The Impact of the Digital Economy on the Convergence of China's Regional Economic Growth

Weikang ZENG*, Shan LIU and Lili MA

School of Economics & Management, Northwest University, Xi'an, China; 625710961@qq.com; nwu_liushan@163.com; nihaolili@sina.com

* Corresponding author: 625710961@qq.com

Abstract: The development of digital economy can improve the efficiency of resource allocation and thus enhance the vitality of regional economic development. Based on the analysis of the development of digital economy in China from 2012 to 2018, this paper uses the conditional β convergence mechanism to examine the impact of digital economy on the economic growth rate of different regions in China and the impact path. The results show that: (1) China's digital economy is developing rapidly, with obvious development characteristics from coastal to inland, and there are certain differences in the development degree of digital economy, but this difference in the development of digital economy is decreasing. (2) There is a phenomenon of economic convergence in China's different provincial administrative regions. The improvement of the human capital level can promote regional economic convergence, while corporate R&D expenditure and foreign direct investment weaken the regional economic convergence effect. (3) The development of digital economy enhances the convergence effect of regional economy through the improvement of corporate R&D expenditure and human capital level, while industrial structure upgrading, foreign direct investment in combination with digital economy shows the inhibitory effect on economic convergence.

Keywords: digital economy; conditional β convergence; coordinated development of regional economy

JEL Classification: E61; E65

1. Introduction

The digital economy is an economic form which has a strong role in driving regional economic growth. According to the *White Paper on China's Digital Economy Development* released by the China Academy of Information and Communications Technology in July 2022, the value added of China's digital economy reached 45.5 trillion yuan in 2021 which was growing 16.2 percent year on year, accounting for 39.8 percent of GDP. The features of digital economy determine that developing digital economy is the necessary path for China to achieve high-quality economic growth. Digital economy is not only an endogenous driving force to optimize allocation of productive factors and increase returns to scale, but an important driving force that achieves inclusive growth and coordinated regional development (World Bank, 2016). At present, China's economy has shifted from a stage of high-speed growth to a stage of high-quality development, and regional coordination will

become an important driving force for high-quality development. In March 2021, the *Chinese government's Report on the Work of the Government* pointed out that digital industrialization and digitalization of industry should be promoted coordinately. There is a close connection between digital economy and regional coordinated development. To clarify the relationship between the two is of great practical significance for narrowing the economic gap between regions, reshaping the pattern of regional economic growth, and promoting the high-quality development of macro economy.

The research on the mechanisms of digital economy's effect on regional coordinated development needs to be improved. This paper analyzes the convergence of regional economy under the condition of digital economy, and explores the specific path of digital economy influencing the coordinated development of regional economy from four aspects: regional industrial structure, innovation level, openness and human capital. This paper further clarifies the effect mechanism of digital economy on regional economic growth, and provides empirical evidence for digital economy driving regional economic coordinated development.

This paper finds that China's digital economy is developing rapidly, and there are some differences in the development degree between the eastern, middle and western regions and within regions. However, in recent years, the development difference of digital economy shows a continuous downward trend both from the national level and the regional level. In addition, there is a significant economic convergence in different provincial administrative regions in China, and the development of digital economy can regulate the economic convergence through the channels of industrial structure, enterprise research and development, foreign investment, and human capital. In order to promote the coordinated development between different regions, it is significant to give full play to the positive regulating effect of digital economy on regional economic convergence and prevent its disorderly expansion in a few developed regions.

2. Literature Review

In the modern society with increasingly fierce competition of comprehensive national strength, the development of digital economy based on information technology, with the nature of high penetration, external economy and increasing marginal returns, and it has attracted widespread attention from different countries. At present, the relatively authoritative definition of digital economy comes from the G20 Digital Economy Development and Cooperation Initiative at the G20 Hangzhou Summit. It states that digital economy refers to a series of economic activities that use digital knowledge and information as key factors of production, modern information network as an important carrier, and effective use of information and communication technology as an important driving force to improve efficiency and optimize economic structure. Digitalization will affect all aspects of people's economic life, such as online payment, administrative office and electronic communication (Teau, 2014). In recent years, with the rapid development of domestic information infrastructure construction, digital economy has effectively supported the promotion of digital China strategy, and has become a new driving force for the high-quality

development of China's economy under the new normal (Liu, 2019). It can be seen that digital economy, with its wide scope and depth of influence, will have an important impact on the coordination of economic development among regions and the sustainability of economic development within a region.

At present, there are two opposite views on the role of digital economy in the coordinated development of regional economy Views. One view is that the development of digital economy related industries can promote regional economic growth (Jorgenson & Nomura, 2005), and the economic growth pole will have a diffusion effect on the surrounding regions under a series of linkage mechanisms, and then drive the coordinated development of surrounding regions (Perroux, 1950). With the popularization of the Internet, the digital economy has developed rapidly and narrowed the income gap between urban and rural regions (Gao & Zang, 2018). In addition, the digital economy is conducive to knowledge diffusion and technology spillover, thus narrowing the differences in economic development between different regions (Forman & Zeebroeck, 2018). Another view is that the application of digital technology has different effects on improving the productivity of different market players, which may lead to polarization (Amuso et al., 2020). Specifically, the popularization of digital technology and the unbalanced configuration of digital skills restrict the development of underdeveloped regions, aggravating the imbalance of regional economic development (Jin & Li, 2016).

Through a large number of studies, domestic and foreign scholars have found that industrial structure, technological progress, foreign trade, resource endowment and other factors cause regional development differences (Krugman, 1991; Deng & Gong, 2018). The industrial economic structure plays a fundamental role in the economic development of a country, and the rise of new infrastructure will affect the industrial structure of the national economy (Brynjolfsson & Hitt, 2000). The construction of digital infrastructure can help accelerate the digital transformation and upgrading of traditional industries. And improving the quality of economic development (Han et al., 2020). The deep integration of digital technology and the real economy has cultivated new growth points in many fields, and optimized the allocation of factors between regions. The innovative and efficient characteristics of digital are in line with the requirements of high-quality development, and the development of digital economy can improve the efficiency of technological innovation, the development of digital economy can improve the efficiency of technological innovation (Kleis et al., 2012). In addition, in the foreign investment of digital multinational enterprises, digital technology and infrastructure quality, play an increasingly important role in the direction of international investment flows, and foreign investment can more effectively promote economic development in countries with low levels of economic fluctuations (Mody & Murshid, 2011). Labor is also a key factor that cannot be ignored in the economic market. In the case of labor skill heterogeneity, the ability gap caused by the skill difference of digital equipment users may widen the economic development gap between underdeveloped regions with low-skill labor and developed regions with high-skill labor power (Hawash & Lang, 2011).

To sum up, accurately defining and measuring digital economy is the basis for studying related issues, and the contribution of digital economy to high-quality economic development has been recognized by most scholars. Therefore, it is of great significance for China's high-quality economic development to explore the path to achieve coordinated regional development. Based on this consideration, this paper will conduct an in-depth analysis of the development of digital economy in China, economic convergence in different regions, and the adjustment channels of digital economy to economic convergence, in order to provide policy suggestions for the high-quality development of digital economy.

3. Identification Method and Calculation Result

To analyze the time series and identify the spatial distribution characteristics of China's digital economy development from 2012 to 2018, This paper uses the digital economy development index in *China Digital Economy Index Report*, and draws the spatial distribution maps of China's digital economy development index in 2012, 2015 and 2018 (Figure 1.) by Geoda software. It can be seen from Figure 1 that the development of China's digital economy shows an obvious feature of gradient. Digital economy first emerged in the eastern region, and perfect infrastructure and open ideas laid a good foundation for the development of local digital economy, especially in the southeast coastal provinces. Under the background of rapid development of informatization, digital economy develops rapidly in inland regions with perfect information infrastructure due to its fast and direct characteristics, and forms a diffusion circle of digital economy with these provinces as the core. From the perspective of spatio-temporal evolution characteristics, China's digital economy is developing rapidly and the overall situation is good.
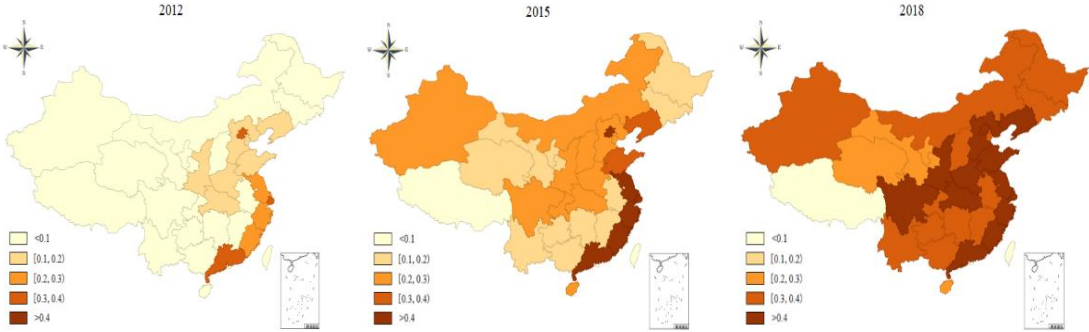

Figure 1. Spatio-temporal evolution of China's digital economy development

To deeply understand the development status of China's digital economy, this paper uses the digital economy development difference index (DI) to measure the different degree of China's digital economy development, which is expressed by the ratio of the standard deviation of the observation sample to the sample mean. The larger the value is, the smaller the gap of digital economy development between different regions is. Otherwise, it indicates that there is a large gap in the development of digital economy in different regions. The calculation of digital economy development difference index is shown in Formula (1):

$$DI = \frac{\sqrt{\frac{1}{n}\sum_i^n (x_i - \bar{x})^2}}{\bar{x}} \tag{1}$$

In Formula (1), i represents different provincial administrative regions, and n is the sample number of provincial administrative regions (n = 30). x_i represents the digital economy development index of different provincial administrative regions, and Xbar represents the average value of the digital economy development index of different provincial administrative regions.

This paper first measures the development difference of China's overall digital economy. It can be seen from Figure 2 that the development difference index of China's overall digital economy shows a continuous downward trend, from 0.834 in 2012 to 0.393 in 2018, with an average annual decline rate of 13.4%. In 2012, the digital economy development disparity index decreased by 39.3 percent, and then the rate of decline tended to be stable. By breaking the limitations of traditional geographical space, digital economy has greatly developed people's consumption potential, and also fully empowered the further development of digital economy, realizing the rapid development of China's digital economy.
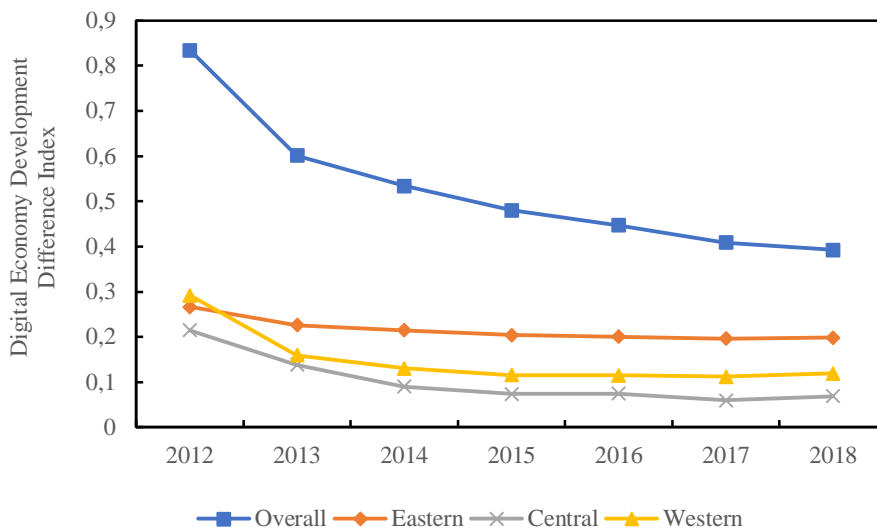

Figure 2. Dynamic trends of China's digital economy development in different regions

Due to the differences in location conditions, China's level of economic development shows a spatial gradient characteristic of gradual decline from southeast to northwest. The heterogeneity of economic environment may lead to the differentiated development of digital economy, and then affect the coordinated development between regions. Therefore, it is necessary to analyze the differences in the development of digital economy in the eastern, middle and western regions. It can be seen from Figure 2 that the development differences of digital economy in the eastern, middle and western regions basically maintain a downward trend, indicating that the development of digital economy in the region tends to be balanced. Among them, the digital economy development difference index in the eastern region decreased from 0.267 in 2012 to 0.198 in 2018, with an average annual decrease of 5.1%; In the central region, it decreased from 0.215 to 0.069, with an average annual decrease of 20.9%; In

the western region, it decreased from 0.292 to 0.119, with an average annual decrease of 16.1%. There are obvious differences in the development of digital economy in different regions. The mean values of the digital economy development difference index in the eastern, central and western regions are 0.215, 0.103 and 0.149 respectively. Although the overall level of digital economy development in the eastern region is relatively high, there may be a "siphon phenomenon" among different provinces, because the digital economy is self-expanding. Under the influence of people's psychological reactions and behavioral inertia, when the advantages or disadvantages of the digital economy reach a certain extent, such advantages or disadvantages will be magnified by themselves. The digital economy in the western region has not been fully developed, especially in the northwest region, Sichuan and Shaanxi provinces are the highlands of digital economy development in western China, and the overall development of digital economy varies greatly among different provinces. The central region fully enjoys the spillover effect of the digital economy in the eastern region. At the same time, the dense population in the central region magnifies the external economy and promotes the rapid development of the local digital economy.

In general, China's digital economy develops rapidly, and shows gradient feature in different regions. There is a big gap between the southeast regions and the northwest regarding the development level of digital economy. In addition, the difference of digital economy in China shows a downward trend, but the decline rate in the eastern region is the slowest. In the development of digital economy, it is necessary to prevent the disordered expansion of digital economy in a few developed regions. The disordered self-expansion of digital economy will be contrary to the original intention of benefiting people's livelihood and promoting regional coordinated development.

4. Results and Discussion

Based on the neoclassical growth theory and considering other factors that affect the coordinated growth of regional economy, this paper uses the conditional β convergence mechanism to examine the impact of digital economy on the economic growth of different regions in China. China's regional coordinated development strategy emphasizes the relative equality of economic development in different regions, rather than the "absolute average", so promoting different regions to achieve economic equilibrium under their own external conditions is the key to achieving regional coordinated development strategy.

Existing studies have shown that digital economy, industrial structure, scientific research and innovation, foreign investment and human capital will all have an impact on the coordinated development of regional economy. Considering the completeness of the data, this paper takes 30 provincial administrative regions in China from 2012 to 2018 as the research unit. Among all the variables, the digital economy development index is obtained from the *China Digital Economy Index Report*, and the data of other variables are mainly from the *China Statistical Yearbook*. The missing part was completed by the *Statistical Bulletin of National Economic and Social Development* of different provincial administrative regions. In order to empirically test the specific effects of the above factors on economic convergence in different regions, this paper constructs the following model for analysis:

$$ln(y_{it+1}/y_{it}) = \beta_0 + \beta_1 lny_{it} + \beta_2 X_{it} + \beta_3(lny_{it} * X_{it}) + \varepsilon_{it} \tag{2}$$

In Formula (2), i represents the provincial administrative region and t represents the year; y_{it} represents per capita GDP (*pgdp*), which is the core explanatory variable and reflects the local economic development; (y_{it+1}/y_{it}) represents the ratio of the per capita GDP of a provincial administrative region in the current year to that last year, and is the explained variable, reflecting the local economic growth; X_{it} includes five control variables: digit economic development index (*digit*), the proportion of total output value of tertiary industry (*serv*), enterprise R&D expenditure (*rd*), actual utilized foreign direct investment (*fdi*), and the proportion of university students (*hc*). β is the parameter to be estimated, where β_1 is the conditional convergence coefficient, β_2 reflects the effect of control variables on regional economic growth, β_3 It reflects the direction and magnitude of the influence of control variables on economic convergence; Epsilon.it Is the random disturbance term with normal distribution.

Table 1. Estimation results of conditional β spatial convergence.

	(1)	(2)	(3)	(4)	(5)	(6)
lnpgdp	-0.069*** (0.024)	-0.085 (0.054)	-0.223*** (0.066)	-0.213*** (0.063)	0.008 (0.051)	-0.308** (0.147)
digit	-1.152* (0.626)					-0.852 (1.981)
serv		-1.403 (1.154)				-1.450 (1.996)
lnrd			-0.303*** (0.116)			-0.513 (0.322)
lnfdi				-0.303*** (0.105)		-0.149 (0.176)
hc					8.525 (26.744)	65.135* (35.385)
*lnpgdp*digit*	0.110** (0.056)					-0.138 (0.142)
*lnpgdp*serv*		0.129 (0.105)				0.134 (0.180)
*lnpgdp*lnrd*			0.029*** (0.011)			0.048* (0.030)
*lnpgdp*lnfdi*				0.029*** (0.010)		0.015 (0.017)
*lnpgdp*hc*					-0.918 (2.449)	-6.102* (3.237)
_cos	1.801*** (0.251)	1.985*** (0.581)	3.386*** (0.708)	3.288*** (0.663)	1.012*** (0.549)	4.316*** (1.592)
R^2	0.283	0.122	0.270	0.104	0.039	0.223
F-value	8.67***	3.51***	15.45***	14.13***	2.76***	20.98***
N	210	210	210	210	210	210

Note: ***$P < 0.01$, **$P < 0.05$, robust standard errors in parentheses.

Table 1 reflects the impact of control variables on economic convergence. The regression results of the interaction terms between regional economic development level and different factors on economic growth rate are reported in the five models (1), (2), (3), (4) and (5) respectively. The conditional convergence coefficient is significantly negative, indicating that

there is economic conditional convergence phenomenon in different provincial administrative regions of China. In addition, the impact of digital economy development, enterprise R&D expenditure and foreign direct investment on regional economic growth is significantly negative, and the impact of the proportion of the total output value of the tertiary industry is negative but not significant. The ratio of the number of students in colleges and universities has a significantly positive impact on regional economic growth. Therefore, the marginal utility of digital economy development, R&D expenditure and foreign direct investment on economic growth is decreasing. The human capital plays an obvious role in promoting economic growth. Under the circumstance of downward pressure on the economy, the investment in human capital should be moderately strengthened to enhance the driving force of economic development. In order to examine the impact of digital economy, industrial structure, enterprise research and development expenditure, foreign direct investment and human capital level on regional economic convergence, this paper introduces the cross-term between regional economic development level and control variables while conducting regression on each control variable. It can be seen from the Table that the development of digital economy, the R&D expenditure of enterprises and the actual use of foreign direct investment weaken the regional economic convergence effect, which is not conducive to the realization of regional economic equilibrium, while the level of human capital can promote regional economic convergence. In addition, the proportion of the total output value of the tertiary industry has no significant effect on the convergence of the economy.

According to the existing research, the development of digital economy will affect economic convergence by moderating industrial upgrading, innovation and R&D, foreign investment and human capital. How will digital economy affect regional economic convergence? In order to explore the channels, direction and magnitude of the effect of digital economy on economic convergence, this paper extends Formula (2) as follows:

$$ln(y_{it+1}/y_{it}) = \beta_0 + \beta_1 lny_{it} + \beta_2 digit_{it} + \beta_3 X_{it} + \beta_4 (lny_{it} * X_{it})$$
$$+\beta_5 (lny_{it} * X_{it} * digit_{it}) + \varepsilon_{it}$$

(3)

In Formula (3), (y_{it+1}/y_{it}) is the dependent variable; y_{it}, $digit_{it}$ are the core explanatory variable, $digit_{it}$ represents the development level of digital economy; X_{it} are control variables, the variable Settings remain the same as above. In order to investigate the moderating effect of digital economic development on economic growth under the existing industrial structure, enterprise R&D expenditure, foreign investment and human capital, Formula (3) further adds the interaction item of digital economic development index based on the interaction item introduced in Formula (2). The interaction term of economic development level (*pgdp*), control variables (*serv, rd, fdi, hc*) and digital economic development index (*digit*) is formed. β_1 is still the conditional convergence coefficient, β_2 reflects the specific role of digital economy development on regional economic growth. β_3, β_4 are the specific effects of control variables on regional economic growth and the effects of control variables on economic convergence The direction and magnitude of the response; β_5 reflects the influence of control variables on economic convergence under the moderating effect of digital economy direction and magnitude.

Table 2. Moderating effect of digital economic development

	(1)	(2)	(3)	(4)	(5)
lnpgdp	0.158 (0.121)	-0.216* (0.131)	-0.223** (0.096)	-0.010 (0.074)	-0.280* (0.209)
digit	-0.552** (0.246)	-0.019 (0.235)	0.053 (0.203)	-0.029 (0.179)	-0.480* (0.630)
serv	4.463* (2.647)				5.836* (3.465)
lnrd		-0.293 (0.238)			-1.103** (0.463)
lnfdi			-0.297* (0.162)		0.043 (0.277)
hc				12.386 (36.468)	7.410 (42.499)
lnpgdp*serv	-0.444* (0.252)				-0.598* (0.332)
lnpgdp*serv*digit	0.113*** (0.043)				0.196*** (0.064)
lnpgdp*lnrd		0.029 (0.023)			0.105** (0.045)
lnpgdp*lnrd*digit		-0.001 (0.003)			-0.009 (0.008)
lnpgdp*lnfdi			0.029* (0.016)		0.004 (0.027)
lnrgdp*lnfdi*digit			0.001 (0.003)		0.001 (0.006)
lnpgdp*hc				-1.305 (3.464)	-0.425 (4.037)
lnrgdp*hc*digit				-1.381* (0.762)	-1.531 (1.036)
_cos	-0.497 (1.263)	3.314** (1.357)	3.382*** (0.981)	1.199 (0.765)	4.095* (2.204)
R^2	0.085	0.263	0.142	0.152	0.202
F-value	13.90***	14.91***	14.68***	4.51***	33.56***
N	210	210	210	210	210

Note: ***$P < 0.01$, **$P < 0.05$, robust standard errors in parentheses.

Table 2 shows the influence of control variables on economic convergence under the adjustment of digital economy. The core explanatory variables' regression coefficient is significantly negative, which proves that there is a trend of conditional convergence in different regional economies, and the marginal utility of digital economy for regional economic growth is decreasing. Among all the control variables, except the total output value of the tertiary industry Except for the proportion, the other regression results are basically consistent with those in Table 1, which further demonstrates the validity of the regression results of Formula (1). In addition, in model (1), the regression coefficient of the cross-term (*lnpgdp*serv*) between the economic development level and the proportion of the total output value of the tertiary industry is significantly negative, and the regression coefficient of the cross term (*lnpgdp*serv*digit*) is significantly positive, indicating that the development of digital economy will offset the promotion effect of industrial upgrading on economic convergence; In models (2) and (3), the regression coefficients of the interaction terms

(*Inpgdp*Inrd* and *Inpgdp*Infdi*) between the level of economic development and enterprise R&D expenditure and actual utilization of foreign direct investment are positive, and the regression coefficients of the interaction terms (*Inpgdp*Inrd*digit*) are negative. The regression coefficient of the interaction term (*Inpgdp*Infdi*digit*) is positive. This shows that the development of digital economy is conducive to the promotion of regional enterprise scientific research investment for economic convergence, but there is no way to promote regional economic convergence through foreign investment channels. In model (4), the regression coefficient of the interaction term (*Inpgdp*hc*) between economic development level and the proportion of high school enrollment is negative, and the regression coefficient of the interaction term (*Inpgdp*hc*digit*) is also negative and the value decreases, indicating that the development of digital economy, The development of digital economy can enhance the role of regional human capital improvement in promoting economic equilibrium.

There are convergence phenomena of economic conditions in different provincial administrative regions in China. Some scholars have discussed the relationship between digital economy and economic convergence from the regional and urban levels respectively, and found that the development of digital economy can improve the speed of economic convergence between regions (Li & Du, 2022), and its effect is heterogeneous in different regions (Shao & Chen, 2022). Consistent with the conclusion of most relevant studies, this paper argues that digital economy will help narrow the economic development gap between different regions. In addition, some scholars believe that technological effect is the key mechanism for digital economy to affect regional economic convergence, that is, digital economy development has significant spatial spillover effect characteristics, and indirectly affects the difference of regional economic development level by narrowing the regional innovation gap (Jin & Yu, 2021). This paper focuses on the direct effect of digital economy development to economic development disparities. Specifically, under the conditions of digital economy, industrial resources and foreign investment tend to be distributed to a few developed regions, resulting in the loss of resources in most underdeveloped regions, thus hindering the process of economic convergence in these regions, resulting in the differentiation of economic development between different regions, which is not conducive to the coordinated development of regional economy. In addition, digital economy can promote the spillover of scientific research achievements and human capital of regional enterprises, thus driving the economy to a balanced state, developing the potential of regional economic growth, and reducing the difference of economic development levels in different regions.

5. Conclusions

With the deepening of China's economic reforms, the goal of high-quality economic growth encounter numerous obstacles. Therefore, Chinese government needs to transform the growth model to support the sustainable development of the Chinese economy. At present, the digital economy has shown strong vitality, it can promote the formation of economies of scale and maximize output under the given resource input. It has become a new driving force for China's economic growth.

This paper uses the conditional β convergence analysis method to test the transmission mechanism of digital economy affecting regional economic growth speed. The main conclusions of this paper are as follows: there are differences in the digital economy development between the eastern, central and western regions, but differences show a trend of continuous decline, economic convergence phenomenon occurs in different provincial administrative regions in China. In addition, the development of digital economy can promote regional economic convergence by exerting the spillover effects of enterprise R&D and human capital. However, the digital economy may cause excessive concentration of resources, which leads to faster economic growth in regions with higher levels of industrial structure and greater foreign investment intensity. It is not conducive to narrowing the regional development gap.

This paper has enlightening policy implications for further developing digital economy and promoting the formation of coordinated development patterns in different regions. First of all, it is necessary to avoid the emergence of digital divide. The gap in the development of digital economy between regions in China is not only caused by the level of infrastructure construction, but the difference in the ability to use digital equipment. It is equally important to improve people's ability to use digital equipment. Secondly, improving the sharing mechanism of enterprises' R&D achievements is as important as promoting the matching of supply and demand information of foreign investment, which can effectively solve the practical problems of backward science and technology and lack of development funds in underdeveloped regions. Finally, it is necessary to stimulate the potential of digital economy and narrow the regional development gap by formulating targeted digital economy development strategies according to the actual situation of different regions.

Conflict of interest: none

References

Amuso, V., Poletti, G., & Montibello, D. (2020). The digital economy: Opportunities and challenges. *Global Policy*, *11*(1), 124–127. https://doi.org/10.1111/1758-5899.12745

Brynjolfsson, E., & Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance. *Journal of Economic Perspectives*, *14*(4), 23–48. httpd://doi.org/10.1257/jep.14.4.23

Deng, M. J., & Gong, Q. L. (2018). The spatial attribute and reconstruction path of China's regional policy. *China Soft Science*, *2018*(4), 74–85.

Forman, C. C., & Zeebroeck, N. V. (2018). Digital technology adoption and knowledge flows within firms: Can the Internet overcome geographic and technological distance. *Research Policy*, *48*(8), 103697. https://doi.org/10.1016/j.respol.2018.10.021

Gao, Y., Zang, L., & Sun, J. (2018). Does computer penetration increase farmers' income? An empirical study from China. *Telecommunications Policy*, *42*(5), 345–360. https://doi.org/10.1016/j.telpol.2018.03.002

Han, J., Sun, Y. W., & Chen, X. (2020). An analysis of the development path of China's digital economy in the post COVID-19 era. *Comparative Economic & Social Systems*, *5*, 20–28.

Hawash, R., & Lang, G. (2010). Does the digital gap matter? Estimating the impact of ICT on productivity in developing countries. *Eurasian Economic Review*, *10*(2), 189–209. https://doi.org/10.1007/s40822-019-00133-1

Li, Z. X., & Du, T. H. (2022). Influence of digital economy on regional economic growth and its convergence. *Statistics & Decision*, *38*(21), 19–24. https://doi.org/10.13546/j.cnki.tjyjc.2022.21.004

Jin, C. Z., & Li, L. (2016). Research on Spatial heterogeneity patterns of digital divide of Chinese internet. *Economic Geography*, *36*(8), 106–112. https://doi.org/10.15957/j.cnki.jjdl.2016.08.015

Jin, H., & Yu, L. H. (2021). Digital economy, urban innovation and regional convergence. *South China journal of economics*, *12*, 21–36. https://doi.org/10.19592/j.cnki.scje.390885

Jorgenson, D. W., & Nomura, K. (2005). The industry origins of Japanese economic growth. *Journal of the Japanese and International Economies*, *19*(4), 482–542. https://doi.org/10.1016/j.jjie.2005.05.002

Kleis, L., Chwelos, P., Ramirez, R. V., & Chwelos, P. (2012). Information technology and intangible output: The impact of IT investment on innovation productivity. *Information Systems Research*, *23*(1), 42–59. https://doi.org/10.1287/isre.1100.0338

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, *99*(3), 483–499.

Liu, S. C. (2019). Targeting path and policy supply for the high-quality development of China's digital economy. *Economist*, 6, 52–61. https://doi.org/10.16158/j.cnki.51-1312/f.2019.06.006

Mody, A., & Murshid, A. P. (2011). *Growth from international capital flows: The role of volatility regimes* (IMF Working Papers).

Perroux, F. (1950). Economic space: Theory and applications. *Quarterly Journal of Economics, 64*(1), 89–104.

Shao, X. Y., & Chen, S. H. (2022). Has the digital economy promoted China's regional economic convergence? Research based on satellite Light Data. *Nanjing journal of social sciences*, 8, 37–46. https://doi.org/10.15937/j.cnki.issn1001-8263.2022.08.005

Teau, A. M. (2014). European Digital Economy. *Romanian Statistical Review Supplement*, *62*(4), 190–196. https://doi.org/10.1109/OCEANS.1995.528866

World Bank (2016). *World development report 2016: Digital dividends.* World Bank.