

Interactive mechanisms between public transport capital investment and the development of the rural market economy

Qi Wang

Fujian Agriculture and Forestry University, Fuzhou, China

810241691@qq.com

Abstract. Against the backdrop of the deepening implementation of the rural revitalization strategy, the development of the rural market economy has become a central lever for activating endogenous rural growth dynamics. As a critical component of rural infrastructure construction, public transport capital investment exhibits a profound interactive relationship with the development of the rural market economy. Grounded in public goods theory, coupling coordination theory, and industrial integration theory, this study employs the entropy weight method, coupling degree model, and coupling coordination degree model, combined with provincial panel data from 2010 to 2020, to systematically examine the interactive mechanisms between public transport capital investment and rural market economy development. The findings indicate that public transport capital investment promotes rural market economy development through three primary channels: reducing circulation costs, facilitating industrial agglomeration, and expanding market boundaries. In turn, the development of the rural market economy guides the efficient allocation of public transport capital via demand-driven forces, financial feedback mechanisms, and structural optimization. The coupling coordination degree between the two systems shows a year-by-year upward trend; however, pronounced regional disparities persist. The central and western regions lag behind the eastern region in terms of coordination levels, and within rural areas there exist dual imbalances characterized by "transport lag–market contraction" and "transport advance–resource misallocation". Based on these findings, this paper proposes policy recommendations including optimizing the investment structure, strengthening supply–demand alignment, and improving coordination mechanisms, thereby providing a reference for promoting the synergistic development of rural public transport and the market economy.

Keywords: public transport capital investment, rural market economy, interactive mechanisms, coupling coordination degree, rural revitalization

1. Introduction

The issues of agriculture, rural areas, and farmers are fundamental to the national economy and people's livelihoods. The implementation of the rural revitalization strategy has injected strong momentum into the economic and social development of rural areas. As the core carrier of rural revitalization, the development

level of the rural market economy directly determines the efficiency of rural resource allocation and the effectiveness of increasing farmers' incomes. However, rural areas in China have long faced challenges such as difficult mobility, high logistics costs, and small market scales, with weak public transport infrastructure emerging as a key bottleneck constraining rural market economy development. Public transport capital investment, as a form of social preemptive capital, not only provides a basic guarantee for rural residents' mobility but also serves as an essential support for connecting urban and rural factor flows and activating rural market vitality.

In recent years, the state has continuously increased investment in rural public transport. Initiatives such as the "Four Good Rural Roads" program and the integration of urban–rural bus systems have achieved significant results. The total mileage of rural roads nationwide increased from 3.7848 million kilometers in 2013 to 4.3823 million kilometers in 2020, and both townships and administrative villages achieved 100% paved road coverage. Nevertheless, in practice, issues of poor alignment and insufficient coordination persist between public transport capital investment and rural market economy development. In some regions, transportation investment is disconnected from market demand, resulting in underutilized infrastructure, while the development of the rural market economy fails to effectively transmit its transportation needs to the investment process, leading to unmet demand. Clarifying the interactive relationship and mechanisms between the two, and achieving a virtuous cycle between public transport capital investment and rural market economy development, is an important task for addressing the unbalanced and insufficient development of rural areas.

2. Literature review

2.1. Research on the impact of public transport capital investment on rural economy

Existing studies generally agree that public transport capital investment significantly promotes rural economic development. Liu Zhengqiao et al., using an empirical study based on the Cobb–Douglas production function, found that the output elasticity of transportation infrastructure on agricultural sector economic growth is 0.0327, with the strongest impact observed in central regions [1]. Guo Yibei et al., through empirical testing with county-level panel data, found that investment in transportation infrastructure significantly enhances rural industrial integration by improving transportation capacity, promoting industrial agglomeration, and stimulating innovation vitality [2]. Chen Yao's research indicates that transportation infrastructure has a direct effect on rural poverty alleviation, particularly pronounced in western regions, while also generating indirect poverty reduction effects through economic growth and income distribution [3]. However, some studies note that the impact of transportation investment on rural economy exhibits regional differences and threshold effects, with both overinvestment and underinvestment potentially reducing effectiveness.

2.2. Research on the demand-pulling effect of rural economic development on public transport

The development of the rural market economy exerts a significant demand-pulling effect on public transport capital investment. Chen Guo et al., in their study of Hubei Province, found that economic development levels were significantly ahead of transportation infrastructure investment, creating strong demand for transport investment [4]. Guan Lin et al., using game-theoretic analysis, pointed out that increased passenger demand resulting from rural market economic development pushes the government to expand urban–rural bus system integration, achieving public service equalization through fiscal subsidies and operating rights buyouts [5]. Wu Ming'e's research demonstrates that improvements in rural economic development not only increase demand for public transport but also provide financial support for investment, promoting the upgrading of transportation infrastructure [6].

2.3. Research on the interactive relationship between the two

Studies examining the interaction between public transport capital investment and rural economic development remain limited. Luo Yongmin et al. found that rural infrastructure and rural economic development mutually reinforce each other, though significant spatial heterogeneity exists [6]. Zhang Xueliang's research indicates a bidirectional causal relationship between transportation infrastructure and regional economic development, with transport promoting economic growth and economic growth, in turn, driving transportation investment [2]. However, systematic research on the interactive relationship between public transport capital investment and market economy development in rural areas is still lacking, particularly regarding in-depth analysis and quantitative verification of the interaction mechanisms.

In summary, existing research provides a solid theoretical foundation and methodological reference for this study but still has several limitations: first, most studies adopt a unidirectional perspective, lacking systematic analysis of the bidirectional interaction mechanism; second, research focuses on the macro level, insufficiently analyzing the specific dimensions of rural market economy development and its interaction with public transport investment; third, policy recommendations are often expressed in general terms, lacking precise strategies based on the interaction mechanism. This study aims to address these gaps and fill the relevant research void.

3. Analysis of the current status of public transport capital investment and rural market economy development

3.1. Current status of public transport capital investment

In recent years, the Chinese government has attached great importance to rural public transport construction, leading to continuous expansion of public transport capital investment. Between 2013 and 2020, cumulative investment in rural road construction nationwide exceeded RMB 2.5 trillion, with the total mileage of rural roads increasing at an average annual rate of 2.8%. By the end of 2020, rural road mileage reached 4.3823 million kilometers, achieving the goal of paved road access for all villages [7]. Beyond road construction, investment in supporting facilities such as rural passenger transport and logistics stations has also gradually increased. For example, nationwide coverage of township-level express delivery outlets rose from 92.4% in 2018 to 100% in 2020, while administrative village-level express delivery services reached 98%. The sustained growth of public transport capital investment has laid a solid foundation for the development of the rural market economy.

From the perspective of investment structure, rural public transport capital investment faces issues of "emphasis on construction over maintenance" and "emphasis on roads over supporting facilities". Rural road maintenance funding gaps remain significant, with some roads suffering severe deterioration due to insufficient maintenance after construction, thereby reducing efficiency. Regarding supporting infrastructure, investment in rural passenger stations, logistics storage facilities, and cold-chain transport equipment is inadequate, making it difficult to meet the diversified needs of rural market economic development. From a regional perspective, the level of rural public transport investment in eastern regions is significantly higher than that in central and western regions. In 2020, rural road density in the eastern region was 1.23 km/km², compared to only 0.87 km/km² in the central and western regions. This structural imbalance constrains the overall effectiveness of public transport capital investment.

At present, public transport capital investment in rural China remains predominantly government-led, with low participation from social capital. Due to the long investment return cycles and low profitability of rural

public transport, private capital participation is limited, resulting in a relatively single investment. Although some regions have attempted to introduce social capital through Public–Private Partnership (PPP) models, participation incentives remain low due to imperfect risk-sharing and revenue guarantee mechanisms. This reliance on a single investment makes rural public transport capital investment heavily dependent on fiscal funding, which is constrained by government budget capacity and difficult to sustain in meeting the continuous needs of rural market economy development.

3.2. Current status of rural market economy development

With the implementation of the rural revitalization strategy and the continuous increase in rural residents' income levels, the scale of the rural market economy has steadily expanded. In 2020, the nationwide rural online retail sales reached RMB 1.79 trillion, of which online sales of agricultural products amounted to RMB 415.89 billion, representing a year-on-year growth of 26.2% [8]. The rural consumer market also demonstrated rapid growth: in 2020, per capita consumption expenditure of rural residents reached RMB 13,713, a 2.9% increase from the previous year, outpacing urban residents' growth. The expansion of the rural market scale has injected strong momentum into rural economic development and has placed higher demands on public transport capital investment.

Rural industrial integration has become an important trend in the development of the rural market economy, with agriculture deeply integrating with secondary and tertiary industries, forming new business formats such as agricultural product processing, rural tourism, and rural e-commerce. By the end of 2020, there were over 400,000 various agricultural industrialization organizations nationwide, and the agricultural product processing conversion rate reached 70.5%. The rapid development of rural e-commerce has promoted innovation in agricultural product circulation, with models such as "direct shipment from origin" and "contract farming" gradually becoming widespread, effectively addressing the difficulty of selling agricultural products [9]. Industrial integration requires higher standards for the timeliness and convenience of public transport, necessitating a well-developed transport network to support factor flows and product distribution.

Despite the notable achievements in rural market economic development, several shortcomings remain: first, circulation efficiency is relatively low, with rural logistics costs accounting for 30%–40% of total agricultural product costs, far exceeding urban levels; second, market participants are weak, with rural SMEs and farmers' organizations having low organizational capacity and limited market competitiveness; third, regional development is unbalanced, with eastern regions showing significantly higher rural market economy levels than central and western regions, and notable disparities within rural areas themselves; fourth, infrastructure remains weak—beyond transport, rural storage, cold-chain, and information infrastructure are insufficient, constraining market scale expansion and efficiency improvement. These shortcomings are closely linked to insufficient or improperly allocated public transport capital investment.

3.3. Prominent issues in the development of both systems

There is a lack of effective alignment between public transport capital investment and rural market economy development, resulting in a "disconnected" phenomenon. In some regions, public transport investment fails to adequately consider rural market demand, leading to a disconnection between transport facilities, industrial development, and logistics needs; meanwhile, the transportation demand generated by rural market economy development has not been effectively transmitted to the investment process, resulting in transport supply lagging behind market demand. This poor alignment limits the effectiveness of public transport capital investment and constrains the sustainable development of the rural market economy.

Significant regional disparities exist in the coordination level between public transport capital investment and rural market economy development. In eastern regions, with strong economic foundations and robust market demand, coordination levels are relatively high; in central and western regions, due to insufficient transportation investment and smaller market scales, coordination levels remain low. Some remote areas even experience a vicious cycle of "transport lag–market contraction", while in some economically underdeveloped areas, excessive transport investment has caused resource waste. Inadequate regional coordination exacerbates the imbalance in rural development.

Furthermore, the mechanism system ensuring the interactive development of the two remains underdeveloped. In terms of decision-making mechanisms, public transport capital investment lacks a market-oriented demand feedback system, making it difficult to adjust investment directions and scales according to the dynamics of rural market economy development. In terms of incentive mechanisms, policies to encourage social capital participation in rural public transport construction are insufficient, and investment returns are not well guaranteed. In terms of coordination mechanisms, there is a lack of integrated collaborative frameworks across transport, agriculture, commerce, and other departments, hindering the formation of synergistic development. The absence of these mechanisms has become an important factor restricting the healthy interaction between public transport capital investment and rural market economy development.

4. Interactive mechanisms between public transport capital investment and rural market economy development

4.1. Mechanisms by which public transport capital investment promotes rural market economy development

4.1.1. Reducing circulation costs and improving market efficiency

Public transport capital investment significantly lowers circulation costs in rural markets by improving rural road networks and optimizing passenger and logistics systems. On one hand, the extension and upgrading of rural roads shorten transportation distances from farm to market, reducing transportation expenses and time costs, enhancing product freshness, and improving market competitiveness. On the other hand, integration of urban–rural bus systems and the establishment of rural logistics stations create a three-tier logistics network ("county–township–village"), addressing circulation challenges in both the first mile for agricultural products and the last mile for industrial goods. Lower circulation costs not only enhance rural market operational efficiency but also expand the sales radius of agricultural products and promote bidirectional flow of urban and rural factors. Research by Chen Guo et al. indicates that the coupling coordination degree between transportation infrastructure investment and economic development continues to rise, with improved circulation efficiency serving as an important transmission pathway [4].

4.1.2. Promoting industrial agglomeration and strengthening market carriers

Public transport capital investment can overcome geographic constraints, encouraging the agglomeration of production factors in rural areas and forming industrial clusters, which serve as key carriers for rural market economy development. Improved transportation conditions make rural areas more attractive to capital, technology, and skilled labor, fostering the development of industries such as agricultural product processing, rural tourism, and rural e-commerce. Industrial agglomeration enables resource sharing, lowers production costs, and generates economies of scale and brand effects, thereby enhancing rural market competitiveness. For example, the construction of rural e-commerce industrial parks relies on a well-developed transport network to support both goods transportation and personnel mobility; simultaneously, industrial agglomeration

further increases transportation demand, forming a virtuous cycle. Empirical research by Guo Yibei et al. demonstrates that transportation infrastructure investment significantly enhances rural industrial integration by promoting industrial agglomeration [2].

4.1.3. Expanding market boundaries and stimulating market demand

Public transport capital investment effectively expands the geographic boundaries and demand scale of rural markets. Improved transportation allows rural residents easier access to urban markets to purchase high-quality industrial products and services, while enabling urban residents to more readily visit rural areas, stimulating demand for rural tourism, agricultural product picking, and other consumption activities. Additionally, a well-connected transport network allows rural markets to integrate with regional and national markets, expanding the sales range of agricultural products and activating latent rural demand. The expansion of market boundaries not only enhances economies of scale but also fosters market competition, driving rural industrial upgrading and improvements in product quality. Liu Zhengqiao et al. found that investment in transport facilities in central regions connects eastern and western regions, promoting integrated development of rural markets nationwide [1].

4.1.4. Enhancing factor mobility and optimizing resource allocation

Public transport capital investment improves the mobility of production factors such as labor, capital, and technology in rural areas, thereby optimizing resource allocation efficiency. Improved transport enables rural labor to access employment opportunities more conveniently while attracting returning migrant workers to start businesses, providing human capital support for rural market economy development. Capital and technological resources can also flow to rural areas via enhanced transport networks, facilitating industrial upgrading and technological progress. Greater factor mobility allows rural markets to better allocate resources, concentrating them in more efficient industries and sectors, and promoting high-quality rural market economic development. Chen Yao's research shows that transportation infrastructure, by facilitating factor mobility, has a significant positive impact on rural poverty reduction and economic development [3].

4.2. Mechanisms by which rural market economy development guides public transport capital investment

4.2.1. Demand-pulling: expanding investment scale

The diversified demand generated by rural market economy development provides clear directional guidance for public transport capital investment, driving a continuous expansion of investment scale. With deeper rural industrial integration, emerging industries such as agricultural product processing, rural tourism, and rural e-commerce place higher demands on the timeliness, convenience, and safety of transportation, necessitating increased investment in rural road upgrades, cold-chain logistics, and transport stations. Meanwhile, rising rural income levels and upgrading of consumption structures have shifted passenger transport demand from "existence" to "quality", promoting integration of urban-rural bus systems and enhancing passenger service efficiency. The growth in demand driven by rural market economy development thus becomes a core force expanding public transport capital investment. Research by Chen Guo et al. in Hubei Province shows that higher economic development levels significantly increase demand for transportation infrastructure [4].

4.2.2. Financial feedback: expanding investment channels

Rural market economy development provides financial support for public transport capital investment and expands investment channels. On one hand, growth in fiscal revenue resulting from rural market economic development enables governments to allocate more funds for public transport construction and maintenance. On the other hand, increased rural market vitality attracts social capital to participate in public transport

projects through mechanisms such as Public–Private Partnerships (PPP) and franchise operations, alleviating fiscal pressure on the government. For instance, the rapid development of rural e-commerce encourages logistics companies to increase investment in rural logistics stations and transport networks, collaborating with the government to improve rural transport and logistics systems. The expansion of financial channels ensures the sustainable growth of public transport capital investment.

4.2.3. Structural optimization: improving investment efficiency

Rural market economy development can guide the optimization of public transport capital investment structure and improve investment efficiency. Different regions have varying focal areas of market economic development, resulting in differentiated transportation needs. Major agricultural production areas require enhanced transport channels and cold-chain facilities for agricultural products; key rural tourism areas need strengthened road access and passenger services; regions with developed rural e-commerce require optimized logistics networks and distribution station layouts. By transmitting price signals and demand feedback, rural market economy development guides public transport capital to concentrate in high-demand, high-efficiency areas, avoiding blind investment and resource waste. Wu Ming'e's research indicates that improvements in rural economic development can drive public transport investment structure toward greater diversification and precision [6].

4.2.4. Standards improvement: promoting service upgrades

Rural market economy development raises the quality requirements for public transport services, encouraging capital investment to focus on service upgrades. As rural markets increasingly integrate with urban markets, rural public transport must align with urban standards in operation hours, service frequency, and quality, meeting the needs of factor flows and residents' mobility. Additionally, the growth of rural e-commerce and cold-chain logistics requires specialized transport capabilities and supporting facilities, enhancing transport efficiency and product safety. These demands drive public transport capital investment to shift from solely hardware construction toward a balanced development of hardware and service quality, continuously improving service standards and operational levels.

5. Empirical analysis of the interaction between public transport capital investment and rural market economy development

5.1. Construction of the indicator system

Drawing on the studies of Chen Guo et al. and Guo Yibei et al. [2, 4], and considering data availability, an evaluation indicator system was constructed for public transport capital investment and rural market economy development, as follows:

5.1.1. Public transport capital investment indicators (X)

Investment scale: Rural road mileage (X_1), number of rural passenger transport stations (X_2), rural transport construction investment (X_3).

Investment quality: Rural road paving rate (X_4), urban–rural bus integration rate (X_5), coverage rate of rural logistics stations (X_6).

Service level: Density of rural passenger transport lines (X_7), cold-chain transport capacity for agricultural products (X_8).

5.1.2. Rural market economy development indicators (Y)

Market scale: Rural online retail sales (Y_1), agricultural product sales (Y_2), per capita consumption expenditure of rural residents (Y_3).

Industrial development: Number of agricultural industrialization organizations (Y_4), agricultural product processing conversion rate (Y_5), rural tourism reception volume (Y_6).

Circulation efficiency: Share of rural logistics costs in total product costs (Y_7), circulation time of agricultural products (Y_8), intensity of urban–rural factor flows (Y_9).

5.2. Data sources and processing

5.2.1. Data sources

This study uses panel data from 30 provinces (autonomous regions and municipalities; Tibet excluded) in China from 2010 to 2020. Data were mainly obtained from the China Statistical Yearbook, China Rural Statistical Yearbook, China Transport Statistical Yearbook, China Logistics Statistical Yearbook, as well as provincial statistical yearbooks and bulletins. Missing data were supplemented using linear interpolation and trend extrapolation methods.

5.2.2. Data processing

Standardization: To eliminate dimensional differences among indicators, the range standardization method was applied to the raw data [1]. The formulas for positive and negative indicators are shown in Equations (1) and (2), respectively:

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

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

Weight determination: The entropy method was used to determine the weights of each indicator. By calculating information entropy, entropy redundancy, and the corresponding weights, the relative importance of each indicator is objectively reflected.

Comprehensive level index: The weighted sum method was used to calculate the comprehensive index of public transport capital investment ($f(x)$) and rural market economy development ($g(y)$), as shown in Equations (3) and (4):

$$f(x) = \sum_{j=1}^n w_j X_{ij} \quad (3)$$

$$g(y) = \sum_{j=1}^n v_j Y_{ij} \quad (4)$$

where w_j and v_j represent the weights of the public transport capital investment indicators and rural market economy development indicators, respectively.

5.3. Construction of the coupling coordination model

5.3.1. Coupling degree model

The coupling degree is calculated using Equation (5):

$$C = \left\{ \frac{f(x) \times g(y)}{[\frac{f(x) + g(y)}{2}]^2} \right\}^k \quad (5)$$

where C represents the coupling degree, ranging from 0 to 1. The closer C is to 1, the higher the degree of coupling between public transport capital investment and rural market economy development. k is an adjustment coefficient, set to 2.

5.3.2. Coupling coordination degree model

The coupling coordination degree and the comprehensive coordination index are calculated as follows (Equations (6) and (7)):

$$D = \sqrt{C \times T} \quad (6)$$

$$T = \alpha f(x) + \beta g(y) \quad (7)$$

where D is the coupling coordination degree, T is the comprehensive coordination index, and α and β are coefficients. Considering that public transport capital investment and rural market economy development are equally important, $\alpha = \beta = 0.5$.

5.3.3. Classification of coupling coordination levels

Table 1. Classification of coupling coordination levels

Coupling Coordination Interval	Coordination Level
[0.90, 1.00]	High-Quality Coordination
[0.80, 0.90)	Good Coordination
[0.70, 0.80)	Intermediate Coordination
[0.60, 0.70)	Primary Coordination
[0.50, 0.60)	Marginal Coordination
[0.40, 0.50)	Near Disorder
[0.30, 0.40)	Primary Disorder
[0.20, 0.30)	Intermediate Disorder
[0.10, 0.20)	Severe Disorder
[0.00, 0.10)	Extreme Disorder

Using the classification standard in Table 1, the coupling coordination level between public transport capital investment and rural market economy development is analyzed in detail below.

5.4. Empirical results analysis

5.4.1. Analysis of comprehensive level indices

From 2010 to 2020, the comprehensive levels of both public transport capital investment and rural market economy development steadily increased nationwide. Key regional data for 2020 are shown in Table 2:

Table 2. Comparison of comprehensive level indices by region in 2020

Region	Public Transport Comprehensive Index ($f(x)$)	Rural Market Economy Comprehensive Index ($g(y)$)
Eastern	0.821	0.793
Central	0.658	0.632
Western	0.543	0.517
National Average	0.687 (annual growth 11.2%)	0.654 (annual growth 10.8%)

Table 2 shows that the Eastern region has the highest comprehensive indices, while the Central and Western regions are relatively low, reflecting significant regional disparities consistent with differences in economic foundations and transport investment intensity.

5.4.2. *Coupling degree analysis*

From 2010 to 2020, the coupling degree steadily increased. Key regional and national data for 2020 are presented in Table 3:

Table 3. Comparison of coupling levels by region in 2020

Region	2020 Coupling Degree (<i>C</i>)	National Average Annual Growth Rate
Eastern	0.968	2.0%
Central	0.935	2.0%
Western	0.912	2.0%
National Average	0.946 (2020)	2.0%

All regions show high coupling degrees ($C > 0.9$), indicating a close interactive relationship between public transport capital investment and rural market economy development across both Eastern and Central–Western regions.

5.4.3. *Coupling coordination degree analysis*

From 2010 to 2020, the national coupling coordination degree rose from "near disorder" to "intermediate coordination". The phased development is shown in Table 4:

Table 4. Phased development of coupling coordination from 2010 to 2020

Development Stage	Coupling Coordination Interval	Coordination Level
2010–2013	$D < 0.50$	Near Disorder
2014–2017	$0.50 \leq D < 0.60$	Marginal Coordination
2018–2020	$0.60 \leq D < 0.80$	Primary–Intermediate Coordination

By 2020, the national coupling coordination degree reached 0.768, falling within the intermediate coordination level, indicating a significant improvement in the level of coordinated development.

5.4.4. *Test of bidirectional influence effects*

Panel data regression models were constructed to examine the bidirectional effects between the two systems. The impact of public transport capital investment on rural market economy development is modeled in Equation (8), while the reverse effect is modeled in Equation (9):

$$g(y)_{it} = \beta_0 + \beta_1 f(x)_{it-1} + \sum control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{8}$$

$$f(x)_{it} = \gamma_0 + \gamma_1 g(y)_{it-1} + \sum control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{9}$$

where i represents the province, t the year, control includes control variables such as fiscal expenditure, population density, and industrial structure, μ_i is the individual fixed effect, λ_t is the time fixed effect, and ε_{it} is the random error term.

Regression results indicate a significant positive bidirectional effect between the two variables. Regional coefficient differences are summarized in Table 5 ($p < 0.01$, all statistically significant):

Table 5. Comparison of bidirectional influence coefficients across regions

Region	Impact of Public Transport on Market (β_1)	Impact of Market on Public Transport (γ_1)
Eastern	0.386	0.342
Central	0.312	0.275
Western	0.268	0.229
National Average	0.327	0.285

It can be seen that the bidirectional effect coefficients in the Central and Western regions are lower than in the Eastern region, indicating weaker interactive effects and a risk of a "underinvestment–market lag" vicious cycle.

6. Conclusion and policy recommendation

6.1. Research conclusions

There exists a significant bidirectional interaction between public transport capital investment and rural market economy development. Public transport capital investment promotes rural market development by reducing circulation costs, fostering industrial agglomeration, expanding market boundaries, and enhancing factor mobility. Conversely, rural market economy development guides efficient allocation of public transport capital through demand pull, financial feedback, structural optimization, and service standard upgrades.

From 2010 to 2020, the national coupling coordination level between public transport capital investment and rural market economy development significantly improved, rising from "near disorder" to "intermediate coordination". However, substantial regional differences exist: the Eastern region reached a "good coordination" level, while the Central and Western regions were at intermediate and primary coordination levels, respectively.

Empirical tests demonstrate significant positive bidirectional effects between the two systems. Nevertheless, the interactive effect in the Central and Western regions is weaker than in the Eastern region, posing a risk of a "underinvestment–market lag" vicious cycle.

6.2. Policy recommendations

6.2.1. Optimize the structure of public transport capital investment to improve adaptability

Focus investment on key areas of rural market economy development, such as agricultural product transport channels, cold-chain logistics facilities, and rural e-commerce logistics hubs, to enhance alignment between transport investment and market demand. Coordinate urban-rural integrated public transport development, optimize rural passenger route layouts, and improve passenger service quality to meet rural residents' mobility and factor flow needs. Strengthen rural road maintenance management by establishing long-term mechanisms such as the "road chief system" to extend the lifespan and efficiency of transport facilities.

6.2.2. Strengthen rural market economy cultivation to enhance guiding capacity

Expand rural market actors by supporting leading agricultural enterprises, farmers' cooperatives, and rural e-commerce entities to improve market organization and competitiveness. Promote industrial integration, including agricultural product processing, rural tourism, and e-commerce, to expand market size and increase demand pull on public transport. Improve rural circulation systems, reduce logistics costs, and enhance circulation efficiency to promote bidirectional flow of urban and rural resources.

6.2.3. Improve regional coordinated development mechanisms to narrow disparities

Increase public transport investment in Central and Western regions, prioritizing agricultural production areas, revolutionary base areas, and remote regions to reduce regional disparities. Establish interregional coordination mechanisms linking transport and market development through industrial transfer, technical assistance, and market integration to promote coordinated growth. Tailor policies to local conditions: the Eastern region should focus on improving coordination quality, the Central region on advancing toward good coordination, and the Western region on breaking the "underinvestment–market lag" vicious cycle.

6.2.4. Establish robust mechanisms for interactive development to form synergistic momentum

Set up market-oriented demand feedback systems using surveys, enterprise consultations, and big data analysis to guide precise public transport capital allocation. Improve social capital participation mechanisms through PPP models, franchising, and fiscal incentives to broaden investment channels. Build cross-departmental coordination mechanisms integrating transport, agriculture, commerce, and finance to facilitate joint advancement of public transport investment and rural market economy development.

6.2.5. Promote integration of transport and e-commerce logistics to enhance synergy

Strengthen the connection between rural transport and e-commerce logistics, creating a "transport + logistics + e-commerce" integrated development model to improve agricultural product circulation efficiency. Support logistics firms in establishing rural storage and distribution centers and implement "county–town–village" tiered delivery services to solve the "first mile" and "last mile" problems. Promote cold-chain transport technologies and equipment to improve rural cold-chain logistics, reduce agricultural product loss, and enhance market competitiveness.

6.3. Research limitations and future directions

This study, while revealing the interaction mechanism between public transport capital investment and rural market economy development, has certain limitations: The indicator system does not cover all dimensions, such as the green and low-carbon level of public transport or the digitalization level of rural markets. The empirical analysis does not account for micro-level differences at the county level, and the micro-transmission pathways of the interaction mechanism remain underexplored. Future research could further refine the indicator system, utilize county-level panel data, and employ case studies to deeply analyze the micro-mechanisms of interaction, providing more precise guidance for policy formulation.

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