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Analysis of the relationship between industrial structure upgrading and carbon emissions in China

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Abstract
Purpose: Given growing concerns over carbon emissions, upgrading industrial structure emerges as a potential solution. This study examines the influence of industrial structure on carbon emissions, and the role of business environment and digital economy in the connection between industrial structure upgrading and carbon emissions.
Design/methodology/approach: Using panel data from 30 provinces and cities in China from 2012 to 2021, a fixed-effects model is applied for assessment. Robustness tests for the findings of this paper are conducted using four methods: replacing the measurement, excluding the sample, changing the sample period, and replacing the model. Furthermore, heterogeneity analyses were performed separately for southern and northern China, as well as for eastern central and western China.
Findings: (1) Upgrading industrial structures leads to reduced carbon emissions, with greater levels of upgrading resulting in more significant reductions. This relationship has been confirmed through rigorous assessments of robustness and endogeneity. (2) The growth of business and digital economies may attenuate the emissions-reducing effects of industrial upgrading. (3) Industrial structure upgrading have a varied impact on carbon emissions across regions, with greater reductions seen in the south and west compared to the north and east.
Research limitations/implications: This study examined the influence of industrial structure on carbon emissions using provincial-level data. However, it did not conduct a dynamic analysis. Future research endeavors could delve more comprehensively into this subject at either the national or industry levels, incorporating a dynamic perspective to enhance the depth of understanding.
Practical implications: This research provides important implications at the practical and social levels, and companies can plan industrial upgrading strategies to better balance environmental protection and economic benefits. Investors and financial institutions can use these findings to assess the sustainability of their investment projects and reduce risks by selecting projects that meet environmental standards. Promote international cooperation and

knowledge sharing to help the world address climate challenges, share best practices and policy experiences, and achieve the Sustainable Development Goals.
Originality/value: This study employs three dimensions to evaluate industrial structure upgrading. It comprehensively assesses the role of industrial structure upgrading on carbon emissions and explores factors influencing China's carbon emissions from the perspectives of the business environment and digital economy development.

Keywords: industrial structure upgrading, mechanism test, carbon emissions

Introduction

Numerous countries globally have witnessed significant advancements in industrial technology, coinciding with the rapid growth of the manufacturing sector. Consequently, the matter of carbon emissions has emerged as a crucial challenge that developing nations cannot overlook (Hou et al., 2023; Lin & Zhang, 2023). Significant advances in industrial technology have occurred in several countries during the past few years, coinciding with the explosion of the manufacturing sector. As a result, addressing carbon emissions has become an urgent challenge that emerging economies cannot ignore (Huang, 2023). China and the United States are the two countries with the highest rates of carbon dioxide emissions that are above the permitted level. China has implemented various policies and measures to safeguard the ecological environment and advance environmentally friendly and low-carbon growth. Among these, "carbon neutrality" and “carbon peak” targets have important influence in China's carbon emission reduction strategy (Alkhani, 2022; Luan et al., 2019). The United States reached "peak carbon" in 2007, and other wealthy countries such as the United Kingdom and Germany reached it as early as the 1990s. According to Xiang et al. (2021), China must catch up to the above countries in this target mainly because developed countries' carbon emissions are primarily from the consumption sector. In contrast, China, the world's largest developing country today, has a more pressing need for production development, and thus, its carbon emissions are primarily from that sector. China's conventional approach to industrialization and production is associated with significant carbon emissions and adverse environmental consequences. This approach does not align with promoting green and low-carbon development goals. Consequently, experts and scholars have directed their attention toward analyzing the resource allocation dynamics among the three major industries (Li & Zhou, 2021; Pan et al., 2023). This article aims to investigate the influence of China's upgrading of its industrial structure on carbon emissions.

According to Jia (2022), various provinces and industries in China have been diligently implementing the supply-side structural reform policy. They have also been actively advancing the development of a modernized economic system, resulting in a consistent enhancement and refinement of the industrial structure. During the modernization process, China has strengthened the primary industry's position in the overall production structure, brought technological innovation to the secondary sector, encouraged the sustainable development of the secondary sector with innovation as its driving force, and ensured the robust growth of the service sector in the tertiary sector. Optimization of the three industrial structure upgrades from 9.1:45.4:45.5 in 2012 to 7.3:39.4:53.3 in 2021 demonstrates the significant success of the industrial structure upgrading and ensures the continued steady growth of the national economy (Chen, 2022; Zheng et al., 2021). Examining how industrial structure upgrades impact carbon emissions could help set a course for lower emissions in China and provide practical suggestions for policymakers. Literature review revealed many experts have researched regional carbon emissions' economic and technological aspects in relation to the digital economy, green finance, technology, and intelligence. Some included industrial structure upgrading as a control or intermediary variable to analyze its specific carbon emission impact(Chen et al., 2023; Zhang et al., 2023). This research contributes to the field by exploring the mechanism of reducing carbon emissions through industrial structure upgrading, optimizing the business environment, and developing the digital economy.

Literature Review

Theoretical analysis of industrial structure upgrading to empower carbon emission reduction

The environmental Kuznets curve links a country's income level and environmental quality, showing improvement after a certain income threshold. This may be related to changes in industrial structure, as high-income levels may drive the transition to a cleaner industrial structure. Then, considering the current state of industrial structure upgrading and the emission routes, Meng et al. (2022) propose three ways this trend could affect carbon emissions. First, since both the secondary industry and the tertiary industry benefit from the upgrading of the industrial structure, the increase in the proportion of resources consumed by the tertiary industry means that the proportion of consumable resources in the secondary industry decreases. Since the secondary sector encompasses China's industrial production and has higher energy demand and consumption, it accounts for a larger proportion of industrial carbon emissions than the low-energy tertiary sector. As the industrial structure evolves, the tertiary sector grows through successive upgrades, shifting resources from the secondary sector. This transition facilitates the reallocation of resources from the secondary to the tertiary sector, reducing overall carbon emissions. Consequently, industries with lower carbon emissions will consume more resources, while those with higher emissions will consume fewer (Hu et al., 2023). Second, upgrading the industrial structure will cause businesses to prioritize the use of clean energy in their resource utilization, switching to cleaner fuels like natural gas from coal and petroleum to cut down on carbon emissions at the factory gate (Liu & Wang, 2023; Zheng et al., 2022). Finally, changes in the scale of output result from upgrading industrial structures. The primary manifestation is that in the early stages of production scale development, the sectors with higher productivity are primarily concentrated in some heavy industries, so the country will invest its resource endowment in this sector. However, this sector will emit more gases, such as carbon dioxide, during energy use (Xu et al., 2023). This could lead to an increase in carbon emissions at this time. However, as the pressure of competition pushes each industry to innovate technologically, the digitization of the industry is deepening; the degree of digitization determines the level of productivity; the higher the degree of digitization, the higher the productivity of the sector; therefore, when the state needs to invest resources in sectors with a higher degree of digitization, the factors of production invested in the sector will be changed from the original energy and labor inputs. Therefore, when the country needs to invest in sectors with a higher degree of digitalization, it will switch from using energy as a production input to using emerging technologies and information technology talents. This reduces energy input to some extent, moderating carbon emissions (Liang & Yang, 2012; Song & Zhang, 2011). The foregoing analysis leads to the paper's first hypothesis:

H1: Industrial structure upgrading has a negative effect on carbon emissions, meaning that an escalation in the level of industrial structure upgrading can impede the rise in carbon emissions.

Transmission mechanism of industrial structure upgrading for carbon emission reduction

Zou and Lei (2023) argue that business environment has significant effect on carbon emissions alongside industrial structure. The business environment encompasses state policies, the administrative and judicial system, the tax system, infrastructure, and the market environment

(Peng, 2020). There is a correlation between the level of legalization in a country, the robustness and effectiveness of government control of the market, and the degree to which businesses have become marketized. Deng (2021) argues that the business environment may impact industrial structure upgrading from the following two aspects. Fair competition within and between businesses is fostered by a predictable economic climate, which in turn encourages the development and implementation of cutting-edge technologies in the manufacturing process and the equitable distribution of labor, capital, and other resources among the manufacturing, service, and retail sectors. The system can ensure effective energy utilization in enterprises, enhancing production efficiency and having a targeted impact on reducing carbon emissions. Promoting advancements and implementation of scientific and technological advancements in manufacturing process, it also ensures efficient allocation of resources across industries. Conversely, a favorable business climate can reflect the domestic market's stability, luring foreign investment in capital and technology and ensuring domestic businesses have access to the resources they need to undergo an industrial transition. Moreover, improving the industrial structure would help to optimize the business environment. Changes in industrial structure cause corresponding shifts in the demand structure of firms for labor, creating favorable conditions for the employment of workers brought in due to both local and foreign investment (Wang et al., 2023). As the emergence of new industries requires the support of a large number of high-quality technical talents, a good business environment can also attract high-quality technical talents to join, and the state will inevitably introduce corresponding policies to maintain the business environment of the ma to encourage the introduction of such talents to promote the process of industrial structure upgrading (Chen et al., 2020). Unlike other forms of capital, human capital has a higher potential for value creation, and it can take the lead in technological innovation and resource allocation during the process of industrial structure upgrading, thereby lowering the industry's carbon footprint (Mu, 2021; Xie, 2018). The paper's second hypothesis can be derived from the foregoing investigation.
H2: The optimization of business environment can strengthen the negative effect of industrial structure upgrading in suppressing carbon emissions.

The digital economy's rapid growth has led to increased study on industrial structure upgrading (Qiao, 2021). Li (2021) argues that integrating industries through digitalization not only promotes optimal allocation of traditional factors of production but also makes businesses more adaptable to changing market conditions by providing them with new production factors. According to Yi et al. (2023), IT and digital means can simplify production, achieve rational use of natural resources, and boost production efficiency. However, it can also lower the price of enterprise search information and ease the difficulty of inter-enterprise product transactions thanks to big data and other digital technologies. This will allow businesses to share information and data, which will aid in tracking products and managing expenses during the manufacturing, processing, and trade phases. Furthermore, the growth of the digital economy has resulted in the emergence of the network platforms. These platforms can effectively combine the necessary information and resources for businesses during their development, allowing producers to engage in online communication with consumers. This enables a better understanding of consumer demand and facilitates adjustments to the industry's production structure and service mode. The industry adapts its production structure and service mode to meet the needs of its consumers, raising the bar for its operational efficiency and productivity (Zheng, 2022). It is important to note that in recent years, the rise of the network anchor with the goods industry has, through the network platform to achieve the enterprise's sales and customer consumption link, not only effectively solved the traditional industry in the sales process of carbon emissions, but also made more businesses smell the business opportunities,

and more consumers have been drawn to the convenience of the network transaction mode under the development of the digitized economy. As more people are drawn to the ease of doing business online, more resources will move from the secondary sector to the tertiary sector as manufacturing and consumption become informalized and digitized (Saboune, 2022). Ultimately, this will improve efficiency and modernization throughout the manufacturing sector. The study's third hypothesis can be derived from the preceding research:
H3: The development of the digital economy can optimize the dampening effect of industrial structure upgrading on carbon emissions.

Heterogeneity of influence effects Heterogeneity of influence effects
Based on these findings, it is worth investigating whether regions with varying levels of economic development and natural resource reserves will experience varying degrees of this inhibitory effect on regional carbon emissions. China's carbon emissions have increased in the last 20 years, most noticeably in the north and east, with the provinces of Shandong and Hebei consistently ranking in the top five since 2001 (Wang et al., 2022). Notable as well are the provinces with low carbon emissions; since 1997, Hainan, Qinghai, and Ningxia have ranked as China's top three lowest emitters; since 2007-2008, Beijing's carbon dioxide emissions have decreased significantly, and by 2010, Beijing had joined the top ten lowest emitters with decreasing emissions. By 2018, Beijing's emissions had decreased significantly, ranking sixth on the national lowest list. Shandong Province's CO2 emissions have climbed by 580% in the last 20 years, whereas those in Beijing have increased by 180% (Yin et al., 2022). Greater economic development and industrialization have occurred in the Yangtze River Delta, Beijing-Tianjin-Hebei, Guangdong, Hong Kong, and Macao regions of China; if these regions can set an example by achieving their carbon emission reduction targets, it will undoubtedly drive the development of carbon emission reduction in other regions, and significantly alleviate the pressure on China's carbon emissions. When considering China's industrial structure upgrading, the eastern coastal region is notable for its superior production technology and infrastructure, which is a result of its higher level of economic development. Western and central China, as well as outlying areas like Hainan, where transportation infrastructure development has lagged, are dominated by primary and secondary industries. The marginal effect may mean that the western region feels the effects of upgrading industrial structure on carbon emissions more strongly than the eastern coastal region (Lu et al., 2021). Nevertheless, the disparity in policies aimed at upgrading industrial structure among different regions leads to variations in the extent of industrial structure upgrading, which subsequently impacts the reduction of carbon emissions. The above investigation leads to the paper's fourth hypothesis:
H4: There is geographic location and economic sub-region heterogeneity in the level of development of industrial structure upgrading to curb carbon emissions.

Methods

Model Setting
Panel data analysis approaches can be categorized into three main types: fixed, random, and mixed-effect models. This study used the fixed-effect model to investigate the direct impact of industrial structure on carbon emissions. The calculation formula is given:

$$Car_{it} = \beta_0 + \beta_1 Ind_{it} + \beta_2 controls_{it} + \lambda_i + \mu_t + \varepsilon_{it} \qquad (1)$$

In the formula given above, Car_{it} represents the carbon emissions of province i in year t, Ind_{it}

denotes the level of industrial structure upgrading in province i in year t, $Controls_{it}$ denotes the control variable for province i in year t. λ_t denoting spatial fixed effects, μ_t denotes time fixed effects, ε_{it} denotes the disturbance term, Both β_1 and β_2 denote the parameters to be estimated.

Variables Selection and Measurement

The advent of the digital information era has facilitated global interconnectedness, while the ongoing advancement of economic development across nations has propelled the inexorable trend of economic globalization. However, the substantial emission of greenhouse gases during industrialization has had adverse consequences on both the ecological environment and future global development. Since the convening of the 18th National Congress of China, industrialization has steadily progressed. However, the state of carbon emissions presents a less-than-favorable outlook. Consequently, numerous scholars have investigated the avenues for reducing carbon emissions. As a result, they have proposed several useful suggestions that have helped China significantly improve its carbon emissions management. Considering the foregoing, the present investigation isolates carbon emissions as a separate factor. It aims to investigate the impact of the CO_2 scenario in China alongside other relevant variables. Emissions of carbon dioxide are measured relative to gross domestic product (GDP) using the carbon intensity ratio (Deng et al., 2023).

Since 2012, China has sped up the process of new industrialization, and the combination of industrialization and cutting-edge technology has substantially enhanced production efficiency, creating a technological foundation for China's strategy of industrial structure upgrading. The agriculture and industry sectors are capitalizing on the progress of the digital economy, embracing environmentally friendly and low-carbon practices, and gradually shifting towards service-oriented industries such as the service industry, driven by the improvement of the digital economy and green finance. Carbon emissions from production and living have a direct bearing on this process. Considering this, the effect of industrial structures on greenhouse gas emissions is investigated. Based on the work of Zhang et al. (2020), this paper employs three metrics to assess the state of the world's industrial structures: the ratio of the tertiary sector's GDP share to the secondary sector's, the ratio of the national economy's total energy consumption to its GDP, and the degree to which industrial structures have been rationalized. To ensure that social resources are dispersed equitably in response to needs, which are quantified as follows, it is necessary to rationalize the structure of industry so that it evolves in tandem with the structure of employment.

$$NSD = \sum_{1}^{3} \frac{Y_i}{Y} \left| \frac{Y_i}{L_i} \times \frac{L}{Y} - 1 \right| \quad (2)$$

In the above equation, Y_i stands for the value of output in industry i. Y stands for the total value of production, L_i stands for the number of people employed in the industry, L represents all employment.

The calculation process involves several steps:

1. The unfavorable indicators of rationalization and economization are inverted and converted into positive indicators.
2. Entropy calculation uses the transformed indicators to determine their respective weights.

3. Industrial structure upgrading is measured using the weighted summation method.

Businesses environment and the digital economy are considered as potential moderators in this essay. The Marketization Index is based on data of "China Provincial Marketization Index Report (2021)". We evaluate the current state of the digital economy by considering the year when it was first included in the National Employment Report. Thus, all dates before 2017 are assigned a value of 0, and all dates after 2017 are assigned a value of 1 (Han & Li, 2022; Yu & Zhang, 2022).

This paper employs the GDP per capital index both as a price deflator and a control variable to gauge economic development. This choice aligns with the dual-carbon policy's assertion that regions with higher economic development possess a broader array of options for low-carbon production and travel. Likewise, the level of human capital bears a direct relationship to the workforce's size engaged in an enterprise's production processes and the quality of its organizational and managerial capabilities. Consequently, this paper employs the percentage of the population enrolled in higher education as a surrogate for human capital. Given that unemployment significantly impacts individuals' capacity to partake in various social activities, including travel and consumption, it is considered a control variable within this study.

In this paper, we use a methodology that calculates the unemployment rate as a percentage of the total population of the social labor force. Since this metric is directly linked to people's mobility and consumption habits, fluctuations in unemployment may have corresponding impacts on carbon emissions, so it is introduced as a control variable. CO_2 could be affected by environmental regulations that provide oversight and safeguards for environmental preservation from a regulatory and policy perspective aimed at reducing environmental pollution. This study employs a methodology that measures the overall expenditure on industrial pollution control as a proportion of industrial added value in order to assess the level of implementation of environmental regulations in a quantitative manner. This variable is included as a control in an analysis of how environmental regulations affect greenhouse gas emissions. The amount of social consumption is also quantified and used as a control variable in this paper, since the level of urbanization may affect carbon emission due to changes in infrastructure construction and transportation modes, the paper also employs the method to measure the level of urbanization (Yang & Wang, 2023; Zhao et al., 2023).

Data sources

This study relied on easily accessible sample elements to collect valuable data on variables in China from 2012 to 2021. The sample selection was guided by data validity, resulting in the exclusion of some geographical data. The study examines data from 30 provinces and cities in China to investigate the impact of upgrading industrial structures on carbon emissions from 2012 to 2021. Statistics were gathered from various sources, including the "China Environmental Statistical Yearbook," "China Population and Employment Statistical Yearbook," and the "China Industrial Statistical Yearbook".

Table 1 List of variables, definition, and sources

Variables	Definition/measurement	Sources
Carbon emissions	Total carbon emissions/GDP	China Statistical Yearbook
Industrial structure upgrading		
	The ratio of the tertiary sector's GDP share to the secondary sector's	China Industrial Statistical Yearbook

	The ratio of the national economy's total energy consumption to its GDP	
	The degree to which industrial structures have been rationalized	
Economic development level	GDP per capital	China Statistical Yearbook
Human capital level	Number of students enrolled in higher education institutions/total population	
Social consumption level	Consumption level index	
Urbanization level	Ratio of urbanization	
Unemployment status	Unemployment number/social labor force number	China Population and Employment Statistical Yearbook
Environmental regulation	Total investment in industrial pollution control/industrial added value	China Environmental Statistical Yearbook
Business environment	Marketization index	China Provincial Marketization Index Report (2021)

Findings

Benchmark regression results

Both explanatory and controlling factors can be examined in the regression findings. As posited, the service sector has lower carbon emissions than the industrial and manufacturing sectors. Thus, an upgraded industrial structure with increased tertiary industry mitigates carbon emissions. The regression analysis shows a negative coefficient of -2.356 for the relationship between economic development and carbon emissions, which is statistically significant at the 1% level. The finding highlights a correlation between regions with greater economic development and substantially reduced carbon emissions.

Since the 18th National Congress, the concept of ecological civilization has gained widespread acceptance, leading to an increasing number of individuals prioritizing low-carbon approaches in travel and production. Furthermore, as the standard of living increases, there is a corresponding increase in the amount of disposable income per individual. This surplus of funds can be utilized to support the shift towards low-carbon lifestyles. The control variables of human capital level, environmental regulatory level, and social consumption level all exhibit a negative regression coefficient on carbon emissions (at the 10% level). The level of environmental regulation indicates the extent to which national policies on reducing carbon emissions have been implemented and the extent to which social capital and human resources have been invested in carbon emission reduction. Increases in human capital allow for the employment of more highly trained technicians in the manufacturing process, which boosts output per worker, cuts down on carbon emissions, and facilitates the introduction of regulations to regulate the environment.

The escalation in the rate and broader dispersion of social wealth becomes evident through the augmentation of social consumption, which subsequently exhibits a more explicit constraint on carbon emissions. The regression analysis unveils a statistically significant coefficient of -0.530 for carbon emissions, signifying a substantial adverse impact of urbanization on regional carbon emissions. This result remains robust at a 1% significance level. The process of urbanization precipitates various dynamics within an economy. It promotes advancements in technology among businesses and triggers shifts in the demographic composition of the population. This, in turn, leads to a transition of economic activity from the primary sector to the secondary sector, and eventually towards the tertiary sector. Furthermore, rural economies experience heightened productivity because of increased rural-to-urban migration, bolstering the economic landscape.

The preceding control factors do not significantly affect regional carbon emissions; nonetheless, the regression result of unemployment on carbon emissions is 2.995, which passes the significance test at 5%. Several factors contribute to this trend: as technology advances, high-carbon industries become less competitive in the marketplace, resulting in a precipitous decline in the number of jobs available in these sectors; and once traditional industry workers are laid off from the high-carbon sectors, it is difficult for them to engage in low-carbon sectors without specialized training, leading to a significant skills gap in these sectors. Their social activities that involve using resources to produce carbon dioxide and their inability to find jobs in low-carbon industries will significantly increase carbon emissions.

Table 2 Benchmark regression results

VARIABLES	DV= Carbon emissions
Industrial structure upgrading	-2.612(-2.83) ***
Economic development level	-2.356(-2.88) ***
Human capital level	-0.436(-1.72) *
Unemployment status	2.995(2.31) **
Environmental regulation	-0.256(-1.71) *
Social consumption level	-0.347(-1.81) *
Urbanization level	-0.530(-3.41) ***
Constant	26.215(3.32) ***
Observations	300
R-squared	0.304
Number of id	30

Note: T-test values in parentheses; ***, ** and * indicate P<0.01, P<0.05 and P<0.1, respectively.

Robustness testing

Simply put, robustness testing is modifying some aspect of the study's setup, rerunning the test, and checking to see if the outcomes have changed. This procedure has two possible outcomes: robust results, which do not change in sign and significance with the change in parameters, and non-robust results, which do change in sign and significance with the change in parameters. Variable replacement, supplemental variable technique, amending classification criteria of variables, sub-sample regression, varying sample size, varying periods, and varying measurement methods are all common ways to do robustness testing. The results of this research are tested in four different ways: by using GMM model, by changing the sample period to include data from 2013 to 2021, by removing data from Beijing, Shanghai, Chongqing, and Tianjin, and by replacing the original topics with the entropy approach. Testing shows that even after accounting for the above confounds, improving industrial structures negatively and significantly impacts carbon emissions.

Table 3 Robustness test

VARIABLES	(1) Replacement measurement	(2) Dropout sample	(3) Change of sample period	(4) Replacement model
Industrial structure upgrading	-1.619	-3.675***	-3.148***	-5.235***
	(-1.66)	(-2.90)	(-2.76)	(-8.85)
Constant	2.549***	3.598***	3.300***	3.873***
	(52.16)	(11.92)	(10.41)	(15.28)
Control variables	Yes	Yes	Yes	Yes
Observations	300	260	270	300
R-squared	0.118	0.116	0.101	0.167
Number of id	30	26	30	30

Note: T-test values are in parentheses; ***, **, and * indicate P<0.01, P<0.05, and P<0.1, respectively. The model incorporates both time-fixed effects and individual-fixed effects simultaneously.

Endogeneity test

To have endogeneity indicates that the built model may have one or more variables correlated with the random perturbation term. The estimation findings from a model are more likely to be accurate, valid, and interpretable if the endogeneity of the model has been tested and any potential endogeneity problems have been identified. Among the four most frequent approaches to testing for endogeneity, instrumental variable estimation is used here. While the digital economy has been expanding rapidly in recent years, the rate at which industries can upgrade their structures has also accelerated. This is because advances in information technology have increased the efficiency with which industries use energy during production and lowered the price at which businesses can obtain the data, they need to make these improvements. The restructuring of the industrial framework has reallocated the significance of agriculture, manufacturing, and services within the overall production structure, necessitating updates to the physical infrastructure. Consequently, this study employs the road area per capita and the telecommunication services per capita as instrumental variables to investigate their correlation with industrial upgrading. These variables are calculated by dividing the total urban road area and the year-end total telecommunication services by the respective city populations, thus quantifying infrastructural development in relation to the enhancement of the industrial structure. The endogeneity test is conducted using the two-stage least squares estimate method, with the following calculations based on the selection of the variables mentioned above:

$$Ind_{it} = \theta_0 + \theta_1 IV_i + \theta \sum controls_{it} + \varphi_i + \varrho_t + \varpi_{it} \quad (3)$$

The meanings represented by the individual symbols of Equation (3) are given below: IV_i

refers to instrumental variables, which in this paper are road area per capita and telecommunication services per capital, and the meaning of other symbols remains consistent with equation (1). Table 4 presents the outcomes of an instrumental variable selection process, followed by a subsequent regression analysis employing these instrumental variables. The table reveals that upon the inclusion of these instrumental variables, the coefficients denoting the influence of industrial structure on carbon emissions amount to -5.047 and -3.147, respectively. Notably, the suppressive impact of industrial structure on carbon emissions is more pronounced when road area per capita is used as an instrumental variable. All instrumental variables show a positive coefficient for industrial structure upgrading (at the 1% level). The criteria have been met in selecting instrumental variables, and these choices have not affected the analysis outcomes.

Table 4 Endogeneity test

VARIABLES	Road area per capital		Telecommunication traffic per capita	
	Industrial structure upgrading	Carbon emissions	Industrial structure upgrading	Carbon emissions
Industrial structure upgrading		-5.047***		-3.147***
		(-4.64)		(-3.51)
Telecommunication traffic per capital			0.697***	
			(13.07)	
Road area per capital	0.309***			
	(10.36)			
Control variables	No	No	No	No
Constant	-3.344***	3.823***	0.224***	3.313***
	(-9.52)	(7.08)	(4.08)	(4.83)
Observations	300	300	300	300
Number of id	30	30	30	30

Note: T-test values are in parentheses; ***, **, and * indicate P<0.01, P<0.05, and P<0.1, respectively. The model incorporates both time-fixed effects and individual-fixed effects simultaneously.

Mechanisms Tests

This research introduces interaction terms to examine the mechanisms through which industrial upgrading affects carbon emissions. The model is shown as below:

$$Car_{it} = \gamma_0 + \lambda_1 Ind_{it} + \gamma_2 Med_{it} + \gamma_3 Med_{it} \times Ind_{it} + \gamma_k \sum controls_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (4)$$

In the formula given above. Med_{it} denotes the moderating variables used in this study, i.e., digital economic environment and business environment; $Med_{it} \times Ind_{it}$ denotes the interaction term between the moderating variable and industrial structure upgrading, and the rest of the symbols are denoted with the same meaning as in equation (1). After data centralization, regression analysis was carried out on the moderating variables and the regression results are shown in Table 5.

As shown in table 5, the digital economic environment significantly reduces regional carbon emissions, with a coefficient of -0.203 (at the 10% level). The business environment significantly inhibits regional carbon emissions, with a coefficient of -0.346 (at the 1% level). Furthermore, the interaction terms reveal industrial structure consistently exerts a distinct inhibitory influence on regional carbon emissions, evidenced in columns (2) and (4) of the regression results. This implies that the upgrading of industrial structure exerts a distinct inhibitory influence on regional carbon emissions. Intriguingly, the negative and statistically significant regression coefficient for industrial structure upgrading persists when two interaction factors are introduced. However, the introduction of the digital economic environment and the business environment as moderating variables, while maintaining statistical significance at the 5% level, yields a positive effect on carbon emissions. This suggests that these moderating variables mitigate the inhibitory impact of industrial structure upgrading on carbon emissions, leading to an upward trajectory in regional carbon emissions.

Increases in human capital and the pervasiveness of information technology in business operations and everyday life may be to thank for this trend. However, as low-carbon awareness rises and businesses can practice green development, a consensus has emerged in favor of upgrading the industrial structure, and national policies have shifted accordingly, allowing businesses to access more investment opportunities and production technology. Businesses will limit the spread of disruptive technologies and establish price controls through the formation of monopolies in critical industries so that they can reap the most significant rewards from their existing investments; meanwhile, companies in sectors with slower rates of technological advancement will increase their output to compete on the market through quantitative advantages. Industries with a lower rate of technological innovation will increase production volume to achieve the same level of market success through quantity advantage. This will lead to greater resource consumption in inefficient sectors, which will, in turn, increase the overall rate of carbon emissions in the short term.

Table 5 Moderating effect mechanism test results

VARIABLES	Carbon emissions			
	(1)	(2)	(3)	(4)
Industrial structure upgrading	-2.134*	-2.576*	-1.336***	-2.471***
	(-1.72)	(-1.70)	(-3.21)	(-2.71)
Digital economic environment	-0.203*	-0.349*		
	(-1.79)	(-1.89)		
Industrial structure upgrading × digital economic environment		0.597**		
		(2.08)		
Business environment			-0.346***	-0.378***
			(-4.25)	(-4.18)
				0.146**

Industrial structure upgrading × business environment				(2.24)
Constant	3.142***	3.239***	5.640***	5.874***
	(10.58)	(8.87)	(7.71)	(7.47)
Control variables	Yes	Yes	Yes	Yes
Observations	300	300	300	300
R-squared	0.131	0.135	0.300	0.304
Number of id	30	30	30	30

Note: T-test values in parentheses; ***, ** and * indicate P<0.01, P<0.05 and P<0.1, respectively. The model incorporates both time-fixed effects and individual-fixed effects simultaneously.

Heterogeneity test

This analysis demonstrates a clear and noticeable inverse correlation between the improvement of industrial structure and the carbon emissions in a region. Nonetheless, it is important to note that there exist conspicuous disparities among regions concerning factors such as economic development, natural resource endowments, industry distribution, upgrading, and carbon emissions. This study extensively reviews relevant literature and utilizes the study by Li and Wang (2022) as a primary reference. The regions examined in this study are categorized into five dimensions based on their geographic location and economic development level: the South, North, East, Centre, and West. The objective of this research is to examine the variation in the impact of upgrading industrial structure on carbon emissions across different regions.

Table 6 shows a regional breakdown of regression findings. It is observed that industrial structure enhancement reduces carbon emissions across all regions, but with varying impacts. Comparing to other regions， southern regions have a more pronounced effect, with a coefficient of -5.465, statistically significant at 1%. However, the impact in the northern region is less clear, with no statistically significant results. Western regions see more substantial benefits from industrial structure adjustment and carbon reduction compared to central and eastern regions. This is due to higher economic development and faster technological advancement in the south, leading to improved energy efficiency and quicker industry transition with less CO_2 emissions. Due to the rapid economic and technological advancement in the eastern and southern regions, the government has initiated policies encouraging these developed areas to facilitate the economic and technological growth of the western region through technological spillovers and economic investments.

Furthermore, the state gives guarantees and help to the Western region through policies that promote the growth of the Western sector and the advancement of science and technology and increase the application of cutting-edge technology in all aspects of life. This aids in the transition from the primary and secondary sectors to the tertiary sector, in which the West excels. Northern provinces and cities contributed a more significant proportion of national carbon emissions. However, the Northern industry's degree of technological production and innovation is lower than that of the South, and the North's policy bias is lower than that of the West. This indicates that if the North's base is enormous and information technology cannot support it efficiently, the industrial structure upgrading of carbon emissions inhibition effect will be reduced.

Table 6 Heterogeneity of geographic location and economic subdivisions

VARIABLES	Carbon emissions				
	(1)	(2)	(3)	(4)	(5)
	Southern	Northern	Eastern	Central	Western
Industrial structure upgrading	-5.465***	-1.988	-2.383***	-3.240**	-4.511*
	(-4.14)	(-1.42)	(-3.45)	(-2.38)	(-1.89)
Constant	2.733***	4.213***	2.247***	3.624***	4.186***
	(6.47)	(6.09)	(7.60)	(3.38)	(6.21)
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	150	150	110	80	110
R-squared	0.652	0.130	0.344	0.106	0.270
Number of id	15	15	11	8	11

Note: T-test values are in parentheses; ***, **, and * indicate P<0.01, P<0.05, and P<0.1, respectively. The model incorporates both time-fixed effects and individual-fixed effects simultaneously.

Discussion and Conclusion

To further explore the dynamic relationship between industrial upgrading and carbon emissions in China, this study collected statistical data from 30 provinces for the period 2012-2021 and conducted an analysis using a fixed effects model. Then, we use the business and digital economic environments as moderating variables to investigate the influence mechanism. Finally, we test the heterogeneity of the inhibition effect of industrial structure upgrading on carbon emission in each region and reach the following conclusions:

(1) Increases in industrial structure upgrading are inversely proportional to increases in carbon emissions, meaning that as upgrading progresses, so do emissions reductions. To mitigate the potential bias caused by endogeneity, both a robustness test and an endogeneity test are conducted. The outcomes of these tests validate that upgrading the industrial structure indeed leads to a significant reduction in carbon emissions.

(2) This study explores the effects of industrial structure upgrading on carbon emissions, with the business environments and digital economic environments as moderating variables. Regression analysis shows that these variables can undermine the positive impact of industrial structure upgrading on reducing carbon emissions. Specifically, the presence of business environments and digital economic environments weakens the inhibitory effect of upgrading industrial structure on carbon emissions. Moreover, carbon emissions tend to increase beyond a certain threshold.

(3) Upgrading industrial structures can lower carbon emissions, but the effect varies by region. Factors like economic development, natural resources, industrial distribution, upgrading, and policy implementation influence the impact. Hence, the effects of industrial structure modernization on carbon emissions differ based on the geographical area. The effect is stronger in the South and West regions compared to the North or East regions.

Recommendations

(1) The government should have two goals for policies: First, these policies should encourage businesses to use IT and digital tools to improve production efficiency, lower operational costs, and reduce energy use when upgrading industrial structures. This approach may reduce regional carbon emissions. Second, the policy framework should promote tertiary sector growth. Tax reductions and exemptions should be implemented to encourage primary and secondary industries to become tertiary. These policies should also attract foreign investment. This strategy is essential for maintaining a sufficient labor force during industrial structure upgrades and reducing unemployment. In conclusion, tax cuts and exemptions should encourage primary and secondary industries to enter the tertiary sector and attract foreign investment. This reduces unemployment concerns and overall unemployment.

(2) The government should promote high-quality economic development, provide stable funding for digitalizing and restructuring industries, and create a business-friendly environment to reduce monopolies, price gouging, and other unhealthy competition. As needed, these and other goals should be legalized. Unhealthy competition will be punished more. In the age of industrial digitization, businesses should maximize the digital economy's competitive integration and spillover effects, advance their own digitalization and low-carbonization processes, and guarantee zero-emissions output.

(3) When formulating the welfare policy, the government should shift resources away from resource-poor regions with slow industrial structure upgrading and towards regions with high economic development and industrial structure upgrading, which are best positioned to reduce carbon emissions. While developing welfare policies that provide technical, financial, and human resource support to the former, it encourages regions with high economic development and industrial structure upgrading efficiency to lead. Since upgrading industrial structures takes time, government policy should change to reflect the development landscape so that all underdeveloped areas can benefit.

Theoretical Implications

The research emphasizes the noteworthy impact of industrial structure upgrading on carbon emissions. The higher the level of upgrading, the more significant the emission reduction effect, which offers empirical evidence for promoting a green economy and sustainable development. However, the business environment and digital economy could diminish the impact of industrial upgrading on emissions. This suggests the need for prioritizing carbon emissions and undertaking apt measures by governments and enterprises. Regional differences too influence emission reduction, with southern and western regions showing more notable effects. Such research offers a significant empirical basis for environmental policymaking, underscoring the need to address carbon emissions during industrial upgrading to achieve more effective emission reduction targets.

Practical and Social Implications

This research provides important implications at the practical and societal levels to assist in addressing climate change and sustainable development challenges. Governments can formulate targeted policies to promote industrial upgrading and reduce carbon emissions, including support for upgrading projects, incentives for emissions reduction, and carbon regulations, to achieve emissions reduction targets and promote economic growth. Businesses can use this to plan industrial upgrading strategies that better balance environmental protection and economic benefits, and capitalize on the opportunities that upgrading can bring. Investors and financial institutions can use the findings to assess the sustainability of their investment projects and reduce risk by selecting projects that meet environmental standards. Promote international co-operation and knowledge sharing to help the world address climate challenges, share best practices and policy experiences, and achieve sustainable development goals.

Limitations and Suggestions for Future Research

This study employs provincial-level data to investigate the influence of industrial structure on carbon emissions within a static panel data framework. The analysis is conducted without considering the dynamic perspective. Subsequent research efforts could undertake a more profound examination, specifically employing the dynamic panel data approach. Regarding data considerations, future researchers may enhance the robustness of their analyses by expanding the sample size and transitioning to national-level data. This would allow for a more comprehensive exploration of the ramifications of industrial structure upgrades on carbon emissions.

References

Alkhani, A. F. (2022). Catalytic Dry Reforming of Methane: Paving the Road to a Carbon Neutral Industrial Scale Blue Hydrogen Production Process Technology via Monolithic Catalyst-Based Reformer Bolstered by a Techno-Economic Assessment ProQuest LLC].

Chen, C., Yuan, H., Lin, W., & Xia, Q. (2020). The impact of industrial transfer on industrial structure upgrading in central china take hubei province as an example.E3S Web of Conferences 2020 International Conference on Energy Big Data and Low-carbon Development Management, EBLDM 2020, December 18, 2020 - December 20, 2020, Nanjing, China.

Chen, L., Lu, Y., Meng, Y., & Zhao, W. (2023). Research on the nexus between the digital economy and carbon emissions -Evidence at China's province level. Journal of Cleaner Production, 413. https://doi.org/10.1016/j.jclepro.2023.137484

Chen, M. (2022). A study of low-carbon development, urban innovation and industrial structure upgrading in China. International Journal of Low-Carbon Technologies, 17, 185-195. https://doi.org/10.1093/ijlct/ctab097

Deng, L., Cao, C., & Li, W. (2023). Impacts of Carbon Emission Trading Prices on Financing Decision of Green Supply Chain Under Carbon Emission Reduction Percentage Measure. IEEE Access, 11, 75929-75944. https://doi.org/10.1109/ACCESS.2023.3297649

Deng, S. (2021). Environmental regulation, FDI and the upgrading of industrial structure: Taking the yangtze river economic belt as an example.Conference Proceedings of the 9th International Symposium on Project Management, ISPM 2021 9th International Symposium on Project Management, ISPM 2021, July 3, 2021, Beijing, China.

Han, P., & Li, J. (2022). Measurement and Comparison of Digital Economy Development of Cities in China.Lecture Notes on Data Engineering and Communications Technologies

Hou, J., Kang, W., & Zhang, M. (2023). Does Intelligent Transformation Trigger Low-Carbon Technology Innovation in China?Industrial Upgrading Perspective. SSRN. http://dx.doi.org/10.2139/ssrn.4443985

Hu, J., Zhang, H., & Irfan, M. (2023). How does digital infrastructure construction affect low-carbon development? A multidimensional interpretation of evidence from China. Journal of Cleaner Production, 396. https://doi.org/10.1016/j.jclepro.2023.136467

Huang, B. H.-X. (2023). The future of carbon-neutrality science and technology from an industrial transformation perspective: An interview with Hou-Liang Dai. National Science Review, 10(9). https://doi.org/10.1093/nsr/nwac295

Jia, Y. (2022). Based on big data analysis to study the impact of industrial structure upgrading on carbon emissions.Proceedings of SPIE - The International Society for Optical Engineering 2022 International Conference on Electronic Information Engineering, Big

Data, and Computer Technology, EIBDCT 2022, January 20, 2022 - January 22, 2022, Sanya, China.

Li, C., Zheng, C., Liu, M., & Wang, Z. (2023). Digital Economy Spillover on Energy Saving and Emission Reduction: Evidence from China. SSRN. http://dx.doi.org/10.2139/ssrn.4547745

Li, Y. (2021). The Influence of the Development of Digital Economy on the Upgrading of China's Industrial Structure.E3S Web of Conferences 2020 International Conference on New Energy Technology and Industrial Development, NETID 2020, December 18, 2020 - December 20, 2020, Dali, China.

Li, Z., & Wang, J. (2022). The Dynamic Impact of Digital Economy on Carbon Emission Reduction: Evidence City-level Empirical Data in China. Journal of Cleaner Production, 351. https://doi.org/10.1016/j.jclepro.2022.131570

Li, Z., & Zhou, Q. (2021). Research on the spatial effect and threshold effect of industrial structure upgrading on carbon emissions in China. Journal of Water and Climate Change, 12(8), 3886-3898. https://doi.org/10.2166/wcc.2021.216

Liang, T., & Yang, J.-P. (2012). Interactive relationship between regional human capital and industrial structure upgrading in liaoning province.Proceeding of 2012 International Conference on Information Management, Innovation Management and Industrial Engineering, ICIII 2012 2012 International Conference on Information Management, Innovation Management and Industrial Engineering, ICIII 2012, October 20, 2012 - October 21, 2012, Sanya, China.

Lin, B., & Zhang, Q. (2023). Green technology innovation under differentiated carbon constraints: The substitution effect of industrial relocation. Journal of Environmental Management, 345. https://doi.org/10.1016/j.jenvman.2023.118764

Liu, Y., & Wang, X. (2023). The Impact of Digital Service Trade on Carbon Total Factor Productivity: Empirical Evidence from Cross-Country Panel Data. SSRN. http://dx.doi.org/10.2139/ssrn.4389576

Lu, W., Tam, V. W. Y., Du, L., & Chen, H. (2021). Impact of industrial agglomeration on haze pollution: New evidence from Bohai Sea Economic Region in China. Journal of Cleaner Production, 280. https://doi.org/10.1016/j.jclepro.2020.124414

Luan, B., Huang, J., & Zou, H. (2019). Domestic R&D, technology acquisition, technology assimilation and China's industrial carbon intensity: Evidence from a dynamic panel threshold model. Science of the Total Environment, 693. https://doi.org/10.1016/j.scitotenv.2019.07.242

Meng, X., Xu, S., & Zhang, J. (2022). How does industrial intelligence affect carbon intensity in China? Empirical analysis based on Chinese provincial panel data. Journal of Cleaner Production, 376. https://doi.org/10.1016/j.jclepro.2022.134273

Mu, Z. (2021). Application of Big Data Technology in the Cultivation Mode of Compound Talents in Civil Engineering.Lecture Notes on Data Engineering and Communications Technologies

Pan, X., Wang, M., & Li, M. (2023). Low-carbon policy and industrial structure upgrading: Based on the perspective of strategic interaction among local governments. Energy Policy, 183. https://doi.org/10.1016/j.enpol.2023.113794

Peng, M. (2020). Impact of Business Environment on Industrial Structure Optimization and Upgrading in Liaoning Province through Big Data Analysis.Proceedings - 2020 International Conference on Big Data and Social Sciences, ICBDSS 2020 2020 International Conference on Big Data and Social Sciences, ICBDSS 2020, August 14, 2020 - August 16, 2020, Xi'an, China.

Qiao, S. (2021). Analysis of the impact of digital economy on industrial structure upgrading based on stata.Proceedings - 2021 2nd International Conference on Big Data Economy and Information Management, BDEIM 2021 2nd International Conference on Big Data Economy and Information Management, BDEIM 2021, December 3, 2021 - December 5, 2021, Sanya, China.

Saboune, F. M. F. (2022). Virtual Reality in Social media marketing will be the new model of advertising and monetization.2022 9th International Conference on Social Networks Analysis, Management and Security, SNAMS 2022 9th International Conference on Social Networks Analysis, Management and Security, SNAMS 2022, November 28, 2022 - December 1, 2022, Milan, Italy.

Song, Y., & Zhang, H. (2011). Research on the professional human capital and use foreign capital's impact on the industrial structure upgrading.2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce, AIMSEC 2011 - Proceedings 2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce, AIMSEC 2011 - Proceedings,

Wang, D., Xu, D., Zhou, N., & Cheng, Y. (2022). The asymmetric relationship between sustainable innovation and industrial transformation and upgrading: Evidence from China's provincial panel data. Journal of Cleaner Production, 378. https://doi.org/10.1016/j.jclepro.2022.134453

Wang, S., Tian, W., & Lu, B. (2023). Impact of capital investment and industrial structure optimization from the perspective of "resource curse": Evidence from developing countries. Resources Policy, 80. https://doi.org/10.1016/j.resourpol.2022.103276

Wu, L., Sun, L., Qi, P., Ren, X., & Sun, X. (2021). Energy endowment, industrial structure upgrading, and CO<inf>2</inf> emissions in China: Revisiting resource curse in the context of carbon emissions. Resources Policy, 74. https://doi.org/10.1016/j.resourpol.2021.102329

Xiang, N., Wang, L., Zhong, S., Zheng, C., Wang, B., & Qu, Q. (2021). How does the world view china's carbon policy? A sentiment analysis on twitter data. Energies, 14(22). https://doi.org/10.3390/en14227782

Xie, Z. (2018). Science and technology service industry agglomeration and regional innovation: Does human capital matter?5th International Conference on Industrial Economics System and Industrial Security Engineering, IEIS 2018 - Proceeding 5th International Conference on Industrial Economics System and Industrial Security Engineering, IEIS 2018, August 3, 2018 - August 6, 2018, Toronto, ON, Canada.

Xu, H., Liu, W., & Zhang, D. (2023). Exploring the role of co-agglomeration of manufacturing and producer services on carbon productivity: An empirical study of 282 cities in China. Journal of Cleaner Production, 399. https://doi.org/10.1016/j.jclepro.2023.136674

Yang, Y., & Wang, B. (2023). Stage identification and strategy optimization of industrial evolution of China's digital economy supporting low-carbon effect. International Journal of Low-Carbon Technologies, 18, 295-305. https://doi.org/10.1093/ijlct/ctad007

Yi, M., Zhai, Z., Wu, T., Sheng, M. S., Wen, L., & Meng, R. (2023). *The Technological Path of Collaborative Reduction of Pollutants and Carbon Emissions in China: The Innovation of Digital Technology and Green Technology*. SSRN. http://dx.doi.org/10.2139/ssrn.4480133

Yin, K., Miao, Y., & Huang, C. (2022). Environmental regulation, technological innovation, and industrial structure upgrading. https://doi.org/10.1177/0958305X221125645 (Energy and Environment)

Yu, S., & Zhang, S. (2022). Research on the Impact of Business Environment on the Agglomeration and Development of High-Tech Industries: Empirical analysis based on provincial panel data.*ACM International Conference Proceeding Series* 13th International Conference on E-Business, Management and Economics, ICEME 2022, July 16, 2022 - July 18, 2022, Virtual, Online, China.

Zhang, L., Wu, F., Zhang, C., Pang, Q., & Yu, Q. (2020). The adaptability of basin water resources consumption structure and optimization of industrial structure. *Xitong Gongcheng Lilun yu Shijian/System Engineering Theory and Practice*, *40*(11), 3009-3018. https://doi.org/10.12011/1000-6788-2019-0016-10

Zhang, R., Wu, K., Cao, Y., & Sun, H. (2023). Digital inclusive finance and consumption-based embodied carbon emissions: A dual perspective of consumption and industry upgrading. *Journal of Environmental Management*, *325*. https://doi.org/10.1016/j.jenvman.2022.116632

Zhao, C., Su, J., & Zhang, B. (2023). *Does Digital Economy Agglomeration Improve Energy Efficiency?——Evidence from China*. SSRN. http://dx.doi.org/10.2139/ssrn.4401592

Zheng, J., Shao, X., Liu, W., Kong, J., & Zuo, G. (2021). The impact of the pilot program on industrial structure upgrading in low-carbon cities. *Journal of Cleaner Production*, *290*. https://doi.org/10.1016/j.jclepro.2021.125868

Zheng, K., Deng, H., Lyu, K., Yang, S., & Cao, Y. (2022). Market Integration, Industrial Structure, and Carbon Emissions: Evidence from China. *Energies*, *15*(24). https://doi.org/10.3390/en15249371

Zheng, X. (2022). Research on the Impact of Digital Economy on Consumption in the Era of Big Data.*IMCEC 2022 - IEEE 5th Advanced Information Management, Communicates, Electronic and Automation Control Conference* 5th IEEE Advanced Information Management, Communicates, Electronic and Automation Control Conference, IMCEC 2022, December 16, 2022 - December 18, 2022, Chongqing, China.

Zou, W., & Lei, H. (2023). Business Environment and Resource Allocation Based on the Perspective of the National Value Chain. *Journal of Systems Science and Complexity*, *36*(1), 294-327. https://doi.org/10.1007/s11424-023-2357-8