Digital economy, industrial structure upgrading and carbon emissions

Yingqi Li[1*],Yujie Hou[2]

Wuhan University of Technology, Wuhan Hubei,China

Email:309078@whut.edu.com*

Abstract. Digital economy is a new direction to promote the adjustment of industrial structure, and can also provide new driving force for reducing carbon emissions. Based on the provincial panel data from 2014 to 2021, this paper uses the benchmark regression model to explore the relationship and the path between digital economy and carbon emission intensity. The results show that: first, digital economy can significantly inhibit carbon emission intensity; Second, industrial structure plays an intermediary role in the reduction of carbon emission intensity promoted by digital economy, and digital economy reduces carbon emission intensity by promoting the upgrading of industrial structure.

Keywords: Digital economy; Upgrading of industrial structure; Carbon emissions; Mediating effect

1 Introduction

Digital economy is a new economic form that has emerged rapidly with the development of information technology. Its emergence has profoundly changed the production mode, organization form and transaction mode of traditional economy[1]. In recent years, the vigorous development of digital economy provides a new path and method for the optimization of industrial structure and the realization of the goal of "dual carbon". Digital economy provides important support for the optimization of industrial structure, and the upgrading of industrial structure can reduce carbon emissions through technological innovation and energy saving and consumption reduction. Therefore, under the background of green and sustainable development, the integration of industry and digital economy will become a feasible and important path to effectively reduce carbon emission intensity.

2 Literature Review

2.1 Digital economy and carbon emissions

The digital economy has driven the development of artificial intelligence and other digital industries, and made society more networked, digital and intelligent[2]. Existing

Y. Jiao et al. (eds.), *Proceedings of the 3rd International Conference on Internet Finance and Digital Economy (ICIFDE 2023)*, Atlantis Highlights in Economics, Business and Management 1,
https://doi.org/10.2991/978-94-6463-270-5_14

scholars' research on the factors affecting carbon emission level of digital economy mainly focuses on environmental rules, green innovation, research and development intensity, energy structure and other aspects. Based on the moderated mediating effect test model, Guo Yueqin et al. proposed that environmental rules have a mediating effect in the impact of digital economy on carbon emission intensity[3]. Chen Fuzhong et al. used the generalized nested space model to find that digital economy can achieve emission 4She Qunchi et al. constructed a dynamic panel model, and found that digital economy could achieve energy conservation and emission 5reduction by improving energy efficiency and energy structure[5].

In conclusion, Hypothesis 1 is put forward: The development of digital economy can significantly inhibit carbon emission intensity.

2.2 Digital economy, industrial structure upgrading and carbon emissions

In essence, the upgrading of industrial structure refers to the process or trend of the transformation of industrial structure from low-level form to advanced form, and its ultimate direction is high technology and high intensity of industry[5]. Since 2013, digital economy has become the driving force for the continuous improvement of China's industrial structure[6], and has a nonlinear effect on the upgrading of industrial structure[7]. Wang et al. constructed a mediating effect model and found that green technology innovation plays a significant mediating role[8] between the level of digital economy and the upgrading of industrial structure. Some scholars have found that find that there are interactive effects and spatial effects between industrial structure upgrading and energy conservation and emission reduction, industrial structure upgrading can significantly reduce carbon emissions[9]. At the same time, the upgrading of industrial structure will cause industries to concentrate in low-enerx`gy industries, and reduce the correlation between economic development and carbon emissions. Based on the above theoretical analysis, this paper argues that industrial structure can be used as the "lubricant" in the process of digital economy inhibiting carbon emission intensity. Digital economy can boost the upgrading of industrial structure by promoting the way of production mode and the digitalization of production materials. Meanwhile, industrial structure upgrading can promote the gradual "decoupling" of economic development and carbon emission, and ultimately reduce carbon emission intensity.

In summary, Hypothesis 2 is put forward: Industrial structure plays an intermediary role in the digital economy promoting the reduction of carbon emission intensity, and the development level of digital economy reduces carbon emission intensity by promoting the upgrading of industrial structure.

3 Research design

3.1 Model Setting

Based on the above theoretical analysis, in order to verify Hypothesis 1 and test the direct effect of digital economy on carbon emission intensity, this paper constructs the following measurement model:

$$lnemi_{n,y}=a_0+a_1dig_{n,y}+a_2Con_{n,y}+m_y+\varepsilon_{n,y} \quad (1)$$

Where n is the city and y is the year. $lnemi_{n,y}$ represents carbon emission intensity; a_0 is a constant term; $dig_{n,y}$ represents the digital economy; $Con_{n,y}$ is a control variable; m_y denotes year fixed effects and $\varepsilon_{n,y}$ is a random error term.
In order to verify Hypothesis 2 and Hypothesis 3, this study selects the stepwise regression method to verify the correlation among digital economy, industrial structure and carbon emissions. The regression model is as follows:

$$lnemi_{n,y}=a_0+a_1dig_{n,y}+a_2Con_{n,y}+m_y+\varepsilon_{n,y} \quad (2)$$

$$upd_{n,y}=b_0+b_1dig_{n,y}+b_2Con_{n,y}+m_y+\theta_{n,y} \quad (3)$$

$$lnemi_{n,y}=c_0+c_1dig_{n,y}+c_2upd_{n,y}+c_3Con_{n,y}+m_y+\mu_{n,y} \quad (4)$$

updn,y represents the upgrading of industrial structure; b_0 and c_0 are constant terms, $\theta_{n,y}$、$\mu_{n,y}$ is random error term.

3.2 Variable selection

3.2.1 Explained variables.

Carbon emission intensity (lnemi) refers to the natural logarithm of the total carbon dioxide emissions as the proxy index of carbon emissions. In this paper, the provincial carbon emission data of the multi-scale emission inventory reanalysis and data sharing platform developed by the MEIC team were used for calculation[1110][111110].

3.2.2 Explanatory variables.

Referring to the research[1112] of Pan Weihua et al., this paper selects 17 secondary indicators to construct the evaluation index system of digital economy development level (dig) from the four dimensions of digital economy infrastructure, digital industrialization, industrial digitalization and digital governance, and uses the entropy method to measure the development level of digital economy.

3.2.3 Mediating variables.

Industrial structure upgrading (upd) is measured by the level coefficient of industrial structure upgrading. This study draws on the research of Wang Wei et[13] al., and the specific calculation method is as follows:

$$upd=q1*1+q2*2+q3*3$$

Where qi is the proportion of output value of the ith industry.

3.3 Control variables

In order to prevent the impact of omitted variables on the results of this paper, other factors affecting carbon emissions are also included as control variables in the benchmark regression. The descriptive statistics of the variables are shown in Table 1.

Table 1. Descriptive statistics

Typeofvariable	Variable	Mean	Standard deviation	Min	Max
Explanatoryvariables	Dig	0.131	0.100	0.0217	0.594
Mediatingvariable	Upd	2.413	0.136	2.225	3.445
Variableexplained	Emi	10.17	0.720	8.243	11.45
Variableofcontrol	Lnfiscal	8.538	0.562	6.908	9.812
	Lnfdi	11.63	1.390	8.038	15.33
	Urban	0.615	0.111	0.403	0.893
	Lntech	5.151	1.808	0.431	8.854
	RD	0.0223	0.0153	0.00539	0.0676
	Lnele	7.483	0.684	5.529	8.970
	For	755.1	647.3	8.900	2,615
	Lnind	11.80	1.150	6.165	14.16

3.4 Data Sources

This paper selects the panel data of 30 provinces in China (excluding Tibet, Hong Kong, Macao and Taiwan) from 2014 to 2021. The empirical data are mainly taken from China Statistical Yearbook over the years. This paper uses linear interpolation method to supplement the missing values. In the index "data HP Financial index", "Peking University Digital HP Financial Index" is used as its reference variable[141414]. Provincial carbon dioxide emissions were obtained from the published data of the multi-scale emission Inventory Reanalysis and Data sharing platform developed by the MEIC team.

4 Empirical analysis

4.1 Benchmark regression analysis

Table 2 shows the benchmark regression results between digital economy and carbon emission intensity under the condition of controlling years. It can be seen from the table that the digital economy is negatively correlated with the carbon emission intensity and passes the significance test at the level of 1%, which indicates that for every unit increase in the digital economy, the carbon emission level can be reduced by 2.775 units. This further verifies hypothesis 1 of this paper.

Table 2. Impact of digital economy level on carbon emissions

	Emi
Dig	-2.775***
	(0.395)
Year fixed effect	Yes
N	240
R2	0.875

Note: The values in brackets in the table are t values; *, ** and *** indicate that the coefficient is significant at the level of 10%, 5% and 1%, respectively. The table below is the same.

4.2 Mediating effect analysis

According to the above results, the stepwise regression test method is further used to explore the mediating effect of industrial structure in the process of digital economy affecting carbon emissions. In Table 3, Column (1) shows the benchmark regression results of digital economy on carbon emissions, Column (2) shows the regression results of digital economy on industrial structure upgrading, and Column (3) shows the regression results of digital economy and industrial structure on carbon emissions.

The regression results in Column (2) show that the digital economy is positively correlated with the upgrading of industrial structure, which passes the significance level test of 10%. According to the regression results in Column (3), the industrial structure is significantly negatively correlated with the carbon emission level, which passes the significance level test of 1%. This shows that industrial structure plays a partial mediating role in the impact of carbon emissions and digital economy. This further verifies hypothesis 2 of this paper.

Table 3. Regression results of mediating effect test

	(1)	(2)	（3）
Variables	Emi	Upd	Emi
Dig	-2.775***	0.223*	-2.633***
	(0.395)	(0.131)	(0.389)
Upd			-0.634***
			(0.197)
Year fixed effect	Yes	Yes	Yes
N	240	240	240
R2	0.875	0.609	0.880

4.3 Robustness test

In order to further verify the robustness of the results, considering that the impact of digital economy on carbon emission level may have a lag effect, the carbon emission intensity data are lagged by one period. Table 4 shows the benchmark regression results under one-period-lagged carbon emission intensity. It is found in Table 4 that the digital economy is still negatively correlated with the carbon emission intensity.

Table 4. Regression results of the robustness test

	Emi
Dig	-2.813***
	(0.679)
Year fixed effect	Yes
N	210
R2	0.719

5 Conclusions and suggestions

The main conclusions of this study are as follows: (1) digital economy has an inhibitory effect on carbon emission intensity. (2) Digital economy can significantly promote the upgrading of regional industrial structure. (3) Digital economy can reduce carbon emission intensity by promoting the upgrading of industrial structure.

Based on the above conclusions, this paper puts forward the following policy recommendations: (1) strengthen the application of digital technology, promote industrial digital transformation, and empower industries with high energy consumption to reduce carbon emissions through digital solutions. (2) Adjust the layout of industrial structure, rationalize the optimization of industrial structure, and deepen the application degree of digital technology.

References

1. Jianda W,Kangyin D,Xiucheng D, et al. Assessing the digital economy and its carbon-mitigation effects: The case of China[J]. Energy Economics,2022,113.
2. Qinglan L,Hofmann A T,Miying Y, et al. A framework of digital technologies for the circular economy: Digital functions and mechanisms[J]. Business Strategy and the Environment,2022,31(5).
3. Guo Yue-qin, Guo Bin, Zhang Rong-xia. [Guo Y Q, Guo B, Zhang R X. Modern Management Science,2022(06):138-147.
4. Chen Fuzhong, Jiang Guohai. Emission reduction effect of digital economy: based on spatial panel data of 285 prefecture-level cities [J/OL]. Journal of lanzhou: 1-25 [2023-05-22]. http://kns.cnki.net/kcms/detail/62.1015.C.20230516.1021.002.html
5. SheQunZhi Wu Liu. Digital carbon reduction effect of economic development [J]. Journal of economic frame, 2022, 33 (05) 6:14 to 24. DOI: 10.15931 / j.carol carroll nki. 1006-1096.2022.05.008.
6. Chen. Digital economy influence the direction of the industrial structure evolution path [N]. The economic journal, 2021-05-21 (006). The DOI: 10.28425 / n.c. Nki NJJRB. 2021.008871.
7. Wen Jun, YAN Zhijun, CHENG Yu. Digital economy and the improvement of regional innovation capacity [J]. Inquiry into Economic Issues,2019(11):112-124.]
8. Gao Yu. Digital economy development of China's influence on the upgrading of industrial structure [J]. Journal of expo economy, 2023 (02) : 130-132. The DOI: 10.19995 / j.carol carroll nki/F7.2023.02.130 CN10-1617.

9. Wang Xiao-wen, Chen Ming-yue, Chen Nan-xu. Digital economy, the green technology innovation and upgrade of industrial structure [J]. Journal of economic issues, 2023 (01) : 19-28, DOI: 10.16011 / j.carol carroll nki JJWT. 2023.01.003.
10. Li, M., Liu, H., Geng, G., Hong, C., Liu, F., Song, Y., Tong, D., Zheng, B., Cui, H., Man, H., Zhang, Q., and He, K.: Anthropogenic emission inventories in China: a review, Natl.Sci. Rev., 4, 834-866, doi: 10.1093/nsr/nwx150, 2017.
11. Zheng, B., Tong, D., Li, M., Liu, F., Hong, C., Geng, G., Li, H., Li, X., Peng, L., Qi, J., Yan, L., Zhang, Y., Zhao, H., Zheng, Y., He, K., and Zhang, Q.: Trends in China's anthropogenic emissions since 2010 as the consequence of clean air actions, Atmos. Chem. Phys., 18, 14095-14111, doi: 10.5194/acp-18-14095-2018, 2018.
12. Pan Wei-hua, HE Zheng-chu, Pan Hong-yu. Spatio-temporal evolution and distribution dynamics of China's digital economy development [J]. China Soft Science,2021(10):137-147.
13. Wang Wei, Liu Yufei, Peng Dongdong. The aging of the population of the industrial structure upgrading effect research [J]. China industrial economy, 2015 (11) : 47-61. The DOI: 10.19581 / j.carol carroll nki ciejournal. 2015.11.004.
14. GUO Feng, WANG Jingyi, WANG Fang, KONG Tao, ZHANG Xun, CHENG Zhiyun, "Measuring China's Digital Financial Inclusion: Index Compilation and Spatial Characteristics", *China Economic Quarterly*, 2020