Relationship Research between Digital Economy and High-Quality Economic Development on the view of Foreign Trade Opening

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Abstract. Digital Economy (DE), as a vital impetus for high-level openness, interacts with High-Quality Economic Development (HQED). Researching Coordination mechanism among these three aspects carries substantial weight in a country to achieve common prosperity and strategic goals. Based on this premise, this paper first uses provincial data from 2014-2021 as the research object, measuring the levels of Digital Economy and HQED Employing the comprehensive index, Entropy Weight Method and critic weight. It also employs the coefficient of variation, Theil index, and coefficient of dispersion to analyze the trends in regional disparities concerning the development of DE and HQED. Subsequently, the Dynamic interaction model, grounded in the entropy weight method, was employed to quantitatively assess the coupling coordination between DE and HQED. Then, the random forest model was used to explore the impact of constituent indicators regarding the coupling coordination between the two systems, with XGboost and LASSO models serving as supportive evidence. Empirical analysis results indicate that, on one hand, the disparities in HQED among regions showed an initial increase followed by a decrease, while the disparities in Digital Economy development among regions demonstrated a year-over-year decreasing trend. On the other hand, during 2014-2021, the disparities in harmony with DE and HQED among regions decreased annually. Additionally, foreign-trade dependence and share of foreign investment are found to be significantly important to Coupling efficiency.

Keywords: Digital Economy, High-Quality Economic Development, Foreign Trade, Comprehensive Evaluation, Machine Learning.

1. Introduction

DE, HQED and Opening up are highly complex systems.In 2017, the government work report highlighted DE as a new focus for the first time, and in 2019, DE has risen again to become a national strategy[1-2]. This reflects the country's commitment to Opening up at a high level. This indicates that the government prioritizes advancing high-standard openness for fostering superior growth. At a time when the development of science and Technological advancements are accelerating and the pattern of Opening up is unfolding in an all-round, multi-level and wide-ranging manner, DE and the level of Opening up, as a new type of economic development model, comply with the present-day economic circumstances in China. This study focuses on Coordination mechanism between DE and HQED under the current year's opening-up level, which has far-reaching impact and important practical value in accelerating trade dynamic improvement, enhancing international competitiveness, adapting to the trend of digital transformation, and fostering new trade patterns in the context of economic globalization and the information technology revolution.

There is an interplay between DE and HQED. How to harmonize DE and HQED? This is the proposition that this paper wants to explore[3]. According to existing research, with the proliferation and key integration of information platforms and communication technologies, the rapid proliferation of DE markedly mitigates information inequality, trims transactional fees, and amplifies factor yield by promoting additional industrial differentiation and refining the efficiency with which resources are deployed[4-5] . With the intensifying evolution of DE research, scholars have begun to investigate

the dynamics of DE and its role in HQED from the theoretical and practical level[6]. Jin Chunzhi et al.[7] Based on the reality of China's unbalanced regional development, the study concluded that a substantial digital gap among regions hinders the progress of underdeveloped territories. Zhang Lingjie et al.[8] Relying on panel data between Chinese provinces from 2010-2019, the study concludes that in general DE significantly enhances overall factor productivity by improving the industrial framework. Ye Xu [9] et al.'s empirical exploration premised on panel data of Chinese provinces from 2001-2017 shows that the effect of Digital Economy growth on the job market configuration will see a leapfrog improvement, thus optimizing the economic structure. Tang Yunkai et al.[10]advocate that DE is capable of notably improving the general welfare. Guo Jiatang et al.[11] Presented a theoretical explanation for how DE can influence HQED and the impact of the Internet on overall factor productivity. At this stage, many literatures tend to study DE is considered a component of superior growth, yet there is a scarcity of empirical research into assessing the reciprocal influence of top-tier economic progress on DE. In summary, most studies only qualitatively analyze the connotation, influencing factors, paths and the relationship between DE and HQED from different dimensions, while fewer studies quantitatively evaluate the development level and relationship between the two, and even fewer studies analyze Coordination mechanism between DE and HQED based on the perspective of Opening up.

This paper employs the comprehensive index method to measure the levels of DE and HQED and uses the Dynamic interaction model to quantify and analyze regional disparities Coordination mechanism between DE and HQED. The marginal contributions of this paper are: (1) Proposing a new comprehensive index measurement method based on entropy value critic weight that fully considers the correlation between indicators, their own fluctuations, and the amount of information stored. (2)Through measurement methods, disparity analysis, and research on coupling coordination degrees,while assessing the volatility of both DE and quality development independently. the paper also expands on trend analysis of disparities among provinces in terms of openness, high-caliber advancement, coupled with the digitized economy based on Coordination mechanism between them. It finds that the disparities in DE and coupling coordination degree are decreasing year by year, while the disparities in HQED show a trend of rising first and then declining. (3) This paper innovatively applies machine learning models to solve macroeconomic problems and concludes that foreign trade openness assumes a critical part in the interplay and consistency between DE and high-grade development, providing fresh analytical approaches to econometric topics.

2. Research Principles and Methods

2.1. Research Principles

As two interactive and complex systems, a dynamically progressive relationship is evident between DE and quality advancement, with both entities propelling and influencing each other's progress. The majority of scholars concur that there exists a proactive and beneficial interaction between DE and HQED. Zuo Pengfei et al.[12] believe that DE can drive the economy to realize HQED by promoting the reconstruction of the economic system, and at the same time, the long-term positive development of China's economy has boosted the development of DE to improve quality and efficiency; Song Xiaona et al.[13] By constructing a comprehensive measurement system of innovation-coordination-green-openness-sharing, the study points out that the accelerated development of Digital Economy can inject a strong impetus for HQED; Li et al.[14] believe that the deep integration of DE and the HQED of the economy can promote the economy to realize quality, efficiency and power change; Fan Hejun et al.[15] et al. propose that digitization can substantially boost China's economic growth and HQED, as indicated by the analysis of inter-provincial sample data from 2014 to 2017.

Drawing on extant research and data accessibility, this paper develops Digital Economy measurement indicators from three dimensions: informationization development, Internet development and digital transaction development, each of which unfolds from the perspectives of

foundation and impact.[16].As a result, a Digital Economy development level indicator measurement system as shown in Table 1 is designed to comprehensively measure the level of Digital Economy for each province within China.

Table 1. Digital Economy Development Level Indicator System

Primary Indicators	Secondary Indicators	Tertiary Indicators	Indicator Definition
Digital Economy Development	Information Development	Information Infrastructure	Optical Cable Density (+)
		Information Impact	Proportion of Information Industry Workers (+)
	Internet Development	Fixed Internet Infrastructure	Number of Internet Broadband Ports (+)
		Mobile Internet Infrastructure	Mobile Phone Penetration Rate (+)
		Static Internet Influence	Share of Broadband Internet Users(+)
		Mobile Internet Impact	Proportion of Mobile Internet Users (+)
	Digital Transaction Development	Digital Transaction Infrastructure	Websites per 100 Enterprises (+)
		Digital Transaction Impact	E-commerce Sales Volume (+)

Note: "+" indicates a positive indicator, "-" indicates a negative indicator.

Considering the differences in the level of regional economic development and the diversification of development paths, this paper compares the relative gap of HQED among provinces as the purpose of measuring HQED, by drawing on the evaluation of the degree of economic marketization of each region by Fan Gang et al.[17] Evaluation of the degree of marketization within the regional economy, this paper thus designs an HQED index measurement system as shown in Table 2, using the relative index as the index for measuring the HQED of the provincial economy, and measuring the level of HQED of China's provinces.

Table 2. HQED Indicator System

Primary Indicators	Secondary Indicators	Tertiary Indicators	Indicator Definition
HQED	Innovative Development	GDP Growth Rate (+)	Regional GDP Growth Rate
		R&D Investment Intensity (+)	Industrial Enterprises above designated size R&D Expenditure/GDP
		Investment Efficacy (-)	Investment Rate/Regional GDP Growth Rate
		Technology Transaction Activity (+)	Technology Transaction Turnover/GDP
	Coordinated Development	Demand Structure (+)	Total Retail Sales of Consumer Goods/GDP
		Urban-Rural Structure (+)	Urbanization Rate
		Government Debt Burden (-)	Government Debt Balance/GDP
		Industrial Structure (+)	Increase in the Proportion of Output Value of Tertiary Industry in Regional GDP
	Green Development	Energy Consumption Elasticity Coefficient (-)	Energy Consumption Growth Rate/GDP Growth Rate
		Wastewater per Unit Output (-)	Wastewater Discharge/GDP
		Waste Gas per Unit Output (-)	Sulfur Dioxide Emissions/GDP
	Open Development	Dependence on Foreign Trade (+)	Total Import and Export Volume/GDP
		Proportion of Foreign Investment (+)	Total Foreign Investment/GDP
		Degree of Marketization (+)	Regional Marketization Index
	Shared Development	Labor Income Share (+)	Labor Remuneration/Regional GDP
		Resident Income Growth Elasticity (+)	Per Capita Disposable Income Growth Rate/Regional GDP Growth Rate
		Urban-Rural Consumption Gap (-)	Per Capita Consumer Expenditure of Urban Residents/Per Capita Consumer Expenditure of Rural Residents
		Proportion of Public Welfare Fiscal Expenditure (+)	Housing Security Expenditure, Medical and Health Expenditure, Local Fiscal Education Expenditure, Social Security and Employment Expenditure as a Proportion of Local Fiscal Budgetary Expenditure

Note: "+" indicates a positive indicator, "-" indicates a negative indicator.

2.2. Research Methods

2.2.1 Comprehensive Index Method Based on Entropy Weighting and Critic Weights

For the issue of HQED, the entropy value method reflects the information and difference of the indicators by calculating their entropy value, so as to realize the adaptive weight allocation and avoid the bias of subjective assignment[18]. This paper tries to take statistical data as sample data and adopt the entropy-CRITIC method to make a comprehensive evaluation of Digital Economy and HQED level. The steps for synthesizing weights for the entropy-CRITIC method are as follows:

It is assumed that there is a need to evaluate the development status of regions in year m and that the system of evaluation indicators includes n indicators. In this regard, a mathematical model can be developed as follows.

$$\mathbf{X}=\begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix}$$

In which x_{ij} signifies the value of the j-th assessment criterion for the i-th sample. Initially, determine the entropy weight for each criterion. Then, calculate the standard deviation of the inter-indicator volatility metric.

$$S_j=\sqrt{\frac{\sum_{i=1}^{m}(x'_{ij}-\bar{x}'_j)^2}{n-1}} \tag{1}$$

where $\bar{x}'_j$ represents the mean value of the j-th variable. Then, calculation of inter-indicator conflictivity.

$$A_j=\sum_{i=1}^{m}(1-|R_{ij}|) \tag{2}$$

Where R_{ij} is the correlation coefficient between the indicators. Lastly,calculate portfolio weights.

$$w_j=\frac{W_{ej}S_jA_j}{\sum_{j=1}^{m}W_{ej}S_jA_j} \tag{3}$$

Based on entropy-CRITIC method, we can get the composite index.

$$IFI_i=1-\frac{\sqrt{(w_1-E_1)^2+(w_2-E_2)^2+\cdots+(w_k-E_k)^2}}{\sqrt{w_1^{\,2}+w_2^{\,2}+\cdots+w_k^{\,2}}} \tag{4}$$

the above equation. IFI_i is DE development index or HQED index of the i-th region, and E_k denotes the measured value of the k-th indicator, and w_k denotes the weight of the k-th indicator. When$IFI_i$is 1, it indicates that the level of Digital Economy or HQED at this time is the highest, and when it is 0, this suggests that the current state of DE or the Quality of Economic Development is at its nadir.

2.2.2 Coefficients of variation, Thiel index and coefficient of dispersion

The Thiel index is introduced to measure the level of difference between DE and HQED in each province, modeled as follows:

$$Tl=\frac{1}{n}\sum_{i=1}^{n}\left(\frac{D_{\theta i}}{\overline{D}_{\theta i}}\times \ln\frac{D_{\theta i}}{\overline{D}_{\theta i}}\right) \tag{5}$$

where $D_{\theta i}$ signifies the extent of digital development or HQED for the i-th provincial, regional, or municipal entity. and $\overline{D}_{\theta} = \frac{1}{n}\sum_{i=1}^{n} D_{\theta i}$ represents the mean standard of digital and high-quality economic progress across the provinces, regions and cities across the country, the closer the Tel Index is to 0, the smaller the difference in digital development or HQED of each province is; the closer it is to 1, the larger the difference in digital development or HQED is.

Discrete Coordination mechanism of variation are introduced to measure the convergence characteristics and the degree of deviation of the level of Digital Economy development and the level of HQED, and the model is as follows:

$$\tau_{\theta} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\ln(D_{\theta i}) - \frac{1}{n}\sum_{i=1}^{n} \qquad V_{\theta} = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(D_{\theta i} - \overline{D}_{\theta i})^2}}{\overline{D}_{\theta i}} \tag{6}$$

where τ_{θ} is the coefficient of dispersion, and V_{θ} is the coefficient of variation, the τ_{θ} and V_{θ} The smaller the coefficient, the stronger the convergence.

2.2.3 Coupling coordination degree model based on entropy method

The degree of coupling coordination refers to the degree of benign coupling in the interaction between the two systems, DE and the level of development of that quality, and reflects the state of coordination in order to distinguish whether the two systems are mutually reinforcing at a high level or mutually constraining at a low level.

Introducing a coupled coordination model to measure the synergistic effect of Digital Economy and HQED model is as follows:

$$C_{\theta i} = \sqrt{\frac{S_{\theta i} \times E_{\theta i}}{(\frac{S_{\theta i} + E_{\theta i}}{2})^2}} \qquad \begin{cases} G_{\theta i} = \alpha \times S_{\theta i} + \beta \times E_{\theta i} \\ D_{\theta i} = \sqrt{C_{\theta i} \times G_{\theta i}} \end{cases} \tag{7}$$

where $C_{\theta i}$ denotes the coupling degree, the $G_{\theta i}$ denotes the composite coordination index, and$D_{\theta i}$ is the coupling coordination degree. With the help of entropy value CRITIC weights of the comprehensive index method to calculate DE and HQED of the corresponding α and β weights. The degree of coupling coordination is between 0 and 1, the larger the value, the stronger the ability of coordinated development of the two; the smaller the value, the weaker the ability of coordinated development of the two[19]. The smaller the value, the weaker the ability of coordinated development of the two.

For importance of features based on machine learning algorithms, we use Lasso model,XGboost model and Random forest model. This paper follows the correct process of training models in machine learning, selects three algorithms with integrated strategies to build models, and introduces the feature importance screening method in feature engineering, to carry out deeper screening and extraction for the selected features, so as to extract the features that affect the coupling and coordination of DE and HQED in a deeper degree, and provide targeted suggestions for the coordination of DE and HQED .

3. Empirical analysis

3.1. Data sources and pre-processing

This study is based on 31 provincial-level administrative units in China (excluding Hong Kong, Macao and Taiwan). The data were obtained from China Statistical Yearbook（stats.gov.cn), China Environmental Statistical Yearbook, and China Energy Statistical Yearbook from 2015 to 2022.

3.2. Measurement results of DE and HQED

In order to facilitate comparative research, this paper simultaneously uses the coefficient of variation, the coefficient of dispersion and the Thiel Index to analyze the convergence of HQED and digital development environments, and at the same time divides them according to the year. Figure 1 shows the convergence map of our overall high quality economic development. Based on the data related to the HQED of each province from 2014 to 2021, Table 3 shows the changes in weights of various indicators for HQED from 2014 to 2021. and the combination of Figure 1 and Table 3 can be analyzed to conclude the change of the overall HQED level in China during the sample period. According to Figure 1, although the corresponding numerical intervals of the three indicators of the Thiel Index, the coefficient of dispersion and the coefficient of variation are not the same, their trends are almost the same, which effectively improves the accuracy and credibility of the analysis of regional differences and development trends. The coefficient of variation declined from 2014 to 0.15 in 2015, and after 2015, the coefficient of variation showed an increasing trend, with the largest increase between 2015 and 2018, during which China faced challenges such as slowing economic growth and a tense external trade environment, and shifted from high-speed growth to a development model that emphasized more on quality and efficiency. The change in the pattern of economic growth calls for deeper structural reforms to promote sustainable economic development. Therefore, there are large differences in the level of HQED among provinces. The coefficient of variation is basically stable at about 0.5 in 2018-2019, while the coefficient of variation shows a decreasing trend from 0.5 to about 0.34 in 2019-2021, which indicates that China's overall level of HQED has shown a converging trend in the period of 2019-2021, and that the level of HQED has basically been stabilized. stabilized. This is attributed to the concept of "One Plan for the Whole Country" proposed in 2019, through the implementation of a series of strategies, such as balancing the distribution of public resources and exploring the construction of a standardized regional cooperation framework, as well as providing additional support to special regions.

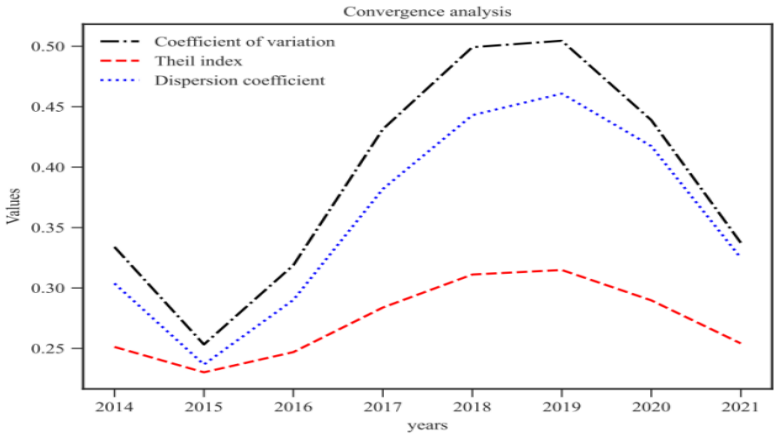


Figure 1. Convergence map of our overall high quality economic development

Table 3. Convergence analysis results for high quality economic development

vintages	coefficient of variation	Thiel index	dispersion coefficient
2014	0.333991485	0.251251721	0.303800695
2015	0.253261875	0.230226688	0.236682681
2016	0.318849319	0.246956089	0.290139835
2017	0.431415918	0.283831178	0.381924555
2018	0.499235558	0.311140875	0.442951827
2019	0.504548697	0.314893507	0.460821074
2020	0.438867868	0.28977146	0.417343945
2021	0.337393476	0.254147012	0.324896675

Figure 2 shows the convergence map of the digital development environment in China. Based on the data related to the development level of Digital Economy in each province from 2014 to 2021. Table 4 shows the changes in weights of various indicators for the digital development environment from 2014 to 2021. Combined with Figure 2 and Table 4 for analysis, the corresponding value intervals of the three indicators of the Thiel Index, the discrete coefficient, and the coefficient of variation are different, while the trend of the Thiel Index and the range of fluctuation are small, and the curve and trend of the discrete coefficient and the coefficient of variation are almost overlapping, so the coefficient of variation is used for comparison. From 2014-2021, the coefficient of variation shows a fluctuating downward trend, indicating that the digital development environment shows a converging trend, while from 2015-2019, the coefficient of variation is basically between 0.48 and 0.54, indicating that during this period, the digital development environment is relatively stable, with no obvious changes. After 2019, the coefficient of variation decreases significantly, which indicates that there is a large change in the digital development environment in 2019-2021. The coefficient of variation decreases from a high level in 2019 to 0.37 in 2021, indicating that the overall digital development environment inter-regional differences are fluctuating and decreasing.

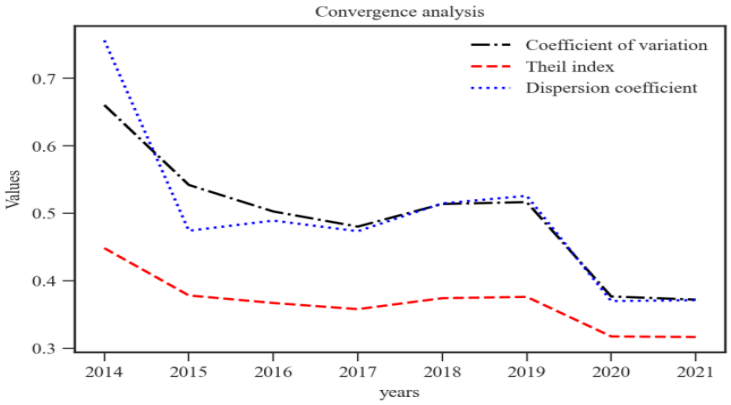


Figure 2. Convergence map of the digital development environment in China

Table 4. Convergence analysis results for the digital development environment

vintages	coefficient of variation	Thiel index	dispersion coefficient
2014	0.660532274	0.448549387	0.7563856
2015	0.542191749	0.378474948	0.474320962
2016	0.502893612	0.367302326	0.489358455
2017	0.480452636	0.358165771	0.473616911
2018	0.513992094	0.374416247	0.514815614
2019	0.516755571	0.376347659	0.526046513
2020	0.376945819	0.317734273	0.370185437
2021	0.37228525	0.316895012	0.371477055

3.3. Coupling coordination of DE and HQED

According to the results of coupling coordination modeling, we get the following conclusions. The coupling and harmonization of DE and HQED is also relatively high in the eastern coastal regions. In studies of regional economic development, regions with a higher degree of coordination often have a significant impact on the economic development of their neighboring regions. This pattern of regional development suggests that regions with a higher degree of coordination are able to drive the economic development of neighboring regions through various mechanisms, such as policy guidance, industrial radiation, talent flow and information sharing. In view of the excessive experimental results, they are omitted in this paper.

Table 5 utilizes the coefficient of variation to gauge the coupling coordination between DE and HQED. This method is validated by comparing with the Thiel index, coefficient of variation, and

discrete coefficient, ensuring the model's accuracy and reliability. According to Figure 3, there's a declining trend in the coefficient of variation from 2014 to 2021, suggesting an improving coordination between Digital Economy and HQED. The decreasing gap indicates progress towards balanced regional economic development. However, an increase in the coefficient during 2017-2019 points to diverging synergies, potentially due to policy disparities and uneven resource distribution. Since 2019, a decrease to 0.14 in 2021 reflects a convergence in synergies, aligning with national strategies for balanced growth.

In summary, although most regions have made some progress in Digital Economy and HQED, there is still a lack of synergistic development.

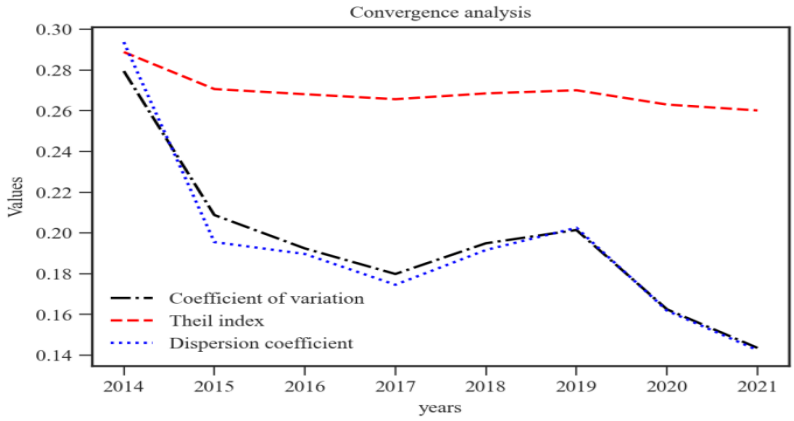


Figure 3. Convergence map of coupling coordination

Table 5. Convergence analysis results for the coupling coordination

vintages	coefficient of variation	Thiel index	dispersion coefficient
2014	0.279536911	0.288883162	0.29375766
2015	0.208836304	0.270700612	0.195568642
2016	0.192431379	0.268164904	0.189696052
2017	0.179878537	0.265723938	0.174592479
2018	0.194970658	0.268570884	0.191663216
2019	0.201488378	0.270109328	0.202600731
2020	0.162519184	0.263086779	0.161858956
2021	0.143564043	0.260198299	0.142471616

3.4. Analysis of factors influencing the degree of coupling coordination

This study explores the degree of influence of the constituent indicators of the two systems on the degree of coupling and coordination of the two systems through the Random Forest model, with the XGboost and LASSO models as supporting evidence. From the study in Table 6, it is concluded that in the analysis of the importance of the characteristics of the three models integrating XGboost, LASSO and Random Forest, it ranks high in the overall importance of five indicators: Internet broadband access ports, government debt burden, and the proportion of foreign investment and dependence on foreign trade, and Cell phone penetration rate.These features have important impacts in many fields such as economy, society and science and technology.

Since XGboost and Random Forest models are able to capture the interaction between features, while Lasso regression focuses mainly on the effect of individual features, it results in some of the metrics having a weaker feature importance in XGboost and Random Forest models and a stronger feature importance in lasso models, e.g., External trade dependence is assessed by Random Forest as 0.095679 in the random forest assessment, 0.098420 in the XGboost assessment, and a higher 0.170609 in the lasso assessment, and at the same time, its composite score is also higher, indicating that it has a greater role in the coupling and coordination of the two systems, and the similar examples

are Share of foreign investment, marketability, the Government debt burden, Cell phone penetration rate (units/100 population)

GDP growth rate, Technology transaction, Demand structure, Industrial structure, Income elasticity of the population, Investment efficiency. Wastewater per unit of output, Optical fibre density, Percentage of Information Technology Employees, Percentage of mobile Internet users These indicators have a weak effect on the coupling of the two systems. The role of the coupling of the two systems is weak, and some of the indicators may have a strong correlation, such as the income level of residents will affect their consumption structure. That is, as income increases, people tend to change their consumption patterns, such as increasing consumption of high-quality or service products. Meanwhile, since the Lasso model, as a linear regression model, prevents over-fitting and enables feature selection by introducing L1 regularization, the Lasso model tends to retain only those features that have a significant impact on the prediction results and exclude other features that are irrelevant or less relevant. As a result, these metrics have a low level of feature importance in the XGboost and random forest models and 0 in the lasso.

Table 6. Analysis results for feature importance analysis

variant	Importance under the random forest model	Importance under the XGboost model	Importance under the LASSO model
GDP growth rate	0.005518	0.003163	0.000000
R&D investment intensity	0.009943	0.004742	0.000040
Technology transaction activity	0.003327	0.002349	0.000000
Demand structure	0.005099	0.005357	0.000000
Urban and rural structures	0.013037	0.014690	0.007131
industrial structure	0.008796	0.008470	0.000000
External trade dependence	0.095679	0.098420	0.170609
Share of foreign investment	0.162151	0.212899	0.055386
marketability	0.083900	0.156437	0.004419
Share of workers' remuneration	0.008835	0.012535	0.000143
Income elasticity of the population	0.002874	0.001927	0.000000
Share of fiscal expenditure on people's livelihoods	0.004479	0.002777	0.009234
Investment efficiency	0.096250	0.079287	0.000000
Government debt burden	0.150728	0.197925	0.021900
Coefficient of elasticity of energy consumption	0.004240	0.001512	0.000013
Wastewater per unit of output	0.003588	0.002269	0.000000
Urban-rural consumption gap	0.006244	0.005113	0.000752
optical fiber density	0.005419	0.003641	0.000000
Percentage of Information Technology Employees	0.009929	0.006892	0.000000
Internet broadband access port	0.220071	0.112899	0.441193
Cell phone penetration rate (units/100 population)	0.043679	0.027140	0.266223
Percentage of broadband Internet subscribers	0.012017	0.007824	0.022955
Percentage of mobile Internet users	0.032088	0.023559	0.000000

4. Conclusions and recommendations

Based on a comprehensive analysis of data on HQED and DE in China's provinces and regions from 2014 to 2021, this study shows significant disparities in HQED and digitalization among Chinese provinces, with the eastern region leading. Despite this, Hebei and Hainan still fall below the national average, highlighting room for improvement. However, since 2019, there has been a trend towards convergence due to integrated regional strategies. While most regions have made progress, the coordination between HQED and DE is weak, particularly outside the eastern coastal region. The establishment of the National Common Wealth Demonstration Zone may further promote synergy in these areas.

In summary, this study makes the following policy recommendations:

Formulation of differentiated regional development strategies: Governments should design and implement precise policy measures to address the development levels and resource endowments of different regions. In particular, more incentives and supportive policies need to be introduced for regions lagging behind in DE in order to narrow the gap with leading regions.

Strengthening scientific and technological innovation and digital technology research and development: promoting the in-depth integration of science and technology with industry, increasing investment in the research and development of digital core technologies, cultivating highly skilled personnel, establishing a collaborative innovation system among industries, universities and research institutes, and upgrading the region's scientific and technological innovation capacity.

Optimizing the construction of digital infrastructure: expanding the scope of broadband access to the Internet, improving network speed and stability, ensuring broad coverage and efficient operation of digital services, and providing solid basic support for the development of DE.

Promoting regional cooperation and synergistic development: Encouraging the establishment of cooperation mechanisms between local governments to share information, technology and resources, and to realize complementarity of advantages and win-win development through measures such as industrial chain integration and infrastructure connectivity.

Strengthening digital governance and service model innovation: promoting the digital transformation of government, using big data, cloud computing and other technologies to improve administrative efficiency, innovating social management and service models, and enhancing the universality and convenience of public services.

Implementation of the strategy of balanced regional development: adhering to the concept of "one game of chess for the whole country", support for the economic and social development of less developed regions through financial transfers, industrial support policies and other means, with a view to gradually realizing regional balance.

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