Research on the Coupling and Coordination between Regional New Quality Productive Forces and High-Quality Economic Development in China under the Background of "Double Carbon"

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Abstract: Based on panel data from 30 provincial-level administrative regions in China spanning the years 2010 to 2023, this paper develops an evaluation index system for assessing new quality productive forces and high-quality economic development. The entropy-based method is adopted to quantify the development levels of new-quality productive forces and high-quality economic development, and further assess the degree of their coupling coordination. Empirical findings reveal that both the development levels of assessing new quality productive forces and high-quality economic development have generally exhibited a steady upward trajectory, with their spatial distribution presenting a distinct "east-high, west-low" pattern characterized by regional disparity. The coupling coordination levels between new-quality productive forces and high-quality economic development across eastern, central, and western regions exhibit a stepped distribution pattern, decreasing progressively from east to west. To address these regional disparities in coupling coordination, differentiated strategies are imperative: Eastern provinces should prioritize enhancing scientific and technological innovation capacity and advancing industrial upgrading to lead the frontiers of assessing new quality productive forces development; central and western provinces, in turn, should focus on fostering niche industries aligned with local resource endowments, upgrading innovation infrastructure, and optimizing factor allocation mechanisms and policy environments. By implementing differentiated guidance to promote regional coordinated development and harnessing the radiating effects of more developed areas, this study offers actionable insights to facilitate the integrated advancement of new-quality productive forces and high-quality economic development nationwide.

Keywords: New Quality Productive Forces (NQPF); High-Quality Economic Development (HQED); Coupling and Coordination

1. Introduction

Developing new quality productive forces (NQPF) is both an intrinsic requirement and a key driver for promoting high-quality development (HQED). The new production technologies, organizational forms, and industrial models corresponding to new productive forces serve as core mechanisms to realize HQED. As two important theoretical concepts, NQPF and HQED have attracted extensive attention from the academic community. Productivity is a concrete and important material force formed in the labor process, serving as the key factor to measure the economic output level. It inherently comprises three core components: labor force, objects of labor, and means of labor. And NQPF represent an innovative evolution beyond traditional productivity. More precisely, they embody an endogenous reconfiguration of China’s economic growth drivers, propelled by emerging technological paradigms and restructured industrial organizations. This process enables traditional productivity to adapt to data production factors and disruptive technologies, thereby rejuvenating the innovative capacity and vitality of traditional productivity and achieving higher economic efficiency [1-3].

The process of economic development involves transformations in key factors such as production elements, organizational forms, technological innovation, industrial patterns, energy supply, and energy efficiency. NQPF demonstrates its significance in multiple dimensions: First, it fully leverages the prominent advantages of digital-intelligent production factors in mobility, marginal returns, and sustainability. By expanding, extending, or upgrading the functions of traditional production factors, and using digital technologies to give birth to new production organizational forms, it optimizes resource allocation efficiency and forms scientific and technological productivity. Second, it can foster the continuous optimization of the industrial structure. By deepening the integration of key industries with digital technologies, it comprehensively forms an efficient digital industrial pattern, thus constructing digital productivity. Third, it further advances the green transformation of industries. The large-scale application of intelligent digital technologies has significantly accelerated the development of new energy sources, improved energy utilization efficiency, thereby forming green productivity [1]. Collectively, these mechanisms propel the progression of HQED. HQED requires accelerating the formation of NQPF. At the same time, only by accelerating the development of NQPF can HQED be effectively advanced.

This paper makes marginal contributions in the following areas: First, it systematically examines the convergences and divergences between NQPF and HQED in terms of their connotative definitions and practical requirements, thereby elucidating the intrinsic mechanisms governing their coupling and coordination. Second, a comprehensive indicator system is constructed, and the entropy-weight method is employed to systematically calibrate the levels of new-quality productive forces and HQED. Third, a coupling-coordination model is applied to evaluate the coupling–coordination nexus between provincial-level new-quality productive forces and HQED, thereby offering a theoretical reference for China’s acceleration of new-quality productive forces and its advancement of high-quality economic growth.

2. The Coupling and Coordination Mechanism between New Quality Productive Forces and High-Quality Economic Development

As a representative of advanced productivity, NQPF integrates new elements such as innovation, efficiency, and quality, demonstrating digital and intelligent characteristics in different fields, and continuously giving birth to new business forms, models, and momentum. The rapid development of new-quality productive forces will fundamentally transform China’s industrial structure, and drive the gradual upgrading of industrial structures. Technology-intensive and knowledge-intensive industries will progressively evolve into the pillars of the national economy. By virtue of their characteristics of industrial relevance, sustained growth, high permeability, and high added value, these industries will act as an engine to enhance the efficiency of the entire industrial system, thereby feeding back into economic development.

Du Chuanzhong et al. (2023) posit that NQPF promotes HQED through a four-dimensional analytical framework, which encompasses production factors, organizational forms, industrial systems, and technological innovation [4]. Zou Qihao and Ren Baoping (2024) argue that strengthening institutional arrangements conducive to the development of NQPF can provide both incentives and constraints for HQED, thereby lowering its implementation costs [5]. Yao Yu and Liu Zhenhua (2024) argue that HQED lays the foundational framework that defines both the orientation and the strategic focal points of new-quality productive forces [6]. Xu Jiayang and Guo Fuchun (2024) construct an innovative "factor deepening-technological progress-industrial iteration-institutional change" dynamic model to reveal the mechanism [7].

Uphold high-quality development as the overarching priority, and integrate the strategy of expanding domestic demand with deeper supply-side structural reform in a coordinated manner. It aims to strengthen the endogenous impetus and resilience of the domestic economic cycle, upgrade the quality and standard of the international economic cycle, accelerate the construction of a modern economic system, prioritize the enhancement of TFP, bolster the resilience and security of industrial and supply chains, advance urban-rural integration and coordinated regional development, and ultimately propel the economy toward effective qualitative enhancement coupled with sustainable quantitative growth. Evidently, HQED entails achieving growth with minimal production factor input, high resource allocation efficiency and greater socio-economic benefits. It involves coordinating three transformations of quality, efficiency, and driving force, continuously improving TFP, and building an innovative and competitive modern industrial system [8]. HQED requires balancing environmental benefits with economic growth, using innovative approaches to enhance factor allocation efficiency, breaking away from the traditional economic development path reliant on factor input quantity, transforming economic development momentum. New-quality productive forces represent a multidimensional leap of traditional productivity against the backdrop of the latest scientific and technological revolution. They fully align with the requirements that HQED places on the transformation of productive forces. In essence, new-quality productive forces constitute the endogenous engine, whereas HQED embodies the developmental paradigm; the former furnishes powerful innovative impetus for the latter, which in turn lays the industrial foundations and sets the strategic direction for the further advancement of new-quality productive forces.

3. Research Design

3.1 Construction of Evaluation System

3.1.1 New quality productive forces Level

This paper argues that NQPF is a comprehensive concept. Its evaluation requires relying on multi-attribute comprehensive evaluation methods. Jiang Yongmu and Ma Wenwu (2023) believe that NQPF include digital productivity, green productivity, and blue productivity [9]; Xu Zheng et al. (2023) think NQPF is the entirely new driving force supporting economic growth formed based on scientific discoveries, technological breakthroughs, and innovative applications. It is a more integrated and connotative productivity in the digital era, and also contains the meaning of greenness, environmental protection, and sustainability [10]; Hong Yinxing (2024) argues that NQPF include new technologies, new energy, and digital economy [11].The study integrates the research contributions of Wang Yuping and Gao Yuan [12] to classify NQPF into primary dimensions within the construction of its evaluation index system: scientific-technological productivity, digital productivity, and green productivity. Subsequently, it identifies the constituent components and associated sub-indicators for each dimension, and employs the entropy weight method to assign weights to these indicators, as shown in Table 1.

Table 1. Evaluation Index System for NQPF

Primary Indicators	Secondary Indicators	Tertiary Indicators
Scientific and Technological Productivity	Innovative Productivity	Innovation and R&D(+)
		Innovative Industries(+)
		Innovative Products(+)
	Technological Productivity	Technical Efficiency(+)
		Technical R&D(+)
		Technical Production(+)
Green Productivity	Resource-Saving Productivity	Energy intensity(-)
		Energy structure(-)
		Water intensity(-)
	Environment-Friendly Productivity	Waste utilization(+)
		Wastewater utilization(-)
		Exhaust gas utilization(-)
Digital Productivity	Digital Industrial Productivity	Electronic information manufacturing(+)
		Telecommunication services and communication(+)
	Industrial Digital Productivity	Network penetration rate(+)
		Software services(+)
		Digital information(+)
		E-commerce(+)

3.1.2 High-quality economic development level

With reference to the studies by Sun Hao [13], Hou Yuxia [14], and others, an assessment index system for HQED was established, covering five dimensions—innovation-driven development, balanced development, green development, open development, and inclusive development—with a total of 18 indicators, as presented in Table 2.

Table 2. Evaluation Index System for HQED

Primary Indicators	Secondary Indicators
Innovation-driven Development	GDP growth rate(+)
	R&D intensity(+)
	Investment efficiency(-)
	Activity Level of Technology Transactions(+)
Coordinated Development	Demand structure(+)
	Urban-rural structure(+)
	Industrial structure(+)
	Government debt burden(-)
Green Development	Energy consumption elasticity coefficient(-)
	Wastewater per unit output(-)
	Exhaust gas per unit output(-)
Open Development	Dependence ratio on foreign trade(+)
	Proportion of foreign investment(+)
	Degree of marketization(+)
Inclusive	Proportion of labor compensation(+)

Development	Income growth elasticity of residents(+)
	Urban-rural consumption gap(-)
	Proportion of livelihood-related fiscal expenditure(+)

3.2 Research Methods

3.2.1 Entropy method

In this paper, the entropy weight method is applied to calculate the indicator weights for the two systems: new-quality productive forces and HQED. To eliminate the interference caused by different dimensions in data processing, all indicator data are standardized, and comprehensive scores are finally obtained.

The procedural steps of the entropy weight method are outlined as follows. Assume the number of provinces is n, the time span is r, and the number of indicators is m. Let $X_{\theta ij}$ denote the j-th indicator of province i in the θ-th year.

Step 1: Standardize these indicators. Positive indicators are normalized in the positive direction, while negative indicators are normalized in the negative direction. The processing formulas are as follows:

$$x'_{\theta ij}=\frac{x_{\theta ij}-x_{\theta j}^{min}}{x_{\theta j}^{max}-x_{\theta j}^{min}} \quad (1)$$

$$x'_{\theta ij}=\frac{x_{\theta j}^{max}-x_{\theta ij}}{x_{\theta j}^{max}-x_{\theta j}^{min}} \quad (2)$$

In Formulas (1) and (2), $x_{\theta j}^{min}$ and $x_{\theta j}^{max}$ represent the minimum and maximum values of the indicator.

Step 2: Homogenize the data, with the formula as follows:

$$y_{\theta ij}=\frac{x'_{\theta ij}}{\sum_{\theta=1}^{r}\sum_{i=1}^{n}x'_{\theta ij}} \quad (3)$$

Step 3: Determine the weight of each indicator.Calculate the entropy value of the j-th indicator:

$$e_j=-k\sum_{\theta=1}^{r}\sum_{i=1}^{n}y_{\theta ij}*lny_{\theta ij} \quad (4)$$

In Formula (4), k>0, $k=\frac{1}{ln(rn)}$, $e_j\geq 0$.

Step 4: Calculate the difference coefficient of the j-th indicator, as shown in the following formula:

$$g_i=1-e_j \quad (5)$$

Step 5: Calculate the weight of the j-th indicator:

$$w_j=\frac{g_i}{\sum_{j=1}^{m}g_i} \quad (6)$$

Step 6: Calculate the comprehensive score, using the following formula:

$$U_i=\sum_{j}^{m}w_j\,x'_{\theta ij} \quad (7)$$

3.2.2 Coupling coordination degree model

This paper employs a modified coupling coordination degree model to examine the degree of benign interaction between new-quality productive forces and HQED.

Additionally, this paper applies the coupling coordination degree model to evaluate the coupling and coordination dynamics between new-quality productive forces and the high-quality development of the construction industry across various provinces, aiming to further explore their coordination level and benign operational status. The coupling coordination degree model is formulated as follows:

$$C=\sqrt{\frac{U_1}{U_2}\left[1-\sqrt{(U_2-U_1)^2}\right]}=\sqrt{\frac{U_1}{U_2}[1-(U_2-U_1)]} \quad (8)$$

$$T=\alpha*U_1+\beta*U_2 \quad (9)$$

In Formulas (8)-(9), C represents the coupling degree; T represents the comprehensive coordination index; U_1 is the minimum value of the comprehensive scores of the two systems, and U_2 is the maximum value of the comprehensive scores of the two systems; α and β are adjustment coefficients. Considering that the two systems of NQPF and high-quality agricultural development are regarded as equally important in this study, it is assumed that α=β=0.5.

The introduction of the coupling coordination degree model can reflect the degree of consistency between NQPF and high-quality agricultural development, and the formula is as follows.

$$D=\sqrt{C*T} \quad (10)$$

A higher magnitude of D indicates a greater degree of coordination between NQPF and the high-quality development of the construction industry, while a lower D value corresponds to a reduced level of coordination. Drawing on the classification framework from prior research [15], the coupling coordination degrees are categorized into distinct grades, as elaborated in Table 3.

Table 3. Classification of Coupling Coordination Grades

Coupling coordination degree	Coordination grade	Coupling coordination degree	Coordination grade
[0,0.1)	Extreme disharmony	[0.5,0.6)	Barely coordination
[0.1,0.2)	Severe disharmony	[0.6,0.7)	Primary coordination
[0.2,0.3)	Moderate disharmony	[0.7,0.8)	Intermediate coordination
[0.3,0.4)	Mild disharmony	[0.8,0.9)	Good coordination

[0.4,0.5)	On the verge of disharmony	[0.9,1.0)	High-quality coordination

3.2.3 Data sources

To ensure data reliability and validity, this paper utilizes panel data spanning 30 provincial-level administrative regions in China over the period 2010-2023. Primary data sources include, inter alia, the China Statistical Yearbook, China Science and Technology Statistical Yearbook, China Research Data Services Platform, and the EPS database. Missing values in the dataset were addressed through interpolation and moving average techniques to enhance data completeness.

4.Empirical Result Analysis

4.1 Analysis of new quality productive forces and High-Quality Economic Development Levels

4.1.1 Dynamic change characteristics of new quality productive forces

From the development of NQPF in various provinces, the overall trend was upward from 2010 to 2023. The national average increased from 0.2684 in 2010 to 0.4512 in 2023, with most provinces and cities showing a stable and sustained growth trend. Comparatively, the development of NQPF in eastern regions was better than that in the other three regions. According to the 2023 data, the top six were Guangdong Province, Jiangsu Province, Zhejiang Province, Beijing Municipality, Shanghai Municipality, and Shandong Province. Among them, the NQPF of Guangdong Province was 0.7997, representing a 102.89% increase compared with 2010. In contrast, the NQPF of Ningxia Hui Autonomous Region, which ranked last in 2023, was lower than that of Guangdong Province in 2010, reflecting significant regional differences. Selecting 2010, 2018, and 2023 for trend analysis, as shown in Figure 1 below, it can be seen that provinces with good growth momentum in NQPF in eastern regions exhibit strong development potential. However, the NQPF of Tianjin Municipality, Fujian Province, Hebei Province, and other regions is instead lower than that of leading provinces in central and western regions, indicating that differences between and within regions are both significant.

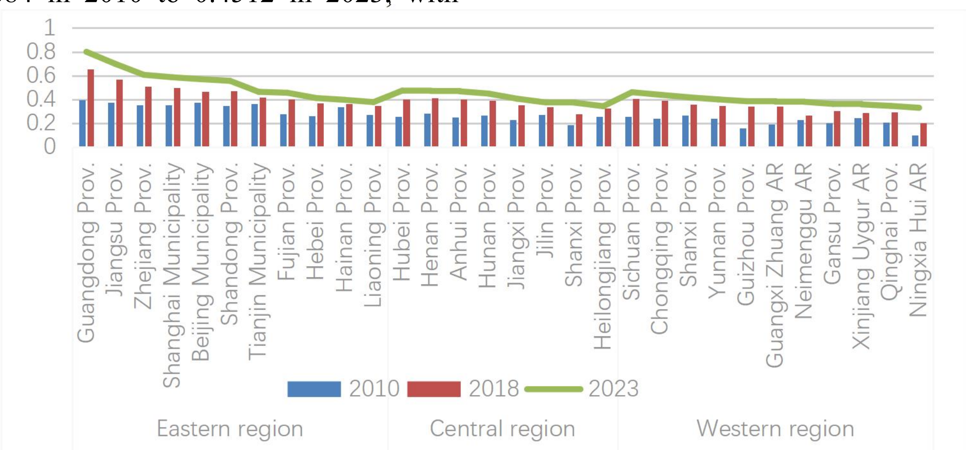

Figure 1. Regional Variation Characteristics of NQPF

The eastern region exhibits notable competitive advantages, manifesting robust competitive strengths and promising development prospects across three dimensions: scientific-technological productivity, green productivity, and digital productivity. As illustrated in Figure 2, it has achieved leapfrog growth in scientific-technological productivity and digital productivity, progressively widening the developmental gap with the central and western regions. This reflects comprehensive leadership in innovative productivity, technological productivity, digital industrial productivity, and industrial digital productivity, indicating that China's regional economic development exhibits the characteristic of "gradient differentiation driven by innovation". Relying on the advantages of talent, capital, and policies in world-class city clusters such as the Yangtze River Delta and the Pearl River Delta, the eastern region has taken the lead in building a modern industrial system with digital economy, artificial intelligence, and biomedicine as the core. With data such as the proportion of listed companies on the Sci-Tech Innovation Board exceeding 60% and the scale of the digital economy accounting for nearly 60% of the country, it has formed a "dual-wheel drive" effect of innovative productivity and digital productivity.

However, restricted by factors such as weak ability to gather high-end elements and slow transformation of traditional industries, the central and western regions have seen an expanding gap with the eastern region in key indicators such as 5G base station density and the number of industrial internet platforms. This differentiation is not only an objective manifestation of the "core-periphery" effect during the technological revolution period but also reflects that China's regional development strategy is transforming from "balanced and inclusive" to "efficiency priority with due consideration to fairness". In the future, it is necessary to strengthen regional coordination through national strategies, cultivate regional innovation poles such as Zhengzhou and Chengdu, establish cross-regional intellectual property sharing mechanisms to promote the spatial rebalancing of innovative productivity and avoid the further solidification of the digital divide.

In terms of green productivity, the three regions show a certain degree of convergence, manifested as significant governance effects in resource conservation, energy consumption, and wastewater/gas/waste emissions across all provinces and cities under the "dual-carbon" framework. This indicates that the national green governance system is exerting a coordinated effect, promoting the gradual convergence of regional green productivity. While the eastern region has led efforts to reduce energy consumption per unit of GDP, the central and western regions have rapidly advanced in pollution prevention and ecological restoration by undertaking green industrial transfers and developing renewable energy sources, forming a regional collaboration pattern of "eastern technological innovation—central ecological barriers—western clean energy."

This convergence benefits not only from institutional constraints such as central environmental inspections and the carbon emissions trading market but also from innovative practices in green financial reforms and ecological product value realization mechanisms. Data shows that from 2018 to 2023, the national energy consumption per unit of GDP decreased by approximately 18%, the average PM2.5 concentration dropped by over 40%, and the proportion of excellent water quality sections in the Yangtze and Yellow River basins reached 98.1% and 95.2%, respectively, reflecting the overall improvement of green productivity in various provinces and cities through differentiated approaches. In the future, it is important to further strengthen the regional ecological mechanism to transform the value of western ecological products into economic benefits, while supporting the eastern region in exporting low-carbon technologies to the central and western regions, thereby advancing green productivity from "convergence" to "common prosperity."

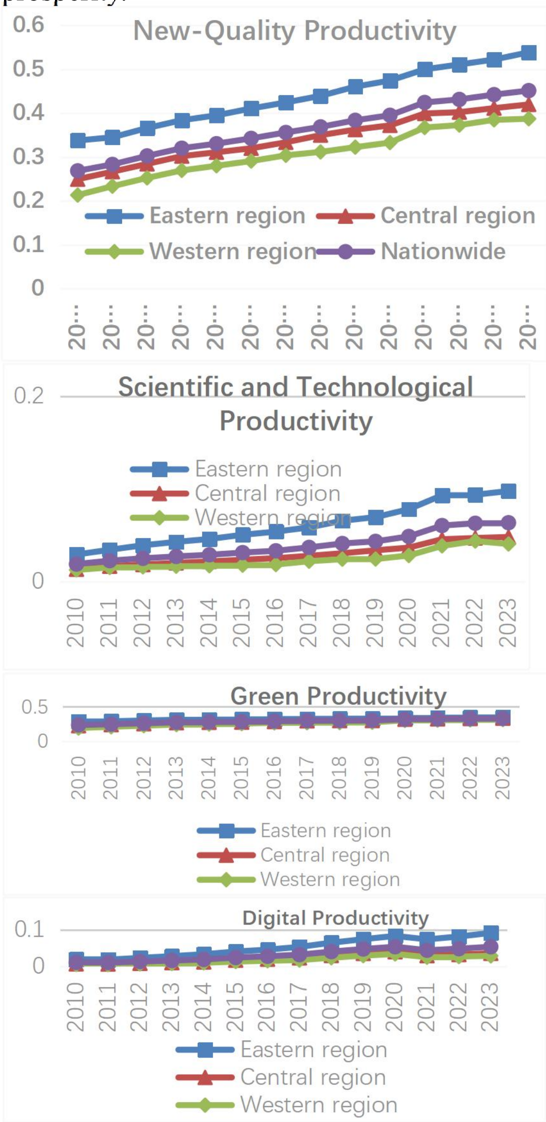

Figure 2. Temporal Variation Characteristics

4.1.2 Dynamic change characteristics of high-quality economic development

From the dynamic changes in HQED from 2010 to 2023, all provincial-level administrative regions have shown a spiral upward trend, with many fluctuations in the intermediate years, as shown in the figure 3.In the eastern region, most provinces have slowed their growth rate, while the central region has maintained an average growth rate of 48.32%. In the western region, half of the provinces have shown good growth, but there are also cases of slow growth or even negative growth. This indicates that developed provinces may have some degree of weakness in HQED, while western provinces need to focus on innovative development, open development, and shared development to strive to narrow the gap with developed regions.

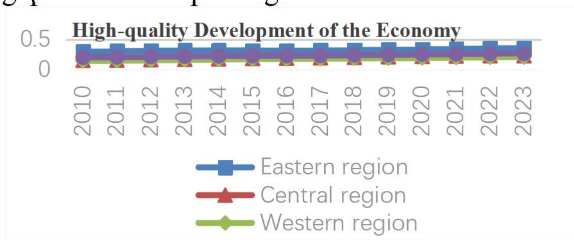

Figure 3. Temporal Variation Characteristics of HQED

Analyzing the HQED in 2010, 2018, and 2023, it is found that most provinces showed a clear growth trend from 2010 to 2018, but only a small number of provinces maintained slight growth from 2018 to 2023, as shown in the figure 4. From 2010 to 2018, driven by factors such as the rapid advancement, most provinces achieved significant growth relying on factor input and scale expansion. After 2018, with the weakening of the demographic dividend, the requirements for high-quality development became prominent. Some provinces experienced slowdowns due to lagging industrial transformation and insufficient innovation capabilities, failing to timely switch growth drivers. Another group of provinces achieved a balance between improved development quality and moderate growth by cultivating new industries and business forms and promoting green and low-carbon development. This transformation reflects a profound shift in China’s economic development philosophy, with an intensified focus on enhancing development efficiency and advancing sustainability.

4.2 Coupling and Coordination Analysis of new quality productive forces and High-Quality Economic Development

The coupling coordination levels between NQPF and HQED in 2010, 2018, and 2023 were selected for trend analysis across the eastern, central, and western regions. The results show that most provinces achieved significant improvements in their coupling coordination degrees. As shown in Figure 5, it has been found that the degree of coupling and coordination among most provinces has significantly improved, reflecting the positive effects of national strategies such as innovation-driven development and regional coordinated development.

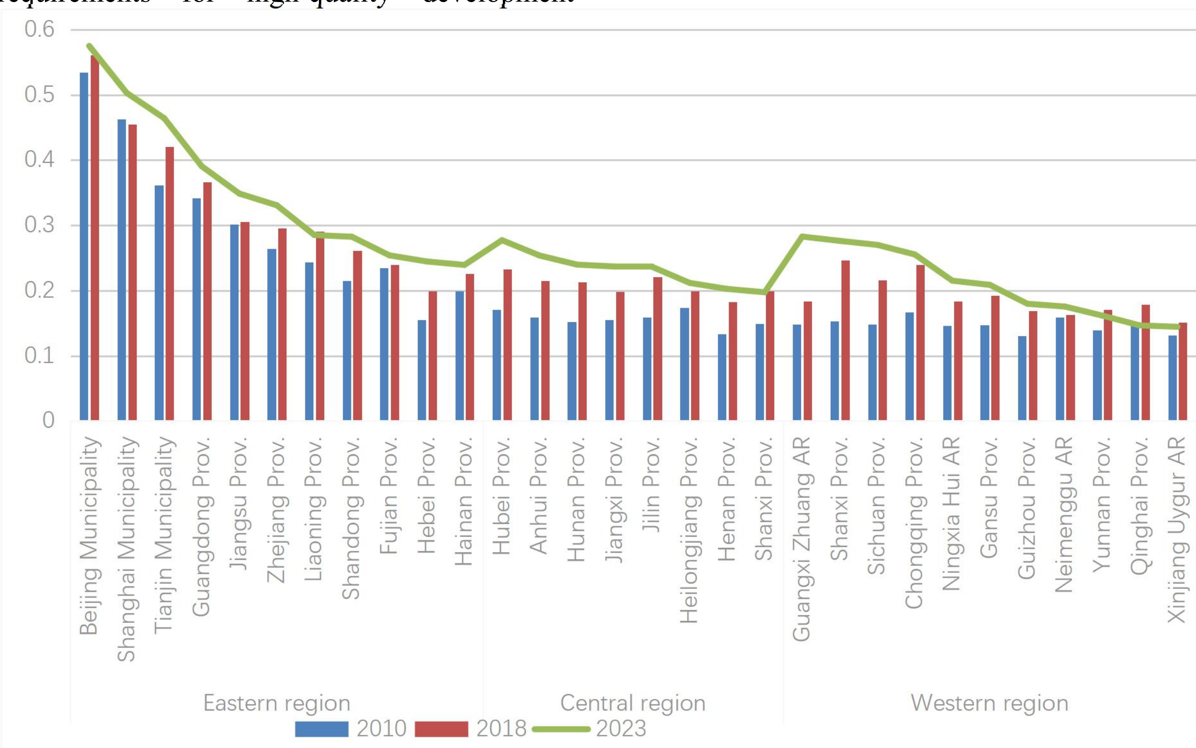

Figure 4. Regional Variation Characteristics of NQPF

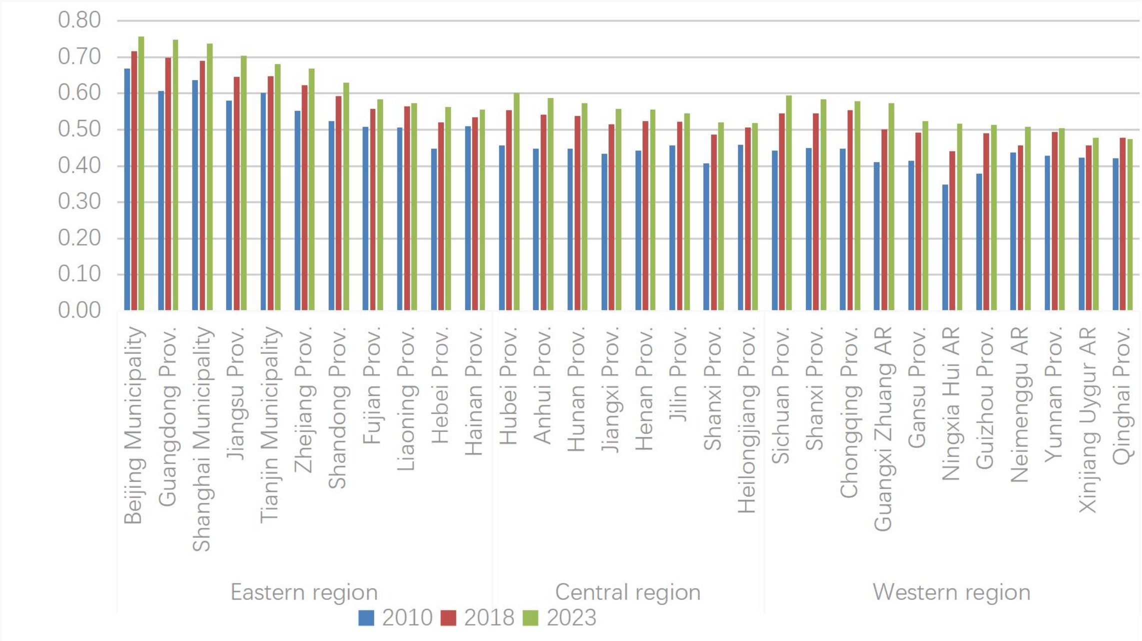

Figure 5. Trend Variation Characteristics of the Coupling Degree

Table 4. The Level of Coupling Coordination Degree between NQPF and HQED

region	province	2010		2014		2018		2023	
Eastern region	Beijing Municipality	0.67	Primary coordination	0.70	Intermediate coordination	0.72	Intermediate coordination	0.76	Intermediate coordination
Eastern region	Tianjin Municipality	0.60	Primary coordination	0.64	Primary coordination	0.65	Primary coordination	0.68	Primary coordination
Eastern region	Hebei Prov.	0.45	On the verge of disharmony	0.48	On the verge of disharmony	0.52	Barely coordination	0.56	Barely coordination
Eastern region	Shanghai Municipality	0.64	Primary coordination	0.67	Primary coordination	0.69	Intermediate coordination	0.74	Intermediate coordination
Eastern region	Jiangsu Prov.	0.58	Barely coordination	0.61	Primary coordination	0.65	Intermediate coordination	0.70	Intermediate coordination
Eastern region	Zhejiang Prov.	0.55	Barely coordination	0.59	Barely coordination	0.62	Primary coordination	0.67	Primary coordination
Eastern region	Fujian Prov.	0.51	Barely coordination	0.54	Barely coordination	0.56	Barely coordination	0.58	Barely coordination
Eastern region	Shandong Prov.	0.52	Barely coordination	0.57	Barely coordination	0.59	Primary coordination	0.63	Primary coordination
Eastern region	Guangdong Prov.	0.61	Primary coordination	0.64	Primary coordination	0.70	Intermediate coordination	0.75	Intermediate coordination
Eastern region	Hainan Prov.	0.51	Barely coordination	0.51	Barely coordination	0.54	Barely coordination	0.56	Barely coordination
Eastern region	Liaoning Prov.	0.51	Barely coordination	0.53	Barely coordination	0.56	Barely coordination	0.57	Barely coordination
Central region	Shanxi Prov.	0.41	On the verge of disharmony	0.44	On the verge of disharmony	0.49	Barely coordination	0.52	Barely coordination
Central region	Anhui Prov.	0.45	On the verge of disharmony	0.50	On the verge of disharmony	0.54	Barely coordination	0.59	Barely coordination
Central region	Jiangxi Prov.	0.43	On the verge of disharmony	0.48	On the verge of disharmony	0.52	Barely coordination	0.56	Barely coordination
Central region	Henan Prov.	0.44	On the verge of disharmony	0.49	On the verge of disharmony	0.52	Barely coordination	0.56	Barely coordination
Central region	Hubei Prov.	0.46	On the verge of disharmony	0.52	Barely coordination	0.55	Primary coordination	0.60	Primary coordination
Central region	Hunan Prov.	0.45	On the verge of disharmony	0.49	On the verge of disharmony	0.54	Barely coordination	0.57	Barely coordination
Central region	Jilin Prov.	0.46	On the verge of disharmony	0.49	On the verge of disharmony	0.52	Barely coordination	0.55	Barely coordination
Central region	Heilongjiang Prov.	0.46	On the verge of disharmony	0.49	On the verge of disharmony	0.51	Barely coordination	0.52	Barely coordination
Western region	Neimenggu AR	0.44	On the verge of disharmony	0.46	On the verge of disharmony	0.46	Barely coordination	0.51	Barely coordination
Western region	Guangxi Zhuang AR	0.41	On the verge of disharmony	0.48	On the verge of disharmony	0.50	Barely coordination	0.57	Barely coordination
Western region	Chongqing Prov.	0.45	On the verge of disharmony	0.54	Barely coordination	0.55	Barely coordination	0.58	Barely coordination
Western region	Sichuan Prov.	0.44	On the verge of disharmony	0.49	On the verge of disharmony	0.55	Barely coordination	0.59	Barely coordination
Western region	Guizhou Prov.	0.38	Mild disharmony	0.44	On the verge of disharmony	0.49	Barely coordination	0.51	Barely coordination
Western region	Yunnan Prov.	0.43	On the verge of disharmony	0.46	On the verge of disharmony	0.49	Barely coordination	0.50	Barely coordination
Western region	Shanxi Prov.	0.45	On the verge of disharmony	0.51	Barely coordination	0.55	Barely coordination	0.58	Barely coordination
Western region	Gansu Prov.	0.41	On the verge of disharmony	0.46	On the verge of disharmony	0.49	Barely coordination	0.52	Barely coordination
Western region	Qinghai Prov.	0.42	On the verge of disharmony	0.45	On the verge of disharmony	0.48	On the verge of disharmony	0.47	On the verge of disharmony
Western region	Ningxia Hui AR	0.35	Mild disharmony	0.43	On the verge of disharmony	0.44	Barely coordination	0.52	Barely coordination
Western region	Xinjiang Uygur AR	0.42	On the verge of disharmony	0.45	On the verge of disharmony	0.46	On the verge of disharmony	0.48	On the verge of disharmony

Note: Due to space constraints, only the results of the coupling coordination degree for 2010, 2014, 2018, and 2023 are presented here.

Applying the coupling coordination degree model, this study evaluates the synergistic relationship between NQPF and HQED across China's 30 provincial-level regions during 2010-2023. The measurement results are systematically presented in Table 4.In 2010, Beijing, Tianjin, Shanghai and Guangdong had achieved a primary coordination level, while Qinghai, Shaanxi, Gansu and other provinces were in a state of near-disharmony, and Guizhou and Ningxia Hui Autonomous Region were in a state of mild disharmony. Over time, by 2014, Beijing took the lead in reaching the intermediate coordination level in the development of NQPF and high-quality economy. Although there were still many provinces in a state of near-disharmony, the mild disharmony in Guizhou and Ningxia Hui Autonomous Region had improved, shifting to near-disharmony. Using the coupling coordination degree framework, this research assesses the interactive dynamics between

NQPF and HQED in China's 30 provincial administrative units (2010-2023). The comprehensive evaluation outcomes are detailed in Table 4. However, the coordination level in some regions still grew relatively slowly. Areas such as Gansu Province, Qinghai Province and so on remained in a state of near-disharmony.

By 2023, Beijing, Shanghai, Jiangsu Province, and Guangdong Province maintained an intermediate coordination level, with the majority of provinces falling into the marginal coordination category, and only two provinces remaining in near-disharmony. The analysis demonstrates that eastern provinces, leveraging their proactive development approach, have successfully fostered NQPF while strategically positioning themselves for high-quality economic advancement. Nevertheless, significant developmental gaps remain observable both intra-regionally among eastern provinces and inter-regionally across China's eastern-central-western territorial spectrum. Core cities such as Beijing, Shanghai lead in high-tech and financial technology fields by virtue of factor agglomeration advantages, while some non-core cities still rely on traditional industries with lagging innovation. Provinces also exhibit distinct industrial characteristics. Technologically and developmentally, central and western regions exhibit significant gaps. To address disparities in technological resource allocation and emerging industrial sectors, these regions require strengthened policy interventions and cross-regional cooperation mechanisms. Such coordinated efforts are essential for achieving balanced nationwide development of NQPF and high-quality economic growth. While all Chinese provinces have demonstrated measurable progress in this coordination, more economically advanced regions maintain superior synchronization levels, suggesting less developed areas require targeted upgrading strategies.

5. Conclusions and Recommendations

This study reveals a consistent annual improvement in the coupling coordination between NQPF and HQED across most Chinese provinces. The analysis demonstrates that NQPF development is increasingly aligning with HQED requirements, while HQED provides a solid foundation for fostering NQPF regionally. This mutually reinforcing relationship has grown stronger over time. However, despite this progress, most provinces remain at the "primary coordination" stage, with only select eastern regions reaching "moderate coordination." Given the distinct developmental disparities among China’s eastern, central, and western regions, policymakers must capitalize on localized resource advantages and adopt differentiated strategies to systematically enhance coordination levels.

To further strengthen NQPF-HQED coupling coordination, four key areas require prioritized intervention.

(1) Deepening the Construction of Scientific and Technological Innovation System

To enhance this system, priority should be given to strengthening fiscal investment in basic research and establishing a diversified funding support framework, with particular emphasis on cutting-edge domains such as artificial intelligence and quantum computing to consolidate original innovation capabilities from "0 to 1." By optimizing policy instruments, including tax incentives and financial subsidies, enterprises will be incentivized to expand their R&D investment scale, fully unlocking their leading role in industry-university-research collaborative innovation. Concurrently, improving mechanisms for the transformation of scientific and technological achievements will help establish a full-chain innovation system spanning "basic research-technological development-achievement transformation," thereby accelerating the efficient conversion of scientific and technological outcomes into tangible productive forces.

(2) Optimizing Industrial Structure and Layout

To modernize traditional industries, governments should spearhead intelligent and sustainable transitions through the integration of next-gen technologies (e.g., digital solutions and renewable energy systems). This technological infusion aims to boost operational efficiency while decarbonizing heavy industries like steel and chemicals. Parallel to this, targeted roadmaps must be developed to accelerate strategic emerging sectors - particularly new energy vehicles and biopharmaceuticals - with clear implementation frameworks. Through cluster-based industrial agglomeration and collaborative integration of industrial chains, economies of scale and scope will be harnessed to strengthen the comprehensive competitiveness of the industrial sector.

(3) Promoting Regional Coordinated

Development

Strengthening regional collaboration among eastern, central, and western regions, we strive to build a development pattern characterized by complementary strengths and synergistic interaction. By fully leveraging the comparative advantages of eastern regions in technology, capital, talent, and other resources, we will guide the orderly transfer of industrial gradients to central and western regions, thereby promoting technology spillover and upgrading of industrial tiers. Meanwhile, we aim to improve cross-regional collaborative innovation mechanisms, jointly develop and share science and technology innovation platforms, facilitate the efficient flow and optimal allocation of innovation factors. Meanwhile, improve talent policies to attract and retain high-end talent by providing support, thereby better balancing the flow of high-end talent and building a talent reserve for the coordinated development of economically less developed regions.

(4) Improving Policy Support and Guarantee Systems

Provincial policymaking should holistically integrate three key dimensions: natural resource endowments, economic development levels, and distinctive cultural features for tailored governance. This enables the formulation of targeted special support policies for the development of new-quality productive forces, with strengthened safeguards in areas such as land allocation, financial assistance, and talent cultivation, ensuring precise policy empowerment for local efforts to enhance NQPF and advance HQED. Building on this foundation, it is critical to clarify the core objective of improving the coupling and coordination level between new-quality productive forces and HQED. This involves refining actionable development pathways and key tasks, while strengthening the coordinated interaction and mutual reinforcement between these two policy domains. In the field of green finance, optimizing financial policies, developing tech finance, and providing diversified financing channels for innovative enterprises will help guide funds toward green technology R&D, low-carbon industrial upgrading, and other areas, alleviating financial constraints on enterprise innovation. Innovations in financial instruments such as intellectual property pledge and green bonds can lower the financing threshold for technology-based enterprises, enhance the coupling efficiency between NQPF and the green economy, and inject sustainable momentum into HQED.

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