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Empirical Study on the Influence of the Level of Digital Economy on the Development of Green Economy

--Taking Anhui Province as an Example

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Abstract

Based on the data of Anhui Province from 2011-2018, the article uses entropy value method and super-efficient SBM model to measure the digital economy level and green economy efficiency of each province in the calendar year respectively and analyze them. The DF GMM model is constructed to conduct empirical research on the impact of digital economy level on green economy efficiency. The results of the study show that the development of digital economy in present Anhui Province can effectively improve the efficiency of green economy. Accordingly, policy suggestions are put forward to strengthen the digital economy to empower the green economy, control the increment of economic growth, control the size of the city, and adhere to the strategy of opening up to the outside world.

Keywords

Super-efficient SBM model, DF GMM model, digital economy, green economy.

1. Introduction

In the past three decades, with the popularization of the Internet, China's digital economy has continued to develop and has been at the forefront of global digital economic development. The digital economy plays a crucial role in China's comprehensive economic strength. However, while the development of digital economy brings economic benefits, it has more or less impact on the environment. The slogan "green mountains are golden mountains" has spread throughout the country and become the development concept and action guide for green development in all provinces[1] . Green development and economic development are inextricably linked, and striving to realize the common development of ecological environment and economic benefits is the core content of the concept of green economic development. Therefore, how to improve the efficiency of the green economy while developing the digital economy has become a matter that needs to be emphasized and solved. The development of digital economy has become one of the key elements to promote the development of green economy.

2. Literature review

As the pace of China's socio-economic development is getting faster and faster, science and technology are also advancing, and the link between the growing digital economy and the green economy is getting closer and closer.

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2.1. Developments in the Digital Economy

Peng Zhang (2019) argues that the development of digital economy is essentially an evolutionary process of resource allocation optimization based on technology, in which technology, organization and institutions interact with each other, which is a macroeconomic emergence[1] . Zhang Yuchuan et al. (2021) verified the coupling relationship between the digital economy and regional economic growth, and found that the digital economy has a significant role in promoting and strong correlation with regional economic growth[2] . Li Linhan (2021) investigated the role of digital finance on economic growth by constructing a spatial Durbin model, and the results showed that local digital finance has a direct promotion effect on economic growth[3] .

At present, there is relatively little literature on the study of the measurement method of the level of digital economy.L.P.Rai (2000) proposed the measurement method of social informatization index[8] . Zhou Ying et al. (2019) used the improved AHP method to assign weights to digital economy indicators, and then normalized and standardized the raw data to make the results comparable[4] .

2.2. Developments in the green economy

Xia Jing et al. (2017) suggested that the green development of industries should be emphasized at the regional economic level, thus promoting the development of green economy[5] . Gong Hengqing (2018) believes that green finance has an extremely important impact on regional economic ecologization[6] . For the measurement of green economic efficiency now the better method is the super-efficient SBM model, Xu Sheng (2020) constructed the green innovation development efficiency index based on the R&D-driven theory, and used the super-efficient SBM model to measure the innovation green development efficiency and the green total factor productivity of 18 countries around the globe from 2008-2017[9] . Su Shuai et al. (2020) constructed the green economic efficiency measurement index. 2020) constructed a green economic efficiency measurement index system, and then used the super-efficient SBM model to measure the efficiency of China's green economy[10] .

2.3. Current status of research on the impact of the level of the digital economy on the efficiency of the green economy

Both digital economy and green economy are related to high quality economic development, but there are few studies linking the two together, Ciocoiu and Carmen Nadia (2011) argued that the integration between digital economy and green economy can lead to a new paradigm, and it can create some opportunities for sustainable development, and also for economic recovery[11] . Liu Jin (2020) calculated the green total factor productivity by using the production frontier surface function, and through empirical analysis found that digital technology has a positive contribution to the improvement of green total factor productivity in cities .[12]

In summary, it can be found that although the research on digital economy and green economy are both related to economic development and green, and many scholars have proposed that the two should be combined to promote sustainable economic development, they are limited to theories and few empirical processes. In this paper, we will conduct empirical research and contribute complementary results.

3. Theoretical analysis and research hypothesis

The digital economy, based on data resources and with digital technology as the core driving force, has promoted the comprehensive application of a variety of digital technologies, such as blockchain, big data, cloud computing, artificial intelligence and so on, and has significantly improved the efficiency of resource utilization and overall economic efficiency. As a new

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economic form, the digital economy breaks the limitations of traditional factors through the use of data elements, changes the way resources are utilized in the traditional economy, realizes the creation of more economic gains with fewer ecological resources, and reduces excessive consumption of resources and environmental pollution, thus promoting sustainable development. In addition, the digital economy leads the development of the green economy in both production and consumption. On the production side, enterprises can use digital intelligent systems to monitor and digitally simulate the production process in real time, improve products by accurately analyzing large amounts of data, and reduce resource waste and environmental pollution. On the consumption side, the digital economy popularizes the concept of green living through Internet big data, leading to the popularization of green consumption concepts. At the same time, the digital economy can also help the government to comprehensively and real-time monitor the environmental pollution of enterprises in the control area, eliminate information asymmetry, improve regulatory efficiency and contribute to green development.

Based on the above points, the hypothesis can be formulated that the development of digital economy can effectively improve the efficiency of green economy.

4. Modeling and Selection of Indicators

4.1. Explained Variables

Green Economic Efficiency (lngee). The article refers to the approach of Tone[13] to study green economic efficiency and related ecological and environmental issues by choosing a super-efficient SBM model with non-expected outputs and continuously supplementing the constraints. Although the model still belongs to the category of super-efficient DEA model, it has many advantages compared with general radial DEA models (e.g. BCC model and CCR model). Among them, three input indicators and two output indicators are selected for the evaluation of green economic efficiency, as shown in Table 1.

Table 1: Table of green economy efficiency indicators

Level 1 indicators	Secondary indicators	Tertiary indicators
Input indicators	labor input	Employed persons at the end of the year by province (10,000 persons)
	capital investment	Total fixed assets of the whole society (billion yuan)
	Energy inputs	Total energy consumption (tons of standard coal)
Output indicators	Expected outputs	Gross regional product (billions of dollars)
	Non-expected outputs	Wastewater discharge (tons)
		SO2 Emissions (tons)
		Fume and dust emissions (tons)

4.2. Explanatory variables

Level of digital economy (lndigital). Considering the difficulty of obtaining data, in order to obtain data of more years, by referring to the existing literature[14][15] and understanding the digital economy index system, we initially choose the following 15 secondary indicators under the 4 first-level indicators of the level of the digital economy, so as to calculate the comprehensive development index through the entropy weighting method, and the specific content is shown in Table 2.

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Table 2: Indicators of digital economy development and corresponding weights

Composite indicators	Level 1 indicators	Secondary indicators	unit (of measure)	Type of indicator	Weighting of secondary indicators	Tier 1 indicator weights
digital economy	Scale of figures	Length of long-distance fiber optic cable per unit area	Kilometers/square kilometers	forward	0.0398	0.2674
		Pages per capita	pcs/person	forward	0.0194	
		Domain names per capita	pcs/person	forward	0.0228	
		Number of websites per capita	pcs/person	forward	0.0296	
		Number of terminals in the electronic reading room	classifier for individual things or people, general, catch-all classifier	forward	0.0702	
		Broadband access ports per capita	Pcs/person	forward	0.0856	
	digital application	Cell phone penetration rate	Departments/100 persons	forward	0.0648	0.2887
		Broadband penetration rate	%	forward	0.0881	
		Digital TV subscription rate	%	forward	0.1358	
	Digital industry development	Total telecommunication services	billions	forward	0.0166	0.1035
		Value added of tertiary industry	billions	forward	0.0508	
		Number of persons employed in the information industry	all the people	forward	0.0360	
	Digital technology innovation	Full-time equivalent of R&D personnel	man-year	forward	0.0443	0.3403
		Number of R&D projects	term (in a mathematical formula)	forward	0.0606	
		R&D expenditure as a share of regional GDP	%	forward	0.2355	

4.3. Control variables

In order to maintain objectivity and accuracy in the results of the study, the following three indicators were selected as control variables in the article.

Level of opening up to the outside world (lnopen). Generally speaking, opening up to the outside world introduces advantageous resources from abroad, which accelerates the accumulation of innovative talents, scientific and technological innovation, the specialization of division of labor and the improvement of labor productivity, and thus realizes the high-quality development of the economy. The article chooses the indicator of the proportion of total import and export to GDP to measure the level of opening up.

City size (lntd). City size is positively correlated with the types and scope of services that cities can provide, and the larger the city, the easier it is to form the agglomeration effect of manpower and material resources, accelerating the process of urbanization as well as urban-rural integrated development. The article chooses the indicator of urban construction land area to measure the city scale.

Economic growth (lnincr). may play a moderating role in the process of influence of the level of the digital economy on the efficiency of the green economy. In the article, the indicator of the growth rate of GDP is chosen as a measure.

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4.4. Model construction

Differential generalized estimator (DF GMM model) is a dynamic panel regression model that contains first-order lagged terms of the explanatory variables, i.e., it takes into account the effect of past values of the explanatory variables.Aerllano and Bond (1991) constructed a dynamic panel regression model, which is constructed as follows:

$$lngee_{it} = \alpha_0 + \gamma llngee_{it} + \alpha_1 lndigital_{it} + \alpha_2 lnincr_{it} + \beta_1 lntd_{it} + \beta_2 lnopen_{it} + \mu_i + \varepsilon_{it}$$

In order to reduce the problem of heteroskedasticity and at the same time to make the economic variables elastic, the variables are logarithmically treated, and in addition, taking into account the green economy inertia, the explanatory variable green economy efficiency is added to Eq.$lngee_{it}$ the first-order lag term of$llngee_{it}$ which$lndigital_{it}$ denotes the level of digital economy, the $lnincr_{it}$ denotes the level of economic growth, the$lntd_{it}$ denotes the city size, the$lnopen_{it}$ denotes the level of openness to the outside world, the α_0 denotes a constant term.i It refers to the region.t refers to time. μ_i denotes unobserved cross-section individual effects, andε_{it} is a random disturbance term.

5. Empirical analysis

5.1. Descriptive statistics of variables

Table 3: Descriptive statistical indicators for Anhui Province

variant	observed value	upper quartile	(statistics) standard deviation	minimum value	maximum values
lngee	240	-0.6700	0.4021	-1.5432	0.1829
llngee	210	-0.6876	0.4003	-1.5432	0.1632
lndigital	240	-1.6320	0.4661	-2.7822	-0.5159
lnincr	240	-0.5616	0.6014	-9.2103	0.0001
lntd	240	7.1860	0.7506	4.8014	8.6265
lnopen	240	1.2648	1.9388	-4.5372	4.5890

5.2. Stepwise regression analysis of the DF GMM model

In order to avoid the potential multicollinearity problem to have an impact on the sign and significance of the explanatory variables, this paper will carry out a stepwise regression on the DF GMM model, and get Table 4, from which it can be found that the coefficients of the explanatory variables (LNDIGITAL) in the process of the stepwise regression are significantly positive, that is to say, the potential multicollinearity problem of the control variables with the explanatory variables does not have the sign and significance of the explanatory variables impact on the sign and significance of the explanatory variables and will not affect the main results of the regression analysis. From the estimation results of the linear dynamic panel regression model in the stepwise regression analysis table of the DF GMM model, the following points can be obtained: the p-value of AR (2) is greater than 0.1, which means that none of the regression equations have second-order serial correlation, and the p-value of Sargan's test is greater than 0.1, which means that the original hypothesis is accepted at the 10% level, i.e., there is no over-identification problem. The coefficient of the explanatory variable lndigital is significantly positive, that is, the increase in the level of the digital economy has a significant effect on the efficiency of the green economy, and for every 1 percentage point change in the digital economy, the efficiency of the green economy changes upward by 0.403 percentage points. Among the control variables: the coefficient of economic growth (lnincr) is significantly negative, i.e., the increase of the level of digital economy has a significant inhibitory effect on the green economic efficiency, and for every 1 percentage point upward change in the level of

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economic growth, the green economic efficiency changes downward by 0.025 percentage points. The coefficient of city size (lntd) is significantly negative, i.e., the increase of city size has a significant inhibition effect on green economic efficiency, and every 1 percentage point upward change in city size will lead to 0.352 percentage point downward change in green economic efficiency. The coefficient of openness to the outside world (lnopen) is significantly negative, that is, the increase of openness to the outside world has a significant role in promoting the green economic efficiency, and for every 1 percentage point upward change in openness to the outside world, the green economic efficiency moves upward by 0.075 percentage points.

Table 4:Stepwise regression analysis of DF GMM model

variant	Step 1	Step 2	Step 3	Step 4
llngee	0.219***	0.233***	0.234***	0.265***
	(15.90)	(19.19)	(15.88)	(13.97)
llngee (-1)	-0.221***	-0.180***	-0179***	-0.185***
	(-16.30)	(-10.74)	(-10.93)	(-6.23)
lndigital	0.256***	0.249***	0.234**	0.374***
	(9.63)	(9.38)	(8.29)	(10.45)
lnincr		-0.022***	-0.023***	-0.024***
		(-12.35)	(-12.02)	(-8.13)
lntd			-0.043	-0.168
			(-0.47)	(-1.10)
lnopen				-0.322***
				(-5.15)
constant	-0.228***	-0.223***	-0252***	2.345***
	(-4.91)	(-5 00)	(-5.18)	(5 35)
N	150	150	150	150
AR (2)	0.9192	0.9047	0.8860	0.7200
Sargan's test p-value	0.3165	0.3472	0.3506	0.3056

Note: t-values are in parentheses in the table, *, **, and *** represent significant at the 10%, 5%, and 1% levels, respectively.

5.3. Analysis of results

The coefficient of the explanatory variable digital economy level (lndigital) is significantly positive, that is, the increase of the digital economy level has a significant role in promoting the efficiency of the green economy. In recent years, China's digital economy has been developing rapidly, and the state and the government have been continuously utilizing the digital economy resources to help green development, such as constructing the digital management platform of natural resources, which ensures the red line of ecological protection, and plays a key role in enhancing the efficiency of the green economy. plays a key role. Among the control variables: ① the coefficient of economic growth (lnincr) is significantly negative, that is, the increase in the level of economic growth has a significant inhibitory effect on green economic efficiency. The coefficient of ② city size (lntd) is significantly negative, that is, the increase of city size has a significant inhibitory effect on green economic efficiency. The coefficient of openness to the outside world (lnopen) is significantly negative, i.e., the increase of openness to the outside world has a significant role in promoting green economic efficiency.

Remove the number of web pages per capita, the number of domains per capita, and the number of websites per capita, which are ranked in the bottom three of the numerical scale weights,

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and tune the Integrate into 3 secondary indicators, recalculate the level of digital economy lndigital, as a proxy variable into the linear model for robustness testing. It can be seen that there is still a lagged effect of green economic efficiency, the regression coefficient of digital economic level on green economic efficiency is still significantly positive, and the significance and sign of the rest of the variables are basically consistent with the original parameter estimation, and the conclusion can be seen to be robust and the model is relatively stable.

6. Policy recommendations

First, strengthening the digital economy to empower the green economy. From the empirical results, it can be found that the linear effect of the level of the digital economy on the efficiency of the green economy is significantly positive, in the development of the digital economy at the same time, efforts to maintain and strengthen the digital economy empowers the green economy, to achieve a win-win situation for the ecology and economy. Second, control the growth rate of economic growth. The impact of economic growth on the efficiency of the green economy is significantly negative, but under the negative regulation of the interaction term between the level of the digital economy and economic growth, the inhibitory effect will turn into a facilitating effect. In addition, the higher the level of economic growth, the level of the digital economy on the promotion of green economic efficiency will become weaker, the growth rate of economic growth should be controlled, so that the level of the digital economy on the promotion of green economic efficiency will only increase not decrease. Third, control the size of the city. The impact of city size on green economic efficiency is biased in the negative direction, and the size of the city should be controlled to reduce the anthropogenic pressure on the ecological environment, so as to enhance the green economic efficiency. Fourth, adhere to the strategy of opening up to the outside world. The impact of opening up to the outside world on green economic efficiency is significantly positive, and the degree of opening up to the outside world should be increased to introduce advanced technology, so as to enhance the efficiency of the green economy.

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References

[1] Yu Jingyuan. Awakening the "sleeping" green resources[J]. Xiaokang.2020,(31):30-32.

[2] Zhang Peng. The nature of digital economy and its development logic[J]. Economist.2019, (02): 25-33.

[3] Zhang Yuchuan, Qin Shanshan. An empirical study on the digital economy to promote regional economic growth - based on 2010-2019 data of the Yangtze River Economic Belt[J]. Logistics Technology.2021, 40(01):56-62.

[4] Li Linhan, Tian Weimin. Digital Financial Development, Industrial Structure Transformation and Regional Economic Growth - An Empirical Analysis Based on Spatial Durbin Model[J]. Financial Theory and Practice.2021, (02): 8-16.

[5] Zhou Ying, Qu Jiaxing, Gu Juntao et al. Research on regional digital economy index system based on hierarchical analysis--Taking Heilongjiang Province as an example[J]. Industrial Science and Technology Innovation, 2019, 1(20):7-9.

ISSN: 2710-0170

[6] XIA Jing, LIU Fuyou, WANG Xingping, GU Hui. A preliminary study on the path of economic green development in the late-developed areas of the Yangtze River Economic Belt--Taking Anchi Copper City Cluster as an example[J]. Modern Urban Research.2017(04):2-8+44.

[7] Gong Hengqing. Research on the impact of green finance on regional economic ecologization[J]. Market Research, 2018, (04): 32-35.

[8] Liu Jin. Empirical study on the impact of digitization level and resource dependence on green total factor productivity[J]. China economic and trade guide (in Chinese).2020, (02): 121-123.

[9] L.P. Rai., K. Lal. Indicators of the information revolution [J]. Technology in Society. 2000, (22): 221 - 235.

[10] Xu Sheng. Research on Global Innovative Green Development Efficiency Measurement Based on Dea Super Efficiency Model[J]. Academic Journal of Business & Management. 2020, 2(5): 121-135.

[11] Su Shuai, Zhang Fan. Modeling the role of environmental regulations in regional green economy efficiency of China: Empirical evidence from super efficiency DEA-Tobit model[J]. Journal of Environmental Management. 2020, (5): 261.

[12] Ciocoiu, Carmen Nadia. INTEGRATING DIGITAL ECONOMY AND GREEN ECONOMY OPPORTUNITIES FOR SUSTAINABLE DEVELOPMENT[J]. Theoretical and Empirical Researches in Urban Management. 2011, 6(1): 33-43.

[13] TONE K. Dealing with undesirable outputs in DEA: a slacks-based measure (SBM) Approach [R].Tokyo: GRIPS Research Report Series I, 2003. European Journal of Operational Research, 2001,130(3):498-509.

[14] JIANG Wenwen, WU Zhuan, HU An. Strategic thinking on high-quality development of digital economy - based on the Yangtze River Delta region[J].Modern Management Science. 2019, (12): 30-32.

[15] HONG Xingjian. Digital economy: connotation, accounting and evaluation[J]. China Statistics.2019, (08): 49-52.