Empirical Research on the Full-Chain Transmission Mechanism of Factor Input to Economic Output in the Context of Low-Altitude Economy

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Abstract. Using data related to the low-altitude economy of 31 provincial-level administrative units in China from 2010 to 2022, this paper conducts a multi-dimensional analysis with SPSS and AMOS. This study investigates the complex relationships among variables by taking scientific and technological innovation as a mediating variable and the technological development of the low-altitude economy as a moderating variable. A structural equation model is employed, incorporating infrastructure construction and industrial structure rationalization as control variables. The results indicate that total social input not only has a direct positive impact on GDP but also indirectly promotes GDP growth by fostering scientific and technological innovation. The technological development of the low-altitude economy plays a moderating role. This research provides theoretical basis and empirical support for regional economic development policies.

Keywords: Low-altitude economy; Factor input; Economic output

1 Introduction

In December 2023, the Central Economic Work Conference proposed the creation of strategic emerging industries such as commercial aerospace and the low-altitude economy. The 2024 Government Work Report also, for the first time, called for the active development of the low-altitude economy. Propelled by policy promotion, growing market demand, and technological innovation, China's low-altitude economy is entering a golden era of rapid development.

Current academic research on the low-altitude economy predominantly focuses on qualitative policy interpretation or single-dimensional input-output analysis, exhibiting two main shortcomings: first, there is a lack of empirical validation for the full-chain transmission mechanism of "resource input - innovation transformation - economic output," making it difficult to clarify the direct and indirect effects of various factors; second, regional efficiency comparisons often remain at a macro-descriptive level, without using scientific tools to measure the comprehensive efficiency of input-output.

J. Rak et al. (eds.), *Proceedings of the 2026 11th International Conference on Social Sciences and Economic Development (ICSSED 2026)*, Advances in Economics, Business and Management Research 391,
https://doi.org/10.2991/978-94-6239-701-9_32

This study aims to fill this gap, providing actionable data support and policy references for the coordinated regional development of this sector.

2 Literature Review

Domestic scholars' research on resource input and economic development in the low-altitude economy has primarily approached the topic from a qualitative perspective. Zou et al. [1] argue that the resilient linkage between the education chain and the low-altitude economy's industrial chain is key to promoting its high-quality development. Zheng et al. [2] posit that airspace resources, infrastructure, and technological innovation are prerequisites for the development of the low-altitude economy. Wang et al. [3] believe that fostering top-tier innovative talent in transportation is essential for its advancement. Du et al. [4] suggest that the development of the low-altitude economy is closely related to local economic foundations, natural environments, and locational conditions.

While scholars have achieved results in research related to resource input in the low-altitude economy, there are deficiencies. First, existing research outcomes may no longer fully reflect current development trends. Second, empirical analysis in most studies is not sufficiently in-depth, failing to uncover the potential correlations between the development of the low-altitude economy and factor inputs[5].

3 Preliminary Analysis with SPSS

3.1 Reliability Analysis

To test the internal consistency reliability of the research scale, this study employed Cronbach's alpha (α). Data such as public budget expenditure on education and science and technology were imported into SPSS 27.0. As shown in Table 1, the overall Cronbach's alpha for the scale is 0.618 with 13 items, which is within the acceptable threshold range for reliability.

Table 1. Reliability Statistics

Cronbach's Alpha	N of Items
0.618	13

3.2 Factor Analysis

3.2.1. Factor Analysis of Factor Input Structure and Infrastructure.

This paper conducted a factor analysis on six aspects related to the low-altitude economy, including public budget expenditure on education and science and technology. The KMO value was 0.719, and the cumulative variance contribution rate was 84.84%, indicating that the extracted factors represent 84.84% of the information from the original evaluation indicators. As shown in the Table 2 and Table 3 below, the factors related to input structure and infrastructure were reduced to two components. Component 1, comprising public budget expenditure on education, public budget expenditure on science and technology, R&D personnel, and employment in the air transport industry, was defined as "Total Social Input." Component 2, comprising the mileage of graded highways and the operational mileage of railways, was defined as "Infrastructure Construction."

Table 2. Total Variance Explained (Factor Input)

Component	Total	% of Variance	Cumulative %
1	3.366	56.107	56.107
2	1.724	28.736	84.843
3	.449	7.485	92.328
4	.332	5.530	97.858
5	.079	1.312	99.170
6	.050	.830	100.000

Table 3. Rotated Component Matrix (Factor Input)

	Component 1	Component 2
Public budget exp. on sci. & tech.	.961	.059
R&D personnel	.936	.157
Public budget exp. on education	.850	.474
Employment in air transport	.792	-.261
Mileage of graded highways	.201	.889
Operational mileage of railways	-.093	.883

3.2.2. Factor Analysis of Technological Development.

This paper conducted a factor analysis on five aspects related to technological development, such as the number of high-altitude sounding stations and high-tech business revenue. The KMO value was 0.681, and the cumulative variance contribution rate was 81.49%, indicating that the extracted factors represent 81.49% of the information from the original evaluation indicators. As shown in the Table 4 and Table 5 below, the technology-related factors were reduced to two components. Component 1, comprising the number of patent grants to domestic applicants, high-tech business revenue, and the number of high-tech industries, was defined as "Technological Innovation." Component 2, comprising the number of meteorological stations receiving satellite cloud images and the number of high-altitude sounding stations, was defined as "Technological Development of Low-Altitude Economy."

Table 4. Total Variance Explained (Tech Development)

Component	Total	% of Variance	Cumulative %
1	2.875	57.498	57.498
2	1.200	23.993	81.491
3	.773	15.456	96.947
4	.129	2.579	99.526
5	.024	.474	100.000

Table 5. Rotated Component Matrix (Tech Development)

	Component 1	Component 2
Number of high-tech industries	.988	-.031
High-tech business revenue	.971	-.080
Patent grants to domestic applicants	.956	-.039
Meteorological stations	.045	.802
High-altitude sounding stations	-.126	.757

4 Model Construction and AMOS Fit Evaluation

To explore the mechanism through which total social input affects GDP, this study constructs a theoretical model that includes both moderating and mediating effects. Total Social Input is the independent variable, and GDP is the dependent variable. Technological Innovation is introduced as a mediating variable, while Technological Development of the Low-Altitude Economy serves as a moderating variable. Infrastructure Construction and Industrial Structure Rationalization are included as control variables. The model is specified as follows:

$$GDP = \alpha_0 + \alpha_1 X + \alpha_2 CV + \mu_1 \tag{1}$$

$$TEC = \beta_0 + \beta_1 X + \beta_2 LED + \beta_3 X*LED + \beta_4 CV + \mu_2 \tag{2}$$

$$GDP = \gamma_0 + \gamma_1 X + \gamma_2 TEC + \gamma_3 CV + \mu_3 \tag{3}$$

Where X represents Total Social Input; TEC is Technological Innovation; LED is Technological Development of Low-Altitude Economy; CV represents control variables.

To more systematically and comprehensively analyze the complex relationships among total social input, technological development of the low-altitude economy, technological innovation, and GDP, this study employs AMOS for structural equation modeling (SEM). SEM is advantageous for handling multiple dependent variables simultaneously, effectively managing measurement errors, and deeply exploring direct, indirect, and moderating effects among variables, which aligns perfectly with the needs of our theoretical model. The fit assessment of the model is shown in the Table 6 below:

Table 6. Regression Weights

			Estimate	S.E.	C.R.	P
Tech. Innovation	<---	Total Social Input	.932	.018	50.450	***
Tech. Innovation	<---	Infrastructure	.105	.018	5.685	***
Tech. Innovation	<---	Ind. Structure	.239	.141	1.699	.089
Tech. Innovation	<---	Tech. Dev.	.076	.018	4.087	***
GDP	<---	Tech. Innovation	7888.220	476.911	16.540	***
GDP	<---	Ind. Structure	-11132.859	1427.960	-7.796	***
GDP	<---	Infrastructure	7464.725	193.373	38.603	***
GDP	<---	Total Social Input	13333.872	482.303	27.646	***

From Table 6, the p-values for the paths from Total Social Input, Infrastructure Construction, and Technological Development of the Low-Altitude Economy to Technological Innovation are all less than 0.01, indicating these three parameters are significantly related to Technological Innovation. The p-value for the path from Industrial Structure Rationalization to Technological Innovation is 0.089, suggesting a correlation. The p-values for the paths from Technological Innovation, Infrastructure Construction, Industrial Structure Rationalization, and Total Social Input to GDP are all less than 0.01, indicating these four parameters are significantly related to GDP. The analysis confirms a direct effect of Total Social Input on GDP, and the model shows good fit.

5 Mediation Effect Analysis

To analyze the intrinsic transmission logic of how total social input affects GDP, this study focuses on the key mediating variable, Technological Innovation. The results show that Total Social Input, Infrastructure Construction, Industrial Structure Rationalization, and GDP are all significantly related to Technological Innovation ($p < 0.01$). Similarly, all these variables, including Technological Innovation, are significantly related to GDP ($p < 0.01$). Notably, as shown in the Table 7 and Table 8 below,the t-value for Total Social Input dropped from 56.569 to 17.224 after Technological Innovation was included in the model. This significant change indicates that Technological Innovation acts as a mediator in the relationship between Total Social Input and GDP.

Table 7. Coefficients (Dependent Variable: Technological Innovation)

Model	B	Std. Error	Beta	t	Sig.
2 (Constant)	-.071	.033		-2.181	.030
Infrastructure	.135	.019	.135	7.176	.000
Ind. Structure	.424	.160	.056	2.649	.008
Total Social Input	.933	.021	.934	44.490	.000
3 (Constant)	-.790	.074		-10.619	.000
Infrastructure	-.086	.027	-.086	-3.190	.002
Ind. Structure	.626	.144	.082	4.341	.000
Total Social Input	.396	.054	.396	7.274	.000
GDP	2.594E-5	.000	.618	10.500	.000

Table 8. Coefficients (Dependent Variable: GDP)

Model	B	Std. Error	Beta	t	Sig.
2 (Constant)	27704.312	568.178		48.760	.000
Infrastructure	8530.187	328.835	.359	25.941	.000
Ind. Structure	-7780.971	2792.698	-.043	-2.786	.006
Total Social Input	20692.100	365.782	.870	56.569	.000
3 (Constant)	28265.166	510.053		55.416	.000
Infrastructure	7462.240	310.691	.314	24.018	.000
Ind. Structure	-11129.439	2513.531	-.061	-4.428	.000
Total Social Input	13326.929	773.732	.560	17.224	.000
Tech. Innovation	7897.383	752.130	.332	10.500	.000

6 Moderation Effect Analysis

To further explore the dynamic mechanism of the relationship between total social input and technological innovation, this study introduces the technological development of the low-altitude economy as a moderating variable. The significance test for the interaction term (XM), which is the product of the standardized independent and moderator variables, is conducted. A significance level below 0.05 for XM confirms the moderation effect.

Table 9. Coefficients (Dependent Variable: Technological Innovation)

Model	B	Std. Error	Beta	t	Sig.
(Constant)	-.007	.030		-.241	.810
Infrastructure	.069	.019	.069	3.711	.000
Ind. Structure	.240	.149	.032	1.613	.108
Total Social Input	.946	.019	.947	51.049	.000
Tech. Dev.	.127	.020	.127	6.294	.000
XM (Interaction)	.238	.023	.180	10.467	.000

According to Table 9, the significance levels for both the moderator (Technological Development of the Low-Altitude Economy) and the interaction term (XM) are less than 0.01. This indicates that the technological development of the low-altitude economy serves as a moderator in the "Total Social Input → Technological Innovation" relationship.

7 Conclusion

Grounded in the context of the low-altitude economy as a strategic emerging industry, this study constructs an "input-innovation-output" theoretical framework. Through reliability and factor analysis in SPSS, structural equation modeling in AMOS, and tests for mediation and moderation effects, it systematically reveals the full-chain transmission mechanism through which total social input affects GDP.

The research findings indicate that the driving effect of total social input on GDP follows a dual path of "direct effect + mediation effect." On one hand, total social input can directly fuel GDP growth by optimizing resource allocation. On the other hand, it can indirectly enhance economic output through the mediating channel of technological innovation. The technological development of the low-altitude economy acts as an "amplifier" in this process—a high level of technological development significantly strengthens the enabling effect of total social input on technological innovation.

From a practical perspective, this transmission mechanism provides a clear direction for regional economic policy formulation. For local governments aiming to leverage total social input for sustained GDP growth, it is insufficient to merely engage in extensive resource injection. Instead, a focus on precise allocation is required, including increasing investment in infrastructure and industrial cultivation of the low-altitude economy, while simultaneously strengthening support for technological innovation[6].

However, this study has certain limitations. The scope of data collection may have geographical limitations. Future research could expand the sample to include more regions and incorporate more potential influencing factors, such as the policy environment and human resources[7].

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