Research on the Effect of Digital Economy Development on the Quality of Economic Growth

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Abstract: This paper explores the impact of the digital economy on the quality of economic growth. Using provincial panel data from 30 provinces (municipalities and autonomous regions) in China from 2012 to 2021, we construct indicator systems for the digital economy and the quality of economic growth, and measure them using the entropy weight method. The results reveal disparities in the development level of the digital economy and the quality of economic growth across Chinese provinces. An empirical analysis using an OLS regression model shows that the development of the digital economy significantly improves China's economic growth quality. Additionally, the increase in the urbanization rate and the upgrading of the industrial structure also exert positive effects on the quality of economic growth.

Keywords: Digital Economy; Quality of Economic Growth; Entropy Weight Method

1. Introduction

With the continuous advancement of science and technology, the digital economy has become a new driving force for economic development in China and even globally. The current development situation in China indicates that the focus of China's economic development has shifted from high-speed growth to high-quality development. Since the reform and opening-up, years of high-speed growth have basically solved the issue of "quantity", but traditional drivers can no longer propel rapid economic growth. For example, China once achieved rapid economic growth relying on cheap labor and large-scale production, but with the rise in labor costs and changes in market demand, this development model has become unsustainable. Therefore, in order to realize the people's aspiration for a better life, it is necessary to focus on "quality" at this stage and accelerate the transformation of the economy from high-speed growth to high-quality and high-efficiency development. The development of the digital economy aligns with the urgent demand for financial innovation in improving China's economic growth quality in the new era. Given the current economic growth trend in China, to leverage financial innovation to boost the quality of economic growth, it is essential to explore the mechanism through which the digital economy affects the quality of economic growth, thereby identifying a suitable financial innovation model for enhancing China's economic growth quality in the new era.

The concept of "digital economy" emerged in 1994 and has attracted attention worldwide. Different countries have varying interpretations of its meaning. Pradhan (2019) argued that with the gradual development of the digital economy, it exerts a significant impact on human production, life processes, and economic growth [1]. Afonasova (2019) defined the digital economy as a digital-oriented institutional system composed of advanced technologies, aiming to improve the efficiency of social production [2]. Kevin J (2019) found that the digital economy, as a new production factor, is increasingly becoming a driver of economic development [3]. Tovma (2019) indicated that the digital economy, as a key driver of economic growth, plays an important role in achieving sustainable economic growth and enhancing industrial competitiveness [4]. Domestic scholars generally consider the digital economy as a crucial factor in promoting the quality of economic growth and emphasize the need to vigorously develop it. Cao (2018) suggested that the digital economy can promote technological innovation and industrial upgrading, thereby improving the quality of economic growth [5]. Ren (2020) proposed that the digital economy can drive high-quality economic growth from three aspects: quality, efficiency, and momentum [6]. Some scholars have analyzed the impact of the digital economy on the quality of economic growth from perspectives such as digital trade, digital finance, and integration with the real economy. He (2019) found that digital financial services have a significant impact on the quality of economic growth [7]. Lu (2019) argued that developing the digital economy is key to promoting the quality of economic growth [8]. Domestic scholars have also explained the impact of the digital economy on the quality of economic growth from the perspectives of technological innovation and industrial upgrading. Jing (2023) noted that the rapid development of digital technology has an increasingly profound impact on the economy and society, and grasping the underlying laws is crucial for achieving high-quality economic development and Chinese-style modernization in China [9]. Pan (2022) measured the development level of China's digital economy from three dimensions: infrastructure, industrial scale, and spillover value, and the results showed that the digital economy helps improve total factor productivity (TFP), thereby promoting the quality of economic growth [10]. As the digital economy continues to develop, its role in enhancing the quality of economic growth becomes increasingly prominent.

2. Theoretical Analysis

2.1 Direct Impact of the Digital Economy on the Quality of Economic Growth

The digital economy directly drives economic growth and provides a strong impetus by improving production efficiency and optimizing resource allocation. Firstly, as a production factor, data, in the process of integrating with production, transforms the combination mode of traditional factors, making production more scientific and division of labor more refined. The digital economy provides more efficient, convenient, and intelligent production methods, thereby improving production efficiency and promoting economic growth. Secondly, the digital economy expands markets and advances globalization. It enables people to freely exchange information and conduct transactions across geographical and cultural barriers. Moreover, digital platforms, which possess massive amounts of data, can enhance the precision and targeting of inputs through data cleaning and analysis, thereby reducing costs, minimizing resource waste, increasing consumer and producer surpluses, and further improving market efficiency and resource allocation efficiency, thus promoting the development of economic quality.

2.2 Indirect Impact of the Digital Economy on the Quality of Economic Growth

The innovation and application of digital technologies have promoted industrial upgrading and transformation, improving the quality and sustainability of economic growth. In addition, the digital economy has driven employment and entrepreneurship, providing stronger momentum and vitality for economic growth. Digital technologies, through the integration of modern information networks, intelligent algorithms, and data resources, have injected new vitality into economic development. These technologies not only improve the efficiency of various economic sectors such as agriculture and manufacturing but also open up new growth spaces. In areas such as consumption, investment, technology transformation, and production and manufacturing, digital technologies have fostered new growth drivers. Digital production processes require workers to master digital technology skills, and it is the young workforce with creativity and new thinking who meet the needs of personalized production. Digital technologies have eliminated time and space constraints, broken the boundaries of traditional physical employment, reduced the cost of labor mobility, and provided people with more employment options. The coordinated development of online and offline models has made information more comprehensive, facilitating job seekers' access to employment information, reducing search costs, and accelerating employment matching. The digital economy has diversified employment opportunities, aided the upgrading and transformation of traditional industries, broken time and space limitations, and improved the skills and quality of the labor force. The demand for labor in its related fields can cover labor groups at all levels, from high-end to low-end.

3. Research Design

3.1 Determination of Digital Economy Indicators

This paper draws on the indicator system for measuring the development level of the digital economy constructed by Wang Jun (2021) [11] and selects appropriate measurement indicators scientifically. Based on the overall requirements of the digital economy, 4 primary indicators and

19 secondary indicators are chosen (see Table 1) to measure the development level of the digital economy in 30 provinces (municipalities and autonomous regions) of China from 2012 to 2021. The data sources include the Statistical Yearbook, Guotai'an Database, and the Digital Finance Research Center of Peking University. The specific selected indicators and their explanations are shown in Table 1.

Table 1. Index System for Digital Economy Calculation

Primary Indicators	Secondary Indicators	Direction
Digital Infrastructuret	Number of internet broadband access ports (10,000)	+
	Number of internet broadband access users (10,000)	+
	Mobile phone base station density (units/km²)	+
	Mobile phone penetration rate (units/100 people)	+
	Length of long-distance optical cables per unit area (10,000 km)	+
Digital Industrialization	Proportion of software business revenue in GDP (%)	+
	Proportion of information technology service revenue in GDP (%)	+
	Number of employees in the information service industry (10,000)	+
	Proportion of telecommunications business volume in GDP (%)	+
Industrial Digitalization	Enterprise e-commerce transaction volume (100 million yuan)	+
	Proportion of enterprises engaged in e-commerce transactions (%)	+
	Number of computers per 100 employees in enterprises	+
	Number of websites per 100 enterprises	+
	Digital inclusive finance index	+
Digital Innovation Capability	Full-time equivalent of R&D personnel in industrial enterprises above designated size	+
	R&D expenditure of industrial enterprises above designated size (10,000 yuan)	+
	Number of R&D projects in industrial enterprises above designated size	+
	Total turnover of technology contracts (10,000 yuan)	+
	Number of authorized patent applications	+

Table 2. Index System for Measuring the Quality of Economic Growth

Primary Indicators	Secondary Indicators	Direction
Innovative Development	GDP growth rate	+
	Investment efficiency	-
	Technology transaction activity	+
Coordinated Development	Demand structure	+
	Government debt burden	-
Green Development	Energy consumption elasticity coefficient	-
	Wastewater per unit of output	-
	Waste gas per unit of output	-
Open Development	Foreign trade dependence	+
	Degree of marketization	+
Shared Development	Proportion of labor remuneration	+
	Elasticity of residents' income growth	+
	Urban-rural consumption gap	-
	Proportion of fiscal expenditure on people's livelihood	+

3.2 Determination of Economic Growth Quality Indicators

This paper mainly refers to Yuan Sichen (2023)'s measurement and evaluation of high-quality economic development at the provincial level in China to construct indicators for the quality of economic growth [12]. Based on the overall requirements for the quality of economic growth, 5 primary indicators and 14 secondary indicators are selected (see Table 2) to measure the development level of economic growth quality in 30 provinces (municipalities and autonomous regions) of China from 2012 to 2021. The data in this section are sourced from the Digital Finance Research Center of Peking

University, China Statistical Yearbook, China Economic Network Industry Database, China Science and Technology Statistical Yearbook, China Environmental Statistical Yearbook, as well as statistical yearbooks and bulletins of various provinces. The specific indicator construction is shown in Table 2.

3.3 Measurement Method for Digital Economy and Economic Growth Quality: Entropy Weight Method

The entropy weight method is an objective evaluation method. It first obtains the information entropy of each indicator based on the relative variation range of each indicator, and then determines the weight of each indicator through the obtained information entropy. If the entropy value is smaller, it indicates that the dispersion degree of the indicator data is larger, and its weight is correspondingly larger. This evaluation method has higher precision and accuracy, stronger objectivity, and effectively avoids interference from human factors. Therefore, this paper uses the entropy weight method to calculate the comprehensive evaluation indices of the digital economy and the quality of economic growth, and uses these indices to measure the development levels of the digital economy and the quality of economic growth, respectively. The specific steps are as follows:

Step 1: Construct an initial matrix consisting of n samples and m indicators.

Step 2: Data standardization. Since the original data have different orders of magnitude and dimensions, the comprehensive value cannot be directly calculated. This paper uses the Min-Max normalization method to standardize the data for each indicator in the digital economy and economic growth quality evaluation systems. The specific operations are as follows:

For positive indicators:

$$x_{ij}^{'} = \left[\frac{x_{ij}-min(x_{1j},x_{2j},\cdots,x_{nj})}{max(x_{1j},x_{2j},\cdots,x_{nj})-min(x_{1j},x_{2j},\cdots,x_{nj})}\right] * 100 \quad (1)$$

For negative indicators:

$$x_{ij}^{'} = \left[\frac{max(x_{1j},x_{2j},\cdots,x_{nj})-x_{ij}}{max(x_{1j},x_{2j},\cdots,x_{nj})-min(x_{1j},x_{2j},\cdots,x_{nj})}\right] * 100 \quad (2)$$

where $x_{ij}^{'}$ is the value of the j-th indicator in the i-th region (i=1,2,…,n; j=1,2,…,m). For convenience, the data is still denoted as $x_{ij}^{'} = x_{ij}$.

Step 3: Calculate the contribution degree p of the j-th indicator in the i-th region during the sample period.

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} (i = 1,2,\ldots,n; j = 1,2,\ldots,m) \quad (3)$$

Step 4: Calculate the entropy value e of the j-th indicator.

$$e_j = -k\sum_{i=1}^{n} p_{ij}ln(p_{ij}), k > 0, k = \frac{1}{ln(n)}, e_j \geq 0 \quad (4)$$

Step 5: Calculate the weight w of the j-th indicator.

$$w_j = \frac{1-e_j}{\sum_{j=1}^{m} 1-e_j} (1 \leq j \leq m) \quad (5)$$

Step 6: Calculate the comprehensive evaluation index s.

$$s_i = \sum_{j=1}^{m} w_j * p_{ij} \; (i = 1,2,\ldots,n) \quad (6)$$

The comprehensive evaluation index s is standardized with 1 as the benchmark. The closer the index is to 1, the better the development level of the digital economy and the quality of economic growth.

3.4 Data Sources

The samples selected in this paper are data from 30 provinces (municipalities and autonomous regions) in China from 2012 to 2021. The variable data involved are mainly sourced from the China Statistical Yearbook, Statistical Yearbooks of Various Provinces, China Economic Network Industry Database, China Science and Technology Statistical Yearbook, and EPS Database. Excel is used for data screening and sorting, and Stata is used for model construction.

3.5 Selection and Definition of Variables

Based on existing research, this paper uses the comprehensive index of the digital economy to measure the development level of the digital economy, with the construction method as described above. Similarly, the comprehensive index of economic growth quality is used to measure the development level of economic growth quality. The following control variables are selected: urbanization level (UR), measured by the proportion of the urban population to the total population in the region; R&D input intensity (TR), measured by the proportion of R&D expenditure of industrial enterprises above designated size to the regional gross domestic product (GDP); industrial structure (IS), measured by the proportion of the output value of the tertiary industry to the regional GDP; and foreign investment proportion (FDI), measured by the ratio of total foreign investment to GDP. Table 3 summarizes the names, categories, and explanations of each variable.

Table 3. Variable Meanings and Symbols

Variable Category	Variable Name	Symbol
Dependent Variable	Quality of economic growth	IN
Independent Variable	Development level of digital economy	FD
Control Variables	Urbanization level	UR
	R&D input intensity	TR
	Industrial structure	IS
	Foreign investment proportion	FDI

3.6 Model Setting

This paper analyzes the effect of the digital economy on the quality of economic growth and uses OLS regression for verification. The model is set as follows:

$$IN_{it} = \beta_0 + \beta_1 FD_{it} + \beta_2 controls_{it} + \varepsilon_{it} \quad (7)$$

In the formula, i represents each province/municipality, t represents time, β_0 is the constant term, β_1 and β_2 are the impact coefficients of the explanatory variables. IN_{it} denotes the dependent variable (quality of economic growth), FD_{it} denotes the independent variable (digital economy), $controls_{it}$ represents other control variables, and ε_{it} is the random error term.

4. Empirical Results Analysis

4.1 Descriptive Statistics

Table 4. Descriptive Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
IN	300	0.301	0.129	0.128	0.780
FD	300	0.123	0.095	0.017	0.552
TR	300	0.011	0.006	0.001	0.032
UR	300	0.594	0.120	0.354	0.950
IS	300	0.499	0.089	0.345	0.841
FDI	300	0.136	0.014	0.001	0.080

From Table 4, the maximum value of the dependent variable (quality of economic growth) is 0.780, and the minimum value is 0.128, indicating a significant gap in the development level of economic growth quality across regions in China from 2012 to 2021. The standard deviation is 0.129, indicating a low degree of fluctuation. The maximum value of the independent variable (digital economy) is 0.552, and the minimum value is 0.017, indicating a considerable gap in the development level of the digital economy among Chinese provinces from 2012 to 2021. This imbalance in development is attributed to factors such as disparities in regional development and geographical locations.

4.2 Correlation Analysis

According to the correlation analysis in Table 5, the digital economy is highly correlated with the quality of economic growth, showing a significant positive correlation at the 1% significance level, indicating that the digital economy can significantly promote the development of economic growth quality. Economic growth is positively correlated with R&D input intensity, urbanization rate, industrial structure, and foreign investment level, suggesting that improvements in these factors are conducive to enhancing the quality of economic growth.

Table 5. Correlation Analysis

Variable	IN	FD	TR
IN	1.000		
FD	0.668***	1.000	
TR	0.452**	0.570***	1.000
UR	0.819***	0.511***	0.506***
IS	0.776***	0.542***	0.079
FDI	0.472***	0.257***	0.512***
Variable	UR	IS	FDI
UR	1		
IS	0.670***	1	
FDI	0.474***	0.183***	1

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.3 Collinearity Diagnosis

The VIF test results in Table 6 show that all variable results are less than 5. Since a VIF value between 0 and 10 indicates a weak degree of multicollinearity in the model, there is no serious multicollinearity problem in the model.

Table 6. Collinearity Diagnosis

Variable	VIF	1/VIF
IS	3.300	0.303
UR	3.240	0.309
TR	2.990	0.334
FD	2.540	0.393
FDI	1.520	0.659
Mean VIF	2.720	

4.4 Benchmark Regression Results

In Table 7, after adding a series of control variables, the digital economy has a positive impact on the quality of economic growth, with a coefficient of 0.282, which passes the significance test at the 1% level. The data indicate that a 1% increase in the development level of the digital economy leads to a 0.282% increase in economic growth quality. This suggests that the development level of the digital economy can promote the quality of economic growth. The coefficient of the urbanization rate is 0.376, significant at the 1% level, indicating a positive correlation between the urbanization rate and economic growth. The coefficient of R&D input intensity is 0.928, which does not pass the significance test. The coefficient of industrial structure is 0.572, significant at the 1% level, indicating a positive correlation between industrial structure and economic growth. The data show that a 1% increase in the industrial structure leads to a 0.572% increase in economic growth. The coefficient of foreign investment level is 1.403, significant at the 1% level, indicating that the foreign investment level can promote economic growth.

Table 7. Benchmark regression results

Variable	IN
FD	0.282***
	(0.052)
TR	0.928
	(0.900)
UR	0.376***
	(0.047)
IS	0.572***
	(0.064)
FDI	1.403***
	(0.267)
_cons	-0.278***
	(0.022)
N	300
r2	0.827

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; t-values are in parentheses.

4.5 Robustness Test

Due to unavoidable errors and biases in data collection and other factors, or the occurrence of data outliers and extreme errors, the model estimation results may be distorted. Therefore, a robustness test is conducted to verify the stability of the equation. By regressing the lagged first period of the digital economy development level, the results remain significant. As shown in the table, after adding control variables, the digital economy development level has a significant positive impact on economic growth at the 1% level, with a coefficient of 0.256, indicating that a 1% increase in the digital economy development level leads to a 0.256% increase in economic growth. This also confirms the validity of the model results.

Table 8. Robustness Test

Variable	IN
FD	0.256***
	(0.058)
TR	1.823**
	(0.924)
UR	0.360***
	(0.048)
IS	0.653***
	(0.068)
FDI	1.195***
	(0.282)
_cons	-0.316***
	(0.024)
N	270
r2	0.834

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; t-values are in parentheses.

5. Conclusions and Policy Recommendations

By constructing indicators for the digital economy and the quality of economic growth, this paper uses the entropy weight method to calculate their comprehensive indices, and then employs empirical analysis to test the impact of the digital economy on the quality of economic growth. The findings are as follows: Firstly, the development level of the digital economy can promote the level of economic growth quality. The quality of economic growth is positively correlated with R&D input intensity, urbanization level, industrial structure, and foreign investment proportion. Secondly, there are disparities in the development level of the digital economy among Chinese provinces, leading to differences in the development level of economic growth quality across provinces. This imbalance is due to factors such as regional development gaps and geographical locations. Thirdly, the conclusions obtained above remain valid after robustness tests.

Policy recommendations include: strengthening FinTech application, increasing R&D investment, promoting industry-university-research cooperation to accelerate innovation in green credit; unifying industry standards, standardizing the green finance system, and building information sharing platforms to reduce information asymmetry.

Firstly, strengthen the construction of digital infrastructure. Currently, compared with other developed countries, China's digital infrastructure construction is relatively insufficient. Secondly, strengthen the cultivation of digital talents. Cultivating digital talents is a systematic project that requires enterprises to invest and make efforts in multiple aspects. Thirdly, strengthen digital technology innovation.

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