

Research on the Impact of the Digital Economy on Regional Economic Disparities

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Abstract: The digital economy is a new engine for China's economic growth and has played a crucial role in addressing the principal contradiction of unbalanced and inadequate development. It is of great significance to conduct an in - depth exploration of the impact of the digital economy on regional economic disparities for resolving the principal contradiction in China. Based on the balanced panel data of 284 prefecture - level and above cities in China from 2011 to 2021, this paper explores the impact of the digital economy on regional economic disparities through the two - way fixed effects model. The research findings indicate that during the sample period, the digital economy has exacerbated the unbalanced development of the regional economy, and this conclusion still holds after a series of robustness and endogeneity tests. The mechanism analysis reveals that the regional innovation capacity plays a decisive role in the impact of the digital economy on regional economic disparities. The higher the regional innovation capacity is, the greater the impact of the digital economy on regional economic disparities will be, while the agglomeration of production factors will inhibit this expanding impact. The heterogeneity analysis shows that the digital economy is conducive to the coordinated development of the eastern and central regions, and the impact of the digital economy on regional economic disparities is characterized by policy phasing and dynamics. The research conclusions of this paper have important implications for promoting the coordinated development of China's regional economy in the digital economy era.

Keywords: Digital economy, Regional economic disparities, Regional innovation capacity.

1. Introduction

For a long time, regional development imbalance has been a critical factor affecting China's economic growth. Since the 18th National Congress of the Communist Party of China (CPC), the central leadership has elevated the mitigation of regional economic disparities to a strategic priority. The implementation of major regional strategies—including the coordinated development of the Beijing-Tianjin-Hebei region, the Yangtze River Economic Belt, the Guangdong-Hong Kong-Macao Greater Bay Area, the integrated development of the Yangtze River Delta, and ecological conservation and high-quality development in the Yellow River Basin—has yielded significant results. The Third Plenary Session of the 20th CPC Central Committee further proposed improving the institutional mechanisms for regional coordinated development, emphasizing the need to "build a regional economic structure and territorial spatial system that leverages complementary advantages," and to "enhance institutional and policy frameworks to advance the new phase of Western Development, achieve breakthroughs in the comprehensive revitalization of Northeast China, accelerate the rise of the central region, and promote modernization in the eastern regions. It also called for strengthening the role of key regions such as the Beijing-Tianjin-Hebei cluster, the Yangtze River Delta, and the Greater Bay Area as engines of high-quality development, optimizing mechanisms for the Yangtze River Economic Belt and Yellow River Basin strategies, advancing the Xiongan New Area with high standards, and deepening the Chengdu-Chongqing economic circle development." However, amid economic transformation and shifting global dynamics, new challenges have emerged in regional development, such as widening disparities between northern and southern regions and imbalances between large, medium, and small cities.

Addressing these issues to achieve coordinated regional development remains pivotal for high-quality growth.

The Third Plenary Session of the 20th CPC Central Committee also highlighted the urgency to "accelerate the establishment of institutional mechanisms for digital economy development and refine policies for digital industrialization and industrial digitization." The rapid rise of the digital economy has become a cornerstone of national economic progress. According to the China Digital Economy Development Research Report (2024), in 2023, China's digital economy accounted for 42.8% of GDP, with a nominal year-on-year growth rate of 7.39%—2.76 percentage points higher than GDP growth—and contributed 66.45% to overall GDP growth. Regions with stronger economic foundations and innovation capabilities have effectively harnessed the scale and scope advantages of the digital economy, achieving more resilient and accelerated development. However, significant disparities persist: among provinces with digital economies exceeding 1 trillion yuan, 45% are in the eastern region, underscoring the continued dominance of eastern areas over central and western regions. Thus, the digital economy may serve as a key driver in reshaping unbalanced regional development patterns.

This study constructs a digital economy evaluation system using the entropy method to measure the development levels of 284 prefecture-level and above cities in China. It explores how the digital economy influences regional economic disparities and examines the roles of factor agglomeration and regional innovation capacity based on neoclassical economic growth theory. Additionally, the research investigates the heterogeneous effects of the digital economy across geographical regions and time periods under varying policy contexts, aiming to enrich existing scholarship on regional economic inequality.

2. Literature Review

2.1. spatial and temporal evolution characteristics and influencing factors of regional economic gap

Since the reform and opening up, China's economic center of gravity from high latitude to latitude is low, the contradiction of regional economic gap mainly in the north and south areas, due to capital accumulation speed, unreasonable economic structure, the level of innovation ability, lead to present a "fast south north slow, north and south differentiation" new development trend (Jiang Jianming, 2021). From the perspective of provinces, due to the internal homogeneity and external heterogeneity of some regions, the regional economy of each province is converging to the steady state of their regions. On the whole, there is no feature of absolute convergence in China's regional economy, showing the overall characteristics of convergence-divergence-convergence (Dong Xuebing, 2020). From a regional point of view, due to resource endowment, policy tendency, industrial structure and other factors, economic development shows obvious regional differentiation between east, east and west, inland and coastal areas (Luojin, 2024).

There are many reasons affecting the regional economic gap. First, from the perspective of geographical location, the economic gap between the eastern region compared with the central and western regions is the key to the relative balance of regional economy. Under the influence of new economic and geographical factors, the eastern coastal areas with geographical advantages will attract a large number of production factors in the central and western regions for cross-regional flow, which gradually widening the gap between China's economic development (Zhou Jia, 2008). Second, due to the different national policy tendencies, it will lead to regional economic development differences. Some studies have found that there is an inverted U-shaped relationship between urbanization and the regional economic gap, and when the economic development reaches a certain level, urbanization mainly plays a role in the economic gap between regions (Peng Yuwen, 2017; Xu Shengxia, 2023). Third, the change of industrial structure contributes to the improvement of total factor production efficiency through the optimization of resource allocation between departments. Because the difference of human capital is the source of industrial structure and efficiency improvement, the change of industrial structure promotes the improvement of total factor production efficiency through the optimization of resource allocation between departments, the economic difference between the eastern region and the central and western regions (Wang Zhiyong, 2013; Yan Chengliang, 2016; Xu Shengxia, 2023). Fourth, the improvement of basic transportation measures is conducive to regional economic growth and promoting the convergence of the western region to the Middle East region (Liu Shenglong, 2010). With the opening of China-Europe freight trains, trade facilitation has been accelerated and is conducive to accelerating factor flow, technology transfer and technological innovation. Compared with coastal areas, inland regions can gain greater benefits from coastal areas, which is conducive to narrowing the gap between regions (Yuan Hang, 2023).

2.2. Digital economy and regional gap

The digital economy has become an important driving force for economic development by virtue of its high

innovation, strong penetration and wide coverage. From a macro point of view, the impact of digital economy on economic growth is mainly reflected in promoting resource allocation, increasing entrepreneurial activity, promoting higher income and consumption, and improving total factor productivity and the level of technological innovation. From a medium perspective, digital economy is conducive to promoting the optimization of market structure and promoting the upgrading and rationalization of industries, so as to promote economic growth. From the micro point of view, the impact of digital economy on the efficiency of the economy is mainly reflected in the impact on the efficiency of resource allocation of enterprises and individuals (Ding Zhifan, 2020; Zhao Tao, 2020; Jing Wenjun, 2019).

However, there are differences between different regions in the access of Internet technology equipment, use skills and influence of results, resulting in a spatial imbalance and an obvious digital divide (Liu Chuanming, 2020). Therefore, the academic circle has aroused controversy about whether digital economy can promote the coordinated development of regions. On the one hand, some scholars believe that digital economy can eliminate market asymmetry, accelerate the agglomeration of factors, promote innovation and entrepreneurship, promote the optimization of industrial structure, and then promote the coordinated development of regions. On the other hand, due to the digital divide, it may lead to the "polarization effect" and the "siphon effect", which may hinder the coordination of regional development (Chen Wen, 2021). From the perspective of digital industrialization and digital industry, due to the differences in different regional economic development level, lead to "two" may be at different stages, the resulting polarization effect and scope economy may lead to the Midwest in a disadvantage, "two" in the opposite effect hinder regional coordinated development (Juan-juan wang, 2023).

Combing through the existing literature and findings, Regional economic gap has always been a hot topic in academic research, Under the catalysis of China's new level of development and the change in the principal contradiction, The imbalance in regional development has once again attracted the attention of many scholars, At a crucial time for China's economy to enter the new normal and the replacement of old growth drivers, The digital economy has become an important engine of economic growth, Digital economy gives us a new perspective to study the regional economic gap, The existing literature mostly focuses on the role of digital economy on economic growth and urban-rural income gap, Few literature deeply study the mechanism of digital economy on regional economic gap, Therefore, the paper may have the following innovative points: (1) in the research perspective, In the study of the coordinated development of digital economy to regions, Most scholars focus on and analyzing the digital economy on economic growth or urban-rural income gap, Lack of research on the regional economic disparities, Therefore, this paper intends to study the impact of the digital economy on the regional economic gap, Thus enriching the existing research of regional coordinated development.(2) In terms of research content, based on the neoclassical economic growth theory, this paper systematically selects the agglomeration of production factors and regional innovation ability as the mechanism variables, and empirically analyzes the effect and heterogeneity of factor agglomeration and technological progress in the regional economic gap of digital economy, in order to provide

a new perspective for interpretation.(3) on the analysis of heterogeneity, not only discusses the digital economy between regions and regions within the influence of regional economic gap, also further discusses the policy influence on the heterogeneity of regional economic gap, from the geographical location and policy influence analyzes the influence of the heterogeneity of regional economic gap.

3. Theoretical Analysis and Research Hypothesis

3.1. The direct effect of digital economy on regional economic gap

With the deepening application of big data, cloud computing, mobile Internet and other technologies, and the deep integration of the digital economy and the real economy, the digital economy has become an important driving force for China's economic transformation and high-quality development in the new era. At the micro level, the digital economy can promote economic growth with the help of scale effect, scope economy and long-tail economy. At the macro level, digital economy can bring new factor input, change the original efficiency of resource allocation and new total factor productivity to promote regional economic growth (Jing Wenjun, 2019; Ding Zhifan, 2020). There is no doubt that digital economy can promote regional economic growth, help solve the problem of inadequacy in regional imbalance and inadequacy, and help solve the problem of efficiency in coordinated regional development. However, at the level of equity, due to the digital divide, whether the digital economy is conducive to solving the problem of equity in the coordinated development of regions is worth thinking about.

According to the circular causality theory, the coordinated development of regional economy depends on the ratio of echo effect and diffusion effect. The cho effect refers to that because the developed areas have greater demand for factors than the backward areas, and the rate of return is higher than that of the backward areas, the capital and labor of the backward areas will transfer to the developed areas, resulting in the lack of factors in the backward areas, and the development is slower. The diffusion effect refers to that the capital, labor force and technology in the developed areas will promote the development of the backward areas through the spillover effect, so as to promote the coordinated development of the regions. Digital economy is based on information and communication technology (Liu Jun, 2020). The development of digital economy needs the support of corresponding digital infrastructure, and it shows a positive relationship with the level of economic development (Pan Weihua, 2021). It also shows significant positive dependence, spatial agglomeration and relative stability in space. The higher the level of regional economic development, the better the development of digital economy. Therefore, the digital economy shows differences between the developed regions and the backward regions, and there is a significant "digital divide", which makes the digital economy have different effects on the regional economic growth, and then leads to the gradual widening of the regional economic gap. Therefore, this paper proposes hypothesis 1.

Hypothesis 1: Digital economy may lead to a widening of the regional economic gap.

3.2. Digital economy affects the agglomeration and adjustment effect of regional economic gap

Factors of production is an important driving force for regional economic development, but also one of the inducements to expand the regional economic gap. Digital economy is improving the agglomeration and diffusion of factors through platform economy, network effect and optimization of resource allocation. At the same time, the agglomeration of agglomeration and diffusion of factors affects the convergence of regional economic gap.

On the one hand, factor agglomeration has a restraining effect on narrowing the regional economic gap in digital economy. With the help of Internet technology, digital economy can break geographic distance restrictions, administrative barriers and information asymmetry between regions (Jiang Changliu, 2020), so as to accelerate the exchange and availability of regional information. Following the principle of profit seeking, capital, labor and other factors will flow to areas with higher marginal returns (Hong Yinxing, 2020), so that resource factors will flow from areas with relatively backward economic development to areas with better economic development, thus producing polarization effect, and areas with better economic development will get more resources and promote their development. On the other hand, factor agglomeration plays a promoting role in narrowing the regional economic gap of digital economy. According to Hirschman's trickle-down effect, after the concentration of elements in the first area reaches a certain extent, it will have a trickle-down spillover effect on the surrounding areas, thus driving the economic growth of the later area. In the digital economy, it can better spread the spatial spillover effect of the first area to the second area through transmission, connection and other functions. At the same time, when the first developing region absorbs the factors of the later developing region, it will also improve the rate of return of the later developing regional factors, stimulate the market potential of the later developing region, and present "coordinated agglomeration", thus making the factor allocation and spatial distribution pattern more efficient. In addition, excessive agglomeration of factors in the first region will also bring diseconomies of scale, thus inhibiting the economic growth of the first region, which may narrow the regional economic gap (Li Xiaoyang, 2014). Therefore hypothesis 2.

Hypothesis 2: Factor agglomeration has a regulatory effect on the regional economic gap in the impact of digital economy.

3.3. Digital economy affects the innovation adjustment effect of regional economic gap

Innovation is the primary driving force for development and the strategic support for building a modernized economic system. The endogenous growth theory holds that technological progress is the endogenous driving force of economic growth. At the same time, regional innovation ability is also the core driving force that determines the development process of digital economy. The core representation of regional innovation ability is the ability of scientific and technological breakthrough. Technological progress can promote the intersection and integration of different industries, establish interdisciplinary, cross-departmental and cross-industry cooperation mechanism, and innovate new business models and technology application

models, thus leading the innovation of digital formats (Sun Junhua, 2024). Digital production factors itself is non-competitive and non-exclusive, with high speed diffusion and low diffusion cost, to reduce market asymmetry, and improve the efficiency of innovation, digital economy can break through the limitation of geographical distance and administrative boundary to obtain greater technology overflow scope, so as to promote regional innovation. However, according to different geographical locations and city size, innovation will also have "marginal increasing effect" with city size as the threshold, which will also cause "siphon effect" and "Matthew effect" on the adjacent areas, which will also affect the regional economic gap (Shen Kunrong, 2023; Zhao Binyuan, 2021). Therefore, this paper proposes hypothesis 3.

Hypothesis 3: Regional innovation ability has a regulatory effect on digital economy and regional economic gap.

4. Research Design

4.1. Mode setting

In order to investigate the impact of digital economy on regional economic gap, this paper takes the relevant data of 284 cities in China from 2011 to 2021 to build a dual-fixed effect model to investigate the impact of digital economy on regional economic gap. Specific expressions such as formula (1):

$$Kakwani_{it} = \beta_0 + \beta_1 Digital_{it} + \gamma Controls_{it} + \lambda_i + \nu_i + \varepsilon_i \quad (1)$$

Where i represents city, t represents gap_{it} time; regional economic $digital_{it}$ gap $controls_{it}$; digital economy; some series λ_i of control variables ν_i ; urban fixed effect ε_{it} , time fixed effect, random β_1 disturbance items; if significant, regular digital economy can promote regional economic gap; if significant, negative, digital economy can suppress regional economic gap.

In order to test whether the agglomeration of production factors and regional innovation ability will have a role on the digital economy affecting the regional economic gap, on the basis of the agglomeration of production factors and technological progress and the intersection with the digital economy, and the adjustment effect model is set as follows (2):

$$Kakwani_{it} = \beta_0 + \beta_1 Digital_{it} + \beta_2 M_{it} + \beta_3 Digital_{it} \cdot M_{it} + \gamma Controls_{it} + \lambda_i + \nu_i + \varepsilon_i \quad (2)$$

It represents M_{it} the agglomeration of production

$Digital_{it} \cdot M_{it}$ factors and regional innovation ability, the interaction item between β_4 digital economy and the agglomeration of production factors and regional innovation ability, and the adjustment effect of the agglomeration of production factors and regional innovation ability on the influence of digital economy on regional economy.

4.2. Selection of indicators and data sources

(1) Interpreted variables: regional economic gap. The explained variable in this paper is regional economic gap. In the past, most of the literature, variance and Thier index are used to calculate the degree of inequality between regions as a whole, but the difference between regions is ignored. The relative deprivation index (Kakwani) can effectively solve this problem. Kakwani The economic gap index obtained by comparing a region with a higher economic level in the reference group can be used as a measure of the degree of inequality between regions. The larger the kakwani index, the greater the income gap between regions. This paper draws on Zhou Wen (2017) and Li Heng (2023) to calculate the regional economic gap. The calculation formula of Kakwani index is shown in Equation (3):

$$Kakwani_i = \gamma_y^+ [(\mu_{y_i}^+ - y_i) / \mu_y] \quad (3)$$

It represents y_i the per capita GDP of the first μ_y city, the average per capita GDP of all cities in the $\mu_{y_i}^+$ country, the average per capita GDP of γ_y^+ the national cities, and the percentage y_i of the sample per capita GDP in the national cities of the total sample. According to (3), the kakwani index does not take the most developed cities in the group as the reference to calculate the regional economic gap, but uses the regions with higher than their own economic development as the reference to calculate the imbalance index between regions. The larger the kakwani index, the larger the economic development level gap between the late-developing regions and the relatively developed regions becomes larger.

(2) Explanatory variables: digital economy. Digital economy is the core variables for the digital economy, given the city level data source is limited, this paper reference zhao tao (2020), Huang Qunhui (2019) to the development level of digital economy method, from digital infrastructure, digital industrialization and digital three dimensions build municipal digital economy development level evaluation index system. And adopt the entropy right method to calculate the development level of municipal digital economy. The development level system of digital economy is shown in Table 1.

Table 1. Evaluation index system of the development level of digital economy

Level 1 indicators	Secondary indicators	Indicator instructions	Indicator attributes
Digital infrastructure	Mobile Internet foundation	Mobile phone users / total population	forward direction
	Internet penetration rate	Number of Internet users / total population	forward direction
Digital industrialization	Telecom business output	Total telecom business per capita	forward direction
	The number of Internet practitioners	The proportion of employees in the computer services and software industry	forward direction
Industrial digitization	Development of digital inclusive finance	The Digital Financial Inclusion Index	forward direction
	Mail business volume	Per capita total postal service volume	forward direction

(3) Control variables. There are many factors affecting regional economic growth, and the existing literature economic growth, government intervention degree, science and technology level, education level, urbanization rate and so on are the main reasons affecting regional economic gap. In this paper, the above variables are selected as control variables, and the measurement indicators are the logarithm of per capita GDP of the constant price in 2011, the proportion of government fiscal expenditure, the proportion of science and technology expenditure in government general fiscal expenditure, the proportion of education expenditure in government fiscal expenditure, and the proportion of urban population in the permanent population.

(4) Adjustment variables. This paper mainly examines the agglomeration of production factors in labor and capital, where the labor agglomeration (M-tale) selects the ratio of non-agricultural employees and urban construction land according to Lei Xin et al. (2014); the capital agglomeration

(M-capi) selects the ratio of the total fixed assets investment and the area of urban construction land according to Li Zheng et al. (2019), in which the total fixed assets of each city are calculated by the perpetual inventory method. Regional innovation ability is expressed by the amount of patent granted per capita.

(5) Data source. Since the digital financial inclusion index has been published since 2011, the data of Tibet Autonomous Region and some cities is seriously missing. In order to ensure the uniformity of the samples and the integrity of the data, this paper is not studied. Therefore, this paper selects 284 cities at or above the prefecture level and above from 2011 to 2021 as the research objects. The data came from China Urban Statistical Yearbook, China Statistical Yearbook, National Economic and Social Development Bulletin and prefecture-level city Statistics Bureau. Some of the missing data were interpolated by interpolation method.

Table 2. Descriptive and statistical analysis results of the variables

Variable name	variable symbol	sample capacity	mean	standard deviation	least value	crest value
Regional economic gap	<i>Kakwani</i>	3124	0.280	0.177	0	0.811
digital economy	<i>Digit</i>	3124	0.163	0.067	0.184	0.688
Economic development level	<i>Gdp</i>	3124	10.752	0.571	8.773	13.056
Government intervention	<i>Gov</i>	3124	0.203	0.102	0.0439	0.916
educational level	<i>Edu</i>	3124	0.176	0.039	0.010	0.356
scientific and technological level	<i>Tech</i>	3124	0.017	0.017	0.000	0.207
Urbanization level	<i>Urban</i>	3124	0.563	0.151	0.181	1

Source: compiled by the author.

5. Empirical Results Analysis

5.1. Benchmark regression

In the benchmark regression, the mixed OLS model, random effect model (RE) and two-way fixed effect model (FE) were selected for the regression, and the regression results are shown in Table 3. The regression results of model (3) show that the digital economy has a significant role in expanding the regional economic gap, which will lead to the aggravation of the economic gap between regions, and the experimental results are still significant after the replacement of model (1) and model (2). Regional economic development level, urbanization rate and scientific and technological development level have a significant inhibitory effect on regional economic gap. The level of regional economic development is negatively correlated to the regional economic gap. According to the inverted "U" hypothesis proposed by Williamson (1965), China's economy may have crossed the inverted "U" inflection point. As a regional coordinated development policy in China, the new urbanization policy plays a restraining role in the regional economic gap, indicating that China's further promotion of the people-oriented new urbanization policy is conducive to the construction of regional economic layout with complementary advantages and high-quality development, and is conducive to promoting the coordinated regional development. As an important driving force of economic growth, science and technology is conducive to regional economic growth. The more investment in science and

technology in local finance, the greater the role it may play in economic growth. Government intervention shows a positive correlation with education level and economic growth. The increase of the proportion of government financial expenditure leads to the aggravation of the unbalanced development of regional economy in China, which may be caused by the problems such as target bias and structural imbalance in the implementation process of transfer payment system.

5.2. Robustness test

To test the robustness of the benchmark regression results, based on the double fixed effects model, we do several tests on the empirical results.

(1) Replace the core explanatory variable. Referring to Zhao Tao (2020), the principal component analysis method is used to remeasure the development level of digital economy.

(2) Replacement by the explanatory variable. Considering that the kakwani index focuses on dynamically measuring the gap between regions, in order to measure the overall economic gap between regions, the digital economy (2018) uses the gap between regions per capita.

(3) Tailing treatment. In order to exclude the influence of outliers on the experimental results, all variables were tailed at 1%.

(4) Special samples were removed. Due to the good economic development and the large economic impact on the economic gap, in order to avoid the impact on the experimental results, the experimental samples of 4 municipalities and 27 provincial capitals were excluded for

the robustness experiment.

(5) Reduce the sample period. In 2016, the G20 Summit held in Hangzhou adopted the G20 Digital Economy Development and Cooperation Initiative, which for the first

time listed the digital "digital economy" as an important topic in the G20 innovative growth blueprint. In order to avoid the impact of external events, the sample period was therefore shortened to 2011 – 2016.

Table 3. Benchmark regression results

Variable name	variable symbol	(1) Ols	(2) re	(3) fe
digital economy	<i>Digit</i>	0.706*** (32.13)	0.333*** (10.46)	0.382*** (11.59)
Economic development level	<i>Gdp</i>	-0.283*** (-73.02)	-0.244*** (-53.41)	-0.216*** (-42.63)
Government intervention	<i>Gov</i>	0.213*** (13.90)	0.242*** (11.50)	0.226*** (9.34)
educational level	<i>Edu</i>	0.189*** (6.41)	0.194*** (5.45)	0.136*** (3.51)
scientific and technological level	<i>Tech</i>	-0.612*** (-9.06)	-0.331*** (-4.69)	-0.228*** (-3.10)
Urbanization rate	<i>Urban</i>	-0.086*** (-8.21)	-0.059*** (-4.43)	-0.047*** (2.78)
constant term	<i>constant</i>	3.188*** (76.10)	2.784*** (55.51)	2.454*** (43.14)
City fixed	<i>City</i>	NO	NO	YES
Time fixed	<i>Year</i>	NO	YES	YES
sample capacity	<i>N</i>	3124	3124	3124
R ²	<i>R²</i>	0.907	0.948	0.940

Note: ***, **, * are significant at the 1%, 5%, and 10% levels, respectively. The z-statistics are given in parentheses.

(6) The explanatory variables lag behind the one phase. Considering that due to the digital gap, the regions with large regional economic gap may have a higher or lower development level of digital economy, in order to avoid the endogenous problems caused by "reverse causality" between the control variables, this paper delays all explanatory variables, and then conducts regression test.

(7) Instrumental variable. Due to the two-way causal relationship between the digital economy and the regional economy of the explained variables, may lead to the

endogenous problem, in order to alleviate the estimation bias caused by the endogenous problem, this paper refers to the practice of Liu Na (2023), select the city to Hangzhou distance as the tool variable, but because the time variation of the index, in order to avoid its difficult to measure in the fixed effect model, the study of Nunn & Qian (2014), selected as the time variation of the historical variables. The interaction term between regional Internet penetration rate and the distance from Hangzhou was selected as the tool variable for model estimation.

Table 4. The robustness test

Variable name	(1) Replace explanatory variables	(2) Replacement by the explanatory variable	(3) Tailing treatment	(4) Special samples were removed	(5) Shorten sample period	(6) lagged variable	(7) instrumental variable
digital economy	0.229*** (12.49)	2.087*** (20.26)	0.329*** (8.92)	0.398*** (11.17)	0.486*** (9.59)	0.357*** (9.47)	0.277** (2.10)
controlled variable	YES	YES	YES	YES	YES	YES	YES
K-P rk LM Statistic							21.526 [0.00]
K-P rk LM F Statistic							605.782 {16.38}
controlled variable	YES	YES	YES	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES	YES
sample capacity	3124	3124	3124	2816	1704	3124	3124
R ²	0.9420	0.253	0.946	0.908	0.917	0.2633	0.581

Note: The p value is shown in [] and the critical value at the 10% level of the Stock-Yogo weak identification test.

The regression results of the robustness test are shown in Table (3). After replacing the core explanatory variables, replacing the explained variables, shrinking the tail, eliminating special samples and reducing the sample period, the estimation coefficient of the core digital economy is still significantly positive, which verifies the robustness of the benchmark regression results. Column (6) shows that after the parameter estimates, for all the explanatory variables, are significantly positive at the 1% level, thus excluding the endogeneity of reverse causality. Column (6) Results test shows that the statistic p-value is 0.0000, and the statistic is greater than the critical value of 10% level of the weak identification test 16.38, passed the "non-identifiable test" and "weak tool variable test", so the selection of tool variables is more reasonable. And the estimated value of digital economy parameters in the model is significantly positive, so it shows that digital economy has a significant role in expanding the regional economic gap.

5.3. Mechanism test

In order to test the influence of factor agglomeration and innovation ability on regional economic gap, combined with the above theoretical analysis and the adjustment model set by model (2), verify whether factor agglomeration and regional innovation ability will affect digital economy on regional economic gap.

(1) The regulatory effect of factor agglomeration

The results are shown in Table 7, and it can be seen that the core explanatory variable of digital economy on regional economic gap is still significantly positive, which further supports the previous role of digital economy in exacerbating regional economic gap. However, the estimation coefficient of digital economy and talent agglomeration and capital agglomeration is significantly negative for the regional economic gap, which indicates that factor agglomeration

plays a role in restraining the expansion of regional economic gap in the regional economic gap. This may be that the development of digital economy can eliminate market asymmetry, so accelerate the flow of factors between regions, improve the efficiency of factor resource allocation, and enhance the benign activities of factors between regions. Moreover, the implementation of urban agglomeration development plan is also conducive to regional factor flow and efficient agglomeration. While improving the regional labor productivity, the market potential of factor outflow from the demand side has shown the trend of "coordinated agglomeration" in the process of the continuous improvement of factor allocation efficiency, which is conducive to narrowing the regional economic gap (Li Hongtao, 2020; Wang Bida, 2020).

(2) Regulatory role of regional innovation capacity

The results in Table 7 (3) show that the interaction term of digital economy and regional innovation capacity is significantly positive, indicating that regional innovation capacity plays a significant role in expanding the role of digital economy in the regional economic gap. Regional innovation capacity is an important driving force for economic growth and a core driving force for digital economy development. Due to the differences in regional economic development level, infrastructure construction level, factor agglomeration and other capabilities, there is a gap in innovation ability between regions. Digital economy as an important driving force to promote economic development, due to different innovation ability between regions, so the promotion of regional economic growth of heterogeneity, may lead to Matthew utility, innovation ability high regional high level of economic development, and regional innovation ability is low area its economic development level is weak, leading to regional economic gap between level is further increased.

Table 5. Analysis of the moderating effects

variable	(1) Capital agglomeration	(2) talent agglomeration	(3) technological innovation
<i>Digit</i>	0.348*** (10.26)	0.375*** (11.26)	0.347*** (9.84)
<i>M-capi</i>	-0.012*** (-4.27)		
<i>Digit × M-capi</i>	-0.056*** (-3.18)		
<i>M-tale</i>		-0.005*** (-2.40)	
<i>Digit × M-tale</i>		-0.056** (-2.65)	
<i>inv</i>			-0.005*** (-3.03)
<i>Digit × inv</i>			0.014** (2.32)
constant term	2.507*** (42.90)	2.505*** (42.91)	2.452*** (40.80)
City fixed effect	YES	YES	YES
Time fixed effect	YES	YES	YES
sample capacity	3124	3124	3124
R ²	0.9395	0.9391	0.9371

Note: ***, **, * indicate significant at the 1%, 5%, and 10% levels, respectively, with z-statistics in parentheses.

6. Research Conclusions and Policy Implications

This paper uses the data of prefecture-level cities from 2011 to 2021 to calculate the development level of digital economy by using the entropy method, and analyzes the impact of the regional economic development gap in China. The research results show that: due to the "digital divide" between regions, the development of digital economy will aggravate the regional economic gap. Digital economy is mainly to further increase the regional economic gap by promoting technological progress, but the agglomeration of production factors will restrain this expanding effect. From the perspective of geographical location, digital economy mainly expands the gap between the western region and the eastern and central region, and from the perspective of the region, the economic gap between the eastern region and the central region has a trend of narrowing, but the regional economic gap within the western region is still widening. Finally, the digital economy will be affected by the stage of policies. After the 19th National Congress of the Communist Party of China, the regional economic coordinated development policy is constantly improved, and the role of the digital economy in the widening of the regional economic gap is also declining. Based on the theory and empirical analysis of the regional economic gap of digital economy, the paper puts forward the following policy suggestions:

First of all, view the gap and improve the level of the digital economy. This paper finds that digital economy will promote economic growth, but due to the imbalance of regional digital economy development in China is still prominent, there are digital divide and other problems, underdeveloped areas are at a disadvantage in the digital economy value chain, so the economic development gap between regions is gradually widening. But in terms of less developed areas, the digital economy caused by technological innovation and progress of permeability, can change the efficiency of resource allocation, less developed areas should realize the importance of developing digital economy, efforts to seize the digital economy development opportunity, improve their digital infrastructure construction, speed up the "east number west" project, accelerate the digital technology of local enterprises, foster new development advantages, timely change the structure of economic development.

Secondly, accelerate the flow of production factors and enhance the endogenous power of less developed areas. This paper finds that the development of digital economy will promote the agglomeration of production factors, and the agglomeration of production factors is conducive to the latecomer region to catch up with the first region, which is more significant in the areas with high development level of digital economy. Therefore, to speed up the construction of digital infrastructure, accelerate the construction of the national unified market, further promote digital, capital and labor elements of cross-regional circulation and trade, eliminate market segmentation, break the market barriers between regions, optimize the allocation of resources in less developed areas, less developed areas did not enable the factors of production.

Finally, regional digital economy cooperation should be improved to promote technology improvement in less developed regions. This paper shows that digital economy plays a key role in the development of regional coordinated

development. The digital economy features its innovation, integration, efficiency and openness, Promoted the rapid dissemination of information, knowledge, and technology, With technology and knowledge spillover and dissemination, So that backward areas to quickly improve their technological level, But this rapid rise in low-risk and low-cost, Backward areas may form a dependence, Reduce the independent research and development capacity of backward regions, If over-reliance on rapid technology improvements resulting from technology spillover, Backward areas will have more difficult access to core technologies, It will be difficult to take the initiative in innovation and economic development, Unable to transform their own "pursuers" status, Therefore, while the backward regions are actively absorbing the technology spillover from other regions, Strengthen the construction of their own talent team, Improve the capacity for independent innovation, Grasp the autonomy of scientific and technological progress.

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