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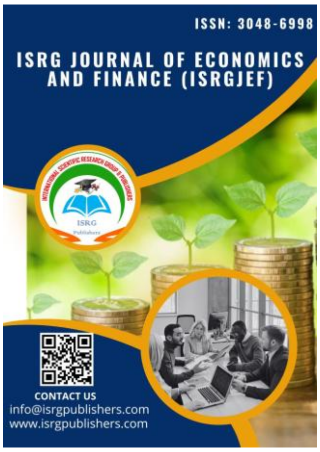

Research on the Coordinated Development of Regional Logistics and Agricultural Economy in Panzhihua City

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Abstract

[Objective] To address the challenge of synergistic adaptation between the regional logistics and agricultural economies under the topographical constraints of southwestern mountainous cities, and to achieve a synergistic development effect where "1+1>2" for regional logistics and agricultural economies, this study analyzes their coupling relationship. This is important for promoting synergistic development between regional logistics and agricultural economies in Panzhihua City. [Method] An evaluation framework was constructed based on three dimensions: scale, efficiency, and development potential. Using data from 2013 to 2022, the entropy method was applied to determine indicator weights and calculate composite evaluation values. A coupling coordination model was employed to quantify the synergistic development status of both systems. [Results] (1) From 2013 to 2022, both regional logistics and the agricultural economy in Panzhihua City demonstrated a significant upward trend in their comprehensive development levels. The comprehensive value of regional logistics increased from 0.197 to 0.610, representing a 2.1-fold growth over the decade. The comprehensive value of the agricultural economy surged from 0.084 to 0.932, growing 10.1 times over the decade—a growth rate significantly higher than that of regional logistics. In 2018, the agricultural economy's comprehensive value surpassed that of regional logistics for the first time, revealing an emerging imbalance in their development. (2) The level of coupled and coordinated development between the regional logistics and agricultural economy systems achieved a qualitative leap. The coupling degree consistently remained within the high range of 0.916–0.999, indicating a high degree of interconnection between the two systems. The coupling coordination degree increased from 0.359 to 0.868, a 140% growth over ten years. The level of coordinated development evolved from mild imbalance to sound coordination, with overall synergistic effects steadily strengthening. (3) Core constraints to coordinated development include dynamic imbalances in supply-demand structures, insufficient resilience in logistics responses under exceptional conditions, and inadequate industrial integration depth. Particularly prominent is the mismatch between high-end logistics service supply and the demands of high-quality agricultural economic development. [Conclusion] While the overall synergistic effects between regional logistics and the agricultural economy in Panzhihua City have steadily strengthened, significant room for improvement remains. Future efforts should prioritize sustaining coordinated development of regional industries in Panzhihua.

Keywords: Agricultural Economy, Collaborative Development, Coupling Coordination Degree Model, Regional Logistics

1. INTRODUCTION

With the further implementation of the rural revitalization strategy and the launch of national policies such as the 14th Five-Year Plan for the Development of Modern Logistics and the 14th Five-Year Plan for Promoting the Modernization of Agriculture and Rural Areas, improving the quality and efficiency of agricultural product logistics has become a key link in advancing the modernization of agriculture and rural areas, and the coordinated development of regional logistics and agricultural economy is a core measure to realize rural industrial integration. An efficient regional logistics system ensures the timeliness and quality of agricultural product circulation and extends the value of the agricultural industrial chain; in turn, the large-scale and specialized development of the agricultural economy generates new demand for high-end logistics services such as cold-chain logistics and precise distribution, forming a dynamic relationship of mutual restriction and mutual promotion between the two systems. In this context, exploring the law of coordinated development between logistics and agricultural economy in mountainous cities is of great practical significance for breaking through bottlenecks in agricultural development constrained by terrain and promoting the upgrading of rural industries.

In existing studies, Yang & Wang (2023) analyzed the coupled development of agriculture and logistics industry in Jilin Province using a time-varying parameter VAR model, and Zhao et al. (2024) explored the coordination mechanism between plateau characteristic agriculture and logistics industry in Yunnan Province via the coupling coordination degree model. However, research targeting southwest mountainous cities remains insufficient, and insufficient attention has been paid to the emergency response capacity of logistics systems under special conditions. Panzhihua City is located at the junction of Sichuan and Yunnan, with mountainous areas accounting for 80% of its territory, so the construction of logistics infrastructure is significantly restricted by terrain. Meanwhile, relying on the dry-hot valley climate, it has formed characteristic agricultural industrial clusters such as mango and vegetable cultivation, making the coordinated development of its logistics and agricultural economy typically regionally specific. Based on relevant data of Panzhihua City from 2013 to 2022, this paper constructs a coupling coordination degree model to quantify the coordinated development state of the two systems, analyzes the restrictive factors, and puts forward targeted countermeasures, so as to provide practical references for the coordinated development of regional logistics and agricultural economy in southwest mountainous cities.

2. ANALYSIS OF RESEARCH STATUS

Most domestic scholars recognize a close synergistic relationship between regional logistics and agricultural economies. Regarding synergistic mechanisms, Yang & Wang (2023) employed a time-varying parameter VAR model to analyze the coupled development of agriculture and logistics in Jilin Province, proposing effective pathways for deep industrial integration based on this analysis. Ma et al. (2023) demonstrated the necessity of the "agriculture + logistics" linkage model from an industrial synergy perspective, simultaneously constructing a corresponding synergistic development pathway system. In empirical research, Yu (2023) examined the impact of modern logistics and factor inputs on agricultural economies using the Yangtze River Delta region as a case study, providing a reference model for rural revitalization efforts; Zhang (2023) combined grey relational analysis with the composite system coordination degree model to quantitatively evaluate the symbiotic development relationship between modern agriculture and regional logistics in western China, revealing the causes of regional disparities. Wang et al. (2024) analyzed the current state of agriculture and logistics development in Zhejiang Province, identified three key issues in integrated development, and proposed countermeasures across six dimensions, including planning coordination and factor safeguards. Liu (2024) employed regression analysis to explore the specific impacts of various components of agricultural product logistics on the agricultural economy, revealing the potential mechanisms through which logistics optimization enhances agricultural output value and promotes rural economic development.

Regarding research methodologies, the coupling coordination model stands as one of the most widely applied empirical analytical tools. Xu et al. (2023) established a coupling coordination model to validate the interactive relationship between rural logistics and the rural economy; Zhao et al. (2024) employed the coupling coordination model to study the coordination mechanism between Yunnan Province's plateau-specific modern agriculture and the logistics industry; Duan et al. (2023) analyzed the synergistic state of agriculture and logistics in Qingyuan City based on a coupling coordination degree model, providing reference suggestions for local industrial regulation. Wang (2024) employed a coupling development model to explore the coupling relationship among urbanization, logistics economy, and rural e-commerce in 77 counties (cities, districts) of Sichuan's revolutionary base areas, proposing recommendations for advancing high-quality regional development. Additionally, Zhu et al. (2024) employed a grey correlation model, while Chen & Yao (2024) utilized a coupling coordination degree model to study the relationship between logistics and agricultural economies in different regions. Both studies confirmed a significant positive correlation between the two sectors.

International research primarily focuses on logistics' role in optimizing agricultural supply chains. Donker (2019) employed a VECM model to study regional logistics development in India, finding it significantly boosts agricultural economic growth. Bogdan (2019) argued that agricultural logistics enhances supply chain efficiency by enabling effective resource allocation. Kurbatova et al. (2020) highlighted how agricultural logistics connects enterprises and activities, thereby driving agricultural economic development. Almalki & Alkahtani (2022) defined regional logistics as a cross-enterprise, cross-city resource allocation mechanism, emphasizing its pivotal role in regional economic coordination. However, most international studies use agricultural powerhouses as research samples, focusing on full-chain logistics integration and technology-driven approaches. They lack sufficient attention to regional disparities, unique geographical conditions, and policy adaptability in developing countries, making it difficult to implement relevant theories in practice.

Although existing research has yielded substantial theoretical and empirical findings, laying a solid foundation for further study, several shortcomings remain: ① Most studies focus on plains or economically developed regions, with limited research on mountainous cities in southwest China, failing to capture the characteristics of logistics and agricultural economic synergy under terrain constraints; ② Some studies analyze only single-dimensional impacts, failing to thoroughly examine critical issues such as the dynamic evolution of supply-demand relationships and logistics responsiveness under exceptional circumstances; ③ Proposed countermeasures are predominantly macro-level, lacking concrete solutions tailored to local resource characteristics. Therefore, this paper conducts an in-depth analysis addressing these research gaps by integrating Panzhihua City's mountainous terrain and distinctive agricultural advantages.

3. OVERVIEW OF THE STUDY AREA AND DATA SOURCES

3.1 Overview of the Study Area

Panzhihua City (located between 101°08′–102°15′ E and 26°05′–27°21′ N) is situated in the southwestern part of Sichuan Province, at the junction of Sichuan and Yunnan provinces. With a total area of 7,414 square kilometers, mountainous terrain accounts for 80% of its territory. As a vital ecological barrier in the upper Yangtze River basin and a regional hub city at the Sichuan-Yunnan junction, Panzhihua leverages its strategic location "bridging east and west, connecting north and south" to serve as a key logistics node for goods circulation in Southwest China.

In logistics development, Panzhihua operates a comprehensive transportation system centered on highways and railways. North-south corridors rely on the Beijing-Kunming Expressway and Chengdu-Kunming Railway to form cross-regional transport arteries, accounting for 78% of highway freight volume. From 2013 to 2022, the city's total graded highway length increased from 2,958.33 kilometers to 4,650.21 kilometers, while expressway mileage expanded from 144.72 kilometers to 233 kilometers. Railway operational mileage remained stable at 181.6 kilometers, with the citywide total road mileage growing by approximately 54% compared to 2013. Warehousing and cold chain facilities underwent simultaneous upgrades, with the establishment of 2 county-level logistics centers and over 30 distribution and low-temperature delivery projects. This achieved full coverage of cold chain logistics centers across all five counties (districts) and 90% coverage of cold chain facilities in townships. In terms of economic contribution, the total output value of the logistics industry surged from 1.513 billion yuan in 2013 to 3.976 billion yuan in 2022. Its share within the tertiary industry has remained stable between 8% and 14%, establishing logistics as a vital pillar industry supporting the region's stable economic operation.

In agricultural development, leveraging its subtropical dry-hot valley climate with an average annual temperature of 20.3°C and 2,700 hours of annual sunshine, Panzhihua has established specialized agricultural production bases for mangoes, pomegranates, tea, navel oranges, and other crops, utilizing the vertical climate zones formed by its mountainous terrain. From 2013 to 2022, the total sown area for local crops expanded from 69,100 hectares to 75,400 hectares. The agricultural workforce remained stable at 220,000 to 240,000 people, while the total agricultural output value surged from 2.822 billion yuan to 12.978 billion yuan—nearly tripling. In 2022, the total output value of agriculture, forestry, animal husbandry, and fisheries reached 12.978 billion yuan, with agriculture's share rising to 75.3%. Agricultural fixed-asset investment hit 5.4 billion yuan, a 3.5-fold increase from 2013. Agricultural output reached new highs, with fruit production exceeding 500,000 tons and vegetable output surpassing 1 million tons.

3.2 Data Sources

The data used in this study were sourced from the Panzhihua City Statistical Yearbook and the Southwest Region Airport Production Statistics System, capturing relevant indicators from 2013 to 2022. The data are complete, and after standardized processing to eliminate interference from zero values, the objectivity and reliability of the calculation results are ensured.

4. RESEARCH METHODS AND MODEL CONSTRUCTION

4.1 Construction of the Indicator System

This paper adheres to the theories of coordinated development and industrial coupling. Guided by principles of scientific rigor, representativeness, operational feasibility, and data availability, it integrates the actual conditions of regional logistics and agricultural economic development in Panzhihua City. Drawing upon indicator systems constructed by Yang & Wang (2023), Zhao et al. (2024), Duan et al. (2023), and Lin & Lin (2025), it establishes an evaluation framework for assessing the coupling coordination degree between the regional logistics and agricultural economic subsystems (Table 1).

Table 1. Regional Logistics and Agricultural Economic Evaluation System

System	First-level indicator	Secondary indicator
Regional logistics	Logistics scale	Logistics transportation route length (km)
		Logistics warehousing land area (km²)
		Freight volume (10^4 tons)
	Logistics efficiency	Logistics industry gross output value (10^4 yuan)
		Logistics industry share of tertiary industry gross output value (%)
	Logistics development potential	Logistics industry fixed asset investment (10^4 yuan)
Agricultural economy	Agricultural scale	Area under cash crops (hectares)
		Area under grain crops (10^4 hectares)
		Agricultural workforce (10^4 persons)
	Agricultural benefits	Agricultural output value (10^8 yuan)
		Agriculture's share of primary industry output value (%)
	Agricultural development potential	Agricultural fixed asset investment (10^4 yuan)

Data Source: Panzhihua City Statistical Yearbook (2014–2023), Southwest Region Airport Production Statistics System

4.2 Determining Indicator Weights Using the Entropy Method

Based on the variability of each indicator, the entropy method can be employed to objectively determine the weight of each indicator, thereby providing an objective basis for multi-indicator comprehensive evaluation.

4.2.1Data Standardization Processing

Due to differences in measurement units and scales across indicators, direct calculations may compromise result objectivity and require standardization. The min-max normalization method is applied, with an additional 0.001 added to prevent zero values. The formula is as follows:

$$X_{\mathrm{ij}} = \frac{X_j - X_{\min}}{X_{\max} - X_{\min}} + 0.001 \qquad (1)$$

In Equation (1), where i represents the year, j denotes the indicator sequence number, X_j is the value of the jth indicator, X_{min} and X_{max} are the minimum and maximum values of the jth indicator from 2013 to 2022, respectively. X_{ij} is the standardized data obtained after processing the original data.

4.2.2Determination of Indicator Weights

Step 1: Calculate the proportion of the jth indicator in the ith year using the following formula:

$$W_{\mathrm{ij}} = \frac{X_{\mathrm{ij}}}{\sum_{i=1}^{n} X_{ij}} \qquad (2)$$

In equation (2), n represents the total number of years (n=10).

Step 2: Calculate the information entropy value E_j for the jth indicator using the following formula:

$$E_j = -\frac{1}{\ln_n} \sum_{i=1}^{n} W_{ij} \ln W_{\mathrm{ij}} \qquad (3)$$

Step 3: Calculate the information utility value d_j for the jth indicator. The larger the information utility value, the greater the indicator weight and the higher the indicator's importance. The calculation formula is as follows:

$$d_j = 1 - E_j \qquad (4)$$

Step 4: Utilize the value coefficient of information entropy to determine the weight of sub-indicators within the indicator layer. A higher value coefficient indicates a greater weight for the sub-indicator within the layer. The calculation formula is as follows:

$$c_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \qquad (5)$$

In Equation (5), m represents the total number of secondary indicators.

Through calculations in Equations (1) to (5), the respective weights assigned to the two sub-indicator levels within each system are determined (as shown in Tables 2 and 3).

Table 2. Regional Logistics Secondary Indicator Weighting Table

System	First Indicator	Secondary Indicator	Weight
Regional logistics	Logistics scale	Logistics transportation route length (km)	0.190
		Logistics warehousing land area (km²)	0.197
		Freight volume (10,000 tons)	0.152
	Logistics efficiency	Logistics industry gross output value (10,000 yuan)	0.143
		Logistics industry share of tertiary industry gross output value (%)	0.212
	Logistics development potential	Logistics industry fixed asset investment (10,000 yuan)	0.105

Table 3: Secondary Indicator Weighting Table for Agricultural Economics

System	First Indicator	Secondary Indicator	Weight
Agricultural Economics	Agricultural Scale	Area under cash crops (hectares)	0.074
		Area under grain crops (10,000 hectares)	0.111
		Agricultural workforce (10,000 persons)	0.103
	Agricultural Economic Efficiency	Agricultural output value (100 million yuan)	0.290
		Agriculture's share of primary industry output value (%)	0.256
	Agricultural Development Potential Agricultural Economy	Agricultural fixed asset investment (10,000 yuan)	0.166

4.3 Building Coupled Models

4.3.1Calculating Composite Values

Calculate the comprehensive value separately for each system. Use the comprehensive value to evaluate the annual comprehensive value of both systems from 2013 to 2022. The calculation formula is as follows:

$$Q_{\mathrm{i}} = \sum_{j=1}^{m} c_j X_{ij} \quad (6)$$

In Equation (6), Q_i denotes the composite value for year i, c_j represents the weight of indicator j, and X_{ij} indicates the standardized indicator value.

4.3.2Coupling Coordination Model

Q_1 and Q_2 represent the composite values of regional logistics indicators and agricultural economic development indicators for Panzhihua City, respectively. Based on these values, a coupling coordination degree model is established.

The coupling degree reflects the intensity of interaction between systems, calculated using the following formula:

$$C = \frac{2\sqrt{Q_1 \times Q_2}}{Q_1 + Q_2} \quad (7)$$

In Equation (7), Q_1 and Q_2 represent the comprehensive values for regional logistics and agricultural economy, respectively. C∈[0,1], where a value closer to 1 indicates a higher degree of coupling.

The coupling coordination index comprehensively reflects the level of coordinated development within the system, calculated as follows:

$$T = \alpha Q1 + \beta Q2 \quad (8)$$

$$D = \sqrt{C \times T} \quad (9)$$

In Equations (8) and (9), T represents the coupling coordination index, where α and β denote the development coefficients of Q_1 and Q_2, respectively. Considering the equal importance of regional logistics and agricultural economy, $\alpha + \beta = 1$, with $\alpha = \beta = 0.5$. D denotes the coupling coordination degree, D∈[0,1], where a higher D value indicates a greater degree of synergy.

Drawing on existing research, the coupling coordination types between regional logistics and agricultural economic development are classified into five major categories and ten levels based on the magnitude of the coupling coordination degree (see Table 4):

Table 4: Classification Criteria for Coupling Coordination Degree

Major categories	Coupling coordination level	Coupling coordination level Type
Dysfunction categories	[0.0,0.1)	Extreme imbalance
	[0.1,0.2)	Severe imbalance
	[0.2,0.3)	Moderate imbalance
	[0.3,0.4)	Mild imbalance
Transitional categories	[0.4,0.5)	Borderline imbalance
	[0.5,0.6)	Barely coordinated
Coordination categories	[0.6,0.7)	Basic coordination
	[0.7,0.8)	Intermediate coordination
	[0.8,0.9)	Good coordination
	[0.9,1.0)	Excellent coordination

5. RESULTS AND ANALYSIS

5.1 Evolutionary Characteristics of Regional Logistics and Agricultural Economic Development Levels

From the perspective of changes in comprehensive evaluation values, both regional logistics and agricultural economic development levels show an upward trend, but their growth rates and fluctuation characteristics differ significantly. Regional logistics experienced steady growth, with the comprehensive evaluation value rising from 0.197 to 0.610 between 2013 and 2022, representing an average annual growth rate of approximately 13%. The period from 2016 to 2019 marked a phase of rapid development, primarily driven by the concentrated construction of infrastructure such as logistics parks and highway networks in Panzhihua City. Notably, the implementation of the Panzhihua Logistics Industry Development Plan significantly optimized the network layout. However, the pandemic in 2020 caused a sharp decline in freight volume, causing the evaluation value to drop to 0.446 and exposing the vulnerability of the existing logistics system in responding to emergencies. Although recovery gradually resumed afterward, the growth rate slowed, indicating that the logistics system still lags in adapting to the rapidly changing demands of the agricultural economy. In the agricultural sector, the comprehensive value of agriculture maintained rapid growth, surging from 0.084 to 0.932, with an average annual growth rate of more than 31%, far surpassing that of the logistics system. Its growth curve became particularly steep after 2018, directly linked to the implementation of the Panzhihua City 14th Five-Year Plan for Advancing Agricultural and Rural Modernization and the expanding brand influence of products like Panzhihua mangoes. Agricultural output value increased from 2.822 billion yuan to 12.978 billion yuan, while agricultural fixed-asset investment increased by approximately 3.5-fold. Notably, agriculture's share of primary industry output rose from 58.7% to 75.3%, revealing internal structural optimization and efficiency gains.

Comparing the two sectors: regional logistics development outpaced agricultural growth from 2013 to 2017, but agriculture accelerated and surpassed logistics after 2018. This reflects Panzhihua's significant achievements in agricultural industrialization and scale expansion. Meanwhile, constrained by topography and impacted by the pandemic, the logistics sector experienced relatively moderate growth (as shown in Figure 1). This led to issues such as gradually failing to keep pace with agricultural upgrades in response to timeliness, specialized services, and network coverage, resulting in a mismatch between supply and demand rhythms. The imbalance in the development of these two sectors has gradually become apparent.

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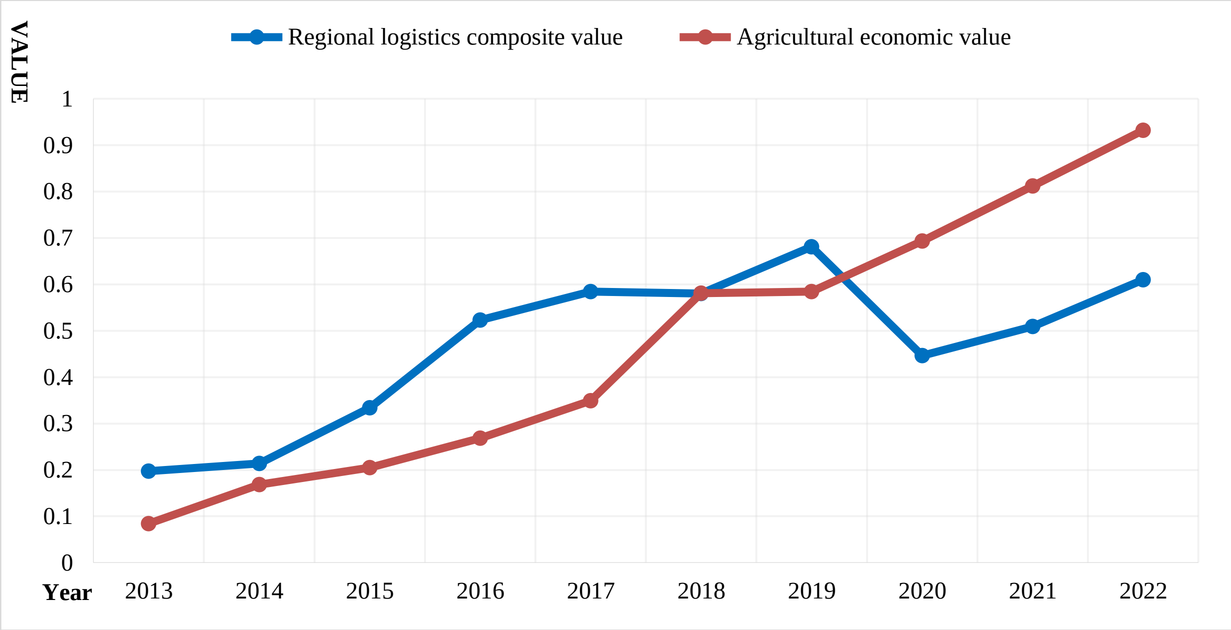
Figure 1: Trend Chart of Comprehensive Regional Logistics Value and Comprehensive Agricultural Economic Value in Panzhihua City, 2013–2022



5.2 Analysis of Regional Logistics and Agricultural Economic Coupling Coordination

From 2013 to 2022, the coupling degree between regional logistics and the agricultural economy in Panzhihua City consistently remained between 0.916 and 0.999 (as shown in Table 7), indicating a state of high coupling. This data indicates a strong interconnection and intense interaction between the two systems. The development of regional logistics infrastructure and the enhancement of service capabilities significantly support agricultural economic growth, while the expansion and structural upgrading of the agricultural economy create a broad market space for the logistics industry, thereby strengthening interdependence between the two.

The coupling coordination index gradually increased from 0.359 in 2013 to 0.868 in 2022 (as shown in Table 5), indicating continuous advancement in coordinated development. The coordination type evolved from “mildly imbalanced” to “well-coordinated.” Between 2013 and 2015, the coordination index remained below 0.5, representing a transitional phase from imbalance toward coordination. During this phase, logistics infrastructure had yet to fully yield benefits, while the agricultural economy remained in its developmental stage. From 2016 to 2017, the sector achieved primary coordination, advancing to intermediate coordination from 2018 to 2020. Coordination levels during this period ranged between 0.6 and 0.8, marking the transition from primary to intermediate coordination. Logistics networks underwent continuous refinement, agricultural industrialization accelerated, and the dual-wheel effect of policy drivers became evident. From 2021 to 2022, the systems entered a phase of sound coordination. Innovative models such as smart logistics and e-commerce supply chains began to empower the systems, further enhancing the efficiency of interactions between them. Notably, the coupling coordination level in 2020 declined slightly compared to 2019, primarily due to reduced logistics efficiency caused by the pandemic. However, it remained within the coordination range overall and recovered rapidly thereafter, demonstrating the stability and resilience of the coordinated development between the two systems.

Table 5: Regional Logistics and Agricultural Economic Coupling Coordination Index, Coupling Degree, Coupling Coordination Degree, and Coordination Type in Panzhihua City, 2013–2022

Year/Index	Coupling Coordination Index(T)	Coupling Degree(C)	Coordination Degree(D)	Coordination Type
2013	0.14035	0.91606	0.35856	Mild imbalance
2014	0.19111	0.99291	0.43561	Borderline imbalance
2015	0.26958	0.97069	0.51155	Barely coordinated
2016	0.39578	0.94664	0.61209	Basic coordination
2017	0.46622	0.96765	0.67167	Basic coordination
2018	0.58048	0.99999	0.76189	Intermediate coordination
2019	0.63215	0.99705	0.79391	Intermediate coordination
2020	0.56920	0.97614	0.74540	Intermediate

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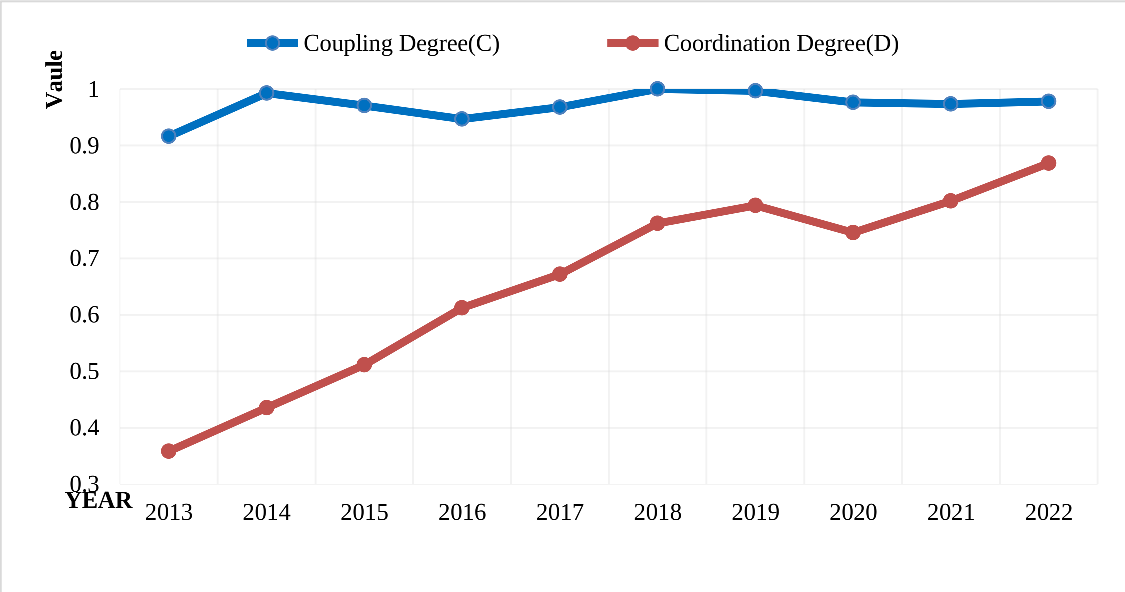
Year/Index	Coupling Coordination Index(T)	Coupling Degree(C)	Coordination Degree(D)	Coordination Type
				coordination
2021	0.66021	0.97333	0.80163	Good coordination
2022	0.77124	0.97791	0.86845	Good coordination

Figure 2: Trends in Regional Logistics-Agricultural Economic Coupling Degree and Coupling Coordination Degree in Panzhihua City, 2013–2022



5.3 Analysis of Factors Constraining Coordinated Development

5.3.1Dynamic Imbalances in Supply-Demand Dynamics

From 2013 to 2015, key logistics projects in Panzhihua City, such as the Midie Modern Commerce and Logistics Park and the Griping Xintie Railway Logistics Park, were in their initial construction phases. Some major transportation arteries had not yet commenced formal operations, and the actual benefits of logistics infrastructure had not been fully realized. Moreover, "regional logistics exerted a highly significant positive impact on agricultural economic development, albeit with a certain time lag effect" (Hou & Hu, 2019). However, agricultural economic growth during this period remained relatively moderate. The development and construction of the logistics sector could still align with agricultural economic needs. Consequently, the coordination status between the two systems transitioned from a state of imbalance to a transitional state.

From 2016 to 2019, Panzhihua City's regional logistics composite value gradually increased. The municipal government issued the "Panzhihua City Logistics Industry Development Plan" to accelerate the planning and construction of facilities such as e-commerce industrial parks with comprehensive logistics service capabilities. The layout of the four-tier logistics network nodes was progressively improved, enhancing Panzhihua's regional logistics competitiveness and driving regional logistics development. During this period, the composite value derived from the established evaluation system indicates that Panzhihua's regional logistics development was generally slightly superior to its agricultural economic development. The coordination between the two systems entered the coordinated category.

5.3.2Insufficient Logistics Response Capability Under Special Circumstances

From 2020 to 2022, the pandemic's impact caused a temporary slowdown in regional logistics development. Freight volume dropped to its lowest point in a decade in 2020, and the logistics industry's share of output value within the tertiary sector declined significantly. Although the full operation of the Midu Modern Commerce and Logistics Park and the Griping Xintie Railway Logistics Park from 2021 to 2022, along with the commissioning of dedicated expressway and railway freight lines, significantly improved logistics timeliness and reduced agricultural product transportation costs by approximately 15%, thereby alleviating the pressure of transporting agricultural products out of the region, it still exposed the shortcomings of the modern logistics network in responding to sudden public events. Meanwhile, the agricultural economy experienced relatively minor pandemic impacts during the same period, maintaining robust development momentum. The coordination status between the two systems remained in the coordinated category, stabilizing at a well-coordinated state in 2022.

5.3.3Insufficient Depth of Industrial Integration

The integration of logistics and agriculture in Panzhihua City currently remains confined to basic transportation and warehousing, with limited progress in supply chain integration and value co-creation. Deep-level integration and collaborative mechanisms are still underdeveloped, hindering the full realization of synergistic efficiency. Logistics enterprises and agricultural producers lack long-term, stable cooperation mechanisms, with insufficient information sharing leading to logistics services that are not sufficiently targeted. This makes it difficult to meet the requirements for full-chain quality control of agricultural products. At the same time, the application of modern technologies such as the Internet of Things and big data in areas like logistics scheduling, demand forecasting, and traceability management remains limited. These technologies have not been deeply integrated into the entire process of agricultural production and processing, resulting in their enabling role not being fully leveraged. This hinders the maximization of synergistic effects between the two systems.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study, based on data from 2013 to 2022, constructs an evaluation system encompassing three dimensions: scale, efficiency, and development potential. Employing the entropy value method and the coupling coordination degree model, it conducts an empirical analysis of the coordinated development of regional logistics and agricultural economy in Panzhihua City, yielding the following conclusions:

(1) From 2013 to 2022, both the comprehensive development levels of regional logistics and agricultural economy in Panzhihua City exhibited a significant upward trend. The comprehensive value of regional logistics increased from 0.197 to 0.610, representing a 2.1-fold growth over the decade. The comprehensive value of the agricultural economy surged from 0.084 to 0.932, achieving a 10.1-fold increase over the same period—a growth rate significantly higher than that of regional logistics. In 2018, the agricultural economy's comprehensive value surpassed that of regional logistics for the first time, gradually revealing an imbalance in their development.

(2) The level of coordinated development between the regional logistics and agricultural economy systems achieved a qualitative leap. The coupling degree consistently remained within the high range of 0.916–0.999, indicating a high degree of interconnection between the two systems. The coupling coordination degree increased from 0.359 to 0.868, a 140% increase over the decade. The level of coordinated development evolved from mild imbalance to sound coordination, with overall synergistic effects steadily strengthening.

(3) Core constraints to coordinated development include dynamic imbalances in supply-demand structures, insufficient resilience in logistics responses under exceptional conditions, and inadequate depth of industrial integration. Particularly prominent is the mismatch between the supply of high-end logistics services and the demands of high-quality agricultural economic development.

6.2 Recommendations

Based on analyses of the coupling coordination degree between regional logistics and the agricultural economy in Panzhihua City, the following developmental recommendations are proposed.

1. Enhance Efficiency of Agricultural Product Logistics Supply Chains

Currently, the efficiency of agricultural product logistics has become a key factor influencing distribution costs, quality assurance, and market competitiveness. Promoting the intelligent transformation of supply chains is not only an industry trend but also an effective pathway to reduce losses, boost farmers' income, and enhance the competitiveness of agricultural products. Leveraging policy directives such as the National Rural Revitalization Strategy and Modern Agricultural Development Plan, a virtuous cycle system should be established where logistics and agricultural economy mutually reinforce each other (Zhu et al., 2024).

First, optimize supply chain layout by leveraging pro-agricultural policies. With policy guidance and fiscal support, enterprises can actively introduce intelligent temperature control, vacuum pre-cooling, and other cold chain equipment to reduce operational costs. Encourage logistics companies to deepen collaboration with agricultural producers, guiding crop structure adjustments based on market demand, developing contract farming, and promoting integrated production and sales. Simultaneously, implement "green channel" policies to streamline quarantine procedures, waive transit fees, and tangibly reduce institutional costs in logistics operations.

Second, integrate IoT technology to advance full-chain digitalization. Utilize IoT to achieve end-to-end traceability and monitoring from production to sales. Sensors collect real-time transport environment data to safeguard agricultural product quality. Data platforms consolidate information from all parties to optimize route planning and resource allocation, enhancing supply chain coordination efficiency. With the objectives of "cost reduction, efficiency enhancement, and quality improvement," we should improve infrastructure, strengthen technological empowerment, and build a smart, collaborative modern agricultural product logistics system.

2. Strengthen Logistics Emergency Response Capabilities Under Special Circumstances

Recent public emergencies have demonstrated the critical role of logistics systems in sustaining economic operations during exceptional periods. Panzhihua must further enhance the resilience and responsiveness of its logistics system to ensure stable agricultural economic development.

First, develop water transport resources and expand intermodal corridors. With the advancement of Jinsha River navigation improvements and Panzhihua Port construction, water transport potential is gradually being unlocked. Accelerate the development of land-water and land-sea intermodal transport, strengthen collaboration with ports like Yibin and Luzhou, actively integrate into the Western Land-Sea New Channel logistics network, and establish low-cost logistics corridors to the east and south. For perishable agricultural products like Panzhihua mangoes, cold chain infrastructure should be strengthened at ports and key nodes. Integrating with local emergency response plans for public incidents, establish protocols to activate emergency intermodal transport modes—combining road short-haul and waterway trunk lines—during sudden disasters like floods or earthquakes. Supplement this with drone emergency delivery to achieve rapid response and precise logistics deployment.

Second, explore low-altitude logistics to supplement last-mile delivery networks. Drones and other low-altitude logistics methods offer flexibility and efficiency, particularly suited to Panzhihua's complex mountainous terrain and transportation constraints. Rational planning of takeoff/landing point networks should prioritize emergency delivery of fresh agricultural products. Concurrently, support vocational colleges in establishing drone operation and low-altitude logistics programs to cultivate local technical talent, laying a solid human resource foundation for low-altitude economic development.

Finally, establish smart platforms to enhance systemic control capabilities. Integrate multidimensional data from agricultural production, warehousing, and transportation, and market supply-demand to build a regional smart logistics information platform.

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This platform can monitor logistics status in real time, dynamically optimize routes, and allocate transport capacity. During emergencies, it can swiftly identify bottlenecks, assist in resource dispatch, and enhance supply chain visibility and coordination, providing stable support for agricultural production and sales

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