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Impact of digital economy on economic growth

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Abstract: *Entering the era of digital economy, China's digital economy is developing rapidly and expanding in scale, and it is becoming an important engine to pull economic growth. This paper firstly analyses the impact of the digital economy on economic growth through demand expansion and supply expansion theoretically, and then empirically tests it by constructing a two-way fixed-effects model based on the panel data of 30 provinces from 2013 to 2021. The results show that the digital economy has a significant role in promoting China's economic growth; there is regional variability in the impact of the digital economy on economic growth, and the degree of its influence on economic growth is in the order from smallest to largest in the central region, the western region, and the eastern region. Therefore, in order to better develop the digital economy to promote China's economic growth, it is necessary to strengthen the construction of digital economic infrastructure, enhance the level of digital technological innovation, and at the same time, to formulate development policies according to local conditions and promote the coordinated development of the digital economy region.*

Keywords: *digital economy; demand expansion; supply expansion; economic growth*

1. Introduction

Since the outbreak of the financial crisis in 2008, most countries in the international arena have noticed that the digital economy is developing rapidly and showing strong vitality, and have realised that the development of the digital economy is capable of injecting new impetus and vitality into the economic development of their countries and promoting economic recovery. Over the past 40 years of reform and opening up, China has achieved rapid growth in its national economy. Behind the "China Miracle" of rapid economic growth, there are still problems and contradictions in China's economic development, such as the aging of the population and the imbalance between urban and rural development. At present, China is facing a severe and complex international environment and arduous domestic development tasks, and there are greater difficulties and serious challenges in achieving the expected economic growth targets.

In recent years, China has successively introduced a number of policies to help build a digital economy, with a view to driving economic prosperity and development. During the 19th National Congress of the Communist Party of China (CPC), the General Assembly pointed out the need to build a digital China; during the 14th Five-Year Plan, the Party Central Committee proposed to promote the core industries of the digital economy to achieve faster growth. It can be seen that China attaches great importance to the development of the digital economy as a new engine to accelerate the realisation of high-quality economic and social development.

It is in view of the important impact of the development of the digital economy on economic growth, as well as the objective facts of the current slowdown in China's economic growth rate, this paper is a theoretical analysis of the intrinsic link between the digital economy and economic growth and empirical research, to examine how the digital economy affects economic growth, and based on this, to accelerate the development of the digital economy in China to promote economic growth to provide policy recommendations.

2. Literature review

2.1. Measurement of the level of development of the digital economy

On the basis of combing the relevant literature, it can be learnt that there are three main practices used to measure the level of development of the digital economy: the national economic growth accounting method, the comparison method and the satellite account method.

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From the perspective of the national economic growth accounting method, the earliest accounting scope of the digital economy includes three parts: e-commerce infrastructure, e-commerce transactions and e-commerce processes[1]. The domestic digital economy measurement work started late, and some scholars drew on the United Nations 1993 version of the SNA to make up for the loopholes in the measurement of the digital economy [2]. In the era of digital economy, the booming development of digital economy has posed a challenge to price statistics and national economic statistics methods[3].

From the perspective of the comparative method, the European Union compiles the Digital Economy and Society Index, which is used to measure the scale and degree of development of the digital economy in each member state[4]. The International Monetary Fund divides the components of the digital sector and applies econometric methods in measuring the level of development of the digital economy[5]. Domestic research institute China Academy of Information and Communication Research constructed a digital economy index for comparing the level of development of the digital economy in each region of the country[6].

From the perspective of the satellite account method, OECD proposed a DESA framework focusing on digital transactions and systematically analysed the actors and objects of the digital economy[7]. China's DESA framework is still being explored, and scholars believe that the general idea of China's DESA should focus on establishing internal satellite accounts and expanding the production boundary of the SNA centre framework, so as to achieve an effective interface between DESA and the traditional classification of national economy industries[8].

2.2. Relevant studies on the relationship between digital economy and economic growth

With the gradual standardisation of the methodology for measuring the size of the digital economy, research on the relationship between the digital economy and economic growth is rapidly unfolding.

The internal logic of the digital economy to promote high-quality economic development can be explored from the micro and macro levels respectively. At the micro level, the gradual integration of emerging digital technologies into traditional industries has reduced marginal costs and created economies of scale and scope. At the macro level, drawing on the Solow model, there are three paths for the digital economy to promote high-quality economic development, namely, increasing factor inputs, improving allocative efficiency and increasing total factor productivity[9].

The development of the digital economy enables the adjustment of the industrial structure from low-level to high-level forms, providing impetus for economic growth. Among them, digital industrialisation and industrial digitisation are the main ways for the digital economy to promote the upgrading of industrial structure. Digital industrialisation increases the proportion of digital industries, on the one hand, digital technology develops into new industries through industrialisation; on the other hand, digital technology gives rise to new business models. Industrial digitisation enhances the digital level of traditional industries. On the one hand, industrial digitisation improves the intelligence level of the production process; on the other hand, traditional industries rely on digital technology to realise the visualisation of industrial organisation mode[10].

The development of digital economy can obviously promote the prosperity and development of the real economy. From the internal mechanism, digital economic development promotes the upgrading of industrial structure to directly affect the real economy, and digital economic development can also act on the supply side of the supply structure, circulation side and demand side, to solve the problem of structural imbalance between supply and demand, and indirectly affect the real economy[11].

Throughout the existing literature, research results on the impact of the digital economy on economic growth are fruitful, but there are still the following shortcomings. First, there is no unified index system for measuring the level of digital economic development; second, there is a relative lack of empirical analyses by scholars on the digital economy to promote economic growth, and few scholars have analysed its intrinsic mechanism of action. In view of this, this paper refers to the research ideas of Jun Wang and other scholars to construct the evaluation index system of the level of digital economic development[12], and conduct an in-depth analysis of the relationship between digital economy and economic growth.

3. Theoretical analysis

Drawing on relevant theories and literature, this paper will reveal how the digital economy affects

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economic growth from both supply and demand perspectives.

3.1. The digital economy, supply expansion and economic growth

The development of the digital economy reduces long-run average costs, prompting firms to increase production and creating supply expansion. Theoretically, enterprises have a positive U-shaped long-term average cost curve in long-term production. In the era of digital economy, the production cost of enterprises has the characteristics of high fixed cost and low marginal cost. Therefore, as enterprises expand the scale of production, the average fixed cost will gradually decrease, and the marginal cost is extremely low or even zero, which in turn reduces the long-term average cost, forms the effect of economies of scale, and promotes the increase of enterprise production.

The digital economy is also characterised by the economy of scope, which realises the diversification of product production. In the era of the digital economy, the conditions for the realisation of the economy of scope are shifted from product relevance to being based on the number of users. Specifically, the digital economy achieves mutual penetration and integration of different business links and industrial chains through platformisation and online, giving rise to personalised and diversified products and services, while also reducing production costs.

The development of digital economy optimises the factor structure and promotes the increase of enterprise productivity. On the one hand, compared with traditional factors of production, data factors of production can break the time and space constraints, combine with traditional factors of production, and optimise the factor structure. On the other hand, the development of digital technology can transform and integrate the factors of production, including data, and drive the productivity of enterprises.

From the above, it can be seen that the development of the digital economy has formed economies of scale and scope, while improving the productivity of enterprises and expanding the total supply of the economy, thus driving economic growth.

3.2. Digital economy, demand expansion and economic growth

The development of the digital economy has increased consumer demand. First, the maturity and wide application of digital technology has promoted the creation of digital means of payment, boosting residents' consumption demand. Second, the development of digital transaction platforms has reduced transaction costs and broken the time and geographical restrictions of traditional transactions. Third, the development of the digital economy promotes innovation in consumer demand, using digital technology to tap the digital consumption capacity of various fields and industries, and to develop digital products and services to broaden the content of demand.

Digital economic development increases investment demand. First, the digital economy uses data as a production factor, which can be integrated with production factors such as technology and capital to increase the value of production factors and form investment demand for data valorisation. Secondly, the development of industrial digitalisation has accelerated the integration of the real economy with the digital economy, promoted the digital transformation of traditional industries, and stimulated industrial digitalisation investment demand. Third, the key to promoting the development of digital industrialisation lies in improving the construction of digital economic infrastructure, a process that has formed investment demand for digital industrialisation.

Digital economic development increases trade demand. First, digital technology is integrated into all aspects of the traditional trade process, reducing circulation links, breaking through time and geographical restrictions, accelerating the speed of transactions, and promoting the growth of trade scale. Second, data, digital products and digital services have become new international trade objects, such as cross-border e-commerce, digital technology services and digital information services, which increase trade demand.

From the above, it can be seen that the development of the digital economy promotes the expansion of consumer demand, investment demand and trade demand, which expands the total demand of the economy, thus promoting economic growth.

Combining the results of the above theoretical analyses, the development of the digital economy can act directly on demand and supply to achieve economic growth.

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4. Model Construction and Indicator Selection

4.1. Model Construction

In order to test the impact of digital economy on economic growth, model (1) is developed in this paper:

$$\ln GDP_{PC}=\beta_0+\beta_1 \ln SDE_{it}+\beta_2 \ln G_{it}+\beta_3 \ln E_{it}+\beta_4 \ln UL_{it}+\beta_5 \ln H_{it}+\beta_6 \ln IS_{it}+\nu_i+u_t+\rho_{it} \quad (1)$$

Where: i stands for province, t stands for year; GDP_{pc} stands for gross regional product per capita; SDE stands for the level of digital economy development; G stands for the level of government intervention in the economy; E stands for technological innovation; UL stands for the level of urbanization; H stands for the level of human capital; IS stands for the level of industrial structure; ν_i stands for the fixed effect controlling for province; u_t stands for the fixed effect controlling for time, and ρ_{it} stands for the random error term in the model.

4.2. Indicator selection and data sources

This paper uses relevant data from 30 provinces in China from 2013-2021. The raw data are from the China Statistical Yearbook (2014-2022).

The explanatory variable is economic growth (GDP_{pc}). In this paper, we refer to Ji Liu[13], which measures economic growth in terms of real per capita gross regional product, using 2013 as the base period.

The core explanatory variable is the level of development of the digital economy (SDE). Drawing on the practice of Jun Wang, Jie Zhu and Xi Luo[12], this paper selects 15 positive indicators to measure the development level of the digital economy, including the number of employed persons in urban units of the information transmission, software and information technology services industry, the number of legal entities in the information transmission, software and information technology services industry, the number of Internet broadband access ports, the number of domain names, the capacity of mobile telephone exchanges, the penetration rate of mobile phones, the length of long-distance fibre optic cables, the revenue from software products, the total amount of telecommunications services, the number of websites owned by enterprises, the number of enterprises with E-commerce trading activities, e-commerce sales, the number of graduates of general institutions of higher education, the number of effective invention patents of enterprises above designated size, and R&D expenditures of enterprises above designated size are 15 positive indicators to measure the level of development of the digital economy. This paper applies the entropy weight method to measure the development level of digital economy, and the calculation formula is:

$$Score=\sum_{i=1}^{m}\left(\frac{1-e_j}{\sum_{j=1}^{n}1-e_{ij}} * S_{ij}\right) \quad (2)$$

$$e_j=-\frac{1}{\ln(mn)}\sum_{j=1}^{n} P_{ij}\ln P_{ij},\ P_{ij}=\frac{SX_{ij}}{\sum_{i=1}^{m} S_{ij}} \quad (3)$$

Where m represents the number of provinces; n represents the number of indicators; e_j represents the information entropy value of each indicator; and SX_{ij} represents the value of the jth indicator in the ith province.

Other control variables. Specifically, they include: the degree of government intervention in the economy (G), measured by the proportion of general budget expenditures of each region to the regional GDP; technological innovation (E), measured by the number of patent applications by industrial enterprises above the size of each region; the level of urbanisation (UL), measured by the proportion of urban population in each region to the year-end resident population; the level of human capital (H), measured by the proportion of the number of graduates from general higher education institutions in each region to the year-end resident population; the level of industrial structure (IS), measured by the proportion of the value added of the tertiary industry in each region to the regional GDP. The level of human capital (H) is measured by the proportion of the number of graduates of general higher education institutions in the year-end resident population of each region; the level of industrial structure (IS) is measured by the proportion of the added value of tertiary industry in the regional GDP of each region.

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5. Results and discussion

5.1. Benchmark regression analysis

This paper adopts a two-way fixed-effects model to carry out the benchmark regression, and the results are shown in Table 1. Specifically, starting from column (2), as the control variables are added one by one, the regression coefficient of the digital economy is always positive, and it is significant at the 1% confidence level, which indicates that the digital economy has a significant role in promoting China's economic growth. The development of digital economy brings data production factors, promotes technological innovation, improves enterprise productivity, increases social supply, and is also capable of expanding consumption, investment, and import and export demand, bringing a new impetus to China's economic development.

Table 1 Benchmark regression analysis results

	$lnGDP_{pc}$					
	(1)	(2)	(3)	(4)	(5)	(6)
lnSDE	0.1741***	0.1723***	0.1632***	0.1313***	0.1313***	0.1314***
	(10.98)	(10.96)	(10.41)	(7.86)	(7.85)	(7.84)
lnG		-0.0546**	-0.0541**	-0.0494**	-0.0471**	-0.0488**
		(-2.40)	(-2.43)	(-2.31)	(-2.14)	(-2.09)
lnE			0.0255***	0.0163**	0.0158*	0.0161**
			(3.18)	(2.04)	(1.97)	(1.97)
lnUL				0.2521***	0.2362***	0.2329***
				(4.45)	(3.62)	(3.47)
lnH					0.0117	0.0124
					(0.49)	(0.52)
lnIS						0.0090
						(0.22)
_cons	11.7131***	11.6239***	11.3644***	11.4676***	11.5316***	11.5326***
	(428.51)	(253.10)	(122.03)	(123.99)	(72.49)	(72.31)
Year_fe	Yes	Yes	Yes	Yes	Yes	Yes
Province_fe	Yes	Yes	Yes	Yes	Yes	Yes
N	270	270	270	270	270	270
R^2	0.9969	0.9970	0.9971	0.9973	0.9973	0.9973

t statistics in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01.

From the data in column (6) of Table 1, it can be seen that the regression coefficient of the degree of government intervention in the economy is significantly negative, indicating that government intervention in the economy is not conducive to economic growth; the regression coefficients of the levels of technological innovation and urbanisation are significantly positive, indicating that the levels of technological innovation and urbanisation have a positive role in promoting China's economic growth.

5.2. Endogenous processing

Considering that the model may have endogeneity problems due to omitted variables and mutual causation, this paper endogenises the one-period lag of the level of digital economic development as an instrumental variable.

Table 2 Endogenous processing results

	$lnGDP_{pc}$		
	(1)	(2)	(3)
lnSDE	0.0657*	0.0657*	0.0657*
	(1.93)	(1.93)	(1.93)
lnG	-0.1450***	-0.1450***	-0.1450***
	(-2.95)	(-2.95)	(-2.95)
lnE	-0.0305	-0.0305	-0.0305
	(-1.53)	(-1.53)	(-1.53)
lnUL	2.0617***	2.0617***	2.0617***
	(23.03)	(23.03)	(23.03)
lnH	-0.0694*	-0.0694*	-0.0694*
	(-1.70)	(-1.70)	(-1.70)
lnIS	-0.0798	-0.0798	-0.0798
	(-0.62)	(-0.62)	(-0.62)

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_cons	11.8354***	11.8354***	11.8354***
	(38.06)	(38.06)	(38.06)
Year_fe	Yes	Yes	Yes
Province_fe	Yes	Yes	Yes
N	240	240	240
R^2	0.8916	0.8916	0.8916

t statistics in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01.

Table 2 demonstrates the regression results of endogeneity treatment using instrumental variables. As can be seen from the data in column (1), the sign of the regression coefficient of the level of digital economic development is still positive after inserting the instrumental variable, and it is significant at the 10% confidence level. It can be seen that after the treatment of endogeneity problem, digital economic development can still promote economic growth.

In addition, in order to improve the credibility of the two-stage least squares results, LIML estimation and GMM estimation are adopted in this paper. Columns (2) and (3) show the regression results of LIML estimation and GMM estimation, respectively, which show that the sign of the regression coefficient of the level of digital economic development is positive and significant at 10% confidence level, indicating that the results of endogeneity treatment are robust.

5.3. Robustness test

5.3.1. Core explanatory variables lagged by one period

Lagging the level of digital economic development by one period is tested for robustness, and the regression results are shown in column (1) of Table 3. The results show that the coefficient of one period lagged in the level of digital economic development is positive and significant at the 1 per cent confidence level, indicating that the baseline regression results for the sample data are robust.

5.3.2. Shrinkage treatment

In order to reduce the interference of extreme values in the data on the empirical results, all the variables are adjusted according to the upper and lower 1% to do the shrinking tail and do the robustness test, and the regression results are shown in column (2) of Table 3. The results show that the coefficient of the level of digital economic development is positive and significant at the 1% confidence level, further indicating that the benchmark regression results of this paper are robust.

Table 3 : Robustness test results

	$lnGDP_{pc}$	
	(1)	(2)
l_lnSDE	0.1081***	
	(6.16)	
lnG	-0.0379	-0.0401*
	(-1.51)	(-1.72)
lnE	0.0069	0.0243***
	(0.79)	(2.92)
lnUL	0.2131***	0.1930***
	(2.73)	(2.82)
lnH	0.0193	0.0079
	(0.79)	(0.34)
lnIS	0.0557	0.0198
	(1.20)	(0.47)
lnSDE		0.1313***
		(7.92)
_cons	11.9771***	11.4377***
	(70.35)	(72.42)
Year_fe	Yes	Yes
Province_fe	Yes	Yes
N	240	270
R^2	0.9976	0.9973

t statistics in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01.

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5.4. Heterogeneity analysis

In this paper, in order to examine whether there are differences in economic growth in different regions of China affected by the digital economy, the 30 provinces examined are divided into eastern, central and western regions for heterogeneity analysis.

As can be seen from the regression results in Table 4, the impact of the digital economy on the economic growth of different regions of China is different, and the degree of its influence on economic growth in order from small to large, in turn, the central region, the western region, the eastern region. This paper argues that the reasons are mainly the following three aspects: first, the central region as China's comprehensive transport hub, but the economic development of the crude growth mode still exists, the impact of the development of the digital economy on economic growth is not significant; secondly, the eastern region has a strong economic strength, the digital economy started early, the development of the fast speed, a strong impetus to economic growth; thirdly, thanks to the "Western Development" strategy, the digital economy has a different impact on the economic growth of different regions. Thirdly, thanks to the implementation of the "Western Development" strategy and the development of the "East Counts, West Counts" project, data elements can flow across regions, and the level of digital infrastructure construction in the west has been further improved, providing new impetus for economic growth.

Table 4 : Heterogeneity analysis results

	$\ln GDP_{pc}$		
	Eastern Region	Central Region	Western Region
lnSDE	0.1025***	0.0619	0.0911***
	(3.52)	(1.47)	(3.38)
lnG	-0.0261	0.0940	-0.2774***
	(-0.70)	(1.45)	(-6.78)
lnE	0.0294	0.0420***	-0.0128
	(1.62)	(3.49)	(-0.83)
lnUL	0.3079**	0.7520***	0.4908***
	(2.57)	(2.95)	(4.64)
lnH	-0.0390	-0.2322***	0.0751***
	(-0.58)	(-4.06)	(2.67)
lnIS	-0.4224***	-0.0316	0.2247***
	(-3.27)	(-0.49)	(3.36)
_cons	11.0232***	9.5298***	11.3129***
	(28.23)	(29.89)	(54.51)
Year_fe	Yes	Yes	Yes
Province_fe	Yes	Yes	Yes
N	99	72	99
R^2	0.9962	0.9935	0.9977

t statistics in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01.

6. Conclusions and policy recommendation

Based on the objective facts of the rapid development of China's digital economy and the need to further promote stable and faster economic growth, this paper theoretically analyses the path of the digital economy affecting economic growth, and based on the provincial panel data from 2013-2021, empirically examines the impact of the digital economy on economic growth, and draws the following conclusions. First, the development of digital economy can promote supply expansion, pull demand, and directly promote economic growth. Specifically, the development of the digital economy creates economies of scale and scope, while driving the improvement of enterprise production efficiency, expanding the total supply of the economy, thus promoting economic growth; at the same time, it promotes the expansion of investment demand, consumer demand and trade demand, further increasing the total demand, thus promoting economic growth. Second, the digital economy has a significant role in promoting China's economic growth. Combined with the results of the benchmark regression, the sign of the regression coefficient for the level of digital economy development is positive and significant at the 1 per cent confidence level; specifically, every 1 per cent increase in the level of digital economy development will raise per capita gross regional product by 0.1313 per cent. In addition, technological innovation and urbanisation levels significantly contribute to economic growth, while government intervention is detrimental to economic growth. Third, there are significant regional differences in the impact of digital

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economy on economic growth in China. From the results of the heterogeneity analysis, it can be seen that, dividing the country into eastern, central and western regions, the degree of influence of digital economic development on economic growth, in order from smallest to largest, is the central region, the western region, and the eastern region.

Based on the above findings, in order to accelerate the development of digital economy to drive economic growth, this paper puts forward the following policy recommendations. First, the construction of digital economy infrastructure should be strengthened to support the rapid development of the digital economy. The Government should provide the necessary policy support for the construction of digital economy infrastructure and improve the level of infrastructure construction in the central and western regions. At the same time, it should focus on the research and development of core technologies, use the mobile Internet to build a technology sharing platform, promote the integration of digital technologies with traditional industries, and accelerate the transformation and upgrading of traditional industries. Second, increase policy support and financial investment in R&D to promote digital technology innovation. The government should increase investment in digital technology R&D and promote the disclosure of technological innovation results to the whole industry. At the same time, enterprises should increase digital technology research and development efforts and digital talent training efforts to promote the digital transformation of enterprises. Third, formulate development policies according to local conditions and promote coordinated regional development of the digital economy. The eastern region should strengthen cooperation with the central and western regions in the field of digital economy and jointly enhance the level of digital economy development. The central region should make use of its resource and location advantages to promote the combination of digital technology and the local real economy, and promote the upgrading of industrial institutions. Western regions should enhance digital awareness, add digital economic development to local economic development planning, and seize digital economic development opportunities.

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