Logistics Factors in the High-Quality Development of Regional Economy: Evidence from Hubei Province, China

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Abstract

Against the background of accelerated transformation and upgrading of the regional economy, the development level of the logistics industry, as a key link to support industrial synergy and efficient allocation of resources, has been increasingly emphasized. In order to deeply assess the economic factors affecting the development of logistics industry in Hubei, this paper introduces the gray correlation analysis method, takes the cargo turnover as the main measurement variable, and analyzes the strength of correlation between each index and logistics development through Matlab2021a software by combining several aspects such as regional gross domestic product per capita, output of major industries, foreign trade and import and export, consumption level, scale of transportation network and employment status of the industry. The study shows that the correlation between the length of transportation routes and the number of employees is the most significant, highlighting the important role of infrastructure improvement and talent support. Hubei's logistics infrastructure continues to be optimized, and six cities have been included in the national logistics hub, showing good development potential and international competitiveness. In order to promote its further development, it is proposed to strengthen infrastructure and technology upgrading, cultivate professional talents, promote service innovation and industry integration, and other strategies, focusing on building an efficient and synergistic modern logistics network, and promoting the regional economy to realize high-quality transformation and upgrading.

Keywords

Development of Logistics Industry, Gray Correlation Analysis Method, Infrastructure Development, Human Resource Cultivation

1. Introduction

In the wave of globalization, the logistics industry has become a fundamental pillar of economic growth and social development, playing an indispensable role in connecting manufacturing, trade, and markets. It not only ensures the smooth functioning of global supply chains but also serves as a key driver for industrial upgrading and resource optimization. The efficiency and sophistication of logistics systems are now widely regarded as important benchmarks of regional competitiveness and overall economic prosperity. In many advanced economies, the logistics industry has already evolved into a highly integrated system that combines information technology, transportation networks, and service innovation. For emerging economies such as China, the continued development of logistics is critical for achieving industrial synergy, regional balance, and sustainable growth [1].

Hubei Province, situated in the heart of Central China, is geographically positioned at the intersection of major national transportation arteries, including the Yangtze River Economic Belt and the Belt and Road Initiative corridors. Its unique location, combined with a strong industrial foundation and abundant resources, makes it a strategic hub for logistics development. Over the past decade, Hubei has transformed from a traditional transport hub into a comprehensive logistics center with growing international influence [2]. Its logistics sector not only supports regional industrial upgrading but also contributes significantly to national goals of high-quality development and global integration [3]. With six cities designated as national logistics hubs, the province has demonstrated remarkable progress in infrastructure construction, multimodal transportation, and international connectivity [4,5]. At the same time, the rapid rise of digital technologies and the global restructuring of supply chains are creating both opportunities and challenges for Hubei's logistics industry. On the one hand, digital transformation and smart logistics platforms offer new tools to enhance efficiency, reduce costs, and improve service quality. On the other hand, logistics development in Hubei faces constraints such as uneven regional infrastructure, the need for highly skilled labor, and increasing demands for green and sustainable operations. These dynamics highlight the importance of analyzing the underlying economic factors that influence logistics development, as such knowledge is essential for both policymakers and industry practitioners.

The economic significance of logistics development in Hubei extends beyond provincial boundaries [6]. As an inland region, Hubei plays a critical role in linking coastal and western areas, thereby facilitating balanced regional development across China. It also acts as a gateway for international trade flows, especially in the context of the Belt and Road Initiative, where inland provinces are expected to assume a larger role in resource distribution and global

connectivity [7]. In this regard, logistics development is not only an internal growth driver for Hubei but also a component of China's broader strategy to deepen integration into the global economy [8]. Understanding the determinants of logistics growth in Hubei therefore provides valuable insights into the challenges and opportunities faced by inland regions in achieving economic transformation [9,10].

From a research perspective, analyzing the economic drivers of logistics development contributes to the broader literature on regional economics and industrial policy. Logistics is inherently a complex, systemic activity influenced by multiple factors, including economic scale, industrial structure, consumption demand, infrastructure capacity, and human resources. Traditional statistical approaches often face difficulties in capturing these multifaceted interactions, especially when data availability is limited or incomplete. To overcome these limitations, this study employs the gray correlation analysis method, which has proven effective in examining systems characterized by uncertainty, partial information, and dynamic interactions. This method enables a more robust and comprehensive evaluation of the relationships between logistics development and diverse economic indicators. Specifically, the research constructs a multidimensional indicator system encompassing per capita GDP, industrial output, foreign trade, consumption level, transportation network scale, and logistics employment. By applying the gray correlation model through Matlab2021a software, the study quantitatively assesses the strength of correlation between these factors and logistics growth in Hubei. This approach not only enhances analytical rigor but also provides empirical evidence on which economic variables exert the most significant influence on logistics development. The results highlight the critical roles of infrastructure expansion and talent cultivation, underscoring the necessity of coordinated investment in both physical and human capital to sustain logistics growth.

Furthermore, this study situates its findings within the context of national and international development strategies. By aligning with initiatives such as the Belt and Road and the Yangtze River Economic Belt, the research emphasizes the strategic importance of Hubei as a logistics hub with both domestic and global relevance. The implications extend beyond Hubei itself, offering policy lessons and strategic insights for other inland provinces seeking to optimize their logistics development pathways. Ultimately, the study contributes to a deeper understanding of how logistics can serve as a catalyst for regional economic transformation, while also offering practical recommendations to strengthen infrastructure, promote technological upgrading, cultivate professional talent, and foster service innovation. In summary, this paper provides a comprehensive exploration of the economic factors shaping logistics development in Hubei Province. It aims to bridge theoretical analysis and policy relevance, combining methodological innovation with practical insights. By doing so, the study not only enriches the academic discourse on logistics and regional development but also offers actionable strategies for achieving high-quality growth in Central China and beyond.

2. Methodological Framework

Grey Relational Analysis is a statistical method used to determine the degree of association among multiple factors, widely applied in economics, management, engineering technology, and other fields [11]. By comparing the similarity between reference sequences and contrast sequences, we can quantitatively estimate their association strength to reveal the influence of various factors on the reference target. This method is primarily used to analyze the association strength between parent and child factors within a system, enabling us to quantitatively compare and analyze the dynamic development trends of the system, thereby distinguishing between primary and secondary factors driving system changes [12]. This method maintains strong adaptability even with limited sample data and does not rely on strict data distribution characteristics. Furthermore, its straightforward computation avoids discrepancies between quantitative results and quantitative analysis, thereby overcoming limitations encountered when using traditional mathematical statistical methods for system analysis [13].

The steps of grey relational analysis are as follows:

Step 1: Select the reference sequence, $X_0 = (X_{01}, X_{02}, X_{03}, X_{04}, X_{05}, X_{06}, X_{07})$,Comparison Sequence $X_i = (X_{i1}, X_{i2}, X_{i3}, X_{i4}, X_{i5}, X_{i6}, X_{i7})$,in which $i = 1, 2, 3 \ldots n$.

Step 2: Perform dimensionless processing on the variables. There are numerous common methods, such as the initial value method and the mean value method. Here, the initial value method is selected, yielding $X'_i = X_i / X_{i1} = (X'_{i1}, X'_{i2} \ldots X'_{in})$, $i = 0, 1, 2 \ldots m$.

Step 3: Calculate the difference sequence, maximum difference, and minimum difference.

The sequence is: $\Delta_{0i}(k) = | X'_0(k) - X'_i(k) |$, $k = 1, 2, \ldots, n$

The maximum difference is: $M = Max_i Max_k \Delta_i(k)$

The minimum difference is: $m = Min_i Min_k \Delta_i(k)$

Step 4: Calculate the correlation coefficient.

$$r\left[X_0(k), X_i(k)\right] = \left(m + \S M\right) / \left[\Delta_{0i}\left(k\right) + \S M\right], \S \in \left(0,1\right)$$

$k = 1, 2, \ldots n;\ i = 0, 1, 2, \ldots m$. Where § denotes the resolution coefficient, typically set to § = 0.5.

Step 5: Calculate the correlation coefficient.

$$r(X_0, X_i) = \frac{1}{n}\sum_{k_i=1}^{n} r\left(X_0(k), X_i(k)\right); \quad i = 0, 1, 2, \ldots, m$$

Step 6: Analyze the results. Supposed that $r(X_0, X_i) > r(X_0, X_j) > r(X_0, X_k) > \ldots > r(X_0, X_z)$,then it can be inferred that X_i is superior to X_j , X_j is superior to X_k , and so on. Setting $X_i > X_j > X_k > \ldots > X_z$. Here, $X_i > X_j$ indicates that factor X_i exhibits a higher grey correlation degree with reference sequence X_0 than X_j . When the correlation degree is elevated, it signifies a stronger association between the variable and the primary influencing factors.

3. Grey Relational Analysis of Factors Influencing the Economic Impact of Logistics Development in Hubei Province

3.1 Selection of Indicator Models

The freight turnover metric effectively reflects the combined weight and distance of goods transported, thereby accurately revealing the scale of logistics activities. Therefore, freight turnover (billion ton-kilometers) X_0 is adopted below as the reference series for measuring the development status of Hubei Province's logistics industry. The following seven indicators are selected as comparative series: GDP per capita X_1 (yuan), primary industry output value X_2 (billion yuan), secondary industry output value X_3 (billion yuan), total import and export value X_4 (billion USD), total retail sales of consumer goods X_5 (billion yuan), transportation route length X_6 (kilometers), and number of logistics industry employees X_7 (persons).

Per capita GDP reflects the income status and living standards of residents in Hubei to a certain extent. A higher per capita GDP in a region indicates stronger purchasing power among residents, leading to increased logistics demand and stronger momentum for logistics development. The added value of the primary industry reflects agriculture's position and role within the overall economy. In Hubei Province, agricultural production and transportation activities are closely intertwined with the logistics industry, forming a crucial pillar of its development. Meanwhile, the secondary industry's gross output encompasses production activities in sectors like manufacturing. The scale of manufacturing output directly impacts the logistics sector, particularly in the storage and transportation of finished goods. Additionally, the total import and export volume reflects Hubei's standing in global trade and the scale of its foreign economic activities, indicating demand for cross-border logistics. The total retail sales of consumer goods represent the scale of the domestic demand market. A larger figure indicates stronger consumption momentum, which in turn increases the demand for logistics services, revealing the high dependency of the retail sector on logistics services. Furthermore, the indicator of transportation route length encompasses the total length of transportation routes for modes such as highways, railways, and waterways. This affects logistics efficiency and costs and is a crucial component of the logistics infrastructure system. The number of logistics personnel reflects the scale of the labor force in this industry, directly impacting the professionalism and service level of the logistics sector. By applying these data through grey relational analysis, we can comprehensively evaluate the impact of various economic factors on logistics development. This reveals the extent to which changes in economic parameters influence logistics trends, enabling the formulation of scientific recommendations to promote long-term and stable growth in Hubei's logistics sector. These seven metrics provide relatively comprehensive coverage of all relevant aspects linking logistics and economic development, enhancing the guidance and practical value of research findings [14].

3.2 Data Collection, Organization, and Empirical Analysis

This study utilizes panel data from Hubei Province spanning 2014 to 2022, with all data sourced from the Hubei Statistical Yearbook. The raw data underwent normalization via the initial value method, yielding the results presented in Table 1. Subsequently, the differences between the comparison series and the reference series were calculated, with specific values shown in Table 2. The grey correlation coefficient between the comparison sequence and the reference sequence was calculated using the formula $r\left(x_0(k), x_i(k)\right) = (m + \varsigma M) / (\Delta_{0i}(k) + \varsigma M)$, with results shown in Table 3. Here, § denotes the discrimination coefficient, §(0,1), and § is typically set to 0.5. Finally, the grey correlation degree between the comparison sequence and the reference sequence was determined using the formula

$r(X_0, X_i) = \frac{1}{n}\sum_{k_i=1}^{n} r(X_0(k), X_i(k))$ [15], with results presented in Table 4. All calculations were performed using Matlab software.

Table 1. Standardized Results of Indicator Data

Year	Freight turnover (billion ton-kilometers) X_0	GDP per capita X_1 (yuan)	Primary industry output value X_2 (billion yuan)	Secondary industry output value X_3 (billion yuan)	Total import and export value X_4 (billion USD)	Total retail sales of consumer goods X_5 (billion yuan)	Transportation route length X_6 (kilometers)	Number of logistics industry employees X_7 (persons)
2014	1	1	1	1	1	1	1	1
2015	1.0190	1.0696	1.0361	1.0432	1.0590	1.1248	1.0785	0.9606
2016	1.0624	1.1688	1.1349	1.1168	0.9149	1.2570	1.1122	1.0401
2017	1.0825	1.2988	1.1757	1.2080	1.0754	1.3972	1.1527	1.0771
2018	1.1392	1.4619	1.1821	1.3510	1.2261	1.4727	1.1783	1.0821
2019	1.0579	1.5773	1.2691	1.4394	1.3266	1.8252	1.2421	0.9760
2020	0.9133	1.5151	1.3770	1.2249	1.4416	1.4446	1.2506	0.9965
2021	1.1631	1.7796	1.5443	1.4862	1.9307	1.7319	1.2860	0.9638
2022	1.3012	1.8929	1.6614	1.6329	2.1533	1.7804	1.3113	1.0084

Table 2. Calculation results of absolute differences between the comparison sequence and the reference sequence

Year	GDP per capita X_1 (yuan)	Primary industry output value X_2 (billion yuan)	Secondary industry output value X_3 (billion yuan)	Total import and export value X_4 (billion USD)	Total retail sales of consumer goods X_5 (billion yuan)	Transportation route length X_6 (kilometers)	Number of logistics industry employees X_7 (persons)
2014	0	0	0	0	0	0	0
2015	0.0506	0.0171	0.0242	0.0400	0.1058	0.0595	0.0585
2016	0.1064	0.0725	0.0544	0.1475	0.1946	0.0498	0.0223
2017	0.2163	0.0932	0.1255	0.0072	0.3147	0.0702	0.0054
2018	0.3226	0.0428	0.2118	0.0869	0.3334	0.0391	0.0572
2019	0.5194	0.2112	0.3815	0.2687	0.7673	0.1842	0.0819
2020	0.6018	0.4637	0.3116	0.5283	0.5313	0.3372	0.0832
2021	0.6165	0.3812	0.3231	0.7676	0.5688	0.1229	0.1993
2022	0.5916	0.3601	0.3317	0.8521	0.4792	0.0100	0.2928

Table 3. Calculation Results of Grey Correlation Coefficients Between Comparison Sequences and Reference Sequences

Year	GDP per capita X_1 (yuan)	Primary industry output value X_2 (billion yuan)	Secondary industry output value X_3 (billion yuan)	Total import and export value X_4 (billion USD)	Total retail sales of consumer goods X_5 (billion yuan)	Transportation route length X_6 (kilometers)	Number of logistics industry employees X_7 (persons)
2014	1	1	1	1	1	1	1
2015	0.8938	0.9615	0.9464	0.9142	0.8011	0.8774	0.8793
2016	0.8002	0.8546	0.8868	0.7428	0.6864	0.8954	0.9503
2017	0.6633	0.8206	0.7725	0.9834	0.5752	0.8585	0.9875
2018	0.5691	0.9086	0.6680	0.8306	0.5610	0.9160	0.8817
2019	0.4506	0.6685	0.5276	0.6132	0.3570	0.6981	0.8388
2020	0.4145	0.4789	0.5776	0.4464	0.4450	0.5582	0.8367
2021	0.4087	0.5278	0.5687	0.3569	0.4282	0.7762	0.6813
2022	0.4186	0.5419	0.5623	0.3333	0.4707	0.9770	0.5927

Table 4. Calculation Results of Grey Correlation Degree Between Comparison Sequence and Reference Sequence

Indicator	GDP per capita X_1 (yuan)	Primary industry output value X_2 (billion yuan)	Secondary industry output value X_3 (billion yuan)	Total import and export value X_4 (billion USD)	Total retail sales of consumer goods X_5 (billion yuan)	Transportation route length X_6 (kilometers)	Number of logistics industry employees X_7 (persons)
Grey Correlation Degree	0.6243	0.7514	0.7233	0.6912	0.5916	0.8396	0.8498

4. Empirical Results Analysis

Through detailed analysis of empirical data, a clear ranking of the grey correlation strength between seven core variables and cargo turnover has been established. Among these, the number of logistics industry employees and the total length of transportation routes occupy the top two positions, demonstrating strong correlation. The gross output value of primary and secondary industries follow closely behind, also exhibiting significant influence. In contrast, the correlation levels of total import and export volume, per capita GDP, and retail sales of consumer goods are relatively weaker, ranking lower. Specifically, the grey correlation coefficients for both logistics workforce size and transportation route length exceeded 0.8, indicating strong correlations. This further confirms the pivotal role these two factors play in Hubei Province's logistics development. Notably, the workforce size achieved a correlation coefficient of 0.8498, making it the strongest correleator with freight turnover among all factors and highlighting its core influence on logistics growth. This finding not only provides crucial reference for Hubei's logistics development but also offers new insights into understanding the industry's growth patterns. Moving forward, Hubei Province should prioritize enhancing the professional capabilities of logistics personnel and optimizing transportation network layouts to elevate overall operational efficiency and service standards. The number of logistics personnel partially reflects the industry's scale and market demand in a region. Hubei's logistics workforce peaked at 440,000 between 2017 and 2018 but declined by 2022, indicating a slight decrease in market demand. By 2022, downward economic pressures intensified due to increasingly complex and severe international conditions alongside the unexpected impact of the domestic pandemic, affecting all sectors [16].

Through meticulous analysis of empirical data, the length of transportation routes ranks second in terms of grey correlation degree among factors influencing the development of Hubei Province's logistics industry, with a specific value of 0.8396. This figure underscores the critical importance of transportation route length to Hubei's logistics sector, highlighting its significant influence. It reflects the development level of Hubei's logistics infrastructure to a certain extent. Efficient logistics facilities not only accelerate the circulation of goods but also effectively reduce transportation costs. Simultaneously, well-developed infrastructure serves as a crucial foundation for ensuring the stable growth of the logistics industry. Therefore, the expansion of transportation routes has played a pivotal role in driving the rapid development of Hubei's logistics sector.

The gross output values of the primary and secondary industries ranked third and fourth respectively in the grey correlation analysis of freight turnover, with specific values of 0.7514 and 0.7233. This indicates that the output value of Hubei's primary and secondary industries exerts a relatively limited driving force on the logistics sector. This situation may be related to Hubei's unique geographical location and favorable natural conditions, characterized by vigorous grain production—particularly in the Jianghan Plain region—where yields of rice, wheat, and other staple crops are exceptionally high. Concurrently, Hubei boasts a highly developed fruit industry, with citrus, lotus root, and other fruit and aquatic products enjoying nationwide renown. This phenomenon has positively influenced the development of the local logistics industry to some extent. However, empirical data indicates that the correlation between the primary industry's GDP and freight turnover is weak, suggesting that synergistic effects between the primary industry and logistics are not significant in Hubei. The correlation coefficient for the secondary industry's GDP is 0.7233. This indicates that the overall output value of secondary industries, such as manufacturing and construction, also exhibits a strong relationship with the logistics industry [17]. Hubei Province's secondary industry, particularly high-value sectors such as automobile manufacturing, relies on efficient logistics systems to distribute raw materials and finished products. The expansion of the secondary industry will undoubtedly drive growth in logistics demand.

Additionally, the correlation coefficient between total import and export volume reached 0.6912, indicating that international trade exerts a significant promotional effect on the logistics industry. Increased imports and exports necessitate robust logistics support to ensure goods are delivered promptly and securely to international markets or imported from them into the domestic market. This is particularly crucial for Hubei Province as an inland province, where the efficiency and capacity of its logistics sector are vital for expanding import and export activities. The correlation coefficient for per capita GDP is 0.6243. Although relatively low, it still indicates a positive relationship between economic level and logistics development. Higher per capita GDP reflects a higher standard of living and stronger consumption capacity, which stimulates more transactions of goods and services, thereby driving growth in logistics operations. Finally, the correlation coefficient for total retail sales of consumer goods was the lowest at 0.5916.

Although this indicator shows a relatively weaker link to the logistics sector, it still indicates that the retail industry has a certain demand for logistics services. As total retail sales of consumer goods grow, particularly with the rapid expansion of e-commerce, logistics distribution faces increasingly stringent challenges in terms of efficiency and service quality.

Through a comprehensive assessment of grey correlation coefficients, the development of Hubei Province's logistics industry maintains close ties with various economic sectors. The output value of primary and secondary industries significantly reflects the logistics sector's supporting role in local economic development, while total import and export volume highlights its central position in international trade. In contrast, per capita GDP and total retail sales of consumer goods exhibit lower correlation with the logistics industry, suggesting that while these economic indicators influence the sector, their impact is relatively weak.

5. Policy Recommendations for Promoting the Development of Hubei Province's Logistics Industry

5.1 Strengthen Infrastructure Development and Optimize Transportation Routes

Given the close correlation between transportation route length and the development of the logistics industry, improving transportation infrastructure is crucial for enhancing logistics efficiency. Hubei Province must intensify investment in logistics infrastructure encompassing multiple transport modes—including highways, railways, waterways, and aviation—with particular focus on resolving bottlenecks in key logistics areas to optimize the overall transport network layout [18]. Concurrently, emphasis should be placed on information technology development, such as advancing the creation and application of intelligent logistics systems. This will enhance the efficiency of cargo tracking and transport management, effectively reducing costs and improving service efficiency through real-time sharing of logistics information.

5.2 Increase the Cultivation and Recruitment of Talent in the Logistics Industry

The number of logistics professionals is closely tied to industry development, underscoring the pivotal role talent plays in the logistics sector. Therefore, strengthening the cultivation and recruitment of specialized logistics professionals is particularly crucial. Hubei Province can enhance collaboration with universities and vocational colleges to develop logistics education programs, providing students with practical opportunities to cultivate high-caliber logistics professionals aligned with market demands. Concurrently, implementing preferential policies will attract top-tier talent and technical personnel to the logistics sector—particularly logistics management and technical experts with international perspectives—to provide professional expertise and strategic guidance for advancing technological progress and management optimization within Hubei's logistics industry.

5.3 Promote Industrial Integration and Enhance Logistics Service Capabilities

Integrating industrial strengths with the development needs of the logistics sector is key to enhancing logistics service capabilities in Hubei Province. Leveraging its advantages in agricultural products, automobiles, and electronic information industries, Hubei can develop specialized services such as cold-chain logistics, automotive parts logistics, and e-commerce logistics to meet the diverse demands of various industrial chains. Furthermore, accelerating the integration of traditional logistics with advanced technologies like the internet, big data, and artificial intelligence will promote the construction of a smart logistics system, elevating the intelligence and personalization of logistics services [19]. This approach will not only elevate the service quality of Hubei's logistics sector but also strengthen its market competitiveness, injecting fresh momentum into the industry's sustained development. By optimizing transportation routes, strengthening logistics talent development, and promoting industrial integration, Hubei's logistics industry will advance to higher levels, providing robust support for enhancing the quality and efficiency of the provincial economy. Moving forward, Hubei's logistics sector must actively adapt to new trends in globalization and informatization, accelerate transformation and upgrading, and achieve sustainable development.

6. Conclusions

Overall, the development of Hubei's logistics industry relies on the collaborative efforts of multiple stakeholders. Infrastructure development and transportation route optimization are crucial for enhancing logistics efficiency, while cultivating and building a pool of specialized talent is equally indispensable. To address growing logistics demands, Hubei should continue advancing the modernization of its logistics infrastructure, particularly by increasing investment in information technology and intelligent logistics systems to expand the coverage and depth of its logistics network. Simultaneously, promoting deeper industrial integration will create more development opportunities for Hubei's logistics sector. By integrating industrial resources, developing specialized logistics services, and actively exploring emerging logistics models such as e-commerce logistics and cold-chain logistics, Hubei's logistics sector can meet more diversified market demands and generate greater economic value. With the advancement of new technologies and globalization, Hubei's logistics industry is poised to achieve innovation-driven transformation and upgrading, injecting new vitality into the regional economy. Ultimately, this will establish a logistics service system aligned with international trade standards, propelling high-quality economic development not only in Hubei but across the central region of China.

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