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Exploring the Impact of the Digital Economy on China's Export Implied Carbon Intensity: A Provincial Panel Data Analysis

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Exploiting the positive effect of digital economy on reducing the implied carbon intensity of exports is an important path to promote the green and low-carbon transformation of China's export trade. In view of this, using the Chinese provincial panel data from 2008 to 2020 to scrutinize the consequential impact and intricate mechanisms at play between these variables. Employing a robust methodology, including fixed-effects models, mediating-effects models, and threshold models, the analysis delves into the multi-faceted impact of the digital economy on export implied carbon intensity. It is found that (1) The enhancement of the digital economy can significantly reduce the implied carbon intensity of exports. (2) The digital economy further diminishes the implied carbon intensity of exports through the mediating influences of industrial structure and technological progress. (3) The relationship between the digital economy, industrial structure, and technological progress exhibits a noteworthy non-linear dynamic concerning export implied carbon intensity.

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Keywords: Digital economy; implied carbon intensity of exports; industrial structure; technological progress.

1. INTRODUCTION

Amidst a growing global focus on climate change, the pursuit of a low-carbon economy and green trade has become an important initiative for the world. China, as the world's second-largest economy, faces heightened international scrutiny due to its annual carbon dioxide emissions surpassing 6 billion tons, ranking it as first in the world. 2020, China clearly put forward the goals of "carbon peak" and "carbon neutral", and the report of the 20th Party Congress in 2022 also pointed out that "promoting economic and social development has become an important step in the fight against climate change". As one of the most important indicators for measuring the green development of the economy, the implied carbon intensity of exports can not only reflect the cost inputs related to carbon emissions in China's export trade, but also reflect the progress of China's economic green and low-carbon transformation. As the world's largest export trading country, a large portion of China's carbon emissions are caused by the carbon implicit in export trade, with about one-third of its carbon emissions coming from export trade. Consequently, the difficult problem of achieving carbon emission reduction goals without compromising the scale of export trade assumes paramount significance in realizing the objectives of a low-carbon economy and green trade in China.

The digital economy has gradually become a key factor in optimizing the allocation of global production factor resources, adjusting China's industrial structure and improving China's competitive landscape. Striving to realize the "building new advantages in the digital economy" proposed in the 14th Five-Year Plan, giving play to the digital economy to empower the transformation and upgrading of export trade is an important way to promote the reduction of the implied carbon intensity of exports and achieve the goal of "carbon peak" and "carbon neutral". The China Digital Economy Development Report (2022) released by the China Academy of Information and Communications Technology (CAICT) shows that the scale of China's digital economy has reached 45.5 trillion yuan in 2021, a year-on-year growth of 16.2%, and the proportion of GDP has increased from 30.3% in 2015 to 39.8%. Against the backdrop of the rapid development of the digital economy, digital technology has gradually become a key production factor, providing a solid foundation for promoting economic growth, adjusting industrial structure, improving technological innovation, and further reducing implied carbon emissions in the import and export trade chain.

The rest of this paper is constructed as follows: firstly, it presents the literature review; secondly, it lists three main hypotheses; thirdly, it describes the methods, which introduces the research models, variables; fourthly, it presents the main results; finally, it sums up the conclusions and provide suggestions.

2. LITERATURE REVIEW

Academic research on export-implied carbon mainly focuses on two aspects. One is the measurement method of trade-implied carbon, and the common research method is based on the input-output model constructed by Leontief. Due to the differences in economic development and production technology between regions, scholars mostly use the multi-regional input-output model (MRIO) for measurement. Xu et al. (2023) empirically analyzed by constructing the MRIO model to verify that sector aggregation can play an adjusting role to promote the accelerated decline of implied carbon emissions from China's industrial sector [1]; Xing et al. (2022) investigated city-level carbon footprints and inter-regional CO_2 transfers implied in domestic and international trade in finished goods by developing MRIO model [2]. Besides, structural decomposition analysis (SDA) is also one of the main research methods. SDA is able to analyze the impacts of various factors, including direct and indirect impacts, and has the advantages of a consistent data format and clear theoretical logic, making it the most commonly used tool for the analysis of implied drivers of carbon emissions [3]. Secondly, the influencing factors of implied carbon changes in trade. Some scholars found through empirical test that the improvement of the degree of global value chain embedding can have a positive impact on the carbon productivity of China's manufacturing industry , promote the technological upgrading of exports, which in turn reduces the implied carbon intensity of exports; improving innovation capacity and introducing foreign investment can promote technological progress, thereby improving resource utilization efficiency, which will also play a positive role in reducing carbon emissions [4]. At present, most scholars decompose the amount of export-implied carbon changes into three major categories: technical effect, structural effect, and scale effect, and propose that carbon emission reduction can be promoted by improving the scale and structure of trade [5].

The impact of digital economy development on carbon emissions has also received attention from most scholars. On the one hand, studies generally agree that the digital economy can not only reduce energy intensity through digital empowerment, promote technological progress and digital infrastructure to achieve carbon emission reduction. On the other hand, it is widely recognized that the digital economy can not only reduce energy intensity, promote technological progress and digital infrastructure to achieve carbon emission reduction through digital empowerment, empowering industrial technological change, adjusting the energy consumption structure, and improving the level of economic development and other factors to play an indirect effect. However, based on data from global 60 countries, it is known that the level of digital economy development varies greatly between countries, and the difference between “hyper-digitalized countries” and “under-connected countries” is increasingly obvious [6]. Besides, some studies also believe that the digital economy has a significant impact on the development of the economy. On the other hand, some studies also believe that the improvement of the development level of the digital economy can promote the green technological innovation of China's resource-based enterprises, reduce the cost of green innovation, improve urban green total factor productivity and play the role of green synergistic development, and enhance the green economic capacity and enterprise technology integration capacity. In addition, not all studies consider the impact of the digital economy on carbon emissions to be linear, such as Hu et al. (2022) verified an inverted U-shaped relationship between the digital transformation of manufacturing and the implied carbon intensity of exports with cross-country manufacturing industry data [7].

In summary, the existing literature has achieved certain results in the impact and mechanism research between digital economy and export carbon emissions, but did not carry out the role of the digital economy to influence the export implied carbon intensity of the role of the mechanism of the thorny state to examine. Therefore, on this basis, this study uses the panel data of 30 provinces in China from 2008 to 2020 and different econometric models are used to study the impact of digital economy growth on export implied carbon intensity. This investigation not only contributes to the understanding of the nexus between the digital economy and carbon efficiency in exports but also provides actionable insights for policy formulation geared toward fostering a green and low-carbon transformation within China's export sector.

2.1 Theoretical Analysis and Research Hypotheses

Digital economy and China's export-implied carbon intensity

The construction of the digital economy has opened up important changes for low-carbon production and green trade, promoting the reduction of the implied carbon intensity of exports. From a macro point of view, the digital economy's expansion of global trade scales enhances the world's economic prowess, subsequently influencing the implicit carbon intensity of export trade [8]. With the expansion of trade scale and the improvement of economic development level, it can widely fosters the comprehensive integration of digital technology with other industries, optimizing resource utilization to diminish the implied carbon intensity of exports. Additionally, the digital economy can also create new trade businesses and modes, giving rise to emergent low-carbon industries.

At the micro level, the rise of the digital economy has driven the development of China's "Internet+", big data, cloud technology, and improved the cross-regional integration of information and resources among enterprises. This augmentation, in turn, enhances the cross-regional systematic innovation capacity, and combines digital technology with all aspects of production and trade.

Moreover, the digital economy enables international trade rely on e-commerce platform, reducing the search cost of both sides of the trade and the unnecessary loss caused by information asymmetry, access to scientific decision-making. Digital technologies further contribute to the optimization of logistics and transportation routes, reducing empty container rates and commodity scheduling costs, then reducing the implied carbon intensity in the export trade process.

H1: The digital economy has a significant negative inhibiting effect on the implied carbon intensity on China's exports.

Mechanisms of the digital economy's impact on the China's export-implied carbon intensity

The digital economy adjusts China's existing industrial structure and export trade structure by realizing the intelligent and green transformation of industries. For producers, labor-intensive enterprises with high pollution and high emissions can transition into environmentally sustainable, knowledge-intensive, and technologically advanced entities by improving the digital infrastructure, integrating digital technology with the process of production practice, and forming a variety of digital industrial forms [9].

For consumers, the advancement of the digital economy promotes economic expansion, markedly enhancing living standards. This drives the transfer of labor resources in the region to the tertiary industry and promotes the upgrading of the industrial structure in the region. Notably, the level of export implied carbon intensity of the tertiary industry is much lower, contributing to an overall reduction in China's export implied carbon intensity.

At the same time, the development of the digital economy makes the large-scale production of personalized needs possible, reducing the export-implied carbon emissions due to a series of problems such as high production costs and low efficiency.

H2: The digital economy reduces the China's export-implied carbon intensity by promoting industrial structure.

The enhancement of the digital economy has produced a certain technological progress effect on domestic related industries, which in turn has a positive impact on China's energy consumption and carbon emissions [10]. First of all, domestic enterprises engage in continuous "learning by doing", absorbing and transforming the technological innovation experience form foreign enterprises to promote the development of their own digital technology, which in turn promotes the high-energy-consuming and high-polluting industries to improve energy efficiency. This, in turn, fosters the growth of green trade and reduces the implied carbon intensity in the export trade process.

Secondly, leveraging its status as a "latecomer", China can learn from the experience of advanced countries, introducing and innovating relevant technologies to elevate the overall digitization level of industries. By promoting the digitization, networking, and intelligent upgrading of traditional industries, the government encourages the use of digital monitoring technology in enterprise production, so that it acts on all aspects of export trade, realizing accurate distribution, accurate measurement, and further predicting emissions. The technology is used to visualize the carbon emission process and formulate relevant measures in a more targeted manner, addressing the root causes of implied carbon intensity in exports.

Finally, the technological progress significantly impacts the quality of the domestic labor force. The conduct of global trade and the international migration are accompanied by the outflow of human resources, bringing specialized talents with high professionalism and character qualities to domestic high-tech guidance industry enterprises[11]. Chinese government’s increasing investment in human capital aims to cultivate more high-level, knowledge-based and application-oriented talents familiar with international trade, thereby increasing labor productivity and reducing the implied carbon intensity of exports.

H3: The digital economy reduces the implied carbon intensity of China's exports by driving technological progress.

3. METHODS

3.1 Models

3.1.1 Benchmark model

The following model was created to examine how the digital economy influences implied carbon emissions:

$$\ln CIE_{it} = \alpha_0 + \alpha_1 \ln Digital_{it} + \alpha_2 Controls_{it} + \varphi_i + \varphi_t + \varepsilon_{it} \quad (1)$$

3.1.2 Mediating effect models

The following model was built to investigate hypotheses 2 and 3, the following model was developed:

$$W_{it} = \beta_0 + \beta_1 InDigital_{it} + \beta_2 Controls_{it} + \varphi_i + \varphi_t + \varepsilon_{it} \quad (2)$$

$$In\, CIE_{it} = \beta_3 + \beta_4\, In\, Digtial_{it} + \beta_5 Mid_{it} + \varphi_i + \varphi_t + \varepsilon_{it} \quad (3)$$

3.1.3 Threshold effect model

To further test the nonlinear characteristics of the digital economy on the implied carbon intensity of exports, this paper constructs the following threshold model:

$$\ln CIE = \gamma_0 + \gamma_1 InDigital_{it} \times I \ (Adj_{it} \leq \theta_1) + \gamma_2 InDigital_{it} \times \ (\theta_1 < Adj_{it} \leq \theta_2) + \gamma_3 InDigital_{it} \times I \ (Adj_{it} \geq \theta_3) + \gamma_4 Controls_{it} + \varepsilon_{it} \quad (4)$$

Where $\ln \mathrm{CIE}$ is the explained variable, denotes the export implied carbon intensity; $\ln \mathrm{Digital}$ is on behalf of the digital economy, and $\mathrm{Controls}$ denotes the control variables; Mid, which is intermediary variables, including industrial structure and technological progress; the φ_i、φ_t and ε_{it} represent the province and year fixed effects and random error terms, respectively. Adj_{it} is the threshold variable, and $I(\cdot)$ is the indicator function that takes the value of 1 or 0, and it takes the value of 1 if it meets the conditions in the parentheses, and 0 if it meets the conditions in the parentheses.

3.2 Variables

3.2.1 Explained variable

Export implied carbon intensity. This paper selects the panel data of 30 provinces from 2008 to 2020 as a sample for research. The measurement of the export implied carbon intensity of each province is measured by the input-output method, and the general input-output model is:$X = AX + Y$. The collation can be obtained: $X = (I - A)^{-1} \times Y$. X is the column vector of total output of each sector, I is the nth order unit matrix, A is the direct consumption coefficient matrix, and Y is the column vector of final use of each sector. Then the formula for calculating the implied carbon intensity of exports of each province can be expressed as:

$$C_t = C \times (I - A)^{-1} \times Y \quad (5)$$

The total carbon dioxide emissions are the sum of those generated by the consumption of each energy source (primary energy, secondary energy sources such as water and electricity are not included) per year, and the direct carbon emission coefficients for each province C_i is:

$$C_i = \sum_i \frac{C_{in}^{EN} \times \lambda}{X_i} \quad (6)$$

C_{in}^{EN} represents the consumption of the n energy source in the i province. λ is the emission factor for each energy source, and X_i is the total output. This paper draws on Du' s calculation method [12], the table of CO_2 emission coefficients of various energy sources is calculated as follows:

3.2.2 Explanatory variables

Digital economy. Combined with the actual situation of China's digital economy development, the number of Internet broadband access users among 100 people, the proportion of employees in computer service and software industry in urban units, the total amount of telecommunications services per capita, the penetration rate of mobile phones and the China Digital inclusive Finance Index are selected as digital economy indicators. The comprehensive index value is obtained through principal component analysis [13].

3.2.3 Intermediary variables

In this paper, the following two intermediary variables are selected to test the mechanism of the digital economy on the implied carbon intensity of China's exports: (1)Industrial structure (dus), which is expressed by the ratio of the value added of the tertiary industry to the value added of the secondary industry in each region. (2) Technological progress (tec), which measures the level of development of technological progress by using the total factor productivity of each region.

3.2.4 Control variables

Economic development level (pgdp): per GDP is selected as the economic development indicator; degree of openness to the outside world (open): it is expressed as the ratio of the total amount of foreign imports and exports of each province in each year to the GDP of the current year. Energy structure (es): measured by the share of coal in the region's total energy consumption [14,15]. Level of capital intensity (cap): measured by the ratio of total fixed capital to total population in each year in each region.

3.2.5 Data description

The sample period selected is from 2008 to 2020. Considering data availability, this study selects 30 provinces in mainland China.

Table 1. CO_2 Emission factors for seven energy sources

Emission	Coals	Coke	Diesel	Gasoline	Diesel fuel	Fuel oil	Petroleum
CO2 emission factor/(ton/ton), (ton/billion m^3)	1.647	2.848	3.045	3.714	3.15	3.064	21.67

Table 2. Variable definitions and descriptive statistics

Variable type	Definition	Variable	Sample size	Mean	Standard deviation	Min	Max
Explained variable	Export implied carbon intensity	Incie	390	4.88	1.46	1.94	8.28
Explanatory variable	Level of digitization	Indig	390	4.93	1.05	1.23	6.13
Control variables	Level of economic development	Inpgdp	390	1.42	0.52	-0.02	2.80
	Open to the outside world	Inopen	390	-3.25	1.90	-9.21	-0.0017
	Energy structure	Ines	390	-0.52	0.38	-3.72	-0.13
	Capital intensity	Incap	390	1.79	0.59	3.37	3.36
Intermediary variables	Industrial structure	Inindus	390	0.13	0.39	-0.63	1.66
	Technological progress	Intec	390	0.23	0.17	0	0.85

4. RESULTS AND DISCUSSION

4.1 Benchmark Regression

4.1.1 Full sample regression analysis

Table 3 shows the benchmark results of the impact of digital economy on export implied carbon intensity. Column (1) excludes additional influencing factors, while columns (2) to (5) progressively introduce control variables, it can be seen that the regression coefficients of the independent variables are significantly negative, which initially verifies H1. Specifically, for every 1% increase in the digital economy, export implied carbon intensity decreases by 0.182%. This indicates that the development of the digital economy can expand the scale of exports, create new forms of trade, enhance the system's innovation capacity, optimize the industrial structure and upgrade the technological level, and achieve the goal of reducing the carbon intensity of exports. industrial structure and enhance the technological level, to achieve the purpose of reducing the export implied carbon intensity.

Furthermore, by observing the regression results of the control variables, it can be seen that with the continuous improvement of the economic development level and the expansion of the scale of foreign trade, there is a significant inhibiting effect on the export implied carbon intensity. This is because as the level of economic development and the expansion of trade scale will increase people's disposable income and consumption level, thus prompting people's consumption preference gradually shifted to high-quality, green and low-carbon products, which promotes the green and low-carbon transformation of various industries, and promotes the reduction of the implied carbon intensity of exports. In addition, the coefficients of energy structure and capital intensity are significantly positive, indicating that the increase in the level of the two will correspondingly increase the implied carbon intensity of China's exports.

4.1.2 Heterogeneity analysis

The results of benchmark regression show the impact of the digital economy on export-implied carbon intensity, but in fact the impact of this reduction in export-implied carbon intensity may also differ in different regions. There, all samples are regressed according to the geographic region delineation, the sub-regional analysis shows in Table 4.

The analysis reveals a significant inhibitory effect of the digital economy's developmental level on export-implied carbon intensity across all regions. However, it can be seen that in the western region and other regions with poorer levels of digital economy development, the impact of the digital economy on export-implied carbon intensity is much higher than in other regions. This is mainly due to recent central government strategies aimed at promoting development in these regions, leading to substantial advancements in digital economy and related infrastructure, which releases the potential of the digital economy to promote the transformation of the industry's greening, and inhibits the growth of the export-implied carbon intensity better.

This indicates that the growth of export implied carbon intensity in the western region is better suppressed. In the future, the regional government should pay more attention to the promotion of the development of the digital economy in the formulation of relevant policies, so as to further reduce China's overall export-implied carbon emissions.

4.1.3 Influence mechanism test

By constructing an intermediary effect model and adopting the step-by-step regression method, we will further test the mediating effect of the digital economy level on the export-implied carbon intensity by influencing the industrial structure and technology level in China, and the results are in Table 5.

As in column (2), the coefficient of the digital economy is 0.146 and significantly positive, indicating that the digital economy can significantly promote the proportion of China's tertiary industry. Column (3) shows that the coefficient of industrial structure is -0.316 and significant at the 1% level, indicating that the adjustment and optimization of China's industrial structure is an effective way to reduce the implied carbon intensity of exports, and Hypothesis 2 holds. For the technological progress effect, column (4) illustrates the coefficient of technological progress is 0.596 at the 1% level, indicating that improving the level of digital economy development can also stimulate the improvement of China's technological level. Column (5) shows the coefficient of the digital economy is -0.133 and the coefficient of technological progress is -0.672, both of them are significantly negative, which verifies hypothesis 3. Therefore, the development level of the digital economy contributes to the reduction of export-implied carbon intensity through the dual mechanisms of the industrial structure effect and technological progress effect.

4.1.4 Threshold feature analysis

To examine potential nonlinear relationships between the digital economy and export implied carbon intensity, this study employs a threshold model for empirical testing. It is determined that the level of digital economy development (dig) and technological progress (tec) passed the single-threshold test, while the industrial structure (indus) passed the double-threshold test, the test results as shown in Table 6.

Table 3. Benchmark regression results

	(1)	(2)	(3)	(4)	(5)
lndig	-0.356***	-0.176***	-0.194***	-0.203***	-0.182***
	(0.0185)	(0.0506)	(0.0479)	(0.0478)	(0.048)
lnpgdp		-0.219***	-0.248***	-0.250***	-0.126*
		(0.0574)	(0.0544)	(0.0541)	(0.071)
lnopen			-0.224***	-0.217***	-0.231***
			(0.034)	(0.0339)	(0.0323)
Ines				0.211**	0.542***
				(0.0932)	(0.134)
lncap					0.337***
					(0.153)
_cons	6.633***	5.616***	4.962***	4.915***	3.213***
	(0.0931)	(0.282)	(0.285)	(0.284)	(0.384)
N	390	390	390	390	390
R-sq	0.508	0.527	0.579	0.585	0.656

*Note: * indicates significant at 1% level*

Table 4. Heterogeneity regression results

	Geographic Area			***Digital Economy***	
	Eastern Region	**Central Region**	**Western Region**	**High Level**	**Low Level**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
lndig	-0.229*	-0.353**	-0.651***	-0.277***	-0.311***
	(0.136)	(0.141)	(0.14)	(0.107)	(0.0625)
lnpgdp	-1.411***	0.574***	0.513***	-1.603***	0.191*
	(0.189)	(0.138)	(0.149)	(0.203)	(0.104)
lnopen	-0.852***	-0.335***	-0.421***	-0.458***	-0.231***
	(0.0733)	(0.0703)	(0.0333)	(0.0788)	(0.0374)
Ines	-0.388***	6.595***	1.886***	-0.293***	0.339
	(0.126)	(0.535)	(0.327)	(0.105)	(0.351)
lncap	0.780***	0.870***	0.830***	1.221***	0.765***
	(0.176)	(0.201)	(0.145)	(0.136)	(0.183)
_cons	1.717**	7.037***	6.669***	-0.828**	5.115***
	(0.854)	(1.092)	(0.933)	(0.703)	(0.511)
N	143	104	143	104	286
R-sq	0.695	0.754	0.691	0.714	0.624

Table 5. Results of the mediation effect test

variant	baseline model	Industrial structure effect		Technological progress effect	
	(1) Incie (1)	(1) Inind (2)	(2) Incie (3)	(3) Intec (4)	(4) Incie (5)
Indig	-0.182*** (0.0185)	0.146*** (0.0174)	-0.065** (-2.73)	0.596*** (0.0612)	-0.133** (0.111)
Inind			-0.316*** (-4.10)		
Intec					-0.672*** (0.0419)
control	Yes	Yes	Yes	Yes	Yes
con_s	5.796*** (0.525)	-0.588*** (0.0876)	-8.208*** (-5.19)	1.947*** (0.309)	8.818*** (0.268)
fixed time	be	be	be	be	be
Area fixed	be	be	be	be	be
N	143	390	390	390	390
R-sq	0.759	0.154	0.97	0.196	0.487
intermediary effect		remain		remain	

Table 6. Results of non-linear relationship test

Threshold variables	Threshold value	Regression coefficient	time control	local control
Indig	Indig≤5.5	-0.01**	yes	yes
	Indig > 5.5	-0.007***		
Inind	Indig≤-1.16	-0.052***	yes	yes
	-1.16＜Indig≤-0.96	-0.156***		
	Indig＞-0.96	-0.218**		
Intec	Indig≤ 0.23	-0.232***	yes	yes
	Indig > 0.23	-0.271***		

According to the results, it can be seen that in the early stage of the development of the digital economy, an increase in its level can effectively reduce the implied carbon intensity of exports, but when the threshold is crossed, the inhibitory effect of the digital economy on the implied carbon intensity of exports will be reduced. After the industrial structure and technology level cross the corresponding threshold, the negative impact coefficient on the export-implied carbon intensity will further increase, which indicates that the inhibiting effect of the digital economy on the export-implied carbon intensity will gradually increase with the optimization of the industrial structure and the improvement of the technology level.

5. CONCLUSIONS AND SUGGESTIONS

This paper examines the relationship between digital economy and export-implied carbon intensity form multiple perspectives by utilizing the panel data of 30 provinces, municipalities and autonomous regions in China from 2008 to 2020, and empirically researches the impact of digital economy on export-implied carbon intensity and its mechanism of action, mainly through the methods of benchmark regression, mediation effect and nonlinear effect. The main findings of this paper found that (1) The digital economy can significantly reduce China's export implied carbon intensity. Its inhibitory effect on export-implied carbon shows regional heterogeneity, with the western region experiencing the most pronounced reduction. (2) The digital economy can further reduce the export-implied carbon intensity by influencing China's industrial structure and technological progress, promoting the growth of tertiary industry's output value and promoting the technological level of related industries, and exerting the two intermediary mechanisms of industrial structure effect and technological progress effect. (3) The non-linear effect model reveals changing impacts on export-implied carbon intensity based on the development level of the digital economy, industrial structure, and technological progress. After crossing a threshold, the inhibitory effect of the digital economy diminishes, while the industrial structure effect and technological progress effect continue to reinforce their impact.

Based on the above conclusions, this paper puts forward the following suggestions:

Firstly, strengthen the construction of digital infrastructure and give full play to the positive role of the digital economy in reducing the implied carbon intensity of exports. Vigorously promote the integration of the digital economy and the manufacturing industry, and focus on reforming and innovating all aspects of export trade by utilizing digital technology and data information. Through the use of digital industrial forms derived from the development of the digital economy, strengthen the construction of data and information platforms based on digital technology.

Secondly, optimize the green and low-carbon transformation of industries and promote the deep integration of the digital economy and the real economy. Attention should be paid to providing economic incentives through market-based means for promoting the low-carbonation of industries and the green transformation of high-pollution and high-energy-consumption industries, so as to synergistically reduce the export-implied carbon intensity. It is all the more important to promote the electrification of more and more production processes, low-carbon development transformation process, and increase the breadth and depth of digital technology empowerment.

Third, promote the green technological innovation of export trade empowered by the digital economy, and promote the development of green technological innovation. Give full play to the technological progress and penetration effect brought about by digital technology, strengthen the core technology research in the manufacturing industry, and realize the transformation of green technological innovation results. The implementation of dynamic differentiation of the digital economy development strategy, focusing on the development of the digital economy at the same time also need to accelerate the deployment of industrial structure upgrading strategy, give full play to the technical effects of the digital economy, and constantly adjust the development strategy of export trade.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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