Research on the Coupling and Coordination of Digital Economy and High Quality Development in Heilongjiang Province

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Abstract. The rise and prosperity of the digital economy have laid a solid foundation for high-quality economic development. Based on the urban Panel data of Heilongjiang Province from 2017 to 2021, the entropy method is used to calculate the comprehensive score of digital economy and high-quality development, and then the coupling coordination model is used to study the coupling coordination problem. Research has found that the indicators of various subsystems of digital economy and high-quality development in Heilongjiang Province are showing an upward trend. The coupling coordination value between the digital economy and high-quality development ranges from 0.2 to 0.7, showing an overall upward trend, but there are regional differences. We need to strengthen the construction of digital economy infrastructure, improve the development level of the digital economy, continuously practice new development concepts, promote coordinated progress between the digital economy and high-quality development, in order to achieve the vigorous development of the digital economy and assist the high-quality development of Heilongjiang Province.

Keywords: Digital economy, high-quality development,Coupling coordination

1 Introduction

The digital economy is a new economic form that leads the future and a new variable for improving economic quality and efficiency. How to correctly understand the relationship between the digital economy and high-quality development, and achieve coordinated development between the two, is a topic that needs to be paid attention to at this stage. At present, there is a lack of analysis on the coupling and coordination between the digital economy and high-quality development in Heilongjiang Province. Based on this, this article selects data from 2017 to 2021 and uses a coupled coordination model to explore the coordination degree between the digital economy and high-quality development in Heilongjiang Province, proposing countermeasures and suggestions to promote the positive interaction between the digital economy and high-quality development in Heilongjiang Province.

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2 Literature review

Analysis from the perspective of theoretical mechanisms, Scholars often conduct research from micro, meso, and macro perspectives. At the micro level, the digital economy is conducive to meeting the personalized needs of consumers, forming a tail effect at the consumer end [1]; Reduce the costs of both suppliers and demanders through economies of scale, Realize Dynamic equilibrium of supply and demand through matching mechanism [2]. Based on the meso level, upgrading the industrial structure promotes high-quality economic development[3]; Promote the transformation and upgrading of industrial structure through industrial correlation effect, industrial innovation effect, industrial structure adjustment effects[4]. Based on the macro level, the digital economy improves market transaction efficiency by reducing costs [5]; Change the traditional input mode and structure of production factors, optimize the efficiency of factor allocation and improve Total factor productivity[6].

From empirical analysis, Shen Y et al. found regional differences in the promotion of high-quality economic development by the digital economy through benchmark regression analysis, regional heterogeneity test, and robustness test analysis [7]. Chen Z et al. used entropy method and DEA Malmquist index method to find that the promotion of digital economy on high-quality development was affected by regions, productivity [8]. Ding, C et al. used the spatial Durbin model to measure the impact mechanism, effects, and regional heterogeneity, and found that technological innovation is an important path for promoting high-quality development in the digital economy [9]; Ge Heping and others found that the promotion of digital economy to high-quality development is constrained by Economic efficiency and economic structure by using the entropy weight TOPSIS method [10].

In summary, scholars mostly focus on the unidirectional research of the digital economy on high-quality development, but the impact between the two systems is mutual. Therefore, it is necessary to study the bidirectional relationship between the digital economy and high-quality development from the perspective of coupling and coordination.

3 Indicator system and research methods

3.1 Evaluation System for the Coupling and Coordination of Digital Economy and High Quality Development

1. Indicator selection.

This article draws on the indicator system constructed by Han Zhao'an et al[11]. The digital economy development indicator system includes internet production, mobile phone penetration rate, and internet penetration rate; The high-quality development indicator system includes innovation, coordination, green, openness, and sharing. Among them, the per capita telecommunications business volume represents internet related output, Mobile phone penetration rate is the number of mobile phone users per hundred people, Internet penetration rate is the ratio of internet users to the number of

permanent residents. Innovation includes the proportion of scientific and technological financial expenditure, the proportion of higher education enrollment, coordination includes urban-rural income ratio, industry coordination, and regional income coordination, and green includes the green coverage rate of built-up areas and the ability to clear household waste, Openness includes domestic trade dependence and foreign investment openness, Sharing includes social security and employment investment ratio, medical facility sharing, and cultural facility sharing.

3.2 Research methods

1. Entropy method.

First, standardize the data.Due to the possibility of data being zero during the standardization process, which may cause inconvenience to subsequent calculations, an additional 0.0001 will be added to the standardized data.

$$Q_{\mathrm{ij}} = N_{ij} + 0.0001 \tag{1}$$

$$P_{\mathrm{ij}} = \frac{Q_{ij}}{\sum_{i=1}^{m} Q_{\mathrm{ij}}} \left(0 \le Q_{ij} \le 1\right) \tag{2}$$

P_{ij} represents the proportion of the i-th sample under the jth indicator.

Calculate information entropy:

$$\mathrm{e}_{\mathrm{j}} = -\frac{1}{\ln m} \sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{3}$$

Calculate the coefficient of difference:

$$\mathrm{d}_{j} = 1 - e_{j} \tag{4}$$

Calculate weight:

$$W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{5}$$

Calculate the comprehensive development index:

$$U_{\mathrm{i}} = \sum_{i=1}^{n} \mathrm{p}_{ij} W_j \tag{6}$$

Among them, U_i represents the comprehensive evaluation score of each sample.

2. Coupling coordination model.

The degree of coupling and coordination represent the degree of interdependence and mutual promotion between modules, U_1 and U_2 are the comprehensive values of the two systems.

$$T = \alpha U_1 + \beta U_2 \tag{7}$$

T is the comprehensive coordination index, α, β For the development coefficients of U_1 and U_2, this article will α, β The values of are all set to 0.5.

The revised coupling coordination model is:

$$C = \sqrt{U_1 * U_2} / (U_1 + U_2) \tag{8}$$

$$D = \sqrt{C * T} \tag{9}$$

Among them, D represents the coordination degree of the coupling system.

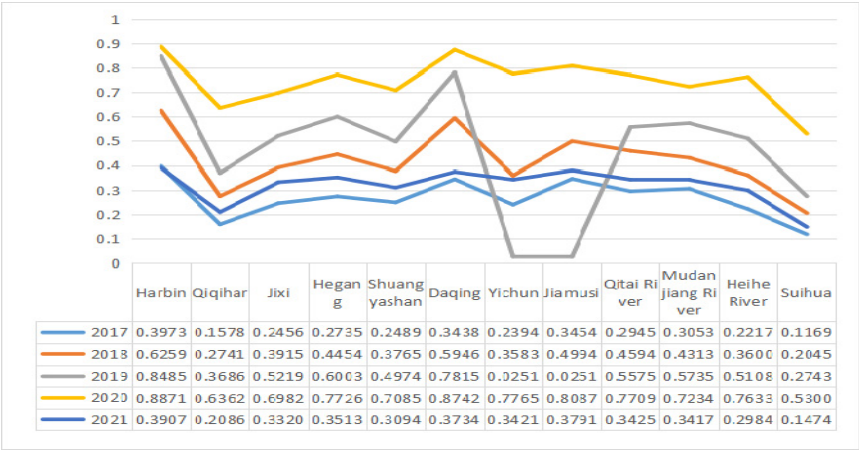
Table 1. Classification of Coordination Levels for the Coupling of Digital Economy and High Quality Development

coupling coordination degree	0≤D≤0.3	0.3<D≤0.5	0.5<D≤0.8	0.8<D≤1.0
Coupling coordination type	Low coupling coordination	Moderate coupling coordination	Highly coupled coordination	Extreme coupling coordination

4 Empirical Analysis on the Coupling and Coordination of Digital Economy and High Quality Development

4.1 Digital Economy and Measurement of High Quality Development Level

Through calculation, the results are as follows.

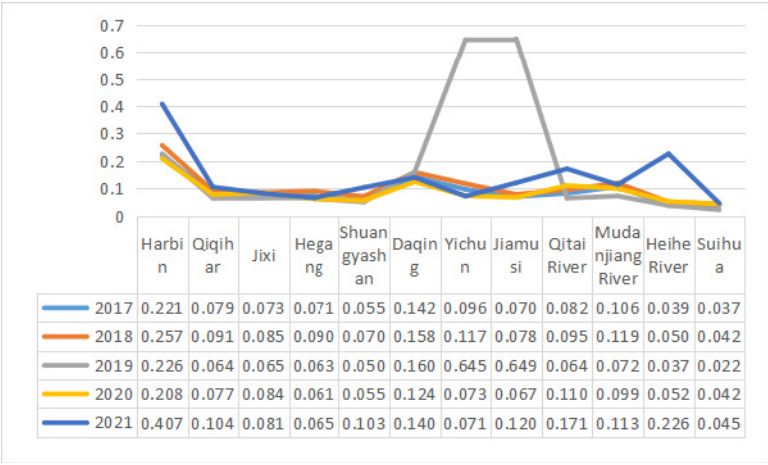


	Harbin	Qiqihar	Jixi	Hegang	Shuangyashan	Daqing	Yichun	Jiamusi	Qitai River	Mudanjiang River	Heihe River	Suihua
2017	0.3973	0.1578	0.2456	0.2735	0.2489	0.3438	0.2394	0.3454	0.2945	0.3053	0.2217	0.1169
2018	0.6259	0.2741	0.3915	0.4454	0.3765	0.5946	0.3583	0.4994	0.4594	0.4313	0.3600	0.2045
2019	0.8485	0.3686	0.5219	0.6003	0.4974	0.7815	0.0251	0.0251	0.5575	0.5735	0.5108	0.2743
2020	0.8871	0.6362	0.6982	0.7726	0.7085	0.8742	0.7765	0.8037	0.7709	0.7234	0.7633	0.5300
2021	0.3907	0.2086	0.3320	0.3513	0.3094	0.3734	0.3421	0.3791	0.3425	0.3417	0.2984	0.1474

Fig. 1. Changes in the Digital Economy Development Index

From Figure 1, it can be seen that the development level of digital economy in various cities has significantly increased since 2017. In 2021, due to the impact of the epidemic, the development of the digital economy showed a slight stagnation. From the

development situation of the digital economy in various cities, Harbin's digital economy has always been at the forefront of Heilongjiang Province, followed closely by Daqing. Harbin relies on its geographical advantages to develop digital economy. Daqing actively builds a "digital oilfield" to promote the development of cloud computing and Big data industries. In contrast, the development level of digital economy in Suihua and Qiqihar is relatively low. In 2017, the development index was 0.116 and 0.157 respectively. By 2020, the development index was 0.530 and 0.636 respectively, which is lower than other cities. Suihua and Qiqihar have insufficient accumulation of data resources, few leading enterprises in the digital economy, a shortage of talent.



	Harbin	Qiqihar	Jixi	Hegang	Shuangyashan	Daqing	Yichun	Jiamusi	Qitai River	Mudanjiang River	Heihe River	Suihua
2017	0.221	0.079	0.073	0.071	0.055	0.142	0.096	0.070	0.082	0.106	0.039	0.037
2018	0.257	0.091	0.085	0.090	0.070	0.158	0.117	0.078	0.095	0.119	0.050	0.042
2019	0.226	0.064	0.065	0.063	0.050	0.160	0.645	0.649	0.064	0.072	0.037	0.022
2020	0.208	0.077	0.084	0.061	0.055	0.124	0.073	0.067	0.110	0.099	0.052	0.042
2021	0.407	0.104	0.081	0.065	0.103	0.140	0.071	0.120	0.171	0.113	0.226	0.045

Fig. 2. Changes in the High Quality Development Index

From Figure 2, it can be seen that the high-quality development level of various cities in Heilongjiang Province is showing a fluctuating upward trend. In 2017, the development of digital economy in all cities started at a low level. Except Harbin, Daqing and Mudan River, the high-quality development level index of other cities was lower than 0.1, among which Harbin ranked first with 0.221, Suihua ranked last with 0.037,and the high-quality development level of Harbin was six times that of Suihua. In 2021, the high-quality development index of Harbin exceeded 0.4, with most cities exceeding 0.1. The level of high-quality development in Harbin is 9 times that of Suihua, with significant regional differences in high-quality development and uneven resource allocation.

Overall, from 2017 to 2021, various cities in Heilongjiang Province achieved significant results in digital economy and high-quality development. The comprehensive development index of various cities has significantly improved, and the level of high-quality development has also steadily improved. However, regional differences are still significant.

4.2 Analysis of coupling coordination degree results

From Table 2, it can be seen that the overall coupling coordination degree between the digital economy and high-quality development in Heilongjiang Province is between 0.258 and 0.662. According to the division rules in Table 1, it can be seen that the development process has gone from low coupling coordination to high coupling coordination. Overall, the coupling and coordination system between digital economy and high-quality development in various cities is constantly improving. Harbin is the best and has always been in a highly coordinated stage. Besides Suihua, other cities have also entered a highly coupled and coordinated stage.

Table 2. Coupled Coscheduling of Digital Economy and High Quality Development

	2017	2018	2019	2020	2021
Harbin	0.545	0.633	0.662	0.656	0.632
Qiqihar	0.335	0.398	0.393	0.471	0.385
Jixi	0.366	0.428	0.429	0.493	0.406
Hegang	0.373	0.448	0.442	0.468	0.390
Shuang-yashan	0.343	0.404	0.398	0.446	0.423
Daqing	0.471	0.554	0.595	0.574	0.478
Yichun	0.390	0.453	0.357	0.489	0.396
Jiamusi	0.394	0.445	0.358	0.483	0.462
Qitai River	0.395	0.458	0.435	0.540	0.492
Mudanjiang River	0.425	0.476	0.451	0.518	0.444
Heihe River	0.306	0.368	0.372	0.448	0.510
Suihua	0.258	0.306	0.280	0.388	0.287

5 Research conclusions and policy recommendations

5.1 Research Conclusion

Through research, the following conclusions can be drawn: First, the development level of digital economy in Heilongjiang Province has significantly improved, the support capacity of digital infrastructure in Heilongjiang Province has significantly improved,; Secondly, the level of high-quality development has been improved, but the ability to coordinate development is insufficient, regional differences are obvious, and the high-quality development of each city is uneven; Third, the degree of coupling and coordination between digital economy and high-quality development continues to improve.There are obvious differences in the types of coupling and coordination among cities and regions.

5.2 Policy recommendations

1. Strengthen the construction of digital economy infrastructure and improve the level of digital economy development. Firstly, consolidate the construction of digital infrastructure, strengthen the construction of communication, and build an artificial intelligence infrastructure platform; Secondly, improve the mechanism for talent cultivation and introduction, enhance talent innovation capabilities.

2. Promote high-quality economic development. Firstly, based on innovation, build a scientific and technological innovation platform; Secondly, continue to promote regional coordinated development, optimize regional economic layout; Thirdly, adhere to green development, improve the compensation mechanism for ecological protection; Fourthly, promote a higher level of openness, and strengthen the position of being the largest province in terms of opening up and cooperation with Russia; Fifth, we must adhere to shared development, expand channels for increasing residents' income.

3.The digital economy and high-quality development are synergistically advancing. Firstly, Enhance the driving role of the digital economy in innovative development, coordinated development, green development, open development, and shared development, The second is to provide material support for high-quality development and the digital economy. Increase infrastructure construction efforts, introduce talents, increase research investment, and provide support for the development of the digital economy.

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