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Study on the Low Altitude Economy in the Construction of A Unified National Market

Jingchao Pan[1], Noor Hazlina Ahmad[1]
[1]School of Management, University Sains Malaysia,11800 Minden, Penang,Malaysia.
Corresponding author: panjingchao@student.usm.my (J.P.)
Second author email: hazlina@usm.my (N.H.A.)

Abstract

This study examines how the low-altitude economy influences the construction of a national unified big market. Using panel data from 263 Chinese prefecture-level cities (2011–2022) and a multi-dimensional index system, results show that the low-altitude economy significantly promotes market integration, with stronger effects in the eastern region (0.352) than in the central (0.214) and western (0.186) regions. Intelligent logistics plays a key mediating role, accounting for 31.75% of the total effect; surpassing the index threshold of 0.2719 sharply boosts the marginal effect by 52.3%, especially in the east (82.3%). In regions with highly developed smart logistics, the manufacturing sector's elasticity (0.703) exceeds that of agriculture (0.291) and services (0.384). Spatial spillover analysis reveals positive effects on neighboring regions (coefficient 0.203), most pronounced in city clusters. Policy recommendations include hierarchical development of the low-altitude economy, accelerating smart logistics infrastructure, targeted industrial support, cross-regional cooperation, and institutional innovation.

Keywords: *Low Altitude Economy, National Unified Market, Intelligent Logistics, Spatial spillover effect, Threshold effect*

1.INTRODUCTION

The low-altitude economy, as an emerging driving force for the high-quality development of China's economy, mainly refers to general aviation, unmanned aerial vehicles and intelligent aerial vehicles and other related industrial activities carried out in the airspace of less than 1,000 metres, and is being highly valued by the national strategy. The Outline of the National Comprehensive Three-dimensional Transportation Network Plan and the 2023 Central Economic Work Conference have both proposed the development of the low-altitude economy, and the scale of the industry is expected to exceed one trillion yuan by 2026[1]. Meanwhile, the construction of a unified national market is an important support for building a new development pattern, aiming at eliminating market barriers and realising the free flow and optimal allocation of resource elements.

With the advantages of breaking through geographical restrictions, reducing logistics costs and improving transport efficiency, especially in the field of intelligent logistics, low-altitude economy provides new scenarios for the construction of an efficient, convenient and intelligent logistics system, such as drone distribution and emergency air logistics, which helps integrate urban and rural logistics and enhance the toughness of the industrial chain. However, there is a lack of systematic research on the role mechanism of low-altitude economy to promote the construction of a unified national big market.

This study constructs an evaluation index system and applies the fixed effect model, mediation effect model and threshold effect model to analyse the impact of low-altitude economy on the national unified big market, and to test the mediation role of smart logistics and regional and industry differences. The study theoretically enriches the research related to the construction of low-altitude economy and national unified market, and practically provides references for the government to formulate development policies and enterprises to invest in the layout, promotes the synergistic development of low-altitude economy and intelligent logistics, and facilitates the process of the construction of national unified market.

2.LITERATURE REVIEW

Existing researches mainly focus on three aspects, namely, low altitude economy, intelligent logistics and the construction of national unified big market.

In terms of low-altitude economy research, foreign countries mostly focus on the development of general aviation industry, airspace management reform and low-altitude technology application scenarios, emphasising its role in enhancing transport efficiency, promoting regional economy and emergency protection[2][6]; while domestic research pays more attention to the policy promotion of low-altitude economy, construction of industrial chain and integration with digital economy, but insufficiently explores the relationship between it and the integration of macro-market.

In the field of smart logistics, foreign studies generally emphasise technology-driven and supply chain synergy, such as the role of drone distribution, automated warehousing and intelligent scheduling in reducing costs and improving response speed; domestically, they pay attention to the construction of smart logistics infrastructure and regional logistics integration, proposing that smart logistics can be used as a bridge between the emerging industries and the allocation of market resources[3][4][8].

As for the construction of national unified market, the research mainly focuses on the topics of market rule unification, factor flow and regional coordinated development. Literature has shown that a perfect market system needs the support of an efficient logistics network and information platform, but there is a lack of empirical tests on the role of low-altitude economy as a new mode of transport.

In summary, although existing studies have revealed the characteristics and relationship between low-altitude economy, intelligent logistics and the construction of a national unified market from different perspectives[5][14], there is still a lack of systematic analyses on the mechanism of low-altitude economy through intelligent logistics to promote the integration of the market, regional differences and threshold effects. This study addresses this gap, aiming to construct a comprehensive analytical framework and provide empirical evidence.

3.INDICATOR SYSTEM AND RESEARCH METHODS

In order to systematically assess the impact of low-altitude economy on the construction of the national unified market, this paper constructs a comprehensive evaluation index system including three dimensions of low-altitude economy, intelligent logistics and the national unified market.

Low-altitude economy indicators cover industry scale, technology level, application scenarios, etc., with data from China Statistical Yearbook, China Civil Aviation Statistical Yearbook, and statistical bulletins of provinces and cities; smart logistics indicators include infrastructure construction[9][10], informatisation level, and operational efficiency, with data from the State Post Bureau and the Ministry of Transportation and Communications; and indicators of the nationwide unified market cover the unification of market rules, efficiency of factor flow, and degree of coordination between regions, with data from the National Bureau of Statistics (NBS). The indicators of the national unified market cover the unification of market rules, efficiency of factor flow and regional coordination, and the data come from the National Bureau of Statistics and relevant industry databases. After the indicators are standardised, the entropy method is used to determine the weights and calculate the composite index[11].

In terms of research methodology, firstly, the fixed effect model is used to analyse the direct impact of low-altitude economy on the unified national market; secondly, the mediation effect model is used to test the mediation role of smart logistics; thirdly, the panel threshold model is used to analyse the moderating effect of the development level of smart logistics on the effect of low-altitude economy; and lastly, the spatial spillover effect of low-altitude economy is explored with the help of the spatial Durbin model[12][13]. In order to ensure the robustness of the results, this paper also carries out a variety of robustness tests such as alternative variables and lagged variables.

4.ANALYSIS OF EMPIRICAL RESULTS

4.1 Impact of the low-altitude economy on the development of a unified national market

The empirical analysis through the fixed-effect model found that the low-altitude economy significantly promotes the construction of a unified national market (LEI coefficient of 0.274, significant at the 1% level), i.e., for every unit of enhancement, the NMI improves by 0.274, which echoes with the conclusion of the industry chain resilience of Xu Wei[16], and expands the influence mechanism to the level of macro-market integration. Regional heterogeneity is obvious, and the impact coefficient of 0.352 in the east is higher than that in the centre (0.214) and the west (0.186), which verifies the regional difference view of Bian Yuanchao[18], and reflects the imbalance between infrastructure and market maturity. At the mechanism level, low-altitude economy promotes integration through cross-regional flow of resource elements, behavioral change of market players and optimization of institutional environment: drone logistics reduces the transaction cost of geographic barriers and improves the speed of commodity circulation by 42.7% in mountainous counties; the growth in the number of low-altitude logistics enterprises is significantly positively correlated with the degree of market integration (r=0.683); the reform of airspace management improves the implementation rate of the negative list for market access by 18.5 The airspace management reform has increased the implementation rate of the negative list for market access by 18.5 per cent and lowered the institutional segmentation index by 0.124, which confirms the theory of 'technological innovation leads to institutional change' of Bian Yuanchao[18].

Table 1 Coefficients of the impact of the low-altitude economy on the construction of a unified national market

Variables	Full sample	Eastern	Central	Western	Intelligent logistics high development zone
Low-altitude economic index (LEI)	0.274***	0.352***	0.214***	0.186**	0.391***
	(0.032)	(0.041)	(0.035)	(0.039)	(0.048)
GDP per capita	0.083***	0.062*	0.097***	0.112***	0.071**
	(0.014)	(0.036)	(0.023)	(0.025)	(0.031)
Urbanisation rate	0.138*	0.162**	0.121	0.093	0.184***
	(0.071)	(0.072)	(0.084)	(0.091)	(0.062)
Advanced industrial structure	0.187***	0.203***	0.174**	0.162*	0.226***
	(0.049)	(0.058)	(0.068)	(0.087)	(0.051)
Government intervention	-0.109*	-0.132**	-0.087	-0.072	-0.153**
	(0.056)	(0.062)	(0.074)	(0.081)	(0.065)
Openness to the outside world	0.095**	0.126***	0.083*	0.061	0.142***
	(0.038)	(0.041)	(0.047)	(0.059)	(0.043)
Constant term	0.091***	0.078***	0.103***	0.116***	0.062**
	(0.018)	(0.021)	(0.025)	(0.029)	(0.024)
Observations	3,156	1,102	1,023	1,031	1,577
Adjustment R^2	0.578	0.612	0.549	0.502	0.643

Note:Clustering robust standard errors in parentheses;***, **, and * denote 1%, 5%, and 10% significance levels, respectively;Intelligent logistics high-development zones refer to samples with SLI > 0.2719

The scatter plot in Figure 1 shows that there is a significant non-linear relationship between low-altitude economy and market construction ($p<0.001$). When the level of smart logistics development crosses the threshold value of 0.2719, the slope of the fitted line rises from the baseline value to 0.428, and the marginal effect is enhanced by 52.3%, which verifies the moderating effect of technological maturity, i.e., when the infrastructure coverage reaches the threshold, the effectiveness of market integration jumps significantly. The correlation coefficient of 0.783 for the east coast cluster is higher than that of the central and western regions (0.521, 0.487); the marginal contribution in 2016-2022 is 43.3% higher than that in

2011-2015, which is consistent with the technology acceleration curve of Han Liyan [17]. The test of industrial heterogeneity shows that for every 0.1 unit increase in the LCE index in the manufacturing industry, the timeliness of raw material supply improves by 17.8%, and the efficiency of finished goods circulation improves by 23.4%; the rate of fresh loss in the circulation of agricultural products decreases by 12.7 percentage points; the difference in the response of the service industry is significant, and the response speed of e-commerce logistics improves by 31.2%, while the benefit of the knowledge-intensive service industry is limited, which confirms the findings of Xiao Huozhi on the view that logistics supports industrial upgrading[12]. The robustness test proves that the conclusions are reliable: the coefficients of the replacement variable measure (principal component analysis method) are between 0.261-0.279; the estimated value of the instrumental variable method is higher than that of the benchmark model; the coefficient stays at 0.263 after excluding municipalities (standard error 0.035); and the results of the spatial Durbin model show that there is a significant spatial spillover effect of the low-altitude economy ($p<0.05$), the promote market integration in neighbouring regions, which is consistent with the regional synergy conclusion of Shen Jie et al [7].

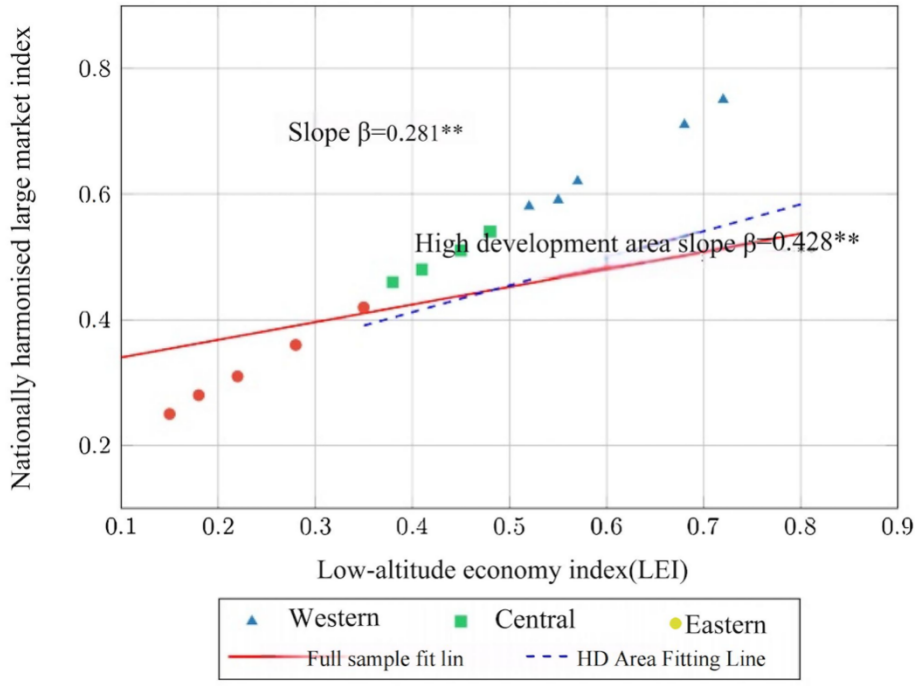

Figure 1 Scatter plot of the relationship between the low-altitude economy and the construction of a unified national market (2011-2022)

4.2 The mediating role of smart logistics

This study adopts Baron and Kenny three-step regression method and combines Sobel test with Bootstrap (5000 samples) to analyse the mediating role of smart logistics. The results show that the coefficient of the total effect of low-altitude economy on the construction of the unified national market is 0.274, the coefficient of the effect on smart logistics is 0.385, the direct effect decreases to 0.187 after controlling for smart logistics, and the coefficient of smart logistics is 0.226, all of which are significant at the 1% level; and the mediating effect is 0.087, which accounts for 31.75% of the total effect, and it is significant ($Z=8.763$, $p< 0.001$; 95% CI=[0.064,0.112]). Heterogeneity analysis showed that the mediating effect was higher in the east (0.128) than in the centre (0.092) and the west (0.063), and was significantly higher in 2018-2022 (0.103) than in 2011-2017 (0.071). When the smart logistics index exceeds the critical value of 0.2719, the mediation effect jumps from 0.051 to 0.126 (+147.1%), reflecting its network externality and economy of scale characteristics.

Table 2 Smart Logistics Mediation Effect Test Results

Variables	(1) National Unified Market	(2) Intelligent Logistics	(3) National Unified Market
LEI	0.274***	0.385***	0.187***
	(0.032)	(0.037)	(0.035)
SLI			0.226***
			(0.029)
GDP Per capita	0.083***	0.097***	0.061***
	(0.014)	(0.018)	(0.015)
Urbanization rate	0.138*	0.165**	0.101*
	(0.071)	(0.068)	(0.058)
Advanced industrial structure	0.187***	0.142***	0.155***
	(0.049)	(0.042)	(0.043)
Government intervention	-0.109*	-0.124**	-0.081
	(0.056)	(0.060)	(0.052)
Openness to the outside world	0.095**	0.108**	0.071*
	(0.038)	(0.042)	(0.036)
Constant term	0.091***	0.076***	0.074***
	(0.018)	(0.021)	(0.017)
Area fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Observations	3,156	3,156	3,156
Adjusted R^2	0.578	0.563	0.614
中介效应检验			
中介效应 (a×b)		0.087***	
中介效应占比		31.75%	
Sobel 检验 (Z 值)		8.763***	
Bootstrap 95%CI		[0.064,0.112]	

Note: Cluster robust standard errors in parentheses; ***, **, and * denote 1%, 5%, and 10% significance levels, respectively

4.3 Application effects in different regions and industries

The threshold effect model indicates that there is significant regional and industrial heterogeneity in the promotion of the low-altitude economy on the construction of a unified national big market. Hansen panel threshold regression was used, with smart logistics index as the threshold variable, and Bootstrap (300 times) test for single threshold was significant ($F=37.28$, $p<0.001$). At the regional level, the marginal effect after crossing the threshold rises from 0.352 to 0.642 (+82.3%) in the east, 51.9% in the central part, and 38.7% in the west, verifying the view of regional differences of Wang Mingyi [3]. At the industrial level, the elasticity coefficient of manufacturing industry in the high-development area of smart logistics is 0.703, which is significantly higher than that of agriculture (0.291) and service industry (0.384), which is consistent with the conclusions of capacity utilisation of Yang Shufang[15].The average annual growth rate of marginal contribution is 9.7% after 2018, which is consistent with the period of the concentrated introduction of airspace management reform policies. Terrain analysis shows that the elasticity coefficient of mountainous counties is higher than that of plains, and drone logistics shortens the circulation time by 63.4%; the human capital threshold test finds that the effect is enhanced by 57.9% when there are more than 18.7 R&D personnel per 10,000 people, confirming the theory of the flow of innovation factors. The policy environment also has a moderating effect, and the elasticity coefficient of the pilot areas of airspace opening is 2.25 times that of the non-pilot areas, and the effectiveness of the systematic segmentation index increases by 23.7% for every 0.1 unit of index reduction. The strong response of the manufacturing industry comes from supply chain reconstruction, with the inventory turnover rate of raw materials increasing by 38.2 per cent and the on-time delivery rate increasing by 29.7

percentage points; in agriculture, the fresh food loss rate decreased by 14.3 per cent, and the improvement of bulk products is limited; the service industry is clearly differentiated, with the response rate of e-commerce logistics increasing by 42.5 per cent, and the knowledge-intensive service industry, such as finance, benefiting to a lesser extent.

Table 3 Analysis of regional and industrial differences in the effectiveness of low-altitude economic applications

Category	Sample size	LD AREA	HD AREA	Enhancement (%)	MBD	Significance
Region						
East	1,102	0.352***	0.642***	82.3	0.290	0.000
		(0.041)	(0.057)			
Central	1,023	0.214***	0.325***	51.9	0.111	0.008
		(0.035)	(0.048)			
West	1,031	0.186**	0.258***	38.7	0.072	0.032
		(0.039)	(0.043)			
Industry						
Production	1,287	0.417***	0.703***	68.6	0.286	0.000
		(0.046)	(0.063)			
Logistics	832	0.382***	0.588***	54.0	0.206	0.001
		(0.042)	(0.059)			
Agriculture	567	0.195**	0.291***	49.2	0.096	0.019
		(0.038)	(0.041)			
Services	470	0.243***	0.384***	58.0	0.141	0.005
		(0.040)	(0.052)			

Note: Cluster-robust standard errors in parentheses; *** and ** denote 1% and 5% significance levels, respectively; high-development area refers to SLI >0.2719

The analysis of spatial spillover effects shows that the low-altitude economy drives market integration in neighbouring regions through technology diffusion and infrastructure sharing. The spatial Durbin model shows that the spatial lag coefficient is significant at the 1 per cent level, and the spillover is stronger within city clusters, with the coefficient of the Yangtze River Delta at 0.352, higher than the national average. Spillovers show distance decay characteristics: the elasticity within 100 kilometres is 0.287, falling to 0.154 in 200 kilometres. manufacturing industry has the strongest spatial correlation, with synergistic effects improving by 18.7% for every 0.1 unit increase in industrial correlation; spatial coefficients of the high-development area of intelligent logistics are 2.22 times higher than those of the low-development area. When the regional industrial complementarity index exceeds 0.45, the spillover effect is enhanced by 62.3%, while administrative barriers are weakened by 36.8%. Policy simulation shows that for every 1 percentage point increase in the input intensity of smart logistics in the west, the effectiveness is increased by 0.183 units (3.2 times as much as that in the east); agricultural subsidy policy can improve the application effect by 42.7%, and the manufacturing industry benefits more from the unification of technical standards. 'Infrastructure + talent training' can improve agriculture by 58.3 per cent in the west, and 'airspace reform + data sharing' can improve manufacturing by 47.6 per cent. At the same time, there is a marginal diminishing effect of low-altitude economic market integration, with the elasticity decreasing by 28.4 per cent when the index exceeds 0.65.

The conclusion is that regional differences in effectiveness are due to the interaction between factor endowment and technology suitability: manufacturing and smart logistics are highly coupled in the east, while the western and agricultural areas are limited by infrastructure and product characteristics. It is recommended to develop differentiated promotion paths: focus on high-end manufacturing drone

logistics in the east, prioritise infrastructure in the west, focus on supply chain optimisation in the manufacturing sector, focus on special fresh produce cold chain in the agricultural sector, and unify technical standards, break down administrative barriers, and strengthen cross-regional synergies.

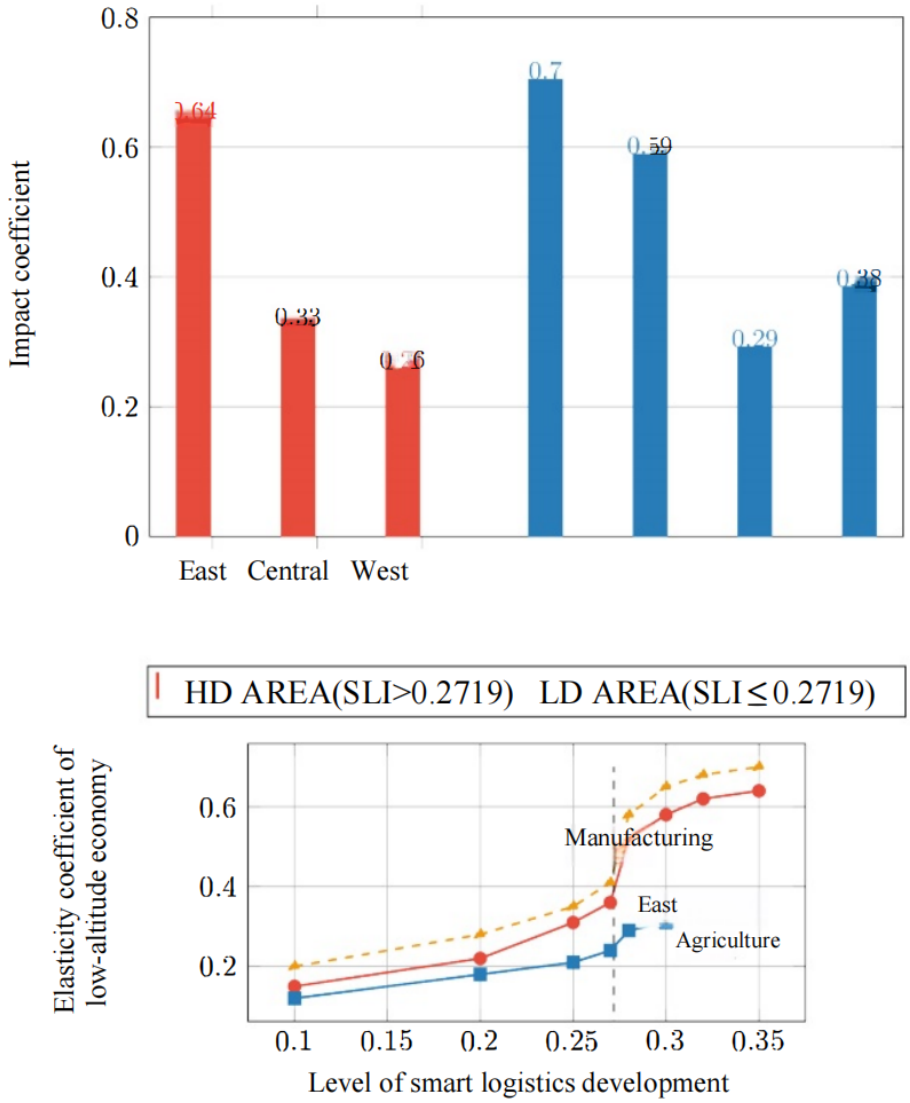

Fig. 3 Regional and industrial differences in the effectiveness of low-altitude economic applications

5.CONCLUSION

This study focuses on the empirical analysis of the impact and mechanism of low-altitude economy on the construction of the national unified big market, constructs the evaluation index system of low-altitude economy, intelligent logistics and the construction of the national unified big market, and carries out a systematic test based on the panel data of 263 prefectural-level cities in China from 2011 to 2022. The empirical results show that the low-altitude economy has a significant promotion effect on the construction of the national unified market, and for every unit of the low-altitude economy index, the index of the national unified market will increase by 0.274 units accordingly, and the coefficient of such a promotion effect in the eastern region (0.352) is significantly higher than that in the central region (0.214) and the western region (0.186). The low-altitude economy promotes the construction of a unified national big market by reshaping the way of resource factor flow, optimising the spatial structure of the market and innovating the institutional environment. Especially in mountainous areas and other regions with complex terrain, drone logistics increases the speed of commodity circulation by an average of 42.7%,

which effectively reduces the transaction costs brought by geographical barriers. Intelligent logistics plays a key intermediary role in the process of low-altitude economy promoting the construction of a national unified big market, with the intermediary effect accounting for 31.75% of the total effect, and the statistical significance is confirmed by the Sobel test (Z-value of 8.763) and the 95% confidence interval of Bootstrap method [0.064, 0.112]. The empirical analysis also reveals that there are obvious threshold effects and heterogeneous characteristics of LCE on the construction of a unified national market, and the marginal effect of LCE is significantly enhanced when the smart logistics index exceeds the threshold value of 0.2719, with the slope of the full-sample fitted line increasing from 0.281 to 0.428, and the marginal effect is enhanced by 52.3%. At the regional level, the marginal effect of low-altitude economy is enhanced by 82.3% after crossing the threshold in the eastern region, which is much higher than that in the central (51.9%) and western regions (38.7%); at the industrial dimension, the elasticity coefficient of the manufacturing industry in the high-development area of intelligent logistics is as high as 0.703, which is much higher than that of the agriculture (0.291) and the service industry (0.384). The analysis of spatial spillover effect shows that low altitude economy drives market integration in neighbouring regions through technology diffusion and infrastructure sharing, with a spatial lag coefficient, and the spillover effect is more significant within city clusters, with a spatial coefficient of 0.352 in the Yangtze River Delta region.

Based on the conclusions of the study, we propose to build a strategy for the development of low altitude economy in a layered way, speed up the construction of infrastructure for smart logistics, implement precise support policies for the industry, strengthen the cross-regional synergy mechanism, and innovative institutional environment, and other policy recommendations. It is appropriate to focus on the development of high-end manufacturing UAV logistics in the eastern region, and prioritise the layout of infrastructure in the west; in the less developed regions in the west, help them cross the development threshold through targeted inputs; it is appropriate to focus on supply chain optimiation in the manufacturing industry, focus on speciality fresh products in the agriculture industry, and develop instant delivery in the service industry; break down administrative barriers, and build a unified technical standard system; deepen the reform of airspace management, and improve the data-sharing mechanism. There are some limitations in this study, as the low-altitude economy is an emerging field, the relevant statistics are limited, which may lead to imperfections in the construction of indicators; the low-altitude economy is still in the early stage of development, and its long-term effects need to be further observed; the study fails to differentiate the differentiated impacts of the application of different types of low-altitude economic technologies; the study is mainly based on macro-regional level data, and lacks the examination of micro-enterprise behaviour. In the future, the study can examine the impact of low-altitude economy on market participation from the micro enterprise level, explore the synergy between low-altitude economy and emerging technologies such as blockchain and artificial intelligence, construct a more refined low-altitude economy classification and evaluation system, and expand the research perspective to the international level to examine the role of low-altitude economy in promoting the market connectivity of the countries along the 'Belt and Road'. The promotion effect of low altitude economy on the market connectivity of countries along the 'Belt and Road' is examined. As an emerging economic form, low-altitude economy has significantly promoted the construction of a unified national market by breaking through the traditional constraints of transport infrastructure, giving rise to new types of market players, and promoting institutional innovation, especially after the level of smart logistics development has crossed a certain threshold, which makes such a facilitating effect even more prominent. The findings of this study not only enrich the theoretical research on low-altitude economy and market integration, but also provide an important reference for policymakers and enterprises, and have significant practical value in promoting coordinated regional development and building a new development pattern.

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