents the t-th year.

Third, calculate the difference sequence, the formula for which is as follows:

$$r_{ij}(t) = |X_i(t) - Y_j(t)| \quad (i=1,2,3,4\ldots,n;\ j=1,2,3,4,\ldots,m;\ t=1,2,3,4\ldots) \quad (2)$$

where $r_{ij}(t)$ represents the difference between the i-th retail index and the j-th logistics index in year t.

Fourth, calculate the gray correlation coefficient. The correlation coefficient between any two indicators in each year is obtained by referencing the difference sequence matrix, and the formula is as follows:

$$k_{ij}(t) = \frac{\mathrm{minmin}|X_i(t)-Y_j(t)|+\rho\,\mathrm{maxmax}|X_i(t)-Y_j(t)|}{|X_i(t)-Y_j(t)|+\rho\,\mathrm{maxmax}|X_i(t)-Y_j(t)|} \quad (3)$$

Fifth, calculate the coupling correlation matrix, which is the number of years as the sample number and the arithmetic average of all samples. The formula is as follows:

$$K_{ij} = \frac{1}{q}\sum_{t=1}^{t} k_{ij}(t) \quad (4)$$

where K_{ij} is the correlation between the i-th retail index and the j-th logistics index, and q is the sample size.

Sixth, calculate the degree of system coupling. The formula for calculating the degree of coupling between retail and logistics industries from the perspective of time is as follows:

$$C(t) = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} k_{ij}(t)}{m*n} \quad (5)$$

where C(t) is the degree of coupling between retail and logistics industries in year t. According to the value of c, the development level of coupling coordination is divided into 10 basic types, as detailed in Table 1.

Table 1. Classification standard of coupling degree

Synergy interval	Synergy level	Synergy interval	Synergy level
0～0.1	Extreme imbalance	0.5001～0.6	Reluctant coordinate
0.1001～0.2	Serious imbalance	0.6001～0.7	Primary coordination
0.2001～0.3	Moderate imbalance	0.7001～0.8	Intermediate coordination
0.3001～0.4	Mild imbalance	0.8001～0.9	Good coordination
0.4001～0.5	On the verge of imbalance	0.9001～1	Quality coordination

2.2 Evaluation index selection method

Using SPSS software, this study conducts factor analysis and reliability tests of index data.The basic steps are as follows:

First, collect indicators. Different index data are collected according to the year.

Second, establish dimensionless data using a range standardization method to remove the influence of dimension.

Third, KMO test statistics and a reflection image correlation matrix are used to screen indicators applying SPSS software, referencing Chen, H.H.(2021)[13] The specific index screening steps are presented in Figure 1, where KMO and partial correlation values between the two indices are bounded by 0.7.

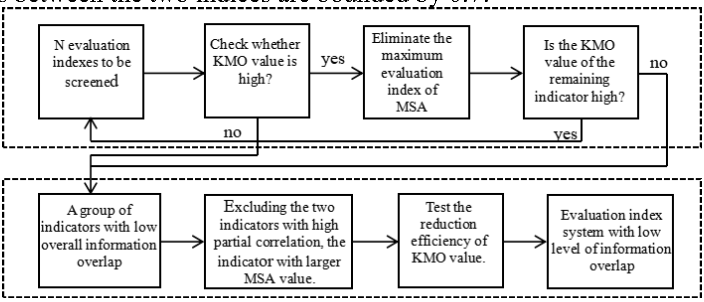

Figure 1 Flow chart of indicator screening

Finally, reliability and validity analyses are conducted. Reliability analysis primarily employs Cronbach's Alpha. Validity analysis first extracts the principal component using principal component analysis. If the extracted principal component explains the total variance well, the original variable information is less lost, and the factor analysis effect is ideal.

3 Empirical research

3.1 Index selection

3.1.1 Selection of retail industry indicators.

Referencing previous research, and according to the completeness and availability of data, 12 indicators are selected, including X1: total retail sales of social consumer goods, X2: number of employees at the end of the retail industry, X3: total purchases of retail goods, X4: total sales of retail goods, X5: operating income of retail enterprises, X6: total inventory of retail goods, X7: total retail assets, X8: total retail current assets, X9: added value of wholesale and retail, X10: total retail liabilities, X11: operating costs of retail enterprises, and X12: number of retail enterprises.

Dimensionless processing is conducted, and the data are then imported into SPSS for factor analysis. The KMO test result of the 12 indicators is 0.805 (greater than 0.7). X6, X3, and X4 are excluded according to the rules of indicator selection. After removing X1 and X11 based on the partial correlation coefficient, the KMO value is 0.681 and seven indices are retained. The reliability and validity of the index passed the test; therefore, we assert that the remaining seven indicators are reasonable.

3.1.2 Selection of logistics industry indicators.

Ten indicators are collected for the selection of logistics industry indicators, including Y1: railway operating mileage; Y2: highway mileage; Y3: employees in urban units of transportation, warehousing, and postal services; Y4: total wages of employees in urban units of transportation, warehousing, and postal services; and Y5: number of civilian cars. Following the same index screening procedure, eight indicators (Y1, Y2, Y3, Y5, Y6, Y7, Y8, and Y9) are retained.

3.2 Calculation of the degree of coupling between logistics and retail industry development

3.2.1 Degree of coupling correlation

This study collects index data for retail and logistics industries from 2010 to 2021 and calculates the degree of coupling correlation, which reflects the closeness between each index of the retail and logistics industries.

Table 2. Coupling correlation between indicators of Beijing retail and logistics industry

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	E_i
X1	0.5187	0.5555	0.7337	0.5469	0.7021	0.6136	0.5083	0.5012	0.5850
	6	4	1	3	6	6	6	9	5
X2	0.7880	0.7349	0.5199	0.8529	0.4390	0.6220	0.6594	0.7041	0.6650

X3	0.79459	0.70643	0.50529	0.83173	0.42218	0.59473	0.67878	0.72681	0.65757
X4	0.84261	0.66729	0.49156	0.78179	0.44646	0.61638	0.68473	0.71565	0.65581
X5	0.72625	0.78457	0.54764	0.86457	0.40765	0.61827	0.62942	0.65857	0.65462
X6	0.82266	0.67208	0.48964	0.78348	0.44859	0.60802	0.67333	0.70515	0.65037
X7	0.61615	0.55400	0.61857	0.53676	0.77920	0.66849	0.50540	0.47949	0.59476
E_j	0.72986	0.66783	0.55805	0.74261	0.52075	0.62023	0.61993	0.64159	

The results for Beijing are presented in Table 2, and those for Tianjin and Hebei can also be obtained. The filtered indicators are rearranged. is the arithmetic average of each line, which represents the correlation coefficient between retail indicators and the logistics system and reveals the degree of interaction between them. is the arithmetic average of each column, indicating the correlation coefficient between each logistics index and the retail system and describing the degree of mutual influence between them.

3.2.2 Calculation of coupling degree.

The gray correlation coefficient for each year is sorted separately and calculated according to the coupling degree formula, from which the coupling degree of retail and logistics development in each year is obtained. The coupling degree results of Beijing, Tianjin, and Hebei provinces and cities are presented in Figure 2.

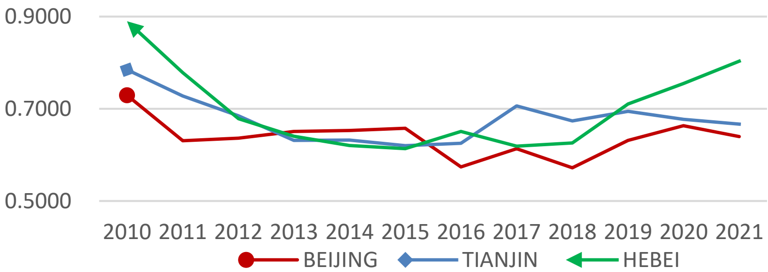

Fig. 2. Degree of Coupling Between Logistics and Retail Industries in Beijing, Tianjin, and Hebei

3.3 Analysis of the coupling results of retail and logistics industries

3.3.1 The primary factors of the interaction between the two industries.

The predominant influencing factors of the development of the retail industry in Beijing are railway mileage and the number of civilian cars. Notably, Beijing is an inland city. The main factors affecting Tianjin are highway mileage and the number of civilian cars, which reflects the importance of highway transportation. The main factors affecting Hebei Province are highway mileage and the number of civilian cars.

The transportation modes of railways and highways in the Beijing–Tianjin–Hebei region have an important role in the degree of coupling.

The five indicators of Beijing retail enterprises' operating income, total assets, total current assets, total added value of wholesale and retail, and total liabilities are closely correlated to the logistics industry, indicating that the scale of retail business is closely coupled with the development of the logistics industry. Tianjin is also closely related to the development of the logistics industry with the above five indicators. The four indicators of retail employees at the end of the year, business income of enterprises, total current assets, and added value of the wholesale and retail industries in Hebei have a significant influence on the development of the logistics industry, underscoring the important influence of retail employees in Hebei Province.

3.3.2 Analysis of coupling results of retail and logistics industries.

Figure 2 indicates that the coupling degree fluctuated in 2010–2021, and the following assertions can be made. First, the degree of coupling fluctuated slightly, and the overall coupling degree was low. The degree of coupling in the Beijing–Tianjin–Hebei region is almost lower than 0.8 from 2010 to 2021, indicating that it is not well coordinated. Second, the study analyzes the coupling degree fluctuation in different periods. From 2010 to 2015, the degree of coupling generally presents a downward trend. Notably, 2011 is the beginning year of China's Twelfth Five-Year Plan. The consumer market further expanded; however, the level of regional logistics was inadequate when retail logistics demand rose, the logistics level at that time could not meet the demand for retail development, and the coupling degree between them continued to decline. In 2015–2016, the coupling degree began to increase. China accelerated the implementation of the Medium-and Long-Term Plan for the Development of Logistics Industry (2014–2020), which accelerated the adjustment of industrial structure and the transformation of development mode. Industrial platform integration and regional logistics are under construction, and the logistics network system is becoming increasingly efficient and effective.

4 Conclusions

First, according to the calculation of the coupling correlation degree, this study concludes that the key retail indicators affecting the logistics development in Beijing, Tianjin, and Hebei predominantly reflect the business scale of the retail industry, and the number of employees at the end of the year in Hebei is also an important indicator. The key logistics indicators that affect the development of the retail industry are primarily reflected in railway and highway transportation expansion.

Second, the change in the degree of coupling in 2010–2021 indicates that the coupling degree decreased first and then increased. This study further analyzes the related reasons and reveals that logistics development was inadequate to meet the demand of the retail industry in the initial stage; thus, the coupling degree continued to decline. In the later period, the development of logistics was continuously improved, and the degree of coupling gradually increased; however, logistics and retail industries have not yet achieved high-quality coupling and must continue to develop.

Therefore, in the future, we should promote the coordinated development of railway and highway transportation in Beijing-Tianjin-Hebei region and promote the high-quality development of the retail industry in Beijing-Tianjin-Hebei region. Give play to the agglomeration effect of Beijing as a railway hub and the regional synergy effect of Beijing-Tianjin-Hebei region, and use modern technology to help the development of logistics industry and retail industry improve quality and efficiency.

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