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Analyzing the Progress and Barriers to High-Quality Economic Development in China's Central Region

(Menganalisis Kemajuan dan Halangan kepada Pembangunan Ekonomi Berkualiti Tinggi di Wilayah Tengah China)

WenJie Chen
Universiti Kebangsaan Malaysia

Mohd Nasir Mohd Saukani
Universiti Kebangsaan Malaysia

ABSTRACT

This study investigates the phased evolution and critical bottlenecks of high-quality economic development (HQED) in China's Central Region from 2012 to 2020. Methodologically, it integrates the CRITIC method with the obstacle degree model to diagnose development constraints, complemented by Principal Component Analysis for cross-method validation. The results reveal that while the Central Region exhibits a steady upward trend in HQED, significant regional disparities and growth fluctuations persist across different phases. Crucially, both deficiency and variance-driven perspectives converge to identify energy consumption, foreign investment utilization, and educational expenditure as the primary bottlenecks hindering HQED. To unlock regional economic potential, policymakers should prioritize innovation-driven green transitions and structural industrial adjustments. This study offers new insights into regional economic dynamics and presents a scalable diagnostic framework for coordinated regional development in China and globally.

Keywords: High-quality economic development; central region; obstacle factor; China

ABSTRAK

Kajian ini mengkaji evolusi berfasa dan kesesakan kritikal pembangunan ekonomi berkualiti tinggi (HQED) di Wilayah Tengah China dari tahun 2012 hingga 2020. Secara metodologi, rangka kerja penilaian komprehensif diproses melalui model darjah halangan bergandingan CRITIC untuk mendiagnosis kekangan pembangunan, dilengkapi dengan Analisis Komponen Utama untuk pengesahan silang kaedah. Keputusan menunjukkan bahawa walaupun Wilayah Tengah menunjukkan trend menaik yang stabil dalam HQED, perbezaan serantau yang ketara dan turun naik pertumbuhan berterusan merentasi fasa yang berbeza. Yang penting, kedua-dua perspektif yang didorong oleh kekurangan dan varians bertemu untuk mengenal pasti penggunaan tenaga, penggunaan pelaburan asing dan perbelanjaan pendidikan sebagai kesesakan utama yang menghalang HQED. Untuk membuka potensi ekonomi serantau, pembuat dasar harus mengutamakan peralihan hijau yang didorong oleh inovasi dan pelarasan perindustrian struktur. Kajian ini menawarkan pandangan baharu tentang dinamik ekonomi serantau dan menyediakan rangka kerja diagnostik yang boleh diskala untuk pembangunan serantau yang diselaraskan di seluruh dunia.

Kata kunci: Pembangunan ekonomi berkualiti tinggi; wilayah tengah; faktor penghalang; China

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INTRODUCTION

China introduced the concept of high-quality economic development (HQED) in 2017. HQED is driven by innovation, promoted through regional coordination, and achieved through shared development supported by market openness, while adhering to the principles of green development (Huang et al. 2020). Since China opened its economy to the global market in 1978, the country has experienced four decades of rapid economic growth, primarily driven by the development of the secondary industry. However, as comparative advantages such as demographic dividends, low labour costs, and energy resources have gradually diminished, economic growth has slowed, and structural issues previously concealed by high-speed growth have become increasingly apparent (Luo et al. 2023). An overemphasis on GDP growth at the expense of quality improvement has led to environmental degradation and regional development imbalances, thereby undermining China's long-term economic prosperity. In response, the Chinese government explicitly stated in the 2017 Government Work Report that the focus of economic development should shift from the pursuit of rapid growth to HQED in order to

mitigate the negative consequences of previous growth patterns (Wang et al. 2024). These dimensions of HQED are interconnected and mutually reinforcing; if any one aspect is not fully implemented, it may hinder progress in the remaining areas.

In the early stages of China's economic opening, the sluggish domestic market constrained economic development. To address this, the government prioritized the development of coastal areas with geographical advantages through policy support. A traditional industrial structure dominated by agriculture and heavy industry has created systemic challenges for China's central region, including ecological degradation and insufficient momentum for economic growth. Economic development in the region has long been characterized by imbalances and inadequacies (Zhao et al. 2023). Transitioning towards quality-driven growth is therefore an inevitable strategy for addressing these regional imbalances (Liu & Qu 2022). The concept of HQED provides a strategic framework for addressing the aforementioned regional development challenges. As a transitional zone between the coast and the interior, the Central Region is tasked with the dual responsibility of absorbing industrial and economic activities relocating from the eastern coastal areas while simultaneously driving economic growth in the western interior. This dual role represents not only the strategic positioning of the central region but also a critical element in China's realization of HQED (Zhao et al. 2023).

The Central Region's role in connecting the developed eastern coastal areas with the underdeveloped western regions makes it strategically important. Economic development in the Central Region not only expands the potential of the inland market's potential but also strengthens economic linkages between central and western China. To achieve HQED, reducing development imbalances between coastal and inland areas, particularly between the eastern and western regions, has become increasingly critical. Therefore, measuring the HQED level of the Central Region and assessing its current development status are of considerable importance. Furthermore, conducting an in-depth analysis of existing shortcomings and proposing targeted improvement strategies will contribute to enhancing HQED of the Central Region, thereby promoting more balanced regional economic development.

The overall framework of this study is as follows: First, the relevant literature is reviewed to identify the shortcomings of existing research on HQED in the Central Region, and analyse the key obstacles. Section 3 describes the data sources and the HQED indicator system. By combining techniques such as the CRITIC method, the study identifies the key obstacle factors and establish a dual-perspective cross-validation mechanism using principal component analysis (PCA). Section 4 provides the empirical analysis, examining HQED levels in the Central Region and the coupling coordination relationships among its subsystems using panel data from large and medium-sized cities in China. It also examines the main obstacle factors affecting HQED at both the dimension and indicator levels. Finally, Section 5 summarizes the core findings of this study and proposes corresponding strategic measures to promote high-quality economic development in China's Central Region.

LITERATURE REVIEW

Currently, HQED is primarily assessed from two perspectives. The first approach measures green total factor productivity (GTFP). Some studies recognize the impact of environmental factors on the quality of economic development and incorporate green development into their analytical framework, using GTFP to measure HQED (Wang et al. 2024; Yan et al. 2024). While this single-indicator approach enables researchers to examine the influence of a specific dimension on HQED, it lacks a comprehensive assessment. The HQED framework emphasizes five dimensions: technological innovation, regional coordination, green development, market openness, and shared development. Consequently, GTFP alone does not fully capture the multidimensional nature of HQED. The second approach constructs a comprehensive evaluation index system. Scholars commonly assess HQED levels by developing composite indices based on the five HQED dimensions. Although some studies do not strictly adhere to these dimensions, they consistently adopt a multidimensional perspective to analyze HQED (Jun et al. 2023; Meiyun & Fan 2022; Wang & Shi 2023). Studies have shown that HQED in the eastern region is significantly higher than that in other regions (Zhao & Liu 2023). Similarly, comparisons among the eastern, central, and western regions indicate that the eastern region consistently outperforms the others in HQED (Liu 2022). Conversely, the Western region has a relatively smaller economic scale, and the direct environmental impact of its industries has not yet fully manifested. However, significant disparities exist among the internal dimensions of HQED, and regional development imbalances within the western region persist (Mao et al. 2023). Overall, although China's HQED has continued to improve, marked regional disparities persist, reflecting its uneven spatial distribution.

Research on coupling coordination relationships, suggests that the subsystems of HQED are mutually interdependent and reinforcing. Accordingly, a comprehensive analysis of HQED in the Central Regions requires a deeper examination of development across its various dimensions. By exploring the coupling and coordination relationships among these internal factors, it is possible to identify the key obstacles hindering HQED. The ecological environment serves as the foundation of HQED (Meng et al. 2023; Ying Zhang et al. 2023), innovation capacity acts as its endogenous driving force (Du 2023; Ma & Xu 2022; Q. Zhang et al. 2023), and the digital economy provides new vitality into HQED (Gu & Liu 2024; Hua et al. 2024; Liu & Liu 2024). Existing research has confirmed the impact of these factors on HQED; however, most studies focus on individual dimensions rather than examining the interactions among HQED's internal subsystems.

In summary, while existing research has acknowledged the issue of regional development imbalances in China's HQED, studies specifically examining the Central Region remain limited. The work of Zhao et al. (2023) is highly relevant because it examines the spatiotemporal evolution of HQED in the Central Region. However, this study does not analysis the factor-level obstacles unique to the Central Region. Furthermore, most of the studies on China's HQED use provincial panel data as the primary data source. However, owing to the uneven distribution of economic fundamentals and natural resource endowments, significant disparities exist among cities in terms of their development levels. Measuring HQED using provincial-level data may overlook these differences, resulting in empirical findings that do not accurately reflect local conditions. This not only affects the reliability of research findings but also hinders the accurate identification of key obstacle factors. Therefore, this study employs data from large and medium-sized cities instead of provincial panel data to analyze the primary obstacles affecting HQED in the Central Region. HQED emphasizes the multidimensional unity of economic growth (Chen & Huo 2022). The subsystems are interconnected and form an organic whole, such that inadequate performance in any single subsystem may hinder the development of the others. This study not only deepens the theoretical understanding of HQED but also provides a comprehensive quantitative assessment of the Central Region, thereby enabling local governments to gain a clearer grasp of its current development status. By identifying the principal constraining factors, this research provides a scientific basis for evidence-based policy design and implementation and, consequently promoting HQED more effective. Furthermore, this research framework offers a valuable reference for other landlocked regions worldwide and economies pursuing high-quality economic development.

METHODOLOGY AND DATA

Drawing on the research methodology developed by Zhang and Luo (2022), this study conducts a multidimensional HQED framework is constructed to capture the multifaceted nature of the HQED Index (HQDI). The CRITIC weighting method is used to calculate the HQDI, evaluate the spatiotemporal characteristics and internal structure of HQED, and identify the main obstacle factors. Although researchers commonly employ the entropy method for quantitative HQED assessment, the CRITIC weighting method has likewise gained academic recognition (Guo et al. 2022; Yin et al. 2023).

Within this HQED system, the five core dimensions exhibit strong interdependencies. The CRITIC weighting method reduces the likelihood of specific indicators from being assigned disproportionately high weights, thereby ensuring a more balanced and objective distribution of weights. Although the entropy method reduces the weight of indicators with smaller fluctuations, it relies primarily on the degree of data dispersion. By contrast, the CRITIC method considers both data variability and the correlation among indicators, thereby mitigating limitation to some extent (Chen et al. 2023; Xiong & Liu 2023). Furthermore, the multidimensional framework enables, the subsequent examination of the intricate coupling and coordination mechanisms within HQED. This approach is conceptually consistent with the principles underlying the CRITIC method, which determines indicator weights based on systemic information dispersion.

Nevertheless, the application of the CRITIC method is not without limitations. Specifically, when the numerical ranges of different indicators vary significantly, the resulting weights thus calculated may become distorted. Consequently, all indicators were standardised through dimensionless transformation prior to the calculation of standard deviations. Although this approach is entirely data-driven and does not incorporate subjective value judgements, it also reduces the uncertainty that could otherwise arise from expert bias.

To evaluate the robustness of our findings, this study supplements the Obstacle Degree Model (ODM) with Principal Component Analysis (PCA) to provide cross-method validation. While ODM identifies critical bottlenecks based on system deficiencies, PCA identifies the primary sources of structural variation through the variance structure of the data. A high convergence between the indicators with the highest PCA factor loadings with the principal obstacle factors identified by the ODM would provide powerful cross-method validation, thereby enhancing the robustness and reliability of the empirical findings.

DATA

Existing studies on HQED primarily rely on provincial panel data. However, intra-provincial economic disparities in the Central Region are pronounced, with policy support predominantly concentrated in more rapidly developing urban centres. To avoid the statistical distortion caused by lower-tier urban data, this study constructs the High-Quality Development Index (HQDI) utilizing panel data from 13 large and medium-sized cities across the six central provinces of Henan, Hubei, Hunan, Shanxi, Jiangxi, and Anhui covering the period 2012 to 2020. The data were sourced from provincial and municipal Statistical Yearbooks, with occasional missing values imputed using the moving average of the preceding two years. According to the National Bureau of Statistics of China, cities with a permanent urban population exceeding 500,000 are classified as large and medium-sized cities.

Uneven urban development remains a defining characteristic of China’s economic landscape (Mai et al. 2022). HQED dimensions, including innovation, green development, and openness, typically exhibit marked spatial agglomeration. Although excluding small-scale cities with population below 500,000, may introduce a modest upward bias into the absolute HQDI scores, this purposive sampling strategy effectively filters out statistical noise associated with lower-tier

economies. Consequently, it provides a more accurate representation of the core growth poles and structural dynamics driving economic transition in Central China.

HQED INDICATOR SYSTEM CONSTRUCTION

Sixteen fundamental indicators are selected to construct the HQED evaluation index system and measure HQDI (TABLE 1).

TABLE 1. Index system for evaluation of high-quality economic development level

HQED Dimensions	Basic Indicators	Proxy for measurement	Type
Innovative	R&D investment intensity (A1)	R&D expenditure as a proportion of GDP	(+)
	Proportion of R&D expenditure (A2)	Science and technology expenditure as a proportion of local government expenditure	(+)
	Patent application (A3)	Number of granted patent applications	(+)
Coordinated	Proportion of public finance expenditure (B1)	Public fiscal expenditure as a proportion of GDP	(+)
	Urban-rural structure (B2)	Urbanization rate	(+)
	Industrial structure (B3)	Value added of the tertiary sector as a proportion of GDP	(+)
	Demand structure (B4)	Total retail sales of consumer goods as a proportion of GDP	(+)
Green	Proportion of environmental protection industry expenditure (C1)	Government expenditure on energy conservation and environmental protection as a proportion of total government expenditure	(+)
	Forest coverage (C2)	Green coverage rate of built-up areas	(+)
	Energy consumption (C3)	Electricity consumption	(-)
Open	Proportion of foreign investment (D1)	Actual foreign direct investment (FDI) utilized as a proportion of GDP	(+)
	Dependence on foreign trade (D2)	Total imports and exports as a proportion of GDP	(+)
	Tourism contribution degree (D3)	Total tourism revenue as a proportion of GDP	(+)
Shared	Proportion of education expenditure (E1)	Educational expenditure as a proportion of regional fiscal expenditure	(+)
	Public medical and health expenditure (E2)	Medical and health expenditure as a proportion of regional fiscal expenditure	(+)
	Urban-rural consumption gap (E3)	Ratio of per capita consumption expenditure of urban to rural residents	(-)

Note: "(+)" and "(-)" indicate the positive and negative impacts of fundamental indicators on HQDI, respectively.

The HQED framework comprises 16 indicators selected through a three-stage process. First, from a theoretical perspective, the framework systematically captures the five core dimensions of HQED. Second, from a methodological perspective, it incorporates the most frequently adopted indicators identified in recent studies to minimize subjective selection bias. Finally, from an empirical perspective, indicators with substantial missing values are excluded to ensure data continuity and feasibility of long-term city-level panel analysis.

Innovation capability is measured using three indicators that capture both innovation inputs and outputs, recognizing that the transformation of investment into innovation outcomes is the key pathway underpinning high-quality development (X. Li et al. 2022). For coordinated development, four indicators reflecting social welfare and structural balance are employed. Public finance fiscal expenditure reflects government support for social security and public services (Zhu et al. 2017), while the urbanization rate is incorporated due to its significant spatial association with surrounding regions (Zhang et al. 2018), and its role in facilitating balanced regional development (Abulimiti et al. 2022). Furthermore, following the structural economic theory that higher development levels entail an expanding tertiary sector (Lu 2021; Yong-bing et al. 2019), the framework incorporates indicators representing industrial and demand structures (Yong-bing et al. 2019)

Green development is a prerequisite for cities to achieve HQED (Niemets et al. 2021). This dimension is assessed through resource conservation and environmental protection (Fan et al. 2022; Xu et al. 2023). Energy production inevitably cause environmental damage; therefore, per capita electricity consumption is used as a negative indicator of environmental pressure (Chen et al. 2020). An open economic system is an important feature of China's HQED (Kong et al. 2021). This study measures open development from two perspectives: domestic and international openness. Greater openness, is associated with higher tourism revenue (Chaudhry et al. 2022). International openness is further reflected in foreign trade and international investment, as imports, exports, and foreign investments have become integral to China’s economic development (Ye et al. 2018).

Shared development is a people-centered approach that pursues the ultimate goal of universal prosperity (Li 2023). It seeks not only to reduce regional wealth disparities and prevent polarization in income levels, but also to promote more equitable public service provision and narrow welfare gaps (Zhu & Wang 2023). Accordingly, this study employs the ratio of per capita consumption expenditure between urban and rural residents as a negative indicator of shared development. In addition, the level of social welfare is measured by the proportion of fiscal expenditure allocated to public services.

HQDI MEASUREMENT

Building on Du and Li (2022), this study employs the CRITIC weighting method to assess the level of HQED. As illustrated in Equation (1) and (2), weights are determined based on their comparative intensity (S_j) and conflict (R_j). These weights are subsequently aggregated to construct the HQDI, which provides a quantitative measure of HQED.

$$C_j = S_j \sum_{t=1}^{p} \left(1 - r_{tj}\right) = S_j \times R_j \qquad (1)$$

$$W_j = \frac{C_j}{\sum_{j=1}^{p} C_j} \qquad (2)$$

HQED COUPLING COORDINATION MODEL

The coupling coordination degree (CCD) model quantifies relationships among subsystems and examines their interconnectedness and spatial co-evolution. across different dimensions. Drawing on the methodology of Liu et al. (2021), this study employs the CCD model to examine the coupling states and collaborative development pathways among cities in central China under the HQED framework, thereby providing an empirical basis for the subsequent analysis of constraint factors. The CCD model first requires the calculation of the coupling degree (Equation (3)).

$$C = \sqrt[5]{\frac{U_a \times U_b \times U_c \times U_d \times U_e}{\left(\frac{U_a + U_b + U_c + U_d + U_e}{5}\right)^5}} \qquad (3)$$

The coupling degree C represents the synergistic association among the five subsystems of HQED, indicating the degree of coupling. The variables U_a, U_b, U_c, U_d and U_e represent the HQDI values for technological innovation, coordinated development, green development, market openness, and shared development, respectively. The coupling scores are classified into four levels based on different degrees, as shown in TABLE 2 (Guo et al. 2023).

TABLE 2. The standards of the stages of coupling

Coupling Degree	Coupling Level
0.0<C≤0.3	Low coupling
0.3<C≤0.5	Antagonism
0.5<C≤0.8	Running-in
0.8<C≤1	High coupling
Coupling Degree	Coupling Level

A high coupling degree may occur even when one or more subsystems exhibit relatively low development levels. To address this limitation and ensure a more comprehensive assessment, the CCD model is introduced, as shown in Equation (4).

$$D = \sqrt{C \times T}, \mathrm{T} = \alpha \mathrm{U}_a + \beta \mathrm{U}_b + \gamma \mathrm{U}_c + \delta \mathrm{U}_d + \varepsilon \mathrm{U}_e \qquad (4)$$

D represents the coupling coordination degree among the five subsystems, while T denotes the coordination index, measuring the overall synchronous development of the five subsystems. The coefficients $\alpha, \beta, \gamma, \delta, \varepsilon$ represent the relative structural weights assigned to each subsystem. The value of D ranges from 0 to1, with higher value indicating a stronger level of synergistic coordination among the subsystems.

Existing studies on coupling coordination degree generally assume that the five subsystems are equally important, assigning $\alpha, \beta, \gamma, \delta, \varepsilon$ to each subsystem a weight of 1/5 (Lai et al. 2020; L. Li et al. 2022; Yu Zhang et al. 2023). However, this assumption fails to capture the empirical variation in regional economic structures. In this study, the weights assigned to each subsystem are derived from the intrinsic statistical characteristics of the HQED evaluation index system. Therefore, when computing D, $\alpha, \beta, \gamma, \delta, \varepsilon$ are assigned weights based on the calculated indicator values rather than equal weights, thereby reflecting the objective structural composition of the system. The D values are classified into five levels, as shown in TABLE 3 (Wei et al. 2023).

TABLE 3. The standards of the coupling coordination relationship

D Value	Coordination Level	D Value	Coordination Level
0-0.09	Badly uncoordinated	0.50-0.59	Barely coordinated
0.10-0.19	Severely uncoordinated	0.60-0.69	Primary coordinated
0.20-0.29	Moderately uncoordinated	0.70-0.79	Intermediately coordinated
0.30-0.39	Mild uncoordinated	0.80-0.89	Well-coordinated
0.40-0.49	On the verge of deregulation	0.90-1.00	Quality coordination

HQED OBSTACLE DEGREE MODEL

The CCD model exhibits limitations in identifying specific obstacle factors. To address this limitation, this study introduces the Obstacle Degree Model (ODM) to identify the key constraints affecting system development. Incorporating the ODM into HQED evaluation framework enables the identification of the major factors restricting HQED advancement in Central Region of China. As the HQDI is assessed at both the dimension and indicator levels, the ODM also facilitates a two-level evaluation of development constraints. The calculation formulas are presented in Equations (5) and (6). The obstacle degrees at the dimension and indicator levels are denoted as Z_{aij} and Z_{ai}. The factor contribution W_j represents the weight of each of the 16 indicators in the evaluation system, reflecting their structural importance within HQED. The values of Z_{aij} and Z_{ai} reflect the structural differences and imbalances among the indicators at each level of HQED.

$$Z_{aij} = \frac{(1 - X_{aij}) \times W_j}{\sum_{j=1}^{k} (1 - X_{aij}) \times W_j} \quad (5)$$

$$Z_{ai} = \sum_{j=1}^{k} Z_{aij} \quad (6)$$

RESULT AND DISCUSSION

Using the CRITIC weighting method, this study calculates the HQDI to analyse HQED trends in Central China from 2012 to 2020. The CCD model is employed to evaluate the coordination among the HQED subsystems, while the ODM is applied to identify key obstacle factors, constraining HQED.

HQED LEVEL IN THE CENTRAL REGION

To reveal the internal structural variations and spatial distribution of HQED across the six central provinces, ArcGIS is used to visualize the weighted scores of the five HQED dimensions. FIGURE 1 presents the results for four selected years: 2012, 2016, 2017, and 2020. The height of each bar above a province is proportional to the actual score of the corresponding sub-dimension. The legend value shown at the bottom-right corner (e.g., 0.14 in 2012) serves as the height scale for that specific year, facilitating cross-sectional comparisons of absolute scores and their temporal trends across the provinces.

The spatial configurations shown in in FIGURE 1 indicate that Jiangxi recorded the highest average HQDI (0.513), whereas Hunan recorded the lowest (0.425). In 2020, the HQDI values for Henan and Hubei reached 0.65 and 0.62, respectively. Anhui recorded an average HQDI of 0.507 over the sample period, positioning it at an upper-middle level. In contrast, Shanxi recorded the lowest HQDI among all provinces and exhibited an overall declining trend. Analysis of subsystem weights during the sample period reveals that the weights for technological innovation, coordination development, green development, open development, and shared development were 0.06, 0.11, 0.08, 0.10, and 0.12, respectively. Among these, technological innovation and green development received the lowest structural weights within the evaluation system.

Overall, from 2012 to 2020, provincial HQDI values in Central China ranged from 0.3 to 0.6, indicating a moderate level of development. Between 2012 and 2017, the HQDI increased by approximately 6%. This trend is consistent with the findings of Chen and Huo (2022), who reported that HQED in Central China remains lower and that of the eastern coastal region and has experienced relatively slower growth. The improvement in HQED across the provinces also exhibits strong spatial consistency with advances in green development and open development.

HQED COUPLING COORDINATION DEGREE

COUPLING DEGREE ANALYSIS

FIGURE 2 utilizes choropleth maps to illustrate the spatial variation in coupling characteristics across the five HQED dimensions. The annual coupling degree is classified into five progressively increasing levels. A darker fill colour (closer to dark red) indicates a higher level of coupling among the provincial sub-systems, whereas a lighter colour (closer to light beige) indicates a lower coupling level. The legends in the bottom-right corner of each panel display the corresponding classification intervals, providing a reference for cross-sectional comparisons of the coupling degree across provinces in the same year.

Overall, the coupling degree among regional subsystems is relatively high, indicating strong interrelationships, though substantial regional disparities remain. The results indicate that prior to 2017, the overall coupling level fluctuated

considerably, reflecting a transitional phase characterized by generally low coupling. From 2012 to 2020, the interconnections among the five HQED subsystems became increasingly evident, exhibiting a positive evolutionary trend.



FIGURE 2. HQDI of the central provinces in major years

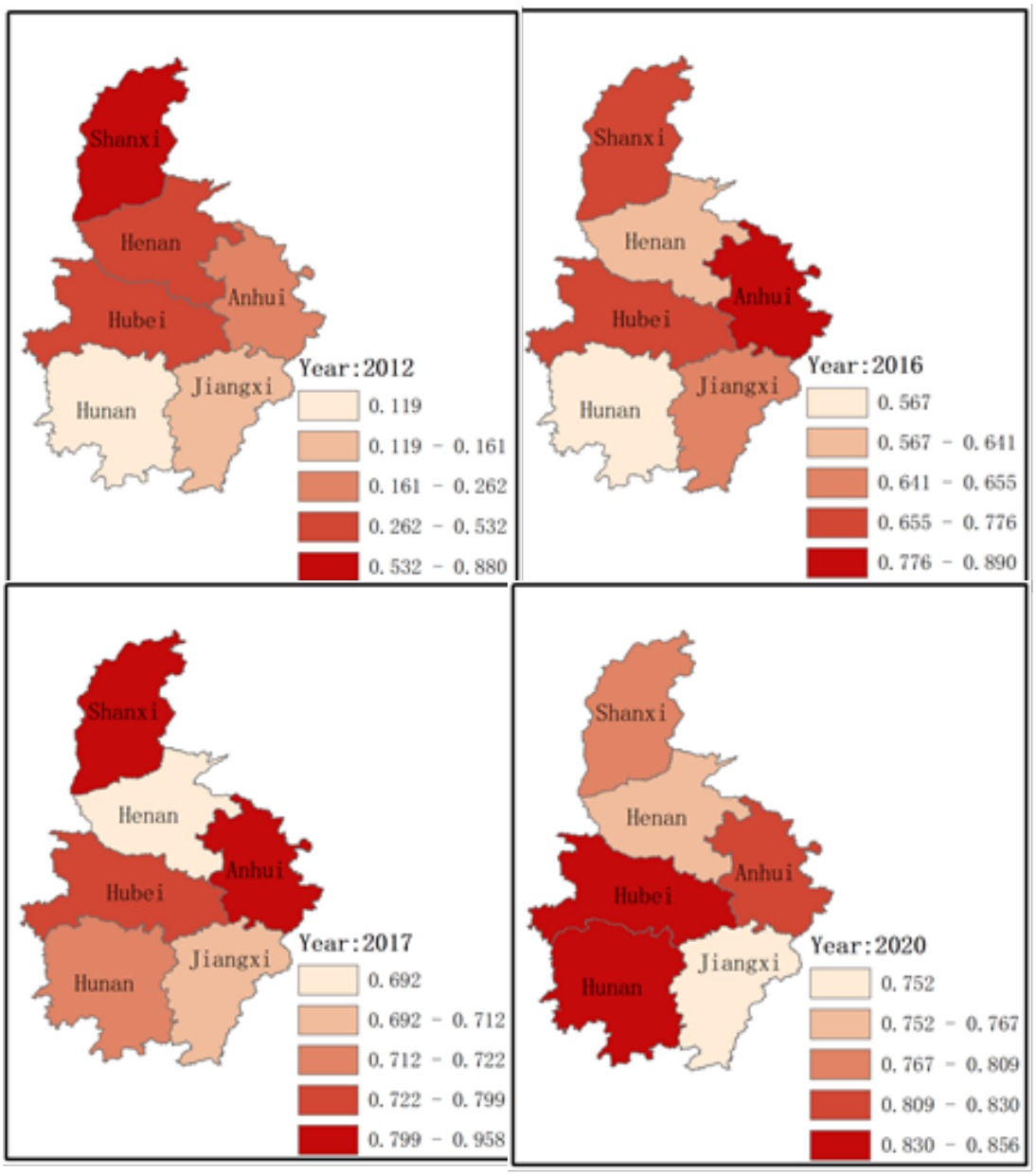


FIGURE 3. Changes in coupling degree of subsystems in the Central Region

COUPLING COORDINATION DEGREE ANALYSIS

FIGURE 3 presents the dynamic evolution of the CCD for each province using individual line charts. In each panel, the horizontal axis denotes the timeline from 2012 to 2020, while the vertical axis indicates the CCD value, ranging from 0.0 to 0.4. The trajectories illustrate the coordination status and operational efficiency of the five subsystems within each province, allowing comparisons of provincial development pathways and structural adjustments.



FIGURE 4. Trends in coupling coordination degree of subsystems from 2012 to 2020

The results indicate that the CCD of the five subsystems increased in all provinces, except for Shanxi, between 2012 and 2020. By the end of 2020, Shanxi and Anhui continued to experience relatively severe systemic imbalances, whereas the remaining provinces had progressed to a state of only mild imbalance. Jiangxi and Hunan notably showed the greatest improvement, progressing from a state of severe imbalance in 2012 to mild imbalance by 2020. Overall, the HQED level improved across all provinces, accompanied by stronger interdependence among the five subsystems. However, the pace of improvement slowed as the CCD increased, suggesting that Central China has entered a stage of structural adjustment, where further improvements in systemic coordination have become increasingly difficult.

HQED OBSTACLE FACTORS

DIMENSIONAL-LEVEL OBSTACLE FACTOR ANALYSIS

FIGURE 4 employs radar charts to illustrate structural evolution of the obstacle degrees of the five subsystems across the four designated temporal nodes. Each radar panel consists of five radiating axes corresponding to the development dimensions, with concentric rings ranging from 0 to 0.4 indicating the intensity of their constraining effects. The morphology and contraction or expansion of the blue pentagonal profiles capture the dynamic evolution of the principal development bottlenecks.

The analysis indicates that while HQED and CCD exhibited an overall upward trend, their growth rates gradually slowed. From 2012 to 2020, the innovation development index increased steadily but not modestly before 2017, while its obstacle degree gradually increased. However, after 2017, this constraining effect weakened markedly, indicating stronger government emphasis on innovation. The shared development index experienced noticeable fluctuations but generally displayed an overall decline in its obstacle degree, as shared development (including education, healthcare, and income) has long been a policy priority. Given its close ties to public welfare, the shared development index is inherently more variable over time.

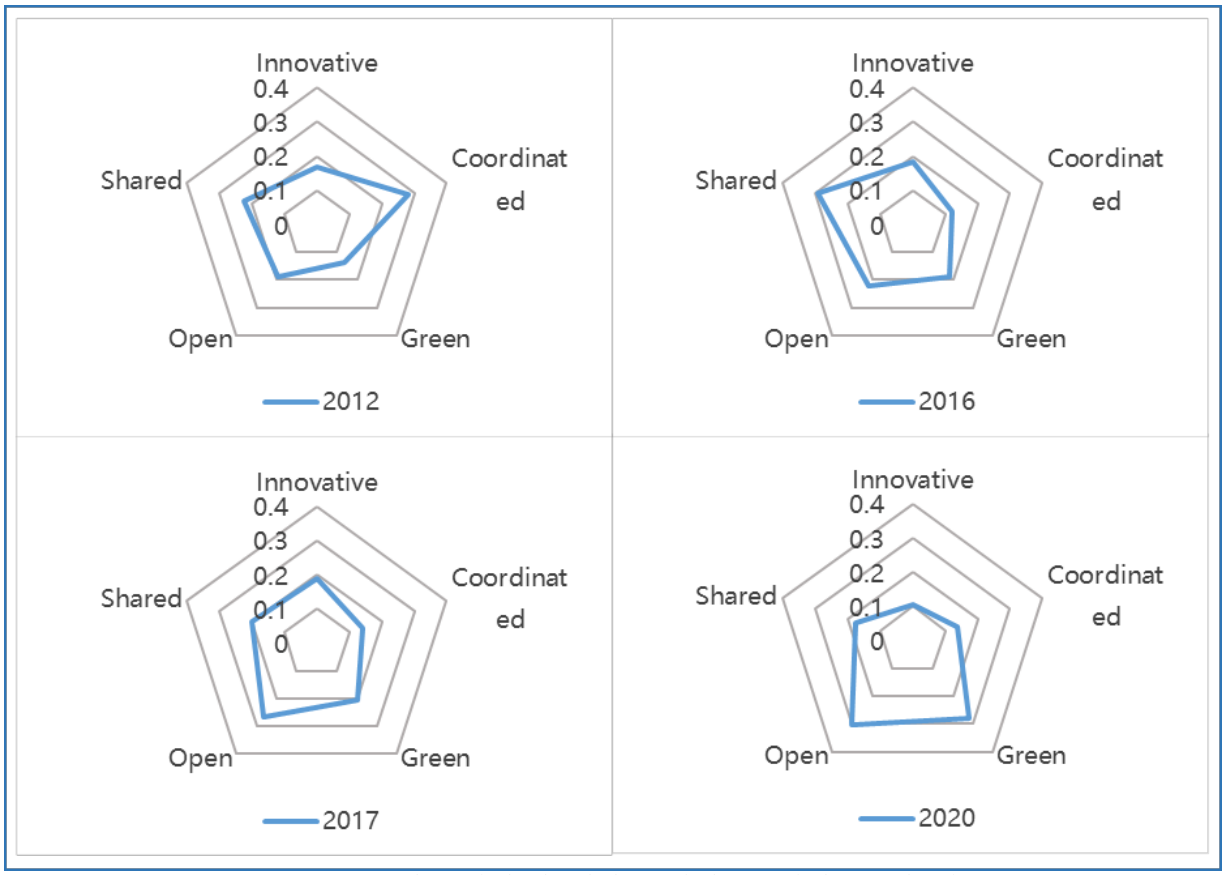


FIGURE 5. Changes in the obstacle degree of subsystems in the Central Region

Green and open development played a critical role in the evolution of HQED, exhibiting a steady upward trend despite occasional slowdowns. Notably, green development can act as a prominent constraint on HQED when innovation levels are low but gradually shifts towards a synergistic relationship once technological advancements reach a certain threshold (Lin et al. 2022). Although innovation is no longer a major obstacle to HQED, further improvements in technological capability remain necessary to enhance the positive association between innovation and green development.

INDICATOR-LEVEL OBSTACLE FACTOR ANALYSIS

To further identify the obstacle factors hindering HQED at the indicator level, TABLE 4 presents the ranking of obstacle factors, with the top four most influential indicators discussed below.

From 2012 to 2017, the main obstacles to HQED in China's Central Region were concentrated in three dimensions: green development, regional coordinated development, and shared development. In terms of green development, government investment in environmental protection (C1) steadily increased with economic growth, with its obstacle degree rising from 0.035 to 0.107, indicating that environmental issues remained one of the primary constraints on HQED. In terms of coordinated development, obstacle degree of tourism openness (D3) gradually declined, indicating steady progress in the region's tourism sector. The expansion of the tourism industry is inherently accompanied by rising energy demand, posing challenges to the structural balance of HQED (Shan & Ren 2023). Accelerating tourism upgrading and cultivating ecotourism are crucial for supporting HQED.

It is important to note that rural areas, which primarily rely on agricultural development, still face significant challenges due to underdeveloped healthcare systems, which continue to constrain HQED. Regarding shared development, insufficient public health expenditure (E2) also restricted HQED. Improving the modern public health system generates a positive spatial spillover effect on regional HQED (Wang et al. 2022). Compared with urban areas, the proportion of public healthcare spending in rural regions remained relatively low, with inadequate medical infrastructure. This highlights the urgent need for increased government support to improve rural healthcare services.

TABLE 4. Ranking of main obstacle factors in the indicator layer of the Central Region

Year	Obstacle Ranking			
	1	2	3	4
2012	C2	D3	E2	E3
	0.098	0.100	0.120	0.096
2013	C2	D3	E2	E3
	0.083	0.105	0.130	0.085
2014	B1	C1	D3	E2
	0.077	0.087	0.101	0.091
2015	C1	D3	E1	E2
	0.105	0.090	0.094	0.085
2016	C1	D2	E1	E2
	0.103	0.086	0.116	0.118
2017	C1	D1	D2	E1
	0.107	0.099	0.123	0.096
2018	C3	D1	D2	E1
	0.098	0.108	0.102	0.090
2019	C3	D1	D2	E1
	0.113	0.121	0.114	0.108
2020	C3	D1	D3	E1
	0.131	0.116	0.107	1.117

With continued economic development and the evolving alignment of government policies, the key obstacle factors restricting HQED have shifted since 2017. The expansion of secondary industries such as mineral extraction, heavy industry, and power generation has been by substantially increasing energy demand, placing substantial pressure on environmental protection. As a result, energy consumption (C3) has become a major constraint. Improving energy efficiency simultaneously generate structural synergy with reduced resource consumption and enhanced innovation capacity, thereby strengthening industrial competitiveness and reducing environmental burdens. The decline in the proportion of foreign investment (D1) reflects the challenges faced by the Central Region in attracting foreign capital. A resource-driven economy presents limited compatibility with foreign investors, while environmental concerns and rising labour costs are further reducing the region's investment attractiveness.

Additionally, the insufficient proportion of government spending on education (E1) indicates its lack of emphasis, coinciding with talent outflow and, consequently, adversely affecting industrial development and attraction for foreign investment. As economic development progresses, market demand for skilled talent will continue to grow, making the structural constraints associated with talent shortages even more pronounced. Based on this analysis, improving energy efficiency and increasing investment in education should be key priorities for promoting HQED.

ROBUSTNESS TEST

To assess the robustness of the identified bottlenecks, a Principal Component Analysis (PCA) was conducted as a complementary validation method. The analysis extracted six principal components with eigenvalues greater than 1 (3.962, 2.934, 1.784, 1.377, 1.295, and 1.021), collectively explaining a cumulative variance of 77.33%. The loading matrix is presented in Table 5.

TABLE 5. Principal component loading matrix for robustness test

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
A1	0.4428	-0.0126	-0.0134	0.0881	-0.1549	0.0664
A2	-0.0427	-0.067	0.1764	0.1673	-0.2655	0.1539
A3	0.4161	0.0156	0.2354	-0.1604	-0.0821	0.1599
B1	-0.3525	0.3914	0.0961	0.2108	0.1751	0.0614
B2	0.4019	0.2148	0.1498	0.0999	0.1584	-0.2318
B3	0.111	0.3686	0.107	0.0143	0.1324	-0.0248
B4	0.0523	0.5396	-0.2303	0.0346	0.0275	0.3311
C1	0.0475	-0.0394	0.0299	0.2004	0.6996	0.2257
C2	-0.0139	-0.2826	0.5335	0.3094	-0.0542	0.18
C3	0.4399	0.0251	0.054	0.0763	0.2203	0.1764
D1	0.1603	0.0196	-0.0786	0.5291	-0.3881	0.1871
D2	0.0755	0.4222	0.0138	-0.2701	-0.3472	0.0152
D3	-0.1881	0.2462	0.3101	0.3463	-0.0569	-0.291
E1	0.2016	-0.1904	-0.461	0.1216	0.0638	-0.2761
E2	-0.1368	-0.1045	0.0092	-0.2639	-0.0131	0.651
E3	-0.0772	-0.0132	-0.4621	0.4287	-0.072	0.21

The empirical factor loadings demonstrate strong consistency with the phased constraints identified by the ODM framework. Specifically, the core bottlenecks characterising the post-2017 phase are prominently captured: C3 (Energy Consumption) has a dominant loading of 0.4399 on Comp1, E1 (Proportion of Education Expenditure) exhibits the highest

loading of -0.4610 on Comp3, and D1 (Proportion of Foreign Investment) is the dominant contributor to Comp4 with a loading of 0.5291.

Crucially, the primary constraints characterizing the early 2012–2016 phase are also independently captured by subsequent components: D3 (Tourism Contribution Degree) shows a strong loading of 0.3101 on Comp3, while C1 (Environmental Expenditure) and E2 (Public Medical and Health Expenditure) emerge as the dominant variables on Comp5 (0.6996) and Comp6 (0.6510), respectively. Consequently, the fact that these critical variables independently emerge as the primary sources of structural variation provides strong dual-perspective validation, thereby confirming the empirical robustness of the study's findings.

CONCLUSSION

From 2012 to 2020, HQED in the Central Region maintained steady growth. Through the analysis, this study concludes that the main obstacles to HQED shifted from public expenditure- and healthcare-related constraints (C1, D3, E2) towards structural constraints associated with energy consumption (C3), FDI attraction (D1), and education investment (E1). Thus temporal transition was further supported by the exploratory PCA, which confirmed the structural robustness of the identified obstacle evolution.

By employing a multi-model coupling approach and a dynamic perspective, this study extends the existing literature on high-quality economic development (HQED). Departing from traditional approaches, the study constructs a cohesive analytical framework by coupling the CRITIC weighting method, the Coupling Coordination Degree Model (CCDM), and the ODM. This methodological synergy extends the literature from static cross-sectional evaluations to the dynamic analysis of evolutionary trajectories, revealing the temporal evolution and multidimensional independence of development bottlenecks.

Crucially, the empirical insights derived from this evolutionary trajectory, which demonstrates the transition of structural constraints from public welfare infrastructure to industrial energy constraints and human capital deficits, offer a highly transferable diagnostic framework for other resource-dependent, industrializing economies (such as specific regions in Latin America, Central Asia, or Southeast Asia) grappling with structural upgrading challenges (Hoa et al. 2024; Zakari & Oluwaseyi Musibau 2024).

Synthesizing these empirical findings, the following policy recommendations are proposed:

Facilitating the Green Transition of Industrial Clusters to Overcome Energy Constraints. Confronting the prominent bottleneck of energy consumption (C3), policy should pivot from traditional industrial expansion to green, low-carbon transformation. For sectors that that have experienced rapid expansion, such as tourism and mineral extraction, the government should formulate stricter energy-efficiency standards and promote digital transformation. Integrating innovation-driven technologies into industrial production will mitigate environmental pressures and reduce the structural constrain imposed by high energy intensity.

Optimizing the Human Capital Ecosystem to Ameliorate Investment Attraction. Addressing the concurrent constraints of foreign capital frictions (D1) and education deficits (E1), the government should spearhead the establishment of regional innovation and talent development platforms. Given the close relationship between technological innovation and human capital, increasing public investment in education and rural human resources is essential to mitigate talent outflow. Expanding the pool of highly skilled workers will reduce structural barriers to foreign investment, thereby creating a virtuous cycle between local capacity building and high-quality foreign investment.

The main limitations of this study are as follows: First, regarding data coverage, this study analyzes HQED in the Central Region using data from medium- and large-sized cities between 2012 and 2020. In consequence, it fails to capture the most recent developments in HQED and does not differentiate cities by size for comparative analysis of HQED performance and the associated obstacle factors. Second, the assessment of HQED relies solely on the CRITIC weighting method. Future research could expand both the temporal and spatial coverage of the dataset to provide a more comprehensive analysis of HQED evolution. Additionally, incorporating alternative measurement methods for comparison would help assess the robustness of the research findings.

REFERENCES

Abulimiti, M., Simayi, Z., Yang, S., Chai, Z. & Yan, Y. 2022. Study of coordinated development of county urbanizationin arid areas of China: The case of Xinjiang. *PloS one* 17(10).

Chaudhry, I.S., Nazar, R., Ali, S., Meo, M.S. & Faheem, M. 2022. Impact of environmental quality, real exchange rate and institutional performance on tourism receipts in East-Asia and Pacific region. *Current Issues in Tourism* 25(4): 611-631.

Chen, C., Pinar, M. & Stengos, T. 2020. Renewable energy consumption and economic growth nexus: Evidence from a threshold model. *Energy Policy* 139.

Chen, L. & Huo, C. 2022. The measurement and influencing factors of high-quality economic development in China. *Sustainability* 14(15).

Chen, W., Du, X., Lan, W., Wu, W. & Zhao, M. 2023. How can digital economy development empower high-quality economic development? *Technological and economic development of economy* 29(4): 1168–1194.
Du, L. & Li, B. 2022. Can the "Belt and Road" initiative promote the high-quality development of my country's economy?——An empirical study based on the double difference method. *North China Finance*(5): 18-34.
Du, X. 2023. Can environmental regulation promote high-quality economic development?: Evidence from China. *Economic Analysis and Policy* 80: 1762-1771.
Fan, L., Liu, H., Shao, Z. & Li, C. 2022. Panel data analysis of energy conservation and emission reduction on high-quality development of logistics industry in Yangtze River Delta of China. *Environmental Science and Pollution Research* 29(52): 78361-78380.
Gu, J. & Liu, Z. 2024. A study of the coupling between the digital economy and regional economic resilience: Evidence from China. *PloS one* 19(1).
Guo, C., Liu, C., Xie, Q. & Lin, X. 2022. Regional entrepreneurship, business environment, and high-quality economic development: An empirical analysis of nine urban agglomerations in China. *Frontiers in Psychology* 13.
Guo, D., Wang, D., Zhong, X., Yang, F., Yang, Y. & Jia, H. 2023. The coupling coordination and interaction mechanism of land ecological security and high-quality economic development in the beijing–tianjin–hebei region. *Sustainability* 15(21).
Hoa, P. X., Xuan, V. N. & Thu, N. T. P. (2024). Nexus of innovation, foreign direct investment, economic growth and renewable energy: New insights from 60 countries. *Energy Reports* 11: 1834-1845.
Hua, J., Yu, J., Song, Y., Xue, Q. & Zhou, Y. (2024). The enabling effect of digital economy on high-quality agricultural development-evidence from China. *Sustainability* 16(9): 1-18.
Huang, X., Binqing, C. & Yalin, L. 2020. Evaluation index system and measurement of high-quality development in China. *Revista De Cercetare Si Interventie Sociala* 68: 163-178.
Jun, W., Xiao, M. & Yi, Z. 2023. Evaluation of the policy effect of establishing free trade zones to promote high-quality economic development——Explanation from resource allocation. *Learning and Exploration*(01): 127-137.
Kong, Q., Peng, D., Ni, Y., Jiang, X. & Wang, Z. 2021. Trade openness and economic growth quality of China: Empirical analysis using ARDL model. *Finance Research Letters* 38.
Lai, Z., Ge, D., Xia, H., Yue, Y. & Wang, Z. 2020. Coupling coordination between environment, economy and tourism: A case study of China. *PloS one* 15(2): 1-18.
Li, L., Fan, Z., Feng, W., Yuxin, C. & Keyu, Q. 2022. Coupling coordination degree spatial analysis and driving factor between socio-economic and eco-environment in northern China. *Ecological Indicators* 135.
Li, X., Zhou, X. & Yan, K. 2022. Technological progress for sustainable development: An empirical analysis from China. *Economic Analysis and Policy* 76: 146-155.
Li, Y. 2023. Level measurement and path exploration of high-quality development in the central region. *Statistical Theory and Practice* 12: 35-40.
Lin, T., Wang, L. & Wu, J. 2022. Environmental regulations, green technology innovation, and high-quality economic development in China: Application of mediation and threshold effects. *Sustainability* 14(11): 1-20.
Liu, J. & Liu, H. 2024. Study on the spatiotemporal evolution of coupled and coordinated digital economic resilience and efficiency. *International Review of Economics & Finance* 93: 876-888.
Liu, L.-K., Liang, L.-T., Gao, P., Fan, C.-S., Wang, H.-H. & Wang, H. 2021. Coupling relationship and interactive response between ecological protection and high-quality development in the Yellow River Basin. *Journal of Natural Resources* 36(1): 176-195.
Liu, S. & Qu, X. 2022. Development quality evaluation from the perspective of coordinated development: Based on the empirical analysis of five provinces' panel data. *Forest Chemicals Review*: 1610-1621.
Liu, Y. 2022. Research on the measurement of the high-quality development index system of China. *Frontiers in Economics and Management* 3(10): 111-115.
Lu, Y. 2021. Empirical analysis on the relationship between tertiary industry structure and economic growth based on multiple regression—A case study of Henan province. E3S Web of Conferences.
Luo, S., Yimamu, N., Li, Y., Wu, H., Irfan, M. & Hao, Y. 2023. Digitalization and sustainable development: How could digital economy development improve green innovation in China? *Business Strategy and the Environment* 32(4): 1847-1871.
Ma, X. & Xu, J. 2022. Impact of environmental regulation on high-quality economic development. *Frontiers in Environmental Science* 10.
Mai, Q., Bai, M. & Li, L. 2022. Study on the dynamic evolution and regional differences of the level of high-quality economic and social development in China. *Sustainability* 15(1): 1-15.
Mao, J., Wang, Z. & Ma, T. 2023. Dynamic evolution of high-quality economic development levels: Regional differences and distribution in West China. *Land* 12(11): 1-21.
Meiyun, Z. & Fan, L. 2022. Can the establishment of free trade zone promote the high-quality development of regional economy? Based on the analysis of free trade zones in Central and Western China. *West Forum on Economy and Management* 33(6): 57-68.

Meng, G., Wang, K., Wang, F. & Dong, Y. 2023. Analysis of the tourism-economy-ecology coupling coordination and high-quality development path in karst Guizhou province, China. *Ecological Indicators* 154.
Niemets, K., Kravchenko, K., Kandyba, Y., Kobylin, P. & Morar, C. 2021. World cities in terms of the sustainable development concept. *Geography and Sustainability* 2(4): 304-311.
Shan, Y. & Ren, Z. 2023. Does tourism development and renewable energy consumption drive high quality economic development? *Resources Policy* 80.
Wang, D., Xue, S., Lu, Z., Zhou, Y., Hou, Y. & Guo, M. (2024). Dynamic evolution and spatial–temporal disparities decomposition of high-quality economic development in China. *Environment, Development and Sustainability* 26(8): 19491-19519.
Wang, D., Zhang, E. & Liao, H. 2022. Does fiscal decentralization affect regional high-quality development by changing peoples' livelihood expenditure preferences: Provincial evidence from China. *Land* 11(9): 1-20.
Wang, S. & Shi , D. 2023. Research on the impact of the establishment of free trade zones on high-quality economic development: An empirical analysis based on 270 prefecture-level cities. *Journal of Dalian Maritime University (Social Science Edition)* 22(04): 63-73.
Wei, X., Zhao, R. & Xu, J. 2023. Spatiotemporal evolution, coupling coordination degree and obstacle factors of urban high-quality development: A case study of Anhui Province. *Sustainability* 15(14): 1-20.
Xiong, Y. & Liu, X. 2023. Research on the synergistic evaluation of regional green finance and regional economy under CRITIC model. *Highlights in Business, Economics and Management* 5: 479-488.
Xu, L., Wang, C., Ba, N. & Hao, Y. 2023. On the urban resource and environment carrying capacity in China: A sustainable development paradigm. *Journal of Environmental Management* 342.
Yan, X., He, T., Qian, P. & Liu, Z. 2024. Does the construction of Pilot Free Trade Zones promote the development of green economy?-A quasi-natural experiment evidence from China. *Economic Analysis and Policy* 81: 208-224.
Ye, Z., Qian, L. & Na, Z. 2018. Financial development, urbanization, and urban-rural income disparity: Evidence based on Chinese provincial data. *Modern Economy* 9(1): 31-60.
Yin, M., Yang, X. & Xiao, B. 2023. Analysis of the synergistic benefits of regional green finance and the regional economy based on the CRITIC model. *Highlights in Business, Economics and Management* 12: 77-87.
Yong-bing, X., Peng, L. & Yue, Z. 2019. Construction and measurement of high quality development indicator system——Taking Hebei Province as an example. *Journal of Hebei University (Philosophy and Social Science)* 44(3): 86-97.
Zakari, A. & Oluwaseyi Musibau, H. 2024. Sustainable economic development in OECD countries: Does energy security matter? *Sustainable Development* 32(1): 1337-1353.
Zhang, M. & Luo, Q. 2022. A systematic literature review on the influence mechanism of digital finance on high quality economic development. *Journal of Risk Analysis and Crisis Response* 12(1): 45-54.
Zhang, Q., Li, J., Li, Y. & Huang, H. 2023. Coupling analysis and driving factors between carbon emission intensity and high-quality economic development: Evidence from the Yellow River Basin, China. *Journal of cleaner production* 423.
Zhang, Y., Fang, Z. & Xie, Z. 2023. Study on the coupling coordination between ecological environment and high-quality economic development in urban agglomerations in the middle reaches of the Yangtze River. *International Journal of Environmental Research and Public Health* 20(4).
Zhang, Y., Su, Z., Li, G., Zhuo, Y. & Xu, Z. 2018. Spatial-temporal evolution of sustainable urbanization development: A perspective of the coupling coordination development based on population, industry, and built-up land spatial agglomeration. *Sustainability* 10(6).
Zhang, Y., Zhu, T., Guo, H. & Yang, X. 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.
Zhao, C. & Liu, H. 2023. Research on the North-South economic development gap in China from the perspective of urban agglomerations. *China Population, Resources & Environment* (33): 134-142.
Zhao, M., Zhang, R., Liu, H., Zhang, X. & Wang, Y. 2023. A study on the spatial-temporal evolution and problem area identification of high-quality urban development in the central region. *Sustainability* 15(14).
Zhu, H., Deng, F. & Liang, X. 2017. Overall urban–rural coordination measures—A Case study in Sichuan Province, China. *Sustainability* 9(2): 1-20.
Zhu, H. & Wang, X. 2023. Research on the evaluation index system of high-quality development of county economy: Taking H Province as an example. *Administrative Reform* 12: 57-64.

WenJie Chen
Faculty of Economics and Management
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor, MALAYSIA.
E-mail: venjay1247@gmail.com

Mohd Nasir Mohd Saukani*
Faculty of Economics and Management
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor, MALAYSIA.
E-mail: nasirs@ukm.edu.my

* Corresponding author