

The Impact of Digital Economy Development on Economic Growth

-- The Intermediary Effect Based on Green Technology Innovation

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Abstract: The digital economy is of great significance in promoting technological innovation and economic development. The article conducts research based on panel data of digital economy, green technology innovation and economic development in the Yangtze River Delta region from 2011 to 2021: Anhui, Zhejiang, Shanghai, and Jiangsu. The results found that: 1) Digital economy can promote economic development. 2) Green technological innovation can promote economic development. 3) Green technology innovation has an obvious intermediary effect in the digital economy and economic development. The article puts forward relevant conclusions and shortcomings based on the research empirical analysis results for subsequent research.

Keywords: Digital economy; green technology innovation; economic development; mechanism of action.

1. Introduction

Digital economy is a new economic model in the digital era, and it is also a new form of human economic and social development. In recent years, with the widespread application of intelligent platforms, big data, cloud computing and other technologies, the digital economy has also achieved further innovative development. The report of the 20th National Congress of the Communist Party of China clearly pointed out that the digital economy is an important goal of future domestic economic development. It is an important development direction of China's modern economic system in the future. At present, China's industrial structure is relatively complete and its population is large. As of December 2022, the number of Chinese Internet users has reached 1.067 billion, making it the economy with the largest digital economy audience in the world. According to data from the "Digital China Development Report (2022)", China's digital economy market size will reach 50.2 trillion yuan in 2022, accounting for 41.5% of the annual GDP. It can be seen that the digital economy plays an important role in China's economic development and is an important issue in the current domestic economic development. So what exactly is the impact of the digital economy on economic development? What is the mechanism of corporate green technology innovation? The article conducts research and discussion based on this.

2. Research Design

2.1. Data selection

It can be seen from previous academic research that the digital economy mainly uses high-tech technologies such as the Internet, big data, and cloud computing, and is mainly used in economically developed or advanced industrial areas, so it has less impact in the central and western regions of China. This article The 2011-2021 panel data of Anhui, Zhejiang, Shanghai, and Jiangsu provinces with developed economies and prosperous high-tech industries in the Yangtze

River Delta were selected for research and analysis. Data sources: National Bureau of Statistics of China, China Economic Net database, statistical yearbook, Guotai'an database.

2.2. Variable selection

2.2.1. Explained variable: economic development (LnGdpper)

Gross national product is mainly composed of the final value of a country or region's production activities, which can measure its economic development level. It is also the most important indicator in the national or regional economic accounting process, Dai Wei (2023). At the same time, in order to avoid the impact of inflationary factors on the accuracy of model testing, this study uses the per capita GDP value of each province after logarithmic calculation as an indicator to measure economic development.

2.2.2. Explanatory variables: Digital economy (Digital)

The development of the digital economy is mainly affected by various factors such as regional Internet technology, digital financial development, and total regional population. The article uses the entropy weight method to calculate the index weight and obtain the final digital economic development index through mathematical calculations. The composition of digital economy-related indicators is shown in Table 1:

2.2.3. Mediating variable: green technology innovation (LnPatents)

Green industry development and green technology innovation, as important factors affecting sustainable development, have always received widespread attention from the country and society. Green technology innovation represents an important indicator of a country or region's sustainable development capabilities, and is generally measured by the number of patents. The article uses the logarithm of the number of domestic invention patents approved, the number of domestic utility model patents approved, and the number of domestic design patents approved as the value to measure green technology innovation.

Table 1. Composition of digital economy index

First level indicator	Secondary indicators	Level three indicators	Indicator properties
Digital economy development level	Internet technology application penetration rate	Number of Internet users/100 people	+
	Number of people engaged in Internet-related industries	Proportion of personnel in computer and software industries	+
	Internet technology output results	Telecommunications business/person	+
	Number of mobile Internet users	Number of mobile clients/hundred people	+
	Development of digital inclusive finance	Digital Finance Development Index published by Peking University Digital Finance Center	+

2.2.4. Control variables

In order to more truly and accurately measure the impact of the digital economy on economic development and the intermediary effect of green technology innovation, ensure the accuracy of the model results. This article combines relevant research in the aforementioned literature that may affect digital economy and economic development, and controls the following factors: population density (PD), technology output value (Tec), and foreign trade (Trade). Among them, population density (PD) is calculated using 1,000 people per square kilometer, technology output value (Tec) is calculated using 1,000 yuan/person, and foreign trade (Trade) is measured using the proportion of total import and export of goods by foreign-invested enterprises to GDP.

2.3. Model setting

Based on the above research analysis and research hypotheses, the article sets the following model:

In order to reflect the impact of the digital economy on economic development, a benchmark regression model (1) (3) is constructed, in which model (1) is regressed separately without considering intermediary variables and control variables, and model (3) is a regression model that considers control variables. case of regression.

$$LnGdpper = \alpha + \beta Digital \tag{1}$$

$$LnGdpper = \alpha + \beta_1 Digital + \beta_2 Pd + \beta_3 Tec + \beta_4 Trade \tag{3}$$

In order to reflect the impact of green technology innovation on economic development, a baseline regression model (2) (4) is constructed, in which model (1) is regressed separately without considering intermediary variables and control variables, and model (3) is a regression model that considers control variables. Regression in the case of variables.

$$LnGdpper = \alpha + \beta LnPatents \tag{2}$$

$$LnGdpper = \alpha + \beta_1 LnPatents + \beta_2 Pd + \beta_3 Tec + \beta_4 Trade \tag{4}$$

In order to consider the mediating effect of green technology on the digital economy and economic development, a mediating effect regression model (5) is constructed.

$$LnGdpper = \alpha + \beta_1 Digital + \beta_2 LnPatents + \beta_3 Pd + \beta_4 Tec + \beta_5 Trade \tag{5}$$

2.4. Empirical analysis

2.4.1. Descriptive Statistics

This article uses stata software to analyze the data. The analysis results are shown in Table 2.

Table 2. Descriptive statistics table

Variable	N	Mean	P50	Min	Max
LnGdpper	44	4.373	4.451	3.307	5.157
Digital	44	0.265	0.226	0.018	0.704
LnPatents	44	5.441	5.400	3.883	6.578
Pd	44	2.604	2.300	1.741	3.926
Tec	44	6.133	6.287	4.175	7.866
Trade	44	0.320	0.242	0.035	1.023

As can be seen from Table 2, among the 44 selected samples, the situation regarding the explained variables and explanatory variables: the average value of economic development (LnGdpper) is 4.373, the median is 4.451, the minimum value is 3.307, and the maximum The value is 5.157. Among them, the difference between the average and the median is small. From the overall level, the gap in economic development levels is not very obvious, but the difference between the minimum and maximum values is large. There are regional There is a problem of obvious differences in economic levels. The average value of the digital economy development level (Digital) is 0.265, the median is 0.226, the minimum value is 0.018, and the maximum value is 0.704. Judging from the performance of the average and the median, there is a significant difference between the two, which represents the existence of the overall data There is a certain gap, and the gap between the minimum value and the maximum value is very large, indicating that there is a large imbalance in the development of the digital economy in the Yangtze River Delta region. The average value of green technology innovation (LnPatents) is 5.441, the median is 5.400, the minimum value is 3.883, and the maximum value is 6.5778. Judging from the performance of the average and median, the difference between the two is very small, representing the Yangtze River Delta region as a whole. The development levels of green technology are similar, but the gap between the minimum value and the maximum value is large, indicating that there are serious imbalances in development in some parts of the Yangtze River Delta region. The control variables also have the above-mentioned related situations. Based on the actual situation, it is mainly due to

the regional industrial level development and economic structure problems.

2.4.2. Correlation analysis

The correlation test can be used to determine whether each variable is related. The article uses stata software for analysis. The results are shown in Table 3:

Table 3. Correlation coefficient table

Variable	LnGdpper	Digital	Pd	Tec	Trade
LnGdpper	1.000				
Digital	0.764	1.000			
Pd	0.460	0.384	1.000		
Tec	0.803	0.704	0.427	1.000	
Trade	0.557	0.193	0.743	0.339	1.000

It can be seen from Table 2 that there is an obvious positive correlation between various variables. Among them, the positive correlation between the explained variable economic development (LnGdpper) and the explanatory variable (Digital) is very strong. Among other variables, population density (Pd), Technology level (Tec) and foreign trade (Trade) have obvious positive correlations with the explained variables.

2.4.3. VIF inspection

Through the VIF (variance inflation factor) test method, the above correlation coefficient can be tested to verify whether the linear correlation exists and to determine whether multicollinearity is obvious. To this end, the article conducts VIF test on the data, and the test results are shown in Table 4.

Table 4. VIF inspection

Variable	VIF	1/VIF
Pd	2.58	0.387515
Trade	2.36	0.424504
Tec	2.17	0.461134
Digital	2.13	0.470579
Mean VIF	2.31	

It can be seen from Table 3 that the VIF test result is $2.31 < 10$, the test passes, there is no obvious multicollinearity in the data, and the correlation coefficient is consistent with the test results.

2.4.4. Empirical results

Table 5. Baseline regression results

Variable	(1)	(2)	(3)	(4)
	LnGdpper	LnGdpper	LnGdpper	LnGdpper
Digital	2.104*** (7.03)		1.373*** (5.62)	
LnPatents		0.249*** (2.70)		0.658*** (9.34)
Pd			-0.193*** (-3.48)	0.595*** (5.82)
Tec			0.169*** (4.22)	-0.038 (-0.87)
Trade			0.870*** (6.97)	0.262 (1.67)
Constant	3.817*** (41.01)	3.017*** (5.54)	3.197*** (14.00)	-0.607 (-1.54)
N	44	44	44	44
Adjusted R2	0.573	0.141	0.853	0.892

This article uses stata16.0 analysis software to analyze the data. The results of the baseline regression model are shown

in Table 2. (1) Represents the impact of the digital economy on economic development without adding any control variables or intermediary variables. (2) represents the impact of green technology innovation on economic development without adding any control variables, (3) represents the impact of digital economy on economic development after adding control variables, (4) represents the impact of green technology innovation on economic development after adding control variables impact on economic development. Table 5 shows the baseline regression results.

It can be seen from Table 2 that the core variables of the benchmark regression results of different models are all significant at the 1% level, and the significance is obvious. Model (1) represents the impact of the digital economy on economic development without adding any control variables or intervening variables. Judging from the results, the development of the digital economy has a significant role in promoting economic growth. Model (3) represents the impact of digital economic development on economic growth after adding control variables. From the empirical results, digital economic development still has a huge promoting effect on economic growth (the coefficient of the equation is: 1.373, at the 1% level significantly), while population density (Pd) has a slight weakening effect on economic growth, and technological output (Tec) and foreign trade (Trade) also have a significant promoting effect on economic growth (equation coefficients are: 0.169, 0.870, significant at the 1% level).

Model (2) represents the impact of green technology innovation (LnPatents) on economic growth without adding control variables. The empirical results show that green technology innovation (LnPatents) also promotes economic growth. Model (4) represents the impact of green technology innovation (LnPatents) on economic growth after adding control variables. From the empirical results, when adding control variables, the effect of green technology innovation on economic growth is stronger (the equation coefficient is: 0.658, significant at the 1% level), while among the control variables, technical output (Tec) has a weak weakening effect on economic growth, and population density (Pd) and foreign trade (Trade) have a significant effect on economic growth. (The coefficients of the equation are: 0.595, 0.262, significant at the 1% level). Judging from the regression results of the constructed benchmark model, digital economic development and green technology progress have significant promoting effects on economic growth to varying degrees, which is consistent with the relevant research conclusions mentioned in the previous literature review.

2.4.5. Mediating effect analysis

The digital economy is a new economic form based on high-tech, digital technology, and digital industrialization. From the previous test of benchmark effect regression, it can be seen that the digital economy has a significant role in promoting economic growth. Green technology innovation is also a product based on the field of advanced technology. Green technology innovation has a varying degree of promoting effect on economic growth. This has been proven through the previous research. However, whether green technology innovation has an intermediary effect in the digital economy and economic development has become a new question. This section will continue to use the above research data to conduct research and analysis on the intermediary effect of green technology innovation in the digital economy and economic growth. The results of the empirical analysis are shown in Table 6: Mediation effect regression results.

Table 6. Mediation effect regression results

Variable	(1)	(2)	(3)
	LnGdpper	LnPatents	LnGdpper
Digital	1.373*** (5.62)	1.188*** (3.39)	0.787*** (3.60)
LnPatents			0.493*** (6.74)
Pd	-0.193*** (-3.48)	-1.142*** (-14.80)	0.370*** (3.72)
Tec	0.169*** (4.22)	0.407*** (8.34)	-0.032 (-0.75)
Trade	0.870*** (6.97)	0.803*** (4.28)	0.474*** (3.49)
Constant	3.197*** (14.00)	5.346*** (17.06)	0.562 (1.23)
N	44	44	44
Adjusted R2	0.853	0.888	0.922

As can be seen from Table 5, Equation (1) corresponds to Equation (3) in Table 4, which represents the impact of digital economy development on economic growth after adding control variables. From the empirical results, the development of digital economy still remains It has a huge promoting effect on economic growth (the coefficient of the equation is: 1.373, significant at the 1% level), and equation (2) in Table 5 represents the impact of digital economy (Digital) on green technology innovation (LnPatents), which can be It can be seen that the regression equation coefficient of digital economy (Digital) on green technology innovation (LnPatents) is positive (the equation coefficient is: 1.188, significant at the 1% level), and the significance level is high. Equation (3) represents the impact of the digital economy (Digital) on economic development (LnGdpper) after adding the intermediary variable green technology innovation (LnPatents). From the empirical results, when the intermediary variable is added, the impact of the digital economy (Digital) on the economy The coefficient of the regression equation of development (LnGdpper) decreases, but overall it is still positive (the coefficient of the equation is: 0.787, significant at the 1% level), and the significance level is still high. It shows that the mediating effect of green technology innovation (LnPatents) is significant.

2.5. Robustness test

In order to further verify the stability of the regression results and eliminate the influence of factors such as random values of variables on the accuracy of the regression results, this paper uses the method of replacing variables to conduct a robustness test.

2.5.1. Replace the explained variable

An important manifestation of economic development is the growth of residents' income. This article selects per capita disposable income (PCDI) as the alternative variable of the explained variable y economic development for regression analysis.

2.5.2. Replace explanatory variables

The digital economy is a new economic form developed by borrowing digital means and digital industries. As an important indicator to measure the level of the digital economy, digital inclusive finance (LnDigitalFinance) can be used as a variable to measure the development level of the

digital economy to a certain extent. This article selects digital inclusive finance (LnDigitalFinance) as the explanatory variable x-digital economy alternative variable for regression analysis.

The robustness test regression results are shown in Table 7

Table 7. Robustness test results

Variable	Substitute x	Substitute y	Change study interval
	LnGdpper	PCDI	LnGdpper
LnDigitalFinace	0.166*** (3.63)		
Digital		64.944*** (7.93)	2.093*** (7.16)
Pd	-0.199*** (-2.87)	3.016 (1.38)	-0.227*** (-4.36)
Tec	0.230*** (6.20)	1.980 (1.07)	0.084** (2.20)
Trade	1.104*** (5.67)	11.606** (2.05)	0.947*** (9.39)
Constant	2.221*** (8.09)	-3.799 (-0.37)	3.594*** (19.56)
N	44	44	36
Adjusted R2	0.792	0.792	0.889

As can be seen from Table 6, equation (1) represents the relationship between digital inclusive finance (LnDigitalFinance) and economic growth after replacing the explanatory variable X-digital economy. It can be seen from the regression results that the regression coefficients of both are positive (The coefficient of the equation is: 0.166, significant at the 1% level). The significance level is relatively high, which means that the robustness test after replacement is passed. Equation (2) represents the relationship between per capita disposable income (PCDI) and the digital economy after replacing the explained variable y-economic growth. From the regression results, the regression coefficient is positive (the equation coefficient is: 64.944, significant at the 1% level), the significance level is very high, and the robustness test passes. Equation (3) changes the research interval. Due to the impact of the epidemic, the overall domestic production status is different to a certain extent compared with before the epidemic. For this reason, the data related to the digital economy affected by the epidemic in 2020 and 2021 are excluded for research, in order to Further explore the stability of the regression results. Judging from the regression results, the regression coefficient between the digital economy (Digital) and economic development is positive (the equation coefficient is: 2.093, significant at the 1% level). Compared with the regression system without excluding the data in 2020 and 2021, The number increased significantly. It can be seen from this that after replacing the core explanatory variables, the explained variables and the control study interval, the regression results are all established, which means that the empirical robustness test has been passed.

3. Conclusions and Suggestions

3.1. Conclusion

Accelerating the development of digital and information technology plays an important role in improving the digital

economy and accelerating green technology innovation. From the empirical analysis results, green technology innovation has a significant mediating effect on the relationship between digital economy and economic development. From the empirical results, green technology innovation affects the relationship between digital economy and economic development. In green technology innovation Under the influence of , there is still a significant correlation between the digital economy and economic development. Therefore, we should focus on the development of the digital economy, increase investment in the digital industry, and improve digital technology capabilities to improve the development level of the regional digital economy.

3.2. Suggestions

Develop the Internet and digital industries and attach importance to the cultivation of digital talents. Internet technology and digital industry have strong driving forces for the development of regional digital economy. For most regions, strengthening the Internet industry and enterprise digital reform will have an important impact on the process of improving green technology innovation and improving the level of digital economic development. The development of the digital economy will promote the development of green technology innovation and thereby promote economic growth. Actively strengthening the development of digital industries in various domestic regions and developing the digital economy are of great significance to optimizing the overall industrial structure. First, use regional resources to develop related industries, actively promote vertical expansion of industries through digital technology, and accelerate industrial transfer. Furthermore, we attach great importance to the cultivation of digital talents and the promotion of industrial innovation and development. Only by increasing investment in the digital field can we occupy a favorable position in the development of the digital economy. With the rapid development of the digital economy, the demand for relevant talents is also increasing. We should attach great importance to cultivating creative talents, attracting and building a comprehensive digital education system, innovating and promoting strategies, and making digital talents a breakthrough and development in the digital industry.

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