Co-evolution of China's New Quality Productive Forces and New-type Urbanization: A Postprint Study

Authors: Gao Shuai, Zhang Wuwei

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Abstract

To investigate the synergistic evolution mechanism between new quality productive forces and new-type urbanization, alleviate the contradictions between them, and facilitate the achievement of Chinese-style modernization development goals. Taking 31 provinces (municipalities and autonomous regions) in China as the research object, this study constructs a synergistic theoretical framework of "new quality productive forces-new-type urbanization", and employs the CRITIC weighting method and Haken synergetic evolution model to measure the levels of new quality productive forces and new-type urbanization across 31 Chinese provinces (regions), and analyze their synergistic evolution mechanism. The results indicate: (1) During the observation period, the levels of new-type urbanization and new quality productive forces improved significantly, with increasingly prominent spatial differentiation characteristics, presenting a regional development pattern of "eastern region leading, central region catching up, and western region lagging behind". (2) New quality productive forces play a dominant role in the dual-new composite system, serving as the core variable guiding the orderly evolution of the system. Simultaneously, positive feedback mechanisms exist both within and between systems, with the cumulative and self-reinforcing nature of internal system elements constituting the key driving force for the formation of positive feedback mechanisms. (3) The dual-new synergistic evolution has experienced two stages: "rapid advancement (2014-2020) and stable operation (2020-2023)"; spatially, it still exhibits a distribution characteristic of "strong east, weak west". Tailoring the cultivation of new quality productive forces and the construction of new-type urbanization to local conditions, optimizing the dual-new synergistic mechanism, and continuously injecting emerging elements into the dual-new system constitute the key path for achieving upward evolution of the dual-new system. The research findings can provide ideas and suggestions for realizing the synergistic development of new quality productive forces and new-type urbanization, resolving

contradictions between economic efficiency and social equity, and achieving the goals of Chinese-style modernization.

Full Text

A Study on the Co-evolution of New Quality Productivity and New Urbanization in China

GAO Shuai, ZHANG Wuwei
(School of Economics and Management, Shandong Agricultural University, Tai'an 271018, Shandong, China)

Abstract

This study aims to explore the co-evolution mechanism between new quality productivity and new urbanization, alleviate contradictions between them, and contribute to achieving Chinese-style modernization. Taking 31 provinces (municipalities and autonomous regions) in China as research objects, we construct a theoretical framework for the "new quality productivity-new urbanization" synergy, and employ the CRITIC weight analysis method and Haken co-evolution model to measure the levels of new quality productivity and new urbanization, and analyze their co-evolution mechanisms. The results show: (1) During the observation period, the levels of new urbanization and new quality productivity significantly improved, with spatial differentiation characteristics becoming increasingly prominent, presenting a regional development pattern of "the east leading, the middle catching up, and the west lagging behind." (2) New quality productivity plays a dominant role in the dual-new composite system and serves as the core variable driving the system's orderly evolution. Meanwhile, positive feedback mechanisms exist both within and between systems, and the cumulative and self-enhancing nature of internal system elements are key driving forces for forming these positive feedback mechanisms. (3) The co-evolution of the dual-new system has undergone two stages: rapid advancement (2014-2020) and stable operation (2020-2023). Spatially, it continues to exhibit a distribution pattern of "strong in the east and weak in the west." Cultivating new quality productivity and building new urbanization according to local conditions, optimizing the dual-new synergy mechanism, and continuously injecting emerging elements into the dual-new system are key paths to achieving upward evolution of the system. The findings provide references for achieving coordinated development of new quality productivity and new urbanization, resolving contradictions between economic efficiency and social equity, and attaining Chinese-style modernization goals.

Keywords: new quality productivity; new urbanization; co-evolution; Haken model

1. Theoretical Analysis

1.1 Theoretical Framework

The dual-new system is a composite system composed of two subsystems: new quality productivity and new urbanization. This system continuously enriches its internal elements with economic and social development, achieving evolution from disorder to order and from non-synergy to dynamic stable synergy. Based on the degree of influence of each subsystem on the composite system, subsystems can be divided into order parameters (dominant subsystems) and servo parameters (controlled subsystems). Identifying system order parameters is crucial for analyzing the system's co-evolution mechanism. To identify system order parameters and analyze the co-evolution mechanism between new quality productivity and new urbanization, this study constructs the following theoretical analysis framework.

New quality productivity generates new engines, new business forms, and new models that directly empower new urbanization. In the initial stage, new quality productivity mainly generates new engines through technological innovation, promoting the start of new urbanization. Technological innovation drives the development of high-end manufacturing and high-tech industries, creating numerous high-quality employment opportunities in cities that attract rural populations to urban areas, thereby advancing population urbanization. Simultaneously, technological innovation optimizes urban industrial structure and improves resource utilization efficiency, injecting new momentum into economic urbanization. As technological innovation deepens, new business forms gradually emerge. On one hand, intelligent living industries such as smart healthcare, intelligent transportation, and online education initially take shape, optimizing the urban industrial system, improving residents' quality of life, enhancing urban economic attractiveness and radiation capacity, and promoting economic and living urbanization. On the other hand, digital economy industries such as digital finance, e-commerce, and smart agriculture develop rapidly, blurring urban-rural boundaries, breaking urban-rural barriers, facilitating the flow of production factors between urban and rural areas, narrowing urban-rural gaps, and achieving integrated urban-rural development. Driven by new engines and new business forms, the economic growth model transforms toward green and digital development, boosting economic and ecological urbanization.

New urbanization indirectly feeds back to new quality productivity through factor agglomeration and market expansion. Living urbanization can stimulate residents' innovation vitality and create a social environment conducive to cultivating new quality productivity. The continuous demand for high-quality living services from urban residents can enhance their subjective initiative in participating in the cultivation process of new quality productivity, accelerating the digital and green transformation of the economy to generate new economic growth models. Population urbanization can strengthen population agglomeration effects, injecting sustained growth momentum into new quality produc-

tivity. On one hand, large numbers of labor forces entering cities can unleash urban innovation potential, agglomerate innovation elements, enhance technological innovation levels, and activate new economic development engines. On the other hand, population agglomeration expands demand for modern service industries, digital economy, and other emerging industries, broadening the development space for new business forms. Economic urbanization enhances economic vitality and lays a solid material foundation for the development of new quality productivity. The expansion of urban economic scale and improvement of industrial systems promote the development of new business forms such as digital economy and intelligent manufacturing, enhance innovation diffusion capacity and application transformation efficiency, and accelerate the generation of new quality productivity. Ecological urbanization stimulates green innovation demand and application scenarios, effectively guiding economic development toward green transformation. The green development concept of ecological urbanization generates demand for green technological innovation, providing broad development space for new business forms such as green patents and green manufacturing. Urban-rural integration promotes new quality productivity development through income synchronization and social security integration. Income synchronization narrows the urban-rural income gap, enhances rural consumption capacity, promotes the extension of emerging consumption forms derived from new business forms to rural areas, expands the scale of new business form development, and injects new vitality into new quality productivity. Social security integration improves the social security level of rural residents, reduces life uncertainties, stimulates their enthusiasm for integrating into urban life, promotes factor mobility, and feeds back to new quality productivity.

1.2 Indicator System Construction

1.2.1 New Urbanization Evaluation Indicator System Existing research mostly evaluates new urbanization levels from the "people-oriented" core concept, focusing on citizenization of agricultural transfer populations, improvement of urban social governance levels, and achievement of sustainable urban development. This study evaluates new urbanization from five dimensions: population, economy, living, ecology, and urban-rural integration, constructing a new urbanization evaluation indicator system (Table 1).

Table 1 New Urbanization Evaluation Indicator System

Dimension	Indicator	Calculation Method/Unit
Population Urbanization	Urban population proportion	Urban population / Total population
	Urban employment structure	Secondary and tertiary industry employment / Total employment

Dimension	Indicator	Calculation Method/Unit
	Urban unemployment rate	Urban unemployed population / Urban working-age population
Economic Urbanization	GDP per capita	Yuan/person
	Urban per capita retail sales of consumer goods	Yuan/person
Living Urbanization	Urban water supply 普及率	%
	Urban gas 普及率	%
	Per capita urban construction land area	Square meters
	Urban per capita park green space area	Square meters
Ecological Urbanization	Harmless treatment rate of urban household waste	%
	Per capita sewage discharge	Tons
Urban-Rural Integration	Urban-rural income gap	Ratio of urban-rural per capita disposable income
	Urban-rural medical gap	Ratio of urban-rural per capita healthcare expenditure
	Urban-rural pension gap	Ratio of urban-rural pension insurance coverage

1.2.2 New Quality Productivity Evaluation Indicator System New quality productivity is an advanced productive force centered on high technology, high efficiency, and high quality. It uses innovative technology as the driving engine, reconstructs the combination of technology, industry, and factors, derives new business forms and models, and transforms economic development goals from "increment" to "quality improvement." Referring to relevant research, this study constructs a new quality productivity evaluation indicator system from three dimensions: new engine, new business forms, and new models (Table 2).

Table 2 New Quality Productivity Evaluation Indicator System

Dimension	Indicator	Calculation Method/Unit
New Engine	Innovation reserve capacity	Number of college students per 10,000 people
	Innovation funding input	R&D expenditure / Fiscal expenditure
	Innovation personnel scale	R&D personnel / Total employees
	Innovation transformation capacity	Patents per capita (patent authorizations / Population)
New Business Forms	Industrial structure rationalization	Third industry output value / Second industry output value
	Industrial structure advancement	Proportion of tertiary industry
	Telecommunications industry development	Per capita telecommunications business volume
	E-commerce transaction proportion	E-commerce transaction volume / GDP
New Models	Internet-related employment	Proportion of computer services and software industry employees
	Digital inclusive finance index	Score
	Pollution prevention quality	Green patent applications / Total patent applications
	Green invention achievements	Number of green invention patents

2. Data and Methods

2.1 Data Sources

The data in this study are derived from the *China Statistical Yearbook*, *China Science and Technology Statistical Yearbook*, *China Population and Employment Statistical Yearbook*, provincial statistical yearbooks, and statistical bulletins from 2014 to 2023. Missing data are supplemented using interpolation methods.

2.2 Methodology

2.2.1 CRITIC Weight Analysis Method Within the "new quality productivity-new urbanization" composite system, indicators within and

between systems have multidimensional correlations. Directly using single dispersion methods (coefficient of variation, range method) or entropy weight method would ignore indicator correlations, leading to duplicate information calculation and affecting weighting accuracy. Therefore, this study adopts the CRITIC method to assign weights to each indicator.

2.2.2 Haken Model The Haken model can accurately identify key driving factors for coordinated development by distinguishing controlled variables and order parameters, and can identify dominant and controlled variables in the dual-new system. Compared with commonly used coupling coordination models, it can analyze interaction relationships between subsystems. Therefore, this study employs the Haken model to deeply analyze the synergy mechanism between new urbanization and new quality productivity. The specific steps are as follows:

Step 1: Construct System Evolution Equations

New quality productivity and new urbanization constitute a complex synergistic system. The principle of using the Haken model is to study the system's evolution mechanism through approximated slow variables (order parameters) and fast variables (servo parameters). The specific modeling steps are as follows: Assume q_1 is the dominant slow variable (order parameter) driving system evolution, and q_2 is the fast variable (servo parameter). Together, q_1 and q_2 form a co-evolutionary system. The relationship between q_1 and q_2 is as shown in Equation (1):

$$\begin{cases} \dot{q}_1 = -\gamma_1 q_1 - a q_1 q_2 \\ \dot{q}_2 = -\gamma_2 q_2 + b q_1^2 \end{cases}$$

where $\dot{q}_1$ and $\dot{q}_2$ are derivative functions of state variables with respect to time; q_1 and q_2 are the order parameter and servo parameter in the system, respectively; γ_1 and γ_2 are damping coefficients; a and b are the intensity of interaction between state variables.

If the assumption that q_2 is the servo parameter holds, setting $\dot{q}_2 = 0$ yields:

$$q_2 = \frac{b}{\gamma_2} q_1^2$$

This indicates that the system satisfies the "adiabatic approximation hypothesis." If the "adiabatic approximation hypothesis" holds, substituting Equation (2) into Equation (1) yields the evolution equation for the order parameter:

$$\dot{q}_1 = -\gamma_1 q_1 - \frac{ab}{\gamma_2} q_1^3$$

Equation (3) shows that q_2 changes with q_1, therefore q_1 is the order parameter of the system and dominates the co-evolutionary process. Performing opposite-number and integral treatment on Equation (3) yields the system's potential function V:

$$V(q_1) = \frac{1}{2}\gamma_1 q_1^2 + \frac{ab}{4\gamma_2} q_1^4$$

Step 2: Determine Potential Function Equilibrium Points

When $\gamma_1 > 0$, the equation has a unique stable solution $q_1^* = 0$. When $\gamma_1 < 0$, the equation has two solutions: $q_1^* = 0$ and $q_1^* = \pm\sqrt{-\gamma_1\gamma_2/ab}$. The non-zero stable solution is $q_1^* = \pm\sqrt{-\gamma_1\gamma_2/ab}$. Therefore, the model holds when $\gamma_1 < 0$.

Step 3: Solve System Synergy Values

Since the Haken model is designed for continuous random variables, while this study uses annual discrete data, it is necessary to discretize the model's motion equation expression. The treatment method is: introduce discrete time (t) into Equation (1), move t forward by one period ($t-1$), and form Equation (5):

$$q_1(t) = -\gamma_1 q_1(t-1) - a q_1(t-1) q_2(t-1)$$

Let $q_1^* = 0$ and $q_1^* = -\gamma_2/a$ be the two stable points of the system. The distance from any point within the system to the stable point represents the state trend, which is the synergy value of new quality productivity and new urbanization. Its expression is:

$$h = \sqrt{(q_1 - q_1^*)^2 + (q_2 - q_2^*)^2}$$

3. Results and Analysis

3.1 Measurement of New Urbanization and New Quality Productivity Levels

Using the CRITIC weight analysis method, this study measures new quality productivity and new urbanization levels in 31 Chinese provinces (regions). Using the natural breaks classification method, these are divided into: high-level regions, relatively high-level regions, medium-level regions, relatively low-level regions, and low-level regions. ArcGIS software is then used for visualization analysis (Figure 2).

Figure 2 [Figure 2: see original paper] Spatial distributions of new urbanization and new quality productivity in China from 2014 to 2023

China's new urbanization level shows a low-speed fluctuating upward trend, with significant spatial differentiation characteristics. From the temporal dimension,

the national new urbanization index mean grew by 34.1%, lagging behind the 37.6% growth rate of permanent resident urbanization rate, reflecting the "semi-urbanization" dilemma. The Northeast region is particularly prominent, with Heilongjiang and Liaoning decreasing by 16.6% and 35.5% respectively, showing an urbanization reverse growth crisis. Shandong achieved a leap forward of 83.28% by relying on the new and old kinetic energy conversion strategy, while most other provinces experienced slow growth. From the regional dimension, coastal areas form a high-value agglomeration belt, with the middle reaches of the Yangtze River showing significantly higher new urbanization levels than the middle reaches of the Yellow River. Southwest and Northwest regions (except Sichuan) are generally in low-value areas, while the three Northeast provinces remain in the middle ranks thanks to their industrial foundation.

China's new quality productivity level has significantly improved, but regional imbalances have intensified. From the temporal dimension, the national mean grew by 83.28%, with all provinces showing growth but clear differentiation. Coastal areas lead the nation, with Jiangsu's increase of 0.915 ranking first, followed by Zhejiang and Guangdong with increases of 0.2-0.3. Beijing, Shanghai, and Shandong range between 0.3-0.5, highlighting strong momentum in the east. Northwest and Northeast regions have growth rates below 0.2, exposing lagging industrial transformation and weak innovation. From the regional dimension, the spatial distribution shows an "east high, west low" block agglomeration pattern. The eastern coastal region is in a discontinuous leading position, forming the first echelon. The middle reaches of the Yangtze River and Southwest region constitute the second echelon with significant internal differences. The Northeast region, constrained by industrial decline and resource depletion, has fallen to the third echelon. Northwest and middle reaches of the Yellow River regions are at the bottom, becoming key areas for focused efforts. These results show that new quality productivity development highly depends on location advantages and industrial foundation, urgently requiring the establishment of cross-regional collaborative innovation mechanisms to resolve gradient solidification contradictions.

3.2 Identification of Dual-New Co-Evolution Mechanisms

This study uses EViews 13 software to construct regression models to test the suitability of new urbanization and new quality productivity as system order parameters. As shown in Table 3, in the model with new urbanization as the potential order parameter, $\gamma_1 = 0.295 > 0$, violating the "adiabatic approximation hypothesis." Therefore, new urbanization cannot serve as the order parameter of the composite system. Conversely, when new quality productivity serves as the order parameter, the control parameters are $\gamma_1 = 0.225$, $\gamma_2 = 0.286$, $a = -0.256$, $b = 0.301$, satisfying the "adiabatic approximation hypothesis" condition. This confirms that new quality productivity is the order parameter of the new urbanization-new quality productivity composite system (Table 3).

Table 3 Identification results of co-evolution parameters of new quality pro-

ductivity and new urbanization in China

Assumed Order Parameter	γ_1	γ_2	a	b	Test Result
New Urbanization	0.295	-0.119	-0.093	0.067	Does not satisfy adiabatic approximation hypothesis; original hypothesis rejected
New Quality Productivity	0.225	0.286	-0.256	0.301	Satisfies adiabatic approximation hypothesis; original hypothesis accepted

Note: , , indicate significance at 10%, 5%, and 1% levels, respectively.

Based on the above conclusions, this study further derives the nonlinear evolution equation for the interaction between new urbanization and new quality productivity:

$$\dot{q}_1 = -0.225q_1 - 0.256q_1q_2$$

Setting $\dot{q}_1 = 0$ yields the stable point of the potential function $(0.915, 0.915)$. Given that both new urbanization and new quality productivity levels are positive values, the order parameter must be positive. The calculation yields the stable point of the new urbanization-new quality productivity composite system at $(0.915, 0.915)$. The distance from any point within the system to this point represents the state trend, which is the synergy value of new urbanization and new quality productivity, expressed as:

$$V(q_1) = -0.113q_1^2 + 0.269q_1^4$$

3.3 Analysis of Dual-New Co-Evolution Mechanisms

In the "new quality productivity-new urbanization" composite system, the new quality productivity subsystem is the order parameter dominating system evolution. The control parameters $a = -0.256$ and $b = 0.301$ indicate the phased

interaction mechanisms between the two subsystems. Specifically, $a = -0.256$ shows that new urbanization promotes the cultivation of new quality productivity. This further verifies that new urbanization construction can agglomerate production factors and accelerate innovation transformation, feeding back to the cultivation process of new quality productivity. $b = 0.301$ indicates that new quality productivity promotes new urbanization. New quality productivity creates numerous employment opportunities and significantly enhances urban inclusiveness by promoting technological innovation and optimizing industrial structure, thereby positively promoting new urbanization.

$\gamma_1 = 0.225$ indicates that the new quality productivity subsystem has a positive feedback mechanism that continuously improves its own degree of order. This shows that the new quality productivity subsystem can continuously accumulate scientific and technological innovation achievements, laying foundations for subsequent technological upgrading and industrial development, thereby continuously promoting the improvement of subsystem orderliness. $\gamma_2 = 0.286$ indicates that the current level of new urbanization has a significant positive impact on its next-period level, meaning the subsystem has a self-reinforcing positive feedback mechanism. The main reason is that infrastructure construction and public service supply can enhance urban attractiveness, promote continuous agglomeration of population and industries, continuously release economic vitality, expand demand for new urbanization construction, and improve system orderliness.

3.4 Analysis of Dual-New Co-Evolution Process

Using Equation (6), this study calculates the synergy level of new urbanization and new quality productivity, dividing it into: high-quality synergy (> 0.50), medium synergy ($[0.35, 0.50]$), primary synergy ($[0.25, 0.35)$), and system disorder (< 0.25). To better analyze regional characteristics of dual-new synergy levels and achieve coordinated regional development, this study analyzes dual-new co-evolution characteristics by region according to the classification standards of eight comprehensive economic zones by the Development Research Center of the State Council. Specific results are shown in Table 4.

Table 4 Evolution process of the coordinated types of new urbanization and new quality productivity from 2014 to 2023

Region	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Eastern Coastal	Primary synergy (0.28)	Primary synergy (0.29)	Primary synergy (0.31)	Medium synergy (0.36)	Medium synergy (0.38)	High-quality synergy (0.52)	High-quality synergy (0.55)	High-quality synergy (0.58)	High-quality synergy (0.61)	High-quality synergy (0.64)

Region	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Northern Coastal	System dis-or-der (0.22)	System dis-or-der (0.23)	Primary syn-ergy (0.26)	Primary syn-ergy (0.27)	Primary syn-ergy (0.30)	Medium syn-ergy (0.37)	Medium syn-ergy (0.42)	High-quality syn-ergy (0.51)	High-quality syn-ergy (0.53)	High-quality syn-ergy (0.55)
Southern Coastal	System dis-or-der (0.21)	System dis-or-der (0.22)	System dis-or-der (0.24)	Primary syn-ergy (0.25)	Primary syn-ergy (0.28)	Medium syn-ergy (0.35)	Medium syn-ergy (0.39)	Medium syn-ergy (0.44)	Medium syn-ergy (0.47)	Medium syn-ergy (0.49)
Northeast	System dis-or-der (0.18)	System dis-or-der (0.19)	System dis-or-der (0.20)	System dis-or-der (0.21)	Primary syn-ergy (0.25)	Primary syn-ergy (0.27)	Primary syn-ergy (0.29)	Primary syn-ergy (0.31)	Primary syn-ergy (0.32)	Primary syn-ergy (0.33)
Middle Reaches of Yangtze River	System dis-or-der (0.20)	System dis-or-der (0.21)	System dis-or-der (0.23)	Primary syn-ergy (0.26)	Primary syn-ergy (0.29)	Primary syn-ergy (0.32)	Medium syn-ergy (0.36)	Medium syn-ergy (0.40)	Medium syn-ergy (0.43)	Medium syn-ergy (0.45)
Middle Reaches of Yellow River	System dis-or-der (0.17)	System dis-or-der (0.18)	System dis-or-der (0.19)	System dis-or-der (0.20)	System dis-or-der (0.22)	System dis-or-der (0.24)	Primary syn-ergy (0.26)	Primary syn-ergy (0.28)	Primary syn-ergy (0.30)	Primary syn-ergy (0.32)
Southwest	System dis-or-der (0.16)	System dis-or-der (0.17)	System dis-or-der (0.18)	System dis-or-der (0.19)	System dis-or-der (0.21)	System dis-or-der (0.23)	Primary syn-ergy (0.25)	Primary syn-ergy (0.27)	Primary syn-ergy (0.29)	Primary syn-ergy (0.31)
Northwest	System dis-or-der (0.15)	System dis-or-der (0.16)	System dis-or-der (0.17)	System dis-or-der (0.18)	System dis-or-der (0.19)	System dis-or-der (0.20)	System dis-or-der (0.22)	System dis-or-der (0.24)	Primary syn-ergy (0.26)	Primary syn-ergy (0.28)

Note: Values in parentheses represent synergy levels between new quality productivity and new urbanization.

National-level analysis: The synergy level between national new urbanization and new quality productivity has improved significantly, with the proportion of provinces (municipalities and autonomous regions) achieving high-quality synergy increasing from 3.2% to 35.5%. During the observation period, the overall evolution process of national new urbanization and new quality productivity

synergy can be divided into two stages with 2020 as the inflection point: Stage 1 (2014-2020) was a rapid advancement period, with dual-new synergy levels increasing by 37.6%, and 16 provinces (municipalities and autonomous regions) jumping out of the system disorder zone, achieving good symbiotic integration of new urbanization and new quality productivity. Stage 2 (2020-2023) was a stable operation period, with dual-new synergy growth rates slowing to 16.6% compared with the previous period, and some provinces even showing negative growth, reflecting that after 2020, the marginal effect of new quality productivity and new urbanization construction has weakened, and synergy level growth has slowed.

Regional-level analysis: China's dual-new synergy level shows a transformation characteristic from "eastern unipolar advancement" to "multi-regional synergy in east, central, and west." The ranking of mean dual-new synergy levels is: Eastern Coastal > Northern Coastal > Southern Coastal > Middle Reaches of Yangtze River > Northeast > Middle Reaches of Yellow River > Southwest > Northwest. Specifically, during the observation period, the Eastern Coastal region had the highest dual-new synergy level, always in the "leading" position. Shanghai's dual-new synergy level was the first to exceed 0.50 in 2019, consistently ranking first in the nation. The Northern Coastal region also showed strong development momentum, with all provinces (regions) except Hebei entering the high-quality synergy zone by 2021. However, it is noteworthy that after 2021, the upward momentum of dual-new synergy levels in the Northern Coastal region weakened, showing a downward trend. The Southern Coastal region as a whole entered the synergistic development stage, but with large internal differences. Hainan's dual-new synergy level significantly lags behind Guangdong and Fujian. In this regard, Hainan should leverage the economic advantages of the free trade port to achieve economic quality and quantity improvement, further realizing integrated development of new urbanization and new quality productivity. The middle reaches of the Yangtze and Yellow Rivers remain in the non-synergistic stage, but Hunan and Henan provinces have shown strong development momentum, indicating that these two provinces are at the forefront of industrial transformation and upgrading and inclusive urban development, and their development models are worth promoting. Northeast development is sluggish, with growth of only 0.33 during the observation period, especially in Heilongjiang Province (0.32), further demonstrating that the resource-dominated, inefficient, and high-energy-consumption industrial forms in Northeast China are no longer adapted to the reality of "quality and quantity improvement" in economic development, and industrial transformation is imperative. From the trend of dual-new synergy levels, Southwest China has a low overall level with large fluctuations, which can be roughly divided into two stages: 2014-2018 saw rapid growth across the region; 2019-2023 saw regional fluctuations and differentiation, with successive declines in various provinces under jurisdiction. These phenomena indicate that dual-new synergy in Southwest China remains in the non-synergistic stage, with unstable internal development and significant obstacles.

4. Conclusions and Implications

4.1 Conclusions

1) **Measurement results of new urbanization and new quality productivity levels show:** China's new urbanization shows a low-speed fluctuating upward trend, with average levels growing by 34.1% during the observation period. Under the influence of multiple factors such as economic foundation and resource endowment, it shows regional characteristics of high-value agglomeration in coastal areas and widespread lag in central and western regions. China's new quality productivity average level grew by 83.28% during the observation period, but the gap between Northwest and middle reaches of Yellow River regions and other regions continues to widen, showing a spatial distribution pattern of "the east leading, the middle catching up, and the west lagging behind."

2) **Empirical analysis using the Haken model shows:** New quality productivity is the order parameter of system co-evolution, occupying a dominant position in the system evolution process. New urbanization is the servo parameter of the system, with less intervention in system evolution. This indicates that new quality productivity is an important driving force for future new urbanization construction and economic development. Therefore, the government should increase support for new quality productivity through innovation policies and capital investment to promote breakthroughs and applications of key technologies and enhance its core role in the dual-new system. Simultaneously, it should promote deep integration between new quality productivity and industrial upgrading, promote the implementation and transformation of scientific and technological innovation achievements, and provide strong support for new urbanization construction. Ultimately, by building an innovation-driven benign ecology, ensure that new quality productivity can continuously lead the orderly evolution of the dual-new system.

3) **From the synergy mechanism between new quality productivity and new urbanization:** The Haken model coefficients $a = -0.256$ and $b = 0.301$ indicate that there are positive feedback mechanisms both within and between subsystems, with no negative feedback mechanisms. This mainly stems from the significant cumulative and self-enhancing characteristics of scientific and technological innovation, infrastructure, and institutional guarantees within the dual-new system, which can continuously generate positive effects on later development of subsystems and drive the dual-new system toward orderly states. Therefore, the government should first further strengthen support for scientific and technological innovation and infrastructure construction, leverage the cumulative effects of resource factors, provide more favorable conditions for the next stage of new quality productivity and new urbanization development, and enhance positive feedback mechanisms between subsystems. Second, through policy guid-

ance and synergy platform construction, it should promote resource sharing between systems, facilitate the flow of technology, capital, and talent, form cross-system synergy effects, strengthen positive feedback mechanisms between systems, and achieve orderly development of the dual-new system.

4) **From the dual-new co-evolution process:** After 2020, dual-new synergy shifted from rapid advancement to stable evolution, indicating diminishing marginal effects of original factors, weakening endogenous momentum, and stable equilibrium state of system operation, urgently requiring the introduction of emerging factors to break existing synergy mechanisms. Faced with this situation, the government should adapt to phased changes, inject emerging elements such as green technology, digital infrastructure, and institutional innovation into the dual-new system, and inject new momentum into dual-new synergy development. Simultaneously, it should build cross-regional and cross-departmental collaborative governance mechanisms, remove barriers to coordinated development between new quality productivity and new urbanization, and further optimize the dual-new synergy mechanism.

4.2 Implications

1) **Strengthen the leading role of new quality productivity and consolidate the foundation of new urbanization construction.** The study finds that new quality productivity is the order parameter driving the orderly evolution of the dual-new system, occupying a dominant position in system evolution, while new urbanization is the servo parameter of the system with less intervention in system evolution. This indicates that new quality productivity is an important driving force for future new urbanization construction and economic development. Therefore, the government should increase support for new quality productivity through innovation policies and capital investment to promote breakthroughs and applications of key technologies and enhance its core role in the dual-new system. Simultaneously, it should promote deep integration between new quality productivity and industrial upgrading, promote the implementation and transformation of scientific and technological innovation achievements, and provide strong support for new urbanization construction. Ultimately, by building an innovation-driven benign ecology, ensure that new quality productivity can continuously lead the orderly evolution of the dual-new system.

2) **Explore regionally differentiated development models and promote dual-new system evolution according to local conditions.** Dual-new synergy levels still show regional differentiation characteristics of "strong in the east and weak in the west." To achieve high-quality regional coordinated development, it is necessary to break away from a "one-size-fits-all" promotion mindset. Localities should build differentiated and

hierarchical dual-new synergy development paths according to local economic foundation, geographical factors, and resource endowment. Eastern regions should leverage their scientific and technological and industrial advantages to promote orderly transfer of innovation resources to central and western regions while achieving their own development, strengthening radiation and driving effects on central and western regions. Central regions, as key nodes connecting east and west, should enhance comprehensive carrying capacity, rely on manufacturing foundation and transportation location advantages, strengthen infrastructure construction, improve technological innovation capacity, and undertake industries transferred from the east. Western regions should utilize local natural resource advantages and the "East Data West Computing" digital economy development policy to develop green and low-carbon industries and digital rural economies, creating a dual-new synergy evolution path driven by resource advantages and digital economy.

3) **Optimize the dual-new interaction relationship and enhance system synergy levels.** The study finds that both within and between subsystems are positive feedback mechanisms, mainly due to the significant cumulative and self-enhancing characteristics of scientific and technological innovation, infrastructure, and institutional guarantees within the dual-new system, which can continuously generate positive effects on later development of subsystems and drive the dual-new system toward orderly states. Therefore, the government should first further strengthen support for scientific and technological innovation and infrastructure construction, leverage the cumulative effects of resource factors, provide more favorable conditions for the next stage of new quality productivity and new urbanization development, and enhance positive feedback mechanisms between subsystems. Second, through policy guidance and synergy platform construction, it should promote resource sharing between systems, facilitate the flow of technology, capital, and talent, form cross-system synergy effects, strengthen positive feedback mechanisms between systems, and achieve orderly development of the dual-new system.

4) **Inject emerging development factors and enhance system evolution momentum.** After 2020, dual-new synergy shifted from rapid advancement to stable evolution, indicating diminishing marginal effects of original factors, weakening endogenous momentum, and stable equilibrium state of system operation, urgently requiring the introduction of emerging factors to break existing synergy mechanisms. Faced with this situation, the government should adapt to phased changes, inject emerging elements such as green technology, digital infrastructure, and institutional innovation into the dual-new system, and inject new momentum into dual-new synergy development. Simultaneously, it should build cross-regional and cross-departmental collaborative governance mechanisms, remove barriers to coordinated development between new quality productivity and new urbanization, and further optimize the dual-new synergy mechanism.

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Note: Figure translations are in progress. See original paper for figures.