



Pathways to High-Quality Coordinated Development of Lu'an under the Hefei Metropolitan Area Strategy

Yong Wen^{1,*}

¹ School of Economics and Management, Lu'an Vocational Technical College, Lu'an 237000, Anhui, China

SUMMARY: *Under the Hefei Metropolitan Area strategy, Lu'an is shifting from a western Anhui peripheral city to a coordinated node linking Hefei's manufacturing, innovation and market functions with the Dabie Mountain ecological zone. Based on official statistical bulletins, annual plan reports and policy documents for 2024 - 2025, this study constructs a six-dimensional evaluation framework covering industrial coordination, investment support, innovation transformation, ecological co-governance, public services and opening-up cooperation, and then conducts a coupling diagnosis around three functional blocks: production and market, innovation and ecology, and services and openness. The results show that Lu'an's GDP reached 240.73 billion yuan in 2025 with a growth rate of 5.4%. Industrial investment maintained rapid growth at 19.8%, and the number of new-energy-vehicle supporting enterprises expanded to 304, with expected annual revenue of 45 billion yuan. At the same time, fixed-asset investment turned negative, declining by 5.3%, and R&D intensity remained at 1.54%, indicating that the city's investment structure and innovation conversion capacity still constrain higher-level coordinated development. The comprehensive coordination diagnostic value increased from 0.781 in 2024 to 0.802 in 2025, mainly driven by improvements in public service, tourism consumption and opening-up cooperation. On this basis, the study identifies six pathways for Lu'an: deeper industrial-chain embedding, stabilization of industrial investment, stronger innovation transfer, ecological value realization, public-service integration and broader Yangtze River Delta cooperation. These findings provide an evidence-based basis for improving Lu'an's participation quality within the Hefei Metropolitan Area.*

KEYWORDS: *Hefei Metropolitan Area; Lu'an; coordinated development; coupling diagnosis; regional economy*

1 Introduction

The strategy of Hefei Metropolitan Area pushes Lu'an to the position where the spillover function of the provincial capital metropolitan area meets the ecological function of Dabie Mountain. For Lu'an, synergistic development occurs first in specific production and life scenarios: Hefei's new energy automobile, electronic information and new material industries need more stable supporting space, and Lu'an's platforms such as Jin'an, Shucheng, Huoqiu, and Jinzhai need higher-quality orders, technology, and market interfaces; Hefei metropolitan area's expansion of population and consumption to the periphery also requires that transportation and commuting, public services, ecological supplies, and cultural and tourism consumption form Smoother cross-city connections. If Lu'an only relies on a single project to

*wenyongjeff1981@163.com

<https://doi.org/10.65102/is20261053>

undertake or a single transportation improvement, it is difficult to transform the metropolitan area strategy into a sustainable growth capacity. Therefore, the core issue of this paper is how Lu'an can synergistically organize its industries, innovations, ecological values and public services into a stable development path under the framework of the Hefei Metropolitan Area.

Policy studies of city clusters and metropolitan areas provide the basic explanatory framework for this issue. Regional integration policies can affect the economic performance of cities by reducing institutional fragmentation, improving factor mobility and increasing market connectivity, and city cluster development planning has been shown to have a growth effect in a quasi-natural experiment sense [1]. Research around China's urban agglomeration policy further points out that metropolitan areas and city clusters are not simply expanding the hinterland of the central city, and their policy benefits depend on the ability to form a recognizable division of functions among the central city, nodal cities and peripheral counties [2]. From the perspective of land use and spatial governance, city cluster policies reshape industrial layout, construction land use efficiency, and local government behavior, and the effectiveness of regional integration is often limited by the intensity of cross-administrative coordination [3]. These studies illustrate that Lu'an's integration into the Hefei metropolitan area should not only be based on its distance from Hefei, but also on its actual position in the industrial chain, transportation network, innovation network and ecological governance.

Compared with central cities, the synergistic development of nodal cities is more likely to be constrained by industrial capacity, financial capacity and public service provision. Studies for China's secondary cities have shown that shortcomings in high-quality development are usually focused on insufficient investment in innovation, weak advanced service industries and fragmentation of governance tools [4]. Measurements of high-quality development in the Yangtze River Delta urban agglomeration also show that there are obvious gradient differences within the region, and while spatial correlation between cities has increased, high-level factors do not automatically spread to peripheral cities [5]. The study of old and new momentum transformation further points out that high-quality development has a spatial spillover effect, and whether the peripheral cities can benefit from it depends on their ability to undertake industries, absorb technology and transform market demand [6]. Lu'an is in the middle of this structural relationship: it is close to Hefei, with the location conditions to undertake industrial spillovers from the provincial capital, and at the same time undertake the tasks of ecological barrier, agricultural supply and revitalization of the old revolutionary areas in the west of Anhui, and it is difficult for a single indicator of the total economic output to explain its synergistic quality.

Transportation interconnection is the precondition for Lu'an's integration into the metropolitan area, but transportation improvement itself is not equivalent to synergistic development. Research on the spatial structure of polycenters shows that node connections within city clusters need to be supported by industrial and public service networks, and if the construction of corridors lacks functional embedding, it is easy to form unidirectional spillovers of commuting, logistics, and capital flows [7]. Transportation network connectivity has a significant impact on market integration, with high-speed railroads and highways reducing cross-city transaction costs and increasing the probability of innovative cooperation [8-10]. This finding has direct implications for the Hop-Six relationship. The He-Lu expressway, high-speed rail and municipal transportation connection can shorten the spatial distance, but whether Lu'an can transform the transportation advantage into industrial synergy requires supporting parks, supply chain services, cross-city employment and talent services to follow up together. Otherwise, the improvement of transportation infrastructure may enhance the absorption capacity of Hefei to Lu'an, but it is difficult to enhance the platform capacity of Lu'an itself.

Industry and innovation synergy is a core aspect of high-quality development in

metropolitan areas. The study of regional innovation poles argues that innovation resources have spatial agglomeration characteristics, and the spillover from innovation poles can only be transformed into growth momentum for neighboring cities through industrial interfaces, technology transfer platforms, and the absorptive capacity of enterprises [11]. In the Yangtze River Delta region, regional integration has a positive effect on industrial green transformation, land use green efficiency and pollution reduction, but this effect usually needs to be jointly supported by industrial upgrading, environmental regulation and local governance capacity [12-14]. The study of productive service industry agglomeration also shows that financial, R&D, information, logistics and business services affect the green development of the city and the upgrading of manufacturing industry [15]. Lu'an currently has new energy automobile supporting, green food, culture, tourism, recreation and ecological resources foundation, but R & D intensity, productive service industry and high-end service functions still need to make up. If there is a lack of innovation undertaking and service support, industrial synergy is easy to stay at the level of processing support and project landing, and it is difficult to form high value-added links.

Existing research on city cluster policy, high-quality development measurement and transportation innovation spillover has been fully discussed, but there are still three shortcomings when used to explain such node cities as Lu'an. First, many studies treat city clusters as an overall sample and do not sufficiently develop the functional differences of different cities within the Hefei Metropolitan Area, especially lacking in the segmentation analysis of cities such as Lu'an, which also has the tasks of industrial undertaking, ecological supply, and the revitalization of old districts. Second, some of the studies emphasize composite indices and spatial correlation, and seldom put statistical indicators, policy texts, park platforms, and industrial chain evidence in the same data framework, resulting in a weak connection between the results and policy paths. Third, synergistic development paths are often generalized into broad directions such as transportation interconnection, industrial cooperation and public service sharing, lacking the process of prioritization based on data diagnosis and the explanation of the relationship between investment structure, innovation transformation, open cooperation and ecological value realization.

Based on the above problems, this paper takes Lu'an City as the research object and places it in the composite context of Hefei Metropolitan Area, Yangtze River Delta Integration and Dabie Mountain Ecological Functional Area to construct six subsystems of industrial synergy, investment support, innovation transformation, ecological co-management, public service and open cooperation. The research objective is to identify the realistic foundation, structural shortcomings and path priorities of high-quality synergistic development in Lu'an. The contribution of this paper is mainly reflected in three aspects: first, extracting Lu'an from the general narrative of peripheral cities and clarifying its industrial, ecological and public service functions in the Hefei metropolitan area; second, transforming official statistics, policy texts and platform data into a traceable indicator system to enhance the verifiability of the conclusions; and third, based on the diagnosis of the sub-systems, proposing the embedding of industrial chain, transportation and factor flow, innovation, undertaking, ecological product value realization and open cooperation. Thirdly, based on the diagnostic results of the subsystem, we propose the paths of industrial chain embedding, transportation and factor flow, innovation, ecological product value realization and public service co-location, which will provide an operational basis for Lu'an to enhance the quality of participation in the metropolitan area.

2 Methods

2.1 Research area, data sources and indicator system

This paper takes the city of Lu'an as the research object and evaluates it in the composite context of Hefei metropolitan area, Yangtze River Delta integration and Dabie Mountain ecological functional area. Located in the western part of Anhui Province, Lu'an City is connected to Hefei in the east and the hinterland of the Dabie Mountains in the west, with the jurisdiction of Jin'an, Yu'an, and Yeji Districts, Huoqiu, Shucheng, Jinzhai, and Huoshan Counties, and industrial platforms such as the Lu'an Economic and Technological Development Zone (ETDZ), Jin'an Economic Development Zone (JEDZ), and Shucheng Economic Development Zone (SEDZ). This spatial pattern determines that Lu'an's function in the Hefei metropolitan area has multiple attributes: eastward to undertake Hefei's new energy automobile, electronic information, new materials and equipment manufacturing industry support, and westward to undertake the ecological barrier of the Dabie Mountains, the supply of green agricultural products, and the function of red cultural tourism and recreation and consumption. The research unit of this paper is Lu'an City as a whole, and the results are interpreted by combining key counties and parks.

The data organization adopts four types of sources: official statistics, policy reports, planning texts, and platform evidence. 2024 economic aggregate, industrial structure, state-owned industry, fixed asset investment, residents' income, cultural and tourism consumption, and foreign trade data come from S1; 2025 GDP, primary, secondary, and tertiary value-added come from S2; 2025 state-owned industry data come from S2; 2025 value-added come from S2; and 2025 value-added come from S2. S2; 2025 GDP, primary industry, secondary industry and tertiary industry value-added are from S2; 2025 planned industry, fixed asset investment, industrial investment, manufacturing investment, total retail sales of consumer goods, value-added of service industry and residents' income are from S3; new energy automobile supporting enterprises, HeLu co-citizenship, Shanghai's cooperation with its counterparts, Yangtze River Delta projects, eco-products' value realization and regional tourism data are from S4; for the indexes that can be quantified directly, this paper retains the original values, units, For the indicators that can be directly quantified, this paper retains the original value, unit, year and source number; for the policy and platform indicators, this paper assigns values based on whether institutional arrangements are formed, whether project carriers exist and whether they are included in the annual report. The data source and entry fields are shown in Table 1.

Table 1: Data Sources and Entry Fields

Source ID	Source Type	Year	Key Data Fields	Purpose
S1	Statistical Bulletin	2024	GDP, Industrial Structure, Industry, Investment, Income, Culture and Tourism, Foreign Trade	Construct original indicators for 2024
S2	Official Release from Statistics Bureau	2025	GDP, Value Added and Growth Rate of Three Industries	Construct economic total indicators for 2025
S3	Economic Operation Interpretation	2025	Industrial Enterprises, Investment, Service Industry, Income, Consumption	Construct operational indicators for 2025
S4	Plan Execution Report	2025	New Energy Vehicles, Scientific Innovation, Urban Integration, Yangtze River Delta Cooperation, Ecology, Culture and Tourism	Construct indicators for coordinated development and path verification
S5	Policy Text on Hefei Urban Circle and Hefei-Huainan Urban Integration	2024–2026	Transportation, Industry, Public Services, Collaborative Matters in Factor Markets	Verify policy operability

The indicator system is centered on the actual mechanism of Lu'an's integration into the Hefei Metropolitan Area, as shown in Table 2. Industrial synergy is used to judge whether Lu'an has entered the leading industrial chain of Hefei Metropolitan Area; investment support is used to judge whether industrial undertaking has project and capital carriers; innovation transformation is used to measure Lu'an's ability to absorb Hefei's science and innovation spillover; ecological co-management is used to portray Lu'an's function as an ecological barrier to the Dabie Mountains and as a green supply place; public service is used to measure the life support of cross-city mobility of population, talents and enterprises; openness and cooperation is used to measure the level of connectivity between Lu'an and Shanghai, the cities of Shanghai, Suzhou and Zhejiang, and the industrial network of the Yangtze River Delta. The indicator system avoids evaluating synergistic development purely in terms of economic aggregates, and incorporates industrial chain locations, public service interfaces, and ecological functions into the model at the same time.

Table 2: Indicator System for High-Quality Synergistic Development in Lu'an City

Subsystem	Representative Indicators	Indicator Direction	Data Processing
Industrial Coordination	GDP Growth Rate, Growth Rate of Value Added in Large-Scale Industries, Growth Rate of Strategic Emerging Industries, Number of Supporting Enterprises for New Energy Vehicles, Number of Supporting Enterprises in Hefei	Positive	Raw Value Normalization
Investment Support	Fixed Asset Investment Growth Rate, Industrial Investment Growth Rate, Manufacturing Investment Growth Rate, Completion Rate of Key Projects	Positive	Raw Value Normalization
Innovation Transformation	R&D Expenditure Intensity, Number of High-Tech Enterprises, Number of Technology-Based SMEs, R&D Platforms or Technology Transfer Items	Positive	Combination of Raw Values and Graded Values
Ecological Co-Governance	PM2.5 Concentration, Proportion of Good Air Quality Days, Proportion of Good Water Quality, Decrease in Energy Consumption per GDP Unit, Pilot Value of Ecological Products	Positive or Negative	Normalization after Direction Adjustment
Public Services	Per Capita Disposable Income, Urban-Rural Income Ratio, Urbanization Rate, Coordination of Medical and Educational Services, Employment Service Items	Positive or Negative	Combination of Raw Values and Graded Values
Open Cooperation	Total Import and Export Volume, Projects over 100 Million Yuan in Shanghai, Suzhou, and Zhejiang, Sales of Agricultural Products to Shanghai, Order Amounts from Shanghai Enterprises, Cooperation Items in the G60 Science and Technology Corridor	Positive	Raw Value Normalization

In this paper, we first form the raw data table, then map the indicators to six subsystems, and keep the source, unit, direction, anchored upper and lower limits, and calculation results for each indicator. In order to ensure the traceability of the data chain, all the indicators entering the model correspond to the Source_ID in the data package, and for the indicators that do not form a complete annual statistical bulletin in 2025, priority is given to adopting the authoritative data published in the annual plan implementation report of the Lu'an government and the interpretation of the economic operation of the Bureau of Statistics, and marking the "projected" or "reported" caliber of the indicators in the interpretation of the results. The results are interpreted with the attributes of "expected" or "reporting caliber". In this paper, statistical data, policy texts and platform evidence are unified into a traceable data chain, and the structure of the data organization and evidence chain is shown in Figure 1.

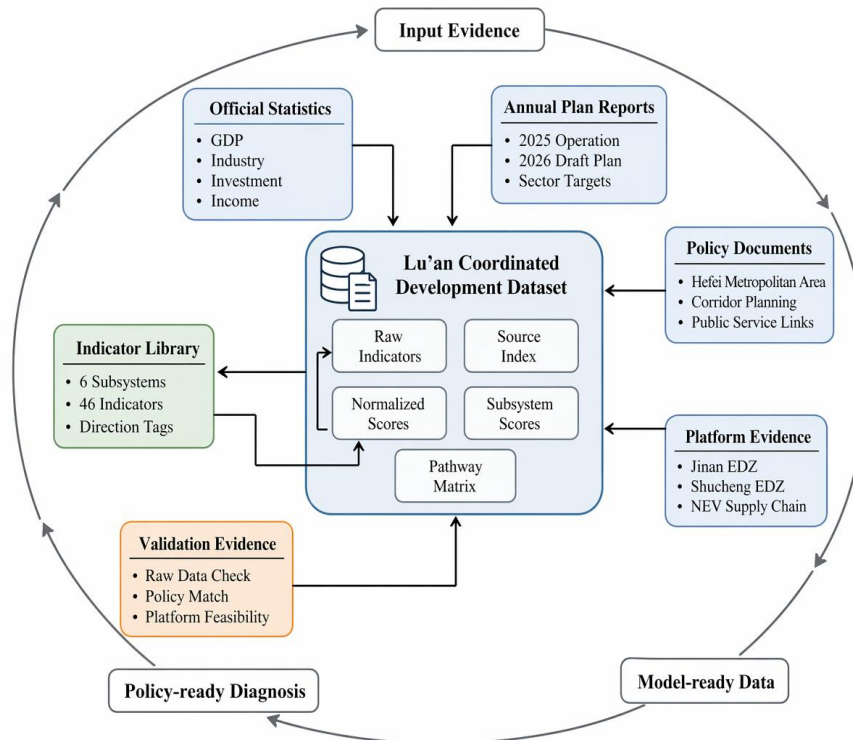


Figure 1: Data organization and evidence chain for Lu'an coordinated development diagnosis.

In Figure 1, the official statistics provide annual comparable data, the plan report supplements the 2025 industry, transportation, science and innovation, and open cooperation matters, the planning and policy texts provide the institutional boundaries of the Hefei metropolitan area's synergies, and the platform evidence is used to check whether the pathway has a carrier. The data structure allows the subsequent model to form both numerical diagnoses and explain the corresponding policy landing points of the diagnostic results.

2.2 Synergistic development evaluation model

The synergistic development evaluation model is used to transform indicators from different sources, different scales and different time calibers in Lu'an into comparable diagnostic results. This paper does not use the model results as an official ranking, nor does it equate short-term scores with long-term development levels, but rather as a tool for identifying synergistic foundations, structural shortcomings and path priorities. Established city cluster studies often use multi-system coupled coordination models to portray the degree of match between economy,

society, resources and environment, and use the method for urbanization quality, ecological security, tourism system and regional resilience analysis [16-19]. Combined with the functional positioning of Lu'an in the Hefei metropolitan area, this paper divides the evaluation object into six subsystems: industrial synergy, investment support, innovation transformation, ecological common governance, public service and open cooperation.

The first step is anchor standardization processing. Since the core data of this paper is concentrated in 2024-2025, if the two-year extreme difference standardization is used directly, the short-term fluctuations of individual indicators will be over-amplified. To avoid this problem, this paper sets the upper and lower limits of indicator anchoring based on planning objectives, common intervals in statistical bulletins and empirical values of similar cities, and uniformly transforms them into scores between 0-1 according to the direction of the indicators. The standardized formula is as follows:

$$S_{j,t} = \begin{cases} \max\{0, \min[1, (x_{j,t} - a_j^L)/(a_j^U - a_j^L)]\}, & x_{j,t} \text{ is positive} \\ \max\{0, \min[1, (a_j^U - x_{j,t})/(a_j^U - a_j^L)]\}, & x_{j,t} \text{ is negative} \end{cases} \quad (1)$$

where $S_{j,t}$ is the standardized score of indicator j in the year, $x_{j,t}$ is the original observation, and a_j^L and a_j^U are the anchored lower and upper limits of indicator j , respectively. Larger values of positive indicators indicate better development conditions, while larger values of negative indicators indicate stronger constraints. After the above processing, each indicator is transformed into a comparable caliber where the larger the value, the better the condition. For policy-based indicators that lack stable upper and lower bounds, this paper adopts three types of evidence, namely, whether institutional arrangements have been formed, whether project carriers are available and whether annual reports have been entered, to assign values in grades, and retains source descriptions in the data package. In order to reduce the extrusion of short-term sample polarity on the results, this paper adopts anchored standardization to deal with indicator direction and magnitude differences, and the indicator construction mechanism is shown in Figure 2.

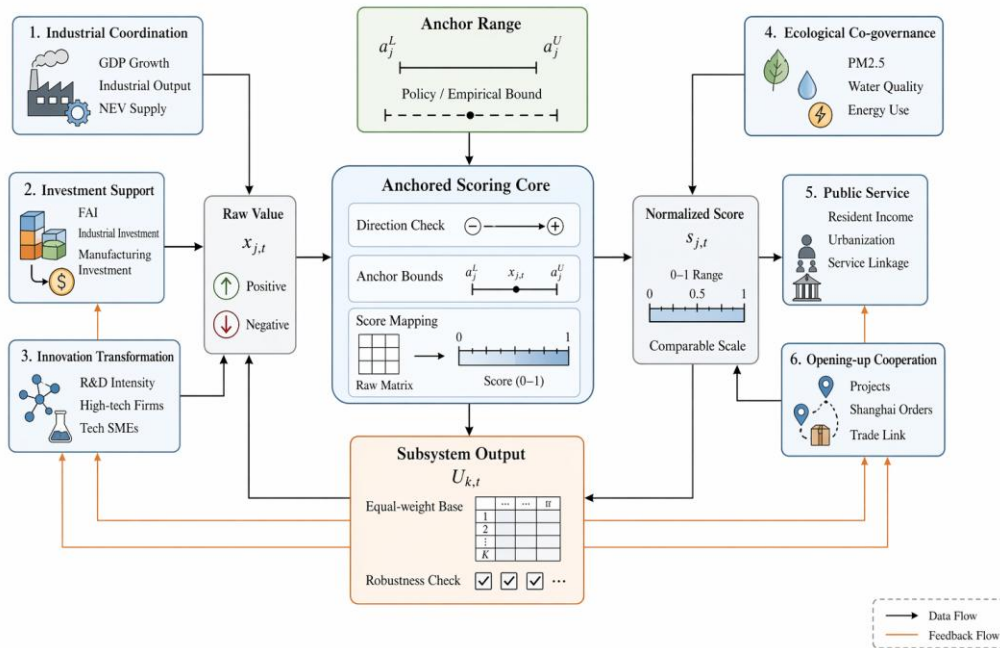


Figure 2: the indicator construction mechanism.

The second step is the calculation of the composite score of the subsystems. The six subsystems are treated with equal weights internally, mainly because the sample years are short, and it is easy to misjudge the abnormal fluctuation of a single indicator as a structural difference if differentiated weights are used directly on the basis of two years of data. The entropy weight method can reflect the indicator dispersion and is suitable as a reference for robustness testing [20]; SBM and super-efficient SBM models can deal with input-output slack in efficiency evaluation and are also suitable for testing the direction of regional development evaluation [21, 22]. The base measurement of this paper retains the equal weighted results and compares the entropy weighted results with the baseline results in additional tests to see if they change the main judgment. The subsystem score is calculated as follows:

$$U_{k,t} = \sum_{j=1}^{n_k} \omega_{j,k} S_{j,t}, \quad \sum_{j=1}^{n_k} \omega_{j,k} = 1 \quad (2)$$

In the formula, $U_{k,t}$ is the comprehensive score of the k th subsystem in the year t , n_k is the number of indicators included in the subsystem, and $\omega_{j,k}$ is the weight of the j th indicator in the k th subsystem. The industrial synergy subsystem is mainly composed of GDP growth, the growth rate of added value of regulated industry, the growth rate of output value of strategic emerging industries, the number of supporting enterprises of new energy vehicles and the number of supporting enterprises of Hefei industry; the investment support subsystem is mainly composed of investment in fixed assets, industrial investment, investment in the manufacturing industry and completion of major projects; the innovation transformation subsystem is mainly composed of the intensity of R&D investment, the number of high and new technology enterprises, the number of science and technology-based SMEs, technology contracts or R&D platform data. The innovation transformation subsystem is mainly composed of R&D investment intensity, the number of high-tech enterprises, the number of science and technology-based small and medium-sized enterprises (SMEs), and the data of technology contracts or R&D platforms; the ecological governance, public service and open cooperation subsystems correspond to the ecological and environmental quality, the income of the residents and the public service, the cooperation in Yangtze River Delta and the outward-oriented economy indicators.

The third step is functional block aggregation. The six subsystems are not independent of each other in their actual role. Industrial synergy needs investment support to form project bearing, innovation transformation needs ecological and green development conditions to constrain industrial quality, and public service and open cooperation jointly affect the cross-regional flow of population, enterprises and market factors. In order to make the model results serve the path identification, this paper further aggregates the six subsystems into three functional blocks: production and market function, innovation and ecological function, service and open function. The aggregation formula is as follows:

$$P_t = (U_{ind,t} + U_{inv,t})/2, \quad I_t = (U_{inn,t} + U_{eco,t})/2, \quad S_t = (U_{pub,t} + U_{open,t})/2. \quad (3)$$

In the formula, P_t is the production and market function index, which consists of industrial synergy $U_{ind,t}$ and investment support $U_{inv,t}$; I_t is the innovation and ecology function index, which consists of innovation transformation $U_{inn,t}$ and ecological co-management $U_{eco,t}$; and S_t is the service and openness function index, which consists of public service $U_{pub,t}$ and open cooperation $U_{open,t}$. This process can transform the changes of individual indexes into changes of functional blocks, which makes it easy to judge whether the synergistic

ability of Lu'an in Hefei Metropolitan Area comes from industrial undertaking, innovation and ecology, public service, or open cooperation.

The fourth step is the coupling coordination diagnosis. In this paper, we use the form of three-system coupling to measure the degree of matching between production and market functions, innovation and ecological functions, and service and openness functions, and calculate the integrated coordination diagnostic value. The formula is as follows:

$$C_t = \frac{(P_t I_t S_t)^{1/3}}{(P_t + I_t + S_t)/3}, \quad T_t = (P_t + I_t + S_t)/3, \quad D_t = \sqrt{C_t T_t}. \quad (4)$$

where C_t is the coupling degree of the three functional blocks, T_t is the comprehensive development index, and D_t is the diagnostic value of coupling coordination. The closer C_t is to 1, the smaller the gap between the three functional blocks is; T_t reflects the overall development level; D_t is affected by the degree of system matching and the comprehensive development level at the same time. If a single indicator of industry or investment grows faster in a certain year, but innovation, public service and open cooperation do not improve simultaneously, T_t may improve and C_t and D_t will still be limited. This setting helps to identify structural contradictions in the synergistic development of Lu'an.

In interpreting the results, this paper does not set a rigid grade for D_t . Instead, the diagnosis is made by combining the subsystem scores, function block scores and changes in raw data. If D_t rises and is mainly driven by open cooperation, public services or innovation transformation, it indicates that the quality of synergy has improved; if D_t rises but the investment and industry scores fall back, it is necessary to determine whether there is a structural differentiation in the growth support. The model output eventually enters the path identification matrix, which is used to prioritize industrial chain embedding, transportation and factor mobility, innovation undertaking, eco-product value realization, public service co-location and open cooperation.

2.3 Diagnostic protocol and path identification

After the model calculation is completed, this paper adopts the diagnostic protocol of "subsystem score, functional block coupling, raw data review, and policy carrier verification" to identify the path. The subsystem score is used to judge in which areas Lu'an has a foundation, the functional block coupling is used to judge whether there is a match between industry, innovation, ecology, public service and open cooperation, the raw data review is used to avoid standardized scores masking the real economic meaning, and the policy carrier verification is used to judge whether the path can be implemented in parks, projects and institutional arrangements. The protocol maintains correspondence between model results and policy recommendations.

The work of pathway identification commences with a comparison on the six subsystem scores between the year 2024 and the year 2025. When a subsystem's score goes up and at the same time the original indicators also get better, hence it is judged that the support has gotten promotion; If the score has a drop but the original data still keep the increasing situation, therefore the anchoring intervals and the adjacent indicators are further checked by us, hence we can find out whether there exists a divergence. if the score rise mainly comes from the promotion of a single index, it is hence judged as a localized improvement, thus avoiding the direct extension into a systemic conclusion. Take openness and cooperation as the example, Lu'an's agricultural product sales toward Shanghai, the order quantity from Shanghai enterprises, and the project number above 100 million yuan in Shanghai, Suzhou, and Zhejiang in 2025, all have clear data support, therefore, the rise of openness and cooperation score can be explained as the enhancement of market connectivity. On the aspect of investment support,

for example, industrial investment increased by 19.8% in 2025, but fixed asset investment decreased by 5.3%, this shows that industrial projects still have resilience, while the overall investment support is pulled down by the structure.

Path identification is followed by calibration in combination with platform and policy text. Jinan Economic Development Zone, Lu'an Economic and Technological Development Zone, Shucheng Economic Development Zone, Huoqiu Iron-Based Materials Platform, Jinzhai New Energy Platform and Huoshan Biomedical Platform are the main spatial carriers for Lu'an to undertake the industrial functions of Hefei Metropolitan Area. If a path lacks a clear platform, it is not directly judged as a prioritized path even if the indicator score is high; if platforms, projects and institutional arrangements exist in a path but the indicator score is low, it is classified as a path to fill in shortcomings. This treatment is suitable for node cities such as Lu'an, because the quality of its synergistic development is affected by both economic indicators and cross-city systems, park permissions, transportation corridors and public service interfaces.

Finally, this paper translates the diagnostic results into six types of paths: industrial chain embedding, transportation and factor mobility, innovation undertaking, eco-product value realization, public service co-location and open cooperation. Industry chain embedding focuses on whether Lu'an can shift from general manufacturing undertaking to stable supporting of main enterprises in Hefei chain; transportation and factor flow focuses on whether expressway, high-speed railway, park logistics and cross-city commuting can jointly reduce the transaction cost; innovation undertaking focuses on whether Hefei's science and innovation resources can enter into Lu'an's pilot test, testing and enterprise R&D link; ecological product value realization focuses on whether Dabie Mountain ecological resources can form consumption, financial and compensation benefits; public service co-location focuses on whether talent, employment, health insurance, education and housing services can reduce the cost of cross-city mobility; and openness and cooperation focuses on whether stable orders, parks and branding channels can be formed between Lu'an and Shanghai, Shanghai, Suzhou and Zhejiang cities. To enable the model results to be translated into policy paths, this paper incorporates subsystem diagnosis, functional block coupling and path calibration into the same evaluation protocol, as shown in Figure 3.

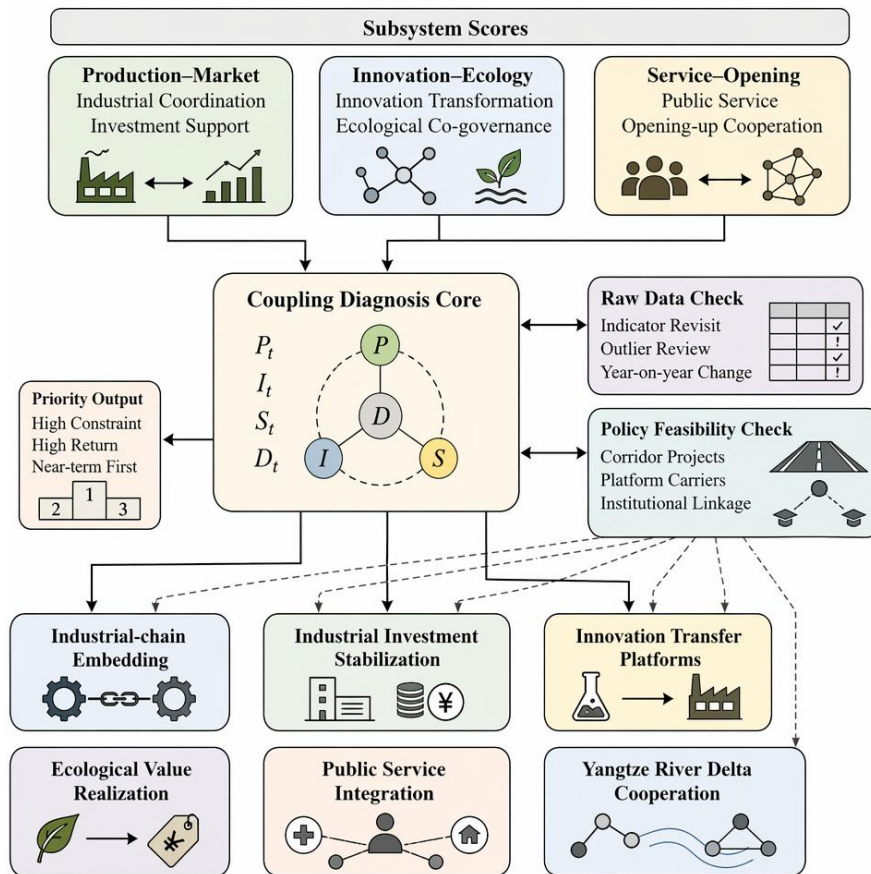


Figure 3: Coupling diagnosis and policy pathway validation protocol

In Figure 3, the six subsystems are first aggregated into three functional blocks and then into a coupled and coordinated diagnostic; the results of the diagnostic are mapped to the six types of development paths after looking back at the raw data and calibrating the policy vectors. This protocol enables the Results and Discussion section to focus on "what is the result, what is the reason, and how to implement the pathway", rather than leaving the model results at the level of a composite index.

3 Results and Discussion

3.1 Lu'an's realistic foundation for synergistic development

This section first answers the question of whether Lu'an has a realistic foundation for deep integration into the Hefei metropolitan area. To judge this question, we cannot only look at the total GDP, but also need to examine the industrial growth, investment structure, science and innovation support, ecological conditions, public services, and openness and cooperation at the same time. 2024-2025 data show that the total economic output of Lu'an has continued to expand, the industrial and strategic emerging industries have maintained growth, the new energy automobile supporting system has expanded significantly, and the ecological and cultural and tourism resources have strong support. strong support; at the same time, fixed asset investment turns from positive to negative, and innovation intensity is still lower than the demand for high-quality synergistic development. The key indicators are shown in Table 3.

Table 3: Key Indicators of Synergistic Development in Lu'an City, 2024-2025

Field	2024 Data	2025 Data	Diagnostic Implications
GDP	230.75 billion yuan, growth 5.4%	240.73 billion yuan, growth 5.4%	Economic scale expands, growth rate remains stable
Tertiary Industry Structure	12.4:36.3:51.3	11.9:35.0:53.1	Proportion of services increases, industry remains core
Value Added in Large-Scale Industries	Growth 8.9%	Growth 7.1%	Industry maintains growth, marginal decline in growth rate
Strategic Emerging Industries	Growth 10.8%	Growth 12.6%	Emerging industries grow faster than GDP
Fixed Asset Investment	Growth 8.3%	Decline 5.3%	Overall investment support weakens
Industrial Investment	Growth 19.6%	Growth 19.8%	Manufacturing resilience remains
Manufacturing Investment	Growth 14.4%	Growth 7.2%	Expansion of manufacturing investment slows down
New Energy Vehicle Support	Hefei's supporting enterprises and revenue begin to expand	304 enterprises registered, expected revenue 45 billion yuan	Strengthened connection in the industrial chain
R&D Intensity	Improvement in scientific achievements and patent indicators	1.54%	Innovation investment still needs to increase
Resident Income	29,832 yuan for all residents	31,650 yuan for all residents	Improvement in public services and consumption support
Cultural and Tourism Consumption Agglomeration Area	68.693 million tourists, revenue 52.2 billion yuan	79 million tourists, consumption 60.1 billion yuan	Enhanced ecological and cultural tourism transformation capacity
Yangtze River Delta Cooperation	142 projects in Shanghai, Suzhou, and Zhejiang, total investment 40.4 billion yuan	150 projects in Shanghai, Suzhou, and Zhejiang, total investment 33.44 billion yuan	Increase in project quantity, decrease in individual project scale

In order to observe the changes of economic and industrial support, this paper compares the GDP growth rate, the growth rate of value added of the industrial sector, the growth rate of output value of strategic emerging industries, the growth rate of value added of the service sector and the growth rate of industrial investment, as shown in Fig. 4.

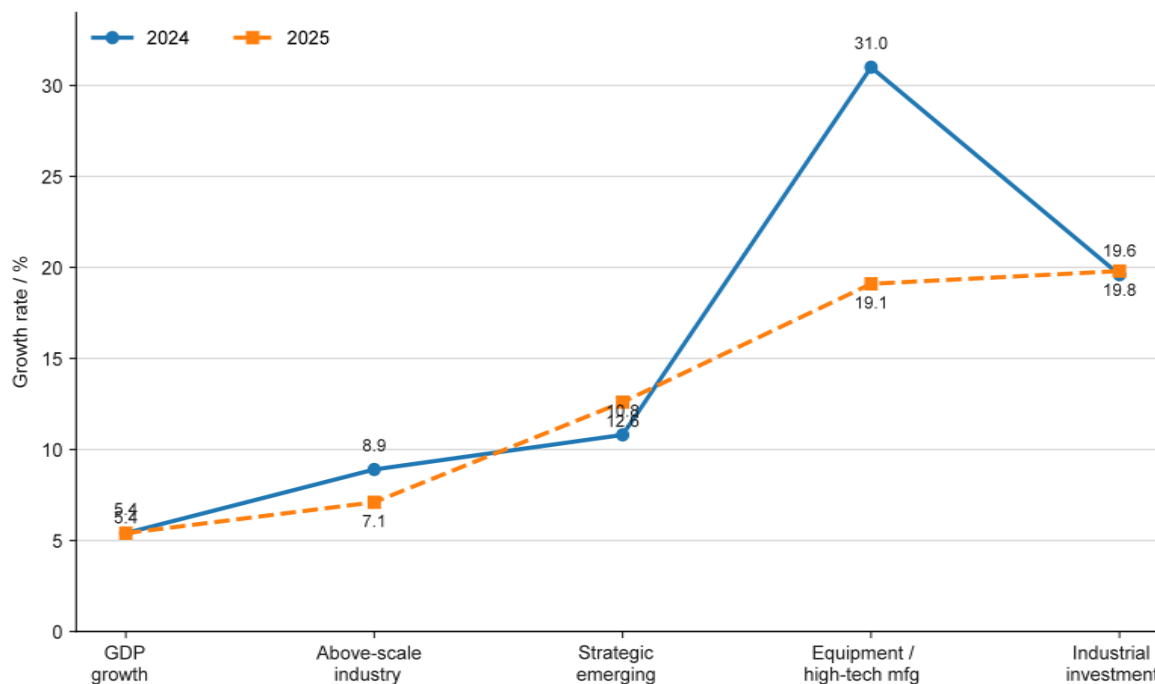


Figure 4: Change in macro-industrial support indicators, 2024 – 2025

In Fig. 4, the GDP growth rate remained at 5.4% for two consecutive years, indicating the stability of Lu'an's economic expansion. The growth rate of value-added of regulated industry decreased from 8.9% to 7.1%, still higher than the GDP growth rate, but the momentum of industrial growth has slowed down. The growth rate of output value of strategic emerging industries rose from 10.8% to 12.6%, indicating that the support of emerging industries for industrial upgrading was enhanced. The growth rate of value-added of the service industry rose from 3.5% to 5.9%, indicating that living services, cultural and tourism consumption and improved public services began to play a role in stabilizing the economy. The continuous growth of industrial investment of more than 19% is the main support for Lu'an to undertake the manufacturing spillover from Hefei.

The divergence of investment structure better explains the pressure of coordinated development in Lu'an. Fixed asset investment will grow from 8.3% in 2024 to 5.3% in 2025, while industrial investment will grow by 19.6% and 19.8%, and manufacturing investment will grow by 14.4% and 7.2%. This set of data shows that the problem of investment in Lu'an is mainly manifested in the total amount of pressure and structural differentiation. Industrial investment still remains high, reflecting industrial undertaking and project construction has not lost support; fixed asset investment turned negative, indicating that real estate, part of the infrastructure and service sector investment on the overall investment drag. The structure of investment in Luan City is shown in Figure 5.

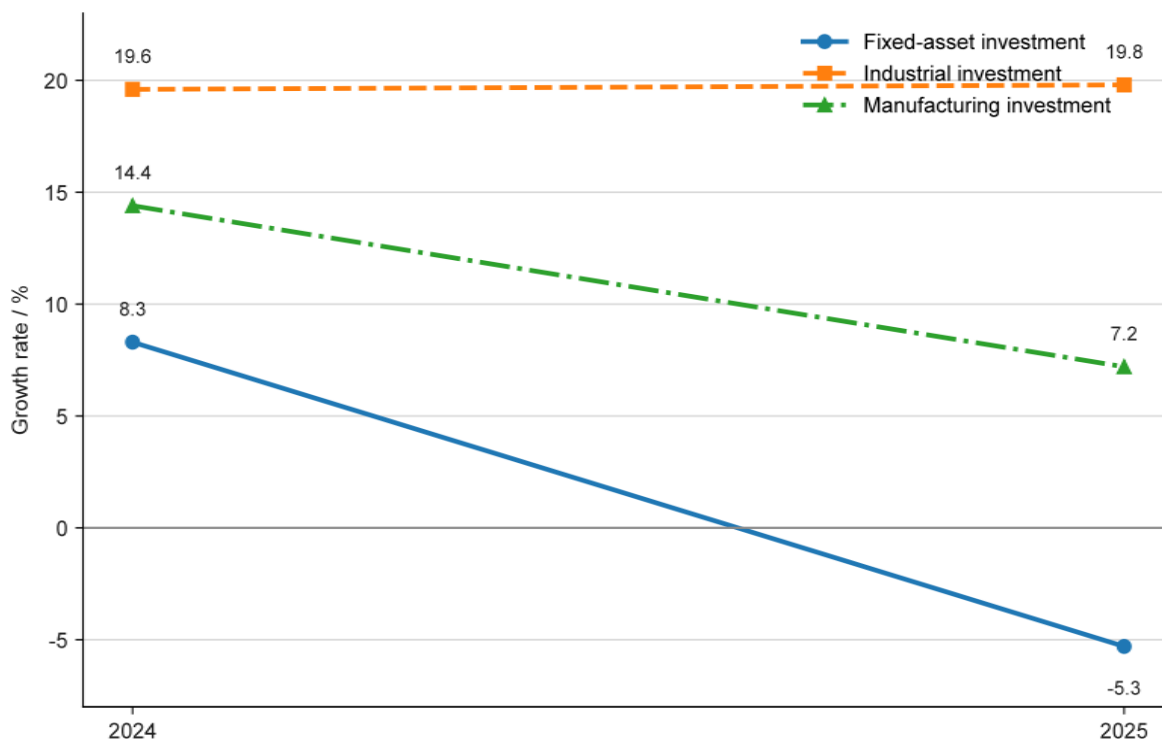


Figure 5: Divergence of investment structure in Lu'an, 2024 - 2025 (Move the label of the dividing line upward)

In Figure 5, the industrial investment curve remains high, the manufacturing investment curve falls back but remains positive, and the fixed asset investment curve goes down through zero. The structure has a direct impact on the subsequent path selection. Lu'an can't simply understand expanding investment as increasing the number of projects, but should prioritize stabilizing industrial investment and manufacturing investment, and invest financial funds, special bonds, policy financial instruments and park resources in new energy automobile parts, electronic information, new materials, deep processing of green food, and productive service industry. Only the investment structure and the Hefei metropolitan area industrial chain demand match, the synergistic development of Lu'an can shift from project undertaking to functional embedding.

From the subsystem calculation, the scores of industrial synergy, investment support, innovation transformation, ecological governance, public service and open cooperation in Lu'an are 0.784, 0.750, 0.677, 0.766, 0.483 and 0.335 respectively in 2024, and 0.686, 0.570, 0.633, 0.756, 0.572 and 0.646 respectively in 2025. The scores of industrial synergy and investment support have dropped, mainly affected by the marginal slowdown of registered industry and negative fixed asset investment; the scores of public service and openness and cooperation have risen, mainly due to the improvement of residents' income, cultural and tourism consumption, cooperation with Shanghai and Yangtze River Delta projects. The diagnostic value of comprehensive coordination rises from 0.781 to 0.802, indicating that the overall degree of matching has improved, but the source of improvement does not come mainly from industry and investment, but from services, openness and regional cooperation.

This result is consistent with the judgment of the city cluster coordination study. Manufacturing undertakings can form a short-term growth support, but for node cities to obtain

higher-quality synergistic gains, they need to be supported by productive services, public services, innovation networks and open cooperation [23-25]. The current advantage of Lu'an lies in the simultaneous existence of industrial spillovers from Hefei and ecological resources of Dabie Mountain, while the pressure lies in the coexistence of high industrial investment growth and downward trend of total investment, and the coexistence of enhanced industrial connectivity and insufficient innovation intensity. The subsequent path needs to be centered around these differentiated relationships.

3.2 Synergy shortcomings and structural constraints

The previous section showed that Lu'an has a foundation for integration into the Hefei metropolitan area, but the foundation is uneven. This section further analyzes the source of short boards. The judgment of short board is not only based on the high or low level of a certain index, but also combines the location of the industrial chain, the innovation undertaking ability, the investment structure, the transformation of ecological value and the depth of open cooperation. Lu'an's current major problems are focused on three aspects: the level of industrial chain embedding still needs to be improved, innovation and productive service support is weak, and transportation and open cooperation have not yet been fully transformed into local high value-added capacity.

The change of industrial synergy is firstly reflected in the supporting system of new energy automobile. 2025, Lu'an City has 304 new energy automobile supporting enterprises in the database, including 205 parts and components enterprises and 99 after-market enterprises, and it is expected that the annual revenue will be 45 billion yuan, which is 66% more than that of the previous year; there are already 91 new energy automobile parts and components enterprises in the city to support the vehicle enterprises in Hefei, and 44 electronic information enterprises have cooperated with the enterprises in Hefei. Cooperation with Hefei enterprises. The data shows that Lu'an and Hefei has formed a clearer industrial chain connection. The problem is that at this stage, Lu'an is more responsible for parts manufacturing, material supply, testing and certification and after-market services, and the links of high-end R&D and design, system integration, industrial software and supply chain finance are still weak. The industrial embedding between Lu'an and Hefei metropolitan industry chain is shown in Figure 6.

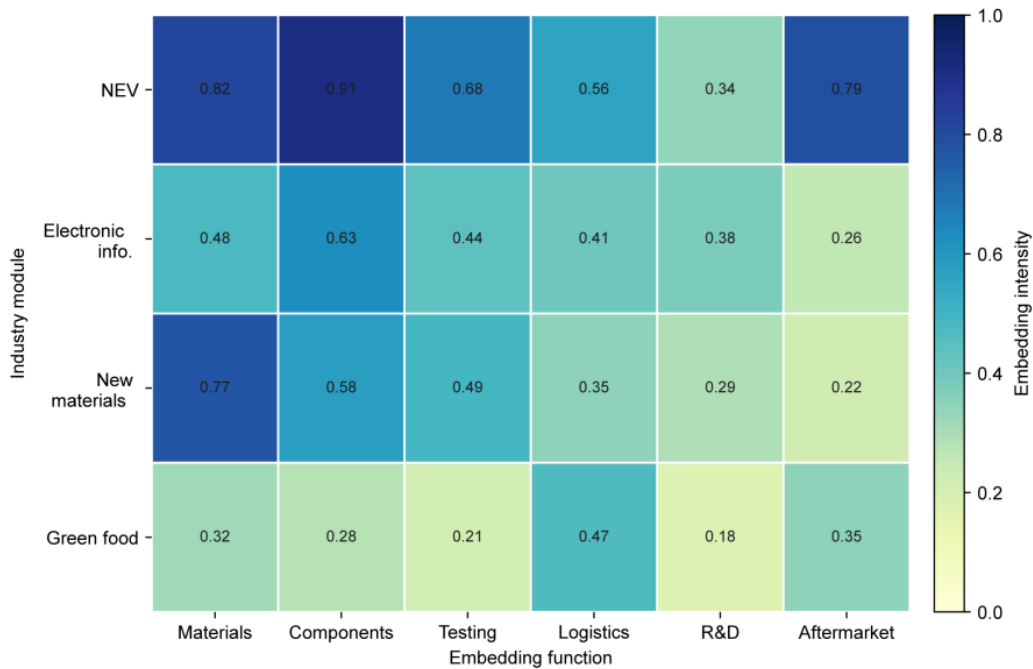


Figure 6: Industrial embedding between Lu'an and Hefei metropolitan industrial chains

In Figure 6, the number of supporting enterprises for new energy vehicles, the number of supporting enterprises for Hefei vehicles, and the number of cooperative enterprises for electronic information constitute the main evidence of industrial embedding. The hotter modules in the figure are concentrated in parts and components, aluminum-based lightweight die-casting, battery recycling, electronic materials and after-market services, while the weaker modules are concentrated in R&D and design, brand channels, industrial software, supply chain finance and high-end testing. The structure indicates that Lu'an has entered the Hefei metropolitan area industrial chain, but the embedded level is still biased towards the manufacturing and supporting end. The synergistic agglomeration of manufacturing and productive service industries will affect the quality of industrial upgrading and green development [23-25], therefore, it is not appropriate for Lu'an to follow up by only expanding the number of supporting enterprises, but also by synchronizing the R&D, testing, logistics, financial and digital services.

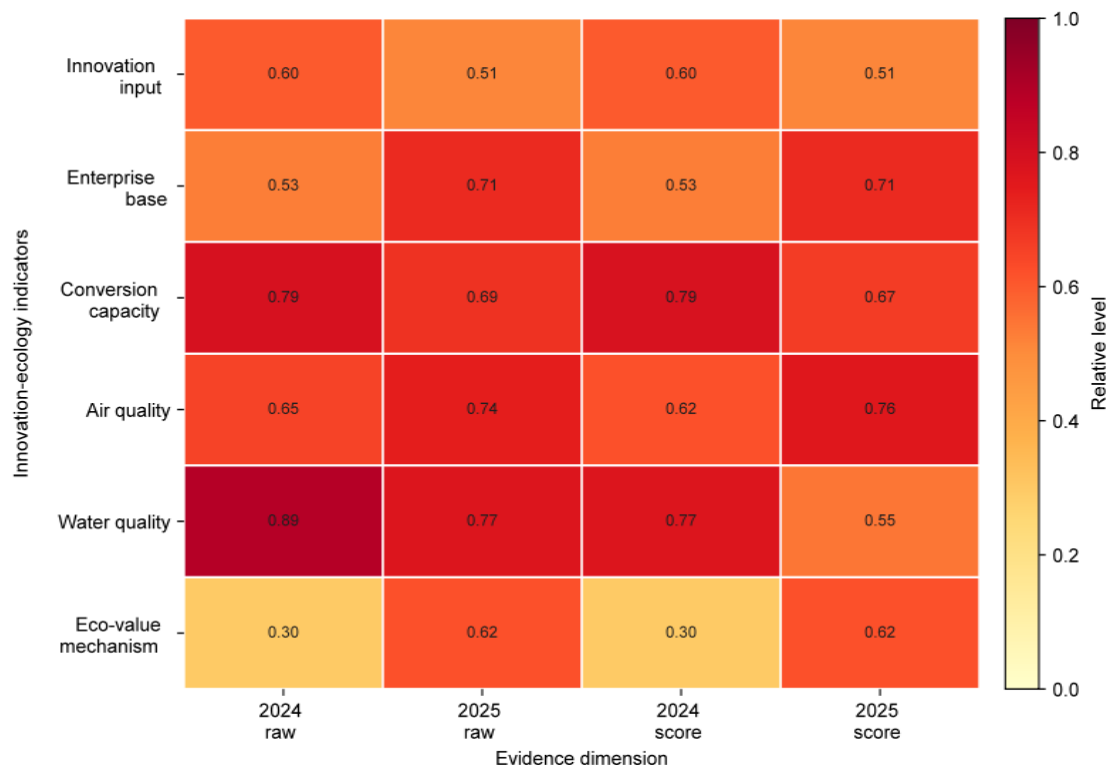


Figure 7: Innovation and ecological support matrix

In Figure 7, innovation transformation and ecological governance are put into the same matrix. Lu'an's ecological indicators are in a high range, and matters such as the pilot of the mechanism for realizing the value of ecological products, the trading of water rights, forestry carbon tickets, new energy installations and zero-carbon parks will appear in the green development in 2025; while the innovation indicators show an increase in the number of business entities but a low R&D intensity. The matrix shows that Lu'an has the conditions to constrain the quality of industry with ecological advantages, and also has the resource base to develop green manufacturing, green food and culture, tourism and recreation, but the innovation and transformation ability still needs to be strengthened. If there is a lack of pilot platforms and enterprise R&D investment, it is more difficult to stably transform ecological resources into high value-added industries.

The comprehensive diagnostic results further reveal the system differentiation: the scores of production and market function, innovation and ecology function, and service and openness function are about 0.767, 0.722 and 0.409 respectively in 2024, and 0.628, 0.695 and 0.609 respectively in 2025; the decline of production and market function is mainly caused by the downturn of fixed asset investment and the slowing down of the industrial sector, and the slight decline of innovation and ecology function is mainly caused by the downturn of fixed asset investment and the slowing down of the industrial sector, while the decline of innovation and ecology function is mainly caused by the slowing down of the industrial sector. The production and market function declines mainly due to the downward investment in fixed assets and the slowdown of the above industry; the innovation and ecological function declines slightly, mainly affected by the R&D intensity and the insufficient transformation of innovation; the service and openness function rises significantly, mainly from the improvement of the residents' income, the consumption of tourism, the cooperation with Shanghai, the projects of Shanghai, Suzhou and Zhejiang and the government services. The diagnostic value of comprehensive

coordination rises from 0.781 to 0.802, indicating an improvement in the balance of the system, but the support for growth is shifting from industrial and investment-led to service and openness-driven. Figure 8 shows a three-dimensional diagnostic plot of the results data section, with the six subsystems on the horizontal axis, the years on the vertical axis, and the standardized scores on the vertical axis.

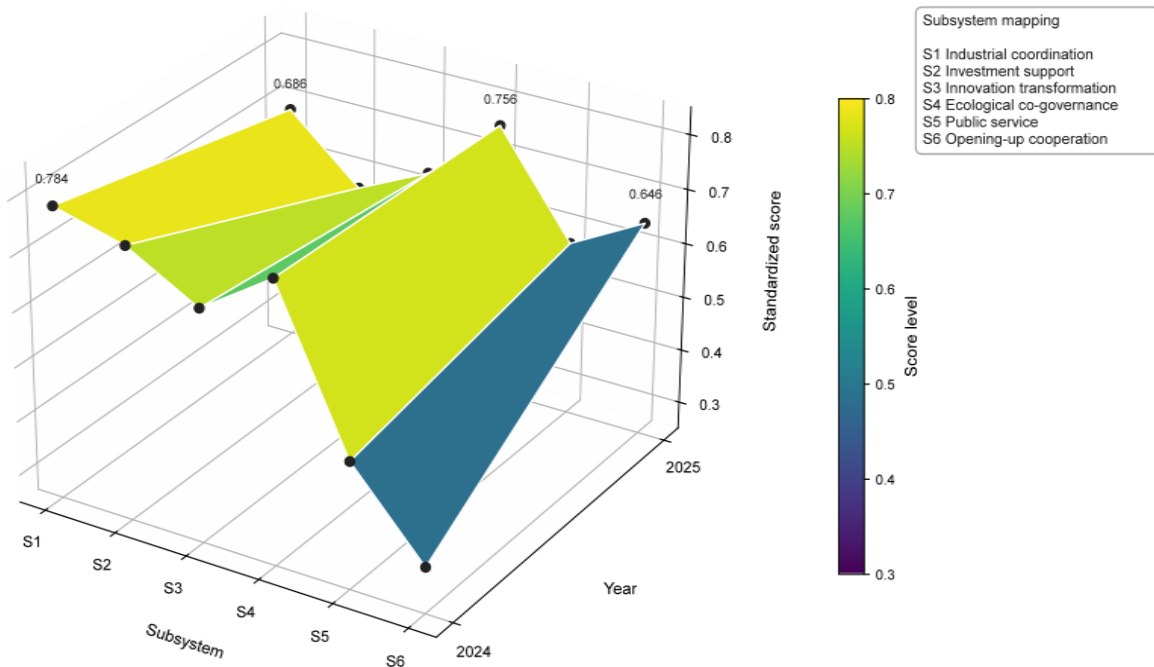


Figure 8: Three-dimensional diagnostic surface of subsystem support scores.

In Fig. 8, in 2024, industrial synergy and investment support form a high point, and open cooperation and public service form a low point; in 2025, open cooperation and public service rise significantly, investment support and industrial synergy fall, and ecological co-management remains relatively stable. The change of three-dimensional surface shows that the synergistic development of Lu'an is not linearly enhanced, but the support structure is transformed. If the subsequent industrial investment remains high, the innovation transformation improves, and the open cooperation continues to expand, the comprehensive coordination value still has room for improvement; if the total investment continues to decline and is transmitted to the manufacturing investment, the existing industrial synergy foundation will be weakened.

Similar problems exist in transportation and open cooperation. 2025, the entire G312 HeLu Expressway will be open to traffic, Hefei-Wuhan High Speed Railway, Luqing Railway, South Xinxhe Railway and other projects will be promoted, and the construction of nodes, such as Lu'an North Railway Station and Jinzhai East Railway Station, will be accelerated. These facilities can reduce logistics, commuting and project organization costs between Lu'an and Hefei. Transportation studies have shown that high-speed rail and highways can enhance urban innovation links and regional resilience [28, 29]. However, for transportation improvements to be translated into local benefits for Lu'an, industrial park logistics, cross-city public transportation, commuter ticketing, talent services, and public service sharing need to be followed up simultaneously. If the system interface is not perfect, the transportation improvement may expand Hefei's absorptive capacity, and Lu'an's platform gains will be weakened.

In terms of openness and cooperation, in 2025, Lu'an signed 150 new projects above 100

million yuan in Shanghai, Suzhou and Zhejiang, with a total investment of 33.44 billion yuan; sales of agricultural products to Shanghai amounted to 24.26 billion yuan, a year-on-year increase of 17.5%; and 143 regulated industrial enterprises have established cooperative relationships with Shanghai enterprises, with an order amount of 7.66 billion yuan. The rising score of openness and cooperation is supported by real data. It should be noted that the number of projects in Shanghai, Suzhou and Zhejiang has increased, but the total investment has decreased compared with 2024, indicating that the scale of individual projects has become smaller; the sales of agricultural products and industrial orders in the cooperation with Shanghai have grown faster, but industrial standards, brand channels, cold chain logistics, park construction and R&D synergy still need to be deepened. Regional integration contributes to the green and low-carbon development of cities and urban-rural integration [30], and Lu'an should extend this cooperation from sales and orders to standards, brands, technologies and benefit-sharing mechanisms.

3.3 Module Ablation, Efficiency Analysis, Sources of Error, and Implications for Deployment

Based on the diagnosis in the previous two sections, the high-quality collaborative development of Lu'an should be centered on "embedding industrial chain, stabilizing investment structure, undertaking innovation, transforming ecological value, co-citizenization of public services, and deepening open cooperation". Path arrangements need to match the division of labor with the Hefei metropolitan area functions, but also to the existing platform in Lu'an. Lu'an should not use the generalized "full integration" as a policy expression, but should prioritize according to the shortcomings of the subsystem. The organic combination of public services, tourism consumption and openness and cooperation is shown in Figure 9.

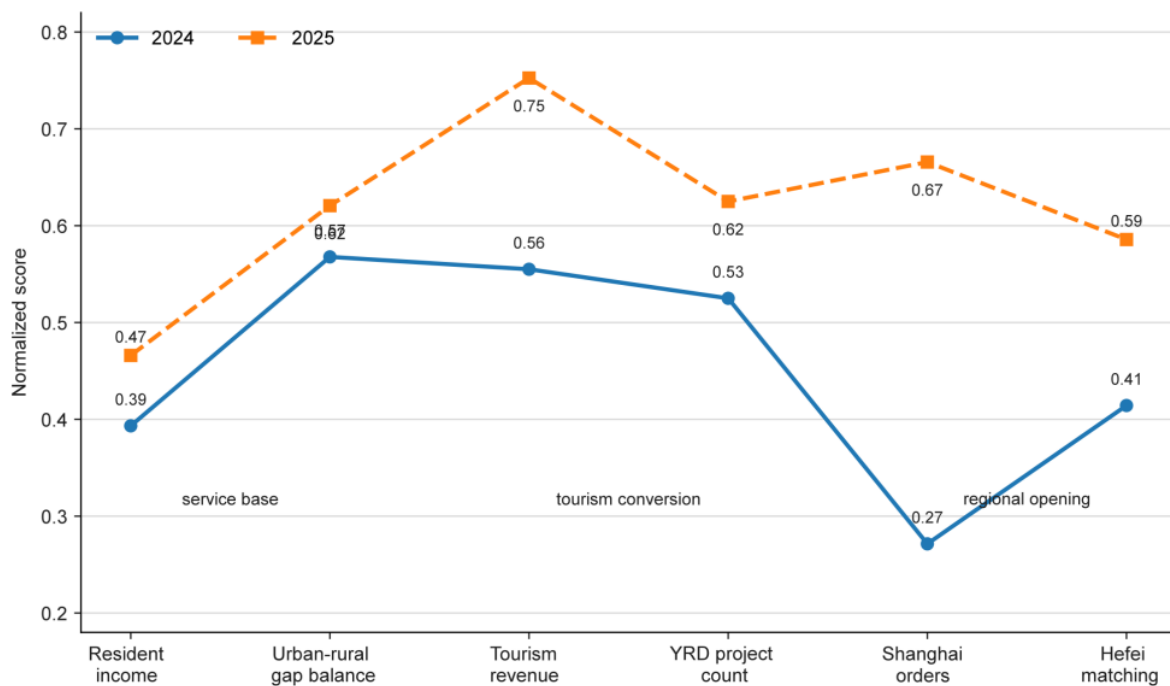


Figure 9: Coupling of public service, tourism consumption and opening-up cooperation.

In Figure 9, residents' income, number of tourists, tourism spending, number of projects in Shanghai, Suzhou and Zhejiang, sales of agricultural products to Shanghai and orders from

Shanghai enterprises reflect the service and openness function. In 2025, the per capita disposable income of the whole population will reach RMB 31,650, the urban/rural income ratio will be reduced from 2.15 to 2.10; the city will receive 79 million tourists, and the total spending on tourism will be RMB 60.1 billion; sales of agricultural products to Shanghai will reach RMB 24.26 billion, and orders from Shanghai enterprises will reach RMB 7.66 billion. The sales of agricultural products to Shanghai reached 24.26 billion yuan, and the orders from Shanghai enterprises reached 7.66 billion yuan. These indicators show that the synergistic development of Lu'an has expanded from a single manufacturing undertaking to include consumption, culture and tourism, agriculture, and open cooperation. Rising service and openness functions are the main source of improvement in the 2025 Comprehensive Coordination Diagnostic Value.

The first path is to raise the embedding level around the Hefei dominant industrial chain. Lu'an should establish a demand list of main enterprises in the Hefei chain, a capacity list of supporting enterprises in Lu'an, and a list of key links to make up for shortcomings, focusing on services for new energy automobiles, electronic information, new materials, high-end equipment, and green food processing. Jinan Economic Development Zone can focus on new energy auto parts, hydrogen energy equipment, electronic information and testing and certification; Shucheng Economic Development Zone can rely on the advantages of neighboring Hefei urban area to develop electronic information, new display and intelligent manufacturing supporting; Huoqiu can rely on iron-based materials and mineral resources to serve high-end equipment and automotive materials; Jinzhai and Huoshan can form a node of specialties around new energy, green food, biomedicine and recreation services. The core indicators of this path should be shifted from the number of enterprises to the proportion of stable orders from the main enterprises of the Hefei chain, the technological content of supporting products, the number of R&D collaborations and the contribution of local tax sources.

The second path is to stabilize industrial investment and improve the quality of project selection. 2025 fixed asset investment in Lu'an declined by 5.3%, but industrial investment grew by 19.8% and manufacturing investment by 7.2%. This shows that Lu'an still has the ability to take over the manufacturing industry, but the total investment structure is under pressure. Follow-up should be policy funds, special bonds, equipment renewal, park funds and investment resources more investment in manufacturing, productive services and infrastructure to fill the short board. Higher dependence on real estate, unstable financial returns or weak industry-related projects should be reduced in priority; to be able to enter the Hefei industrial chain, make up the testing and certification, industrial software, supply chain services and green manufacturing capacity of the project, should improve the intensity of land, financial and approval support.

The third path is to build a pilot and result transformation platform for Hefei's science and innovation resources. Lu'an already has 950 high-tech enterprises and 1965 science and technology-based SMEs, but the R&D intensity is only 1.54%. The follow-up should focus on the construction of pilot platforms for new energy auto parts, aluminum-based lightweight die-casting, battery recycling, green food deep processing, intelligent equipment and biomedicine. For the results formed by Hefei universities and institutes, comprehensive national science centers and new R&D institutions, Lu'an should provide process validation, scenario testing, industrialization plant and order docking. For local enterprises, a linkage support mechanism should be established for "R&D investment, technological reform projects, technology contracts, first set of products, specialized and special new enterprises" to improve the ability of enterprises to absorb external knowledge.

The fourth path is to transform the Dabie Mountain ecological resources into a metropolitan

area functional benefits. Lu'an ecological foundation is better, green development matters including ecological product value realization mechanism pilot, water rights trading, forestry carbon tickets, new energy installation, zero-carbon parks and regional tourism. Subsequently, ecological functions should be incorporated into the Hefei Metropolitan Circle's revenue distribution mechanism to promote water conservation, forest carbon sinks, green food, recreation, culture and tourism, and ecological compensation to form measurable revenue. For green food, the Yangtze River Delta standard certification, cold chain logistics and brand premiums should be strengthened; for cultural tourism and recreation, weekend tours, study tours, recreation tours and red cultural experience products should be constructed for the urban consumer groups in Hefei and Shanghai; and for ecological compensation, a mechanism that combines financial compensation, green finance, carbon trading and consumer procurement should be explored.

The fifth way is to push the same-ization of public services and cut the expense of cross-city movement of people and business bodies. The cooperation effect between Lu'an and Hefei cannot only depend on speed highways and high-speed rails, but also needs system connection surfaces such as employment, health insurance, education, housing, public reserve funds and talent assessment. Jinan, Shucheng and other zones which are adjacent to Hefei may give priority to push forward cross-city public traffic, commuter ticket selling, park shuttle buses, sharing of talent flats, cross-place settling of health insurance and linking of employment service works. To the enterprises, the putting-together of public service facilities can cut down the costs of recruiting workers and the costs of keeping able persons; To the residents, the together placing of public services can promote the convenience of cross-city work and living. The public services mark increases from 0.483 in year 2024 to 0.572 in year 2025, hence it shows that improvement has its foundation in this domain, but the systemization is still required.

The sixth path is to deepen openness and cooperation with Shanghai and the Yangtze River Delta. Cooperation between Lu'an and Shanghai has formed the basis for sales of agricultural products, industrial orders, cultural and tourism activities, and project investment. The next step should be to shift from single exhibition and order cooperation to stabilizing supply chains, brand channels, park co-construction and technical cooperation. The agricultural sector should focus on building the Yangtze River Delta green agricultural production and processing supply base, central kitchen, cold chain logistics and quality traceability system; the industrial sector should promote the entry of Lu'an enterprises into the manufacturing supply chain in Shanghai and the Yangtze River Delta; the park cooperation can explore the statistics and accounting, financial and tax sharing, project co-management and enclave incubation mechanism. Through the Yangtze River Delta cooperation, Lu'an can reduce its dependence on a single central city and improve the external market support for the collaborative development of the Hefei Metropolitan Area.

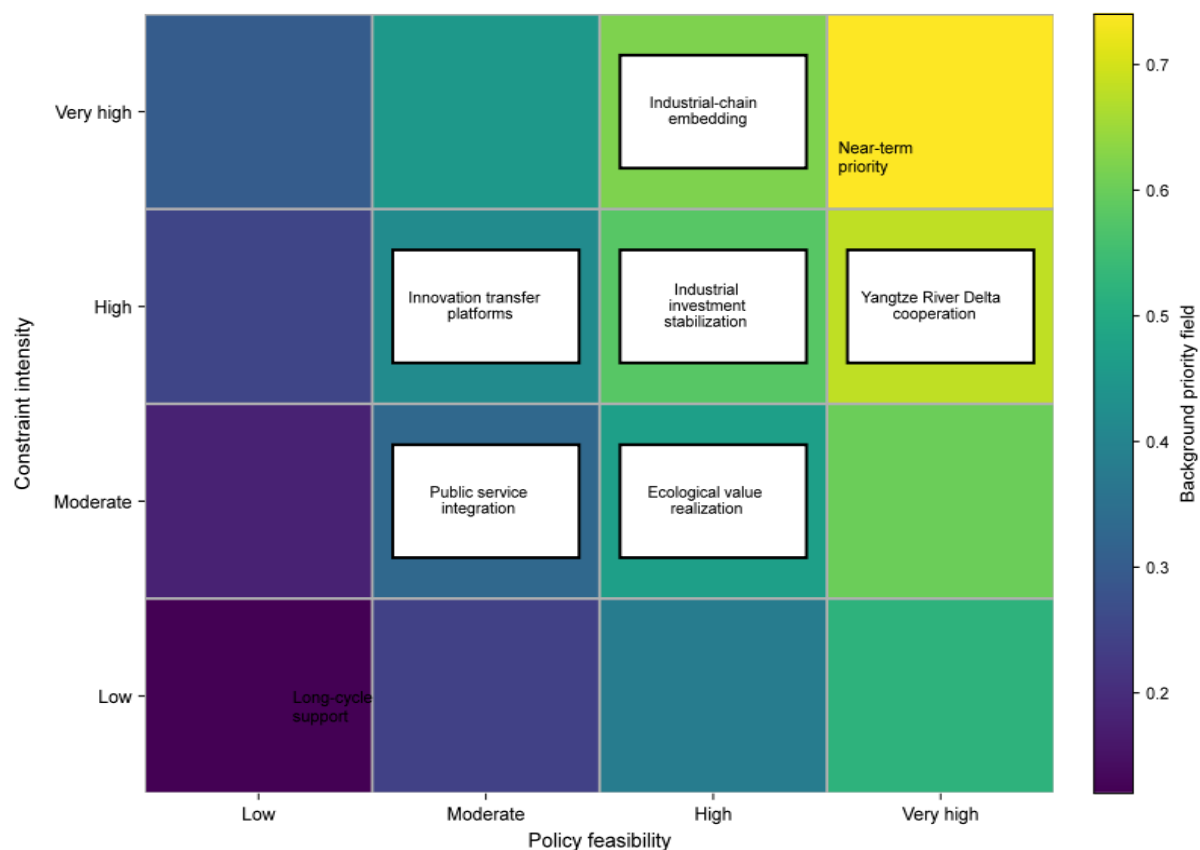


Figure 10: Priority matrix for high-quality coordinated development pathways.

In Figure 10, the horizontal axis is the policy operability, the vertical axis is the strength of constraints, and the size of bubbles (Replace with rectangle?) indicates the expected synergistic benefits. Industry chain embedding, industrial investment stabilization and innovation undertaking are located in the region of high constraints and high gains, which should be the priority path in the near future; ecological product value realization and open cooperation deepening are located in the region of medium and high gains, which are suitable for the path of sustained advancement; co-location of public services has a strong institutional dependence but has a large impact on population and enterprise mobility, which should be piloted in Jinan, Shucheng and other adjacent Hefei regions first. This prioritization is consistent with the model results: service and openness functions improve faster in 2025, but production and market functions decline, suggesting that Lu'an's next step must be to simultaneously stabilize its manufacturing capacity and expand the sources of revenue from service, openness and ecological value.

From a comprehensive point of view, Lu'an has already possessed the foundation of industry, transportation, ecology and openness under the strategy of Hefei Metropolitan Area, but the main contradiction of synergistic development has shifted from "whether to enter the metropolitan area" to "how to improve the quality of entry". The number of supporting enterprises for new energy vehicles, the number of supporting enterprises for Hefei industry, and the data on cooperation with Shanghai show that the external connection has been strengthened; the downward trend of fixed asset investment, the low R&D intensity, and the lack of productive service functions show that the internal support still needs to be supplemented. Subsequent policies should reduce broad statements and focus resources on key links in the industrial chain, the quality of industrial investment, science and innovation pilot platforms, eco-products value mechanisms, co-location of public services, and stable

cooperation networks in the Yangtze River Delta.

4 Conclusion

This paper focuses on the issue of high-quality synergistic development of Lu'an under the strategy of Hefei Metropolitan Area, constructs an evaluation framework consisting of industrial synergy, investment support, innovation transformation, ecological co-management, public service and open cooperation, and makes a systematic diagnosis of Lu'an's realistic foundation, structural shortcomings and path priorities in the light of the official statistics and plan reports for 2024-2025. In general, Lu'an has the conditions to enter the deep synergy of the metropolitan area, but the quality of development still depends on whether the embedded level of industrial chain, the stability of investment structure and the ability of innovation and transformation can be upgraded at the same time.

(1) This paper completes the unified organization of the object, data chain and evidence structure of coordinated development in Lu'an. The study incorporates the statistical bulletin, annual plan report and policy text into the same analytical framework, so that GDP, industry, investment, ecology, public service and open cooperation indicators can be accessed for comparison under a unified caliber. The results show that in 2025, Lu'an's GDP will be 247.73 billion yuan, the structure of the three industries will be further tilted towards the service industry, the number of tourists received will reach 79 million, the total tourism spending will reach 60.1 billion yuan, and the sales of agricultural products to Shanghai will reach 24.26 billion yuan. This shows that Lu'an has formed a clearer node characteristic of the metropolitan area in terms of economic aggregate, ecological supply and consumption acceptance.

(2) The methodology and results of this paper show that the main contradiction in the coordinated development of Lu'an has shifted from "whether to enter the metropolitan area" to "how to improve the quality of entry". In the year 2025, the industrial investment of Lu'an will have a 19.8 percent increase, and the quantity of new energy vehicle supporting enterprises will achieve 304, with an estimated total revenue that is 45 billion yuan.. In the year 2025, the industrial investment of Lu'an will have a 19.8% increase, and the new energy vehicle supporting enterprises will attain the number 304, with the estimated income being 45 billion yuan, this shows that the industrial chain connection and the manufacturing ability are still in the process of increasing; however, the investment on fixed assets will have a decrease of 5.3%, and the strength of R&D investment is only 1.54%, thus it indicates that between the support for growth and the support for innovation, there still exists a very big gap. According to the model, the diagnostic value of comprehensive coordination will increase from 0.781 in 2024 to 0.802 in 2025, which mainly comes from the improvement of public services, cultural and tourism consumption, and open cooperation, rather than the simultaneous enhancement of traditional industry and total investment. From this, it can be judged that Lu'an should subsequently focus its policies on the embedding of Hefei's dominant industrial chain, the quality of industrial investment, the pilot transformation platform, the realization of the value of ecological products, and the co-location of public services.

(3) This paper still has boundaries. The study is mainly based on annual statistics and policy data at the city level, and has not yet obtained continuous panels of counties and districts, microdata on enterprise orders, cross-city commuting flows and data on the whole process of technology transfer, so the portrayal of the synergistic mechanism is still biased towards structural diagnosis, and the explanations of the dynamic conduction and the differences between the counties are not yet sufficiently detailed. Subsequent studies can further introduce supporting relationships of enterprises in the park, innovation cooperation networks, population flows and public service utilization data to form a finer-scale spatial identification and policy

assessment framework, in order to improve the verifiability and operability of the high-quality synergistic development path in Lu'an.

Funding

This work was supported by Key Humanities and Social Sciences Research Project of Anhui Provincial Department of Education in 2025: Research on the High-Quality Collaborative Development Path of Lu'an City under the Hefei Metropolitan Circle Strategy, Project No.: 2025AHGXSK30313

About the Author

Yong Wen was born in Lu'an, Anhui, P.R. China, in 1981. He obtained a master's degree from the University of Science and Technology of China. He is currently working at the School of Economics and Management, Lu'an Vocational and Technical College. He holds the title of Associate Professor. His main research directions are economic management and higher vocational education management.

References

- [1] Guo, L., Tang, M., Wu, Y., et al. (2025). Government-led regional integration and economic growth: Evidence from a quasi-natural experiment of urban agglomeration development planning policies in China. *Cities*, 156, 105482.
- [2] Yao, L., & Luo, R. (2024). Decoding China's urban agglomerations policies: A scientific evaluation and exploration of economic benefits. *Habitat International*, 152, 103159.
- [3] Li, L., Ma, S., Zheng, Y., et al. (2022). Integrated regional development: Comparison of urban agglomeration policies in China. *Land Use Policy*, 114, 105939.
- [4] Du, Y., Cardoso, R. V., & Rocco, R. (2024). The challenges of high-quality development in Chinese secondary cities: A typological exploration. *Sustainable Cities and Society*, 103, 105266.
- [5] Guo, Y., Jiang, X., Zhu, Y., et al. (2024). Measurement and spatial correlation analysis of high-quality development level: A case study of Yangtze River Delta urban agglomeration in China. *Heliyon*, 10(8), e29209.
- [6] Yang, Z., Zhan, J., Wang, C., et al. (2024). Spatial spillover effects of conversion of new and old driving forces on high-quality development: Evidence from 283 cities in China. *Sustainable Cities and Society*, 108, 105487.
- [7] Ji, P., & Yuan, L. (2023). Whether polycentric spatial structure is conducive to regional coordinated development: A study on urban agglomerations in China. *Growth and Change*, 54(4), 940-961.
- [8] Liu, X., Derudder, B., Yu, B., et al. (2023). The impact of cities' transportation network

- connections on regional market integration: The case of China's urban agglomerations. *GeoJournal*, 88(6), 6539-6559.
- [9] Wang, Y., Cao, G., Yan, Y., et al. (2022). Does high-speed rail stimulate cross-city technological innovation collaboration? Evidence from China. *Transport Policy*, 116, 119-131.
- [10] Mao, N., Sun, W., & Zhang, L. (2024). The innovation effects of transportation infrastructure: Evidence from highways in China. *Economics of Transportation*, 38, 100352.
- [11] Zheng, Y., Collins, A., & Yao, S. (2024). Promoting sustainable and high-quality economic development in China via regional innovation poles. *Journal of Regional Science*, 64(3), 671-699.
- [12] Zhang, Y., Gao, T., & Sun, Y. (2025). Exploring the coupling coordination relationship and influencing factors between regional integration and urban land utilization green efficiency in the Yangtze River Delta, China. *Humanities and Social Sciences Communications*, 12, 1660.
- [13] Li, S., & Wu, L. (2024). Can regional integration promote industrial green transformation? Empirical evidence from Yangtze River Delta Urban Agglomeration. *Journal of Environmental Studies and Sciences*, 14(1), 117-134.
- [14] Li, S., & Wu, L. (2024). The impact of regional integration on PM2.5 concentrations: Quasi-natural experimental evidence from city economic coordination committee. *Growth and Change*, 55(3), e12732.
- [15] Gong, W., Wang, C., Men, D., et al. (2024). The influence and spatial spillover effects of producer services agglomeration on urban green development in China. *PLOS ONE*, 19(12), e0315870.
- [16] Zhang, Y., Zhu, T., Guo, H., et al. (2023). Analysis of the coupling coordination degree of the society-economy-resource-environment system in urban areas: Case study of the Jingjinji urban agglomeration, China. *Ecological Indicators*, 146, 109851.
- [17] Zeng, P., Wei, X., & Duan, Z. (2022). Coupling and coordination analysis in urban agglomerations of China: Urbanization and ecological security perspectives. *Journal of Cleaner Production*, 365, 132730.
- [18] Chang, Q., Sha, Y., & Chen, Y. (2024). The coupling coordination and influencing factors of urbanization and ecological resilience in the Yangtze River Delta Urban Agglomeration, China. *Land*, 13(1), 111.
- [19] Meng, Q., Pi, H., Nie, Y., et al. (2024). Research on the coupling and coordinated development of Guangxi's tourism industry, new urbanization and environmental health system in the post-epidemic era. *Frontiers in Public Health*, 12, 1331765.
- [20] Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, 27(3), 379-423.

- [21] Tone, K. (2001). A slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research*, 130(3), 498-509.
- [22] Tone, K. (2002). A slacks-based measure of super-efficiency in data envelopment analysis. *European Journal of Operational Research*, 143(1), 32-41.
- [23] Lei, H., Tang, C., & Long, Y. (2024). Study on the impact of digital economy on industrial collaborative agglomeration: Evidence from manufacturing and productive service industries. *PLOS ONE*, 19(8), e0308361.
- [24] Liu, Y., Li, L., & Yang, X. (2023). The impact of collaborative agglomeration of manufacturing and producer services on carbon emission intensity: Influence mechanism and spatial effect. *PLOS ONE*, 18(12), e0295948.
- [25] Wang, M., Wu, Y., Zhang, X., et al. (2024). How does industrial agglomeration affect internal structures of green economy in China? An analysis based on a three-hierarchy meta-frontier DEA and systematic GMM approach. *Technological Forecasting and Social Change*, 206, 123560.
- [26] Wang, Y., Wang, G., & Chen, G. (2025). Network externalities of the innovation network in China's five urban agglomerations: Based on "buzz-and-pipeline" theory. *Humanities and Social Sciences Communications*, 12, 1096.
- [27] Yan, L., Fu, Y., & Wang, J. (2024). Innovative talent agglomeration, spatial spillover effects and regional innovation performance. *PLOS ONE*, 19(11), e0311672.
- [28] Liang, W., Wang, D., Gao, L., et al. (2025). Study on the impact of China's urban agglomerations' tiered spatial structure on regional economic resilience. *PLOS ONE*, 20(3), e0314538.
- [29] Fan, X., & Xu, Y. (2023). Does high-speed railway promote urban innovation? Evidence from China. *Socio-Economic Planning Sciences*, 86, 101464.
- [30] Chen, S., Du, Y., & Liu, Y. (2025). Regional integration and urban green and low-carbon development: A quasi-natural experiment based on the expansion of the Yangtze River Delta Urban Agglomeration. *Sustainability*, 17(8), 3621.