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A Study on the Impact of Digital Economy on CO_2 Emissions in China: A Mediation Effect Analysis Based on Urbanization

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Abstract: Environmental change is driven by many factors, including economic development and technological progress. As the adverse effects of global warming become more pronounced, environmental issues have received widespread attention, and in recent years China has vigorously promoted ecological civilization to combat climate change while promoting urbanization. As CO_2 levels are intimately related to climate change, Chinese President has put up a variety of proposals to reach the aim of "Carbon Peak Carbon Neutralization." In order to contribute to the country's "double carbon" goal, this article uses data between the years of 2012 and 2021 from 30 Chinese provinces and cities to evaluate the impact of the expansion of the digital economy on emissions via urbanization. A mediation effects model is the foundation of the analysis. According to this study, urbanization and CO_2 emissions are both highly influenced driven by the growing digital economy and the urbanization process, respectively. Based on these findings, this paper suggests that in order to achieve the objectives of carbon neutrality and carbon peaking, it is imperative to vigorously develop green digital economy infrastructure, intensify CO_2 emission regulation, and effectively slow down the growth rate of the high-carbon economy.

1. Introduction

Global warming has come to the forefront in recent years due to the impacts of climatic variation, such as glacial ablation, the rising of sea levels, and a sharp decline in animal habitats. In October 2021, the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) suggested "cutting carbon emissions to attain At COP26 in October 2021, the catchphrase "Reduce carbon emissions to attain 'net-zero emissions' by 2050' was proposed. Although there are many factors that contribute to global warming and the greenhouse effect, numerous studies have shown that CO_2 dioxide is the main contributor to global warming and as CO_2 levels increase dramatically [1], global warming becomes more prominent. Studies have shown that excess CO_2 can affect not only people's breathing, blood pressure and even life-threatening in serious cases [2], so research on CO_2 emissions is crucial. Where to begin? The literature that is now available investigates the connection between the structure of energy utilizaton and carbon emissions. Aslan et al. assert that Economic growth and carbon emissions are linked in an inverse U-shaped relationship

[3], whereas Wang and Su contend that industrialization promotes carbon emissions [4]. It is extremely hard to figure out that a large proportion of the literature currently in existence concentrates on the investigation of the factors that influence carbon emissions and the relationship between a few indicators and CO_2 emissions, in order to make pertinent recommendations for CO_2 emission reduction.

Urbanization and the rising digital economy are in the spotlight as time goes on [5]. It is crucial to note that urbanization and the digital economy are intricately tied to CO_2 emissions. The academic world has focused on the link between carbon emissions and the digital economy. Most researchers are currently conducting cross-disciplinary research on the topic of the digital economy and looking at how it affects CO_2 emissions [6]. On the one hand, the digital economy promotes carbon emissions. On the other hand, the digital economy diminishes CO_2 emissions [6], also, the digital economy has a nonlinear effect on CO_2 emissions [7]. Most of them, meanwhile, did not examine how urbanization's relationship to the digital economy may affect CO_2 emissions.

With the revitalization of the countryside and the reduction of the urban-rural gap, Zheng et al. have turned their attention to urbanization, arguing that urbanization and carbon emissions are closely linked [8]. Increased urbanization leads to increased industrialization, which to some extent encourages CO_2 emissions. The more urbanized a region is, the better it is for reducing CO_2 emissions. However, no comprehensive research of the digital economy, urbanization, or CO_2 emissions exists.

There is no doubt that the existing literature has promoted the development of emission reduction and provided reference and guidance for the following literature. Measuring the relationship between the digital economy and CO_2 emissions and its effects more precisely, the indicators chosen for the digital economy are either too general and simplistic or the studies on the digital economy, urbanization, as well as CO_2 emissions in the available literature are less thorough. This is based on the experience of previous writers. The value of this paper, in general, can be summed up as follows. First off, the indicators used in this research represent the degree to which the digital economy has developed using multidimensional and multi-level data, making it possible to quantify the digital economy somewhat more accurately than using just one variable. In addition, the data sources in this paper are authentic and reliable, and the latest data are adopted. Finally, this article encourages the growth of scholarly inquiry into the digital economy, urbanization, and CO_2 emissions and offers some references and pointers for relevant scholarly inquiry.

2. Review of the literature and theories

2.1 Direct effects of the digital economy on greenhouse gas emissions

We are constantly being influenced by the digital economy as a novel modality of economy, and the rising $\boldsymbol{CO_2}$ emissions are making our lives more stressful. As a result, we are becoming more aware of the connection between the digital economy and $\boldsymbol{CO_2}$ emissions. Fundamentally, carbon emissions are difficult to eliminate when dealing with a digital economy. According to Skudder et al., there might be a "rebound effect" that causes a "green blind spot" in the digital economy as infrastructure grows [9]. The functioning of the infrastructure supporting the digital economy is still largely dependent on power, and as a significant portion of China's electricity is still generated using coal, this contributes to $\boldsymbol{CO_2}$ emissions. In addition, industries where digital economy products are used, such as mining, steel smelting, and communications, still consume energy and consequently have to produce $\boldsymbol{CO_2}$. Further, the ICT (information and communications technology) equipment and hardware have a short operating cycle, the digital economy has a short product innovation cycle and a fast run rate, and the consumption of digital product replacement has grown dramatically. In terms of supply and demand, the booming digital economy has brought demand that exceeds the supply of the productivity improvements that it has driven by technological advances. Due to its convenience, effectiveness, and use of technologies like the Internet, cloud computing, and big data under its aegis, the digital economy is quickly taking the nation by storm. This is because it has elevated e-commerce to the forefront of the times and increased $\boldsymbol{CO_2}$ emissions in the transportation sector. The digital economy encourages physical mobility, but this impact balances out the replacement effect that replaces the trade of the digital economy, leading to an increment in carbon emissions. E-commerce, particularly in times of epidemics, lets people realize the power of the Internet since it allows them to purchase without leaving their homes [10]. As a result, demand for online shopping soars, as do needs for transportation and distribution as well as $\boldsymbol{CO_2}$ emissions.

In terms of technological progress, it is possible that China is still in a weakly intelligent growth phase of economic growth that is highly dependent on energy. The expansion of economic development, green technical advancements, and digital universal finance, according to Dong et al., results in a reduction in CO_2 emissions [6]. According to a study by Wang et al., there is a bias in favor of green technology growth, which will reduce CO_2 emissions [11]. When the economy becomes highly developed, the cost of the infrastructure supporting the digital economy is lower, making it easier to develop the environment. Some statistics on the reduction of carbon emissions caused by the digital economy may be lacking. The indicators of the digital economy are not widely agreed upon, and some industries do not attribute the decrease in CO_2 to the digital economy because of the improvement in efficiency. The comparison between the change in CO_2 emissions and the change in the degree of development of industries driven by the digital economy is difficult to measure due to the specificity of CO_2 itself.

The following assumptions are presented in this study: Hypothesis 1. (H1) This study analyzes that increased CO_2 emissions are enhanced by the rising of the digital economy.

2.2 Indirect effects of the digital economy on carbon emissions

2.2.1 The Impact of digital economy on urbanization

The pace of urbanization has quickened due to the growth of the digital economy. The influencing factors of urbanization are mainly population, industry and politics. From the standpoint of industrial structure, the usage of digital information and communication tools encourages the modernization of established industries, the advancement of primary and secondary industries toward tertiary industries, and the growth of inter-industry integration, which results in the emergence of new industries. The wide spread of emerging industries makes cities more livable, intelligent and convenient, forming smart cities and improving people's happiness [12]. Thus, people are happy to live in the city, which makes the urban population increase, urban development accelerate and urbanization speed up. From a demographic perspective, the digital economy has facilitated people's lives and increased the urban population. As ICT is ubiquitous in cities and jobs are in high demand, more young people are willing to stay in cities to enjoy the convenience of urban life, and the urban population is gradually increasing. From a policy perspective, the digital economy becomes another lever to promote in situ urbanization. The United Nations defines in situ urbanization as when rural areas achieve urban standards of living without having to move to cities [13]. Traditionally, in situ urbanization has been driven by agro-industrial activities and government-led foreign investment. Nowadays, the digital economy is expanding quickly thanks to technologies like the Internet, big data, Al, block-chain, and the like. In order to help the region develop, many governments have introduced projects for digital agriculture, digital health care, and other aspects of the digital economy. It has been proven that under the guidance of government policies, regions that develop digital economy are indeed ahead of regions that do not. The growth of digitalization, seen from the viewpoint of human capital accumulation, promotes the accumulation of human capital [14]. The growth of the network in the digital economy has made it more convenient for individuals to abtain resources and decreased the bar for learning new things to advance their careers, which is advantageous for the development of human capital. When human capital is built up to a certain point, individuals have more chances for employment and entrepreneurship, which boosts the economy of rural regions and raises incomes to reduce the gap in income between the rich and the poor in both urban and rural areas.

Through the debate above, this essay makes the following suggestion: Hypothesis 2 (H2). This study contends that the growth of the digital economy promotes the growth of urbanization.

2.2.2 The Impact of urbanization on carbon emissions

Concerned about how urbanization may affect carbon emissions, several academics domestically and overseas have performed research that have sparked heated debates. Although there is a large research literature, a unified view has not been formed in the academic community. The levels of urbanization have various impacts on carbon emissions at the national level in different countries. According to Wang et al. urbanization in wealthy nations reduces carbon emissions [6]. However, some scholars found that urbanization in developing countries is not conducive to reducing carbon emissions due to factors such as population density and industrialization. Other scholars believe that it may also be related to the population ratio, such as Zhang et al. found that for every 10% increase in the urban population ratio, modern per capita energy consumption increases by 4.5-4.8%, while per capita income and industrialization remain constant [15]. Sun and Huang have studied carbon emissions in countries such as Canada and India and found that urbanization and carbon emissions are positively correlated [16]. Also, Shah et al. discovered a "u"-shaped association between urbanization pairs and carbon emissions [17]. According to, depending on the amount of economic growth, the effect of urbanization on CO_2 emissions varies. The agglomeration effect, technological spillover, and other variables cause urbanization to have a driving influence on CO_2 emissions in the early stages and a suppressing effect on them in the later stages.

The study presented above leads this research to offer the following hypothese (H3): This study makes the claim that urbanization encourages CO_2 emissions.

Based on the above analysis, the mechanism of the impact of digital economy on carbon emissions is shown in Figure 1.

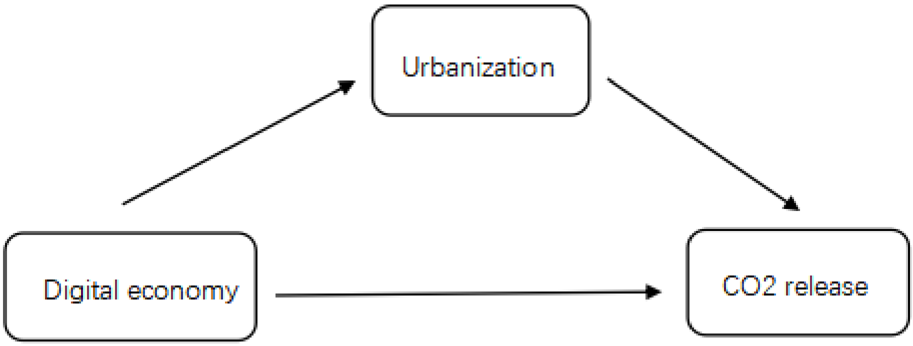

Figure 1: Analysis of the mechanisms of the digital economy affecting carbon emissions

3. Research Methodology, Variable Selection, and Data Sources

3.1 Empirical Model Setting

The digital economy development index, on the other hand, assesses the level of digital economy development by building the information development index, the Internet development index, and the digital transaction development index in three dimensions, and measures the level of digital economy development using entropy weight method. In this study, we substitute CO_2 emissions per capita for CO_2 emissions [18]. The research model used in this paper is as follows.

$$pco2_{it} = \beta_0 + \beta_1 \text{digitale}_{it} + \sum \beta_k X_k + \varepsilon_{it} \quad (1)$$

Where carbon emission per capita (pco2) is the explained variable and the digital economy index (digitale) serves as the explanatory variable, while β stands for the parameter to be computed, X for control variable, i for region and t for year, and ε for random error term.

A mediation effect model is also put up in this research so as to confirm the mediating mechanism of the influence of the digital economy on CO_2 emissions.

$$urbanization_{it} = \alpha_0 + \alpha_1 digitale_{it} + \sum \alpha_k X_k + \varepsilon_{it} \quad (2)$$

$$pco2_{it} = \gamma_0 + \gamma_1 digitale_{it} + \gamma_2 urbanization_{it} + \sum \gamma_k X_k + \varepsilon_{it} \quad (3)$$

The other variables are the same as previously, with the exception that urbanization is the mediation variable and the digital economy's coefficient of mediating impact through the mediating variable influences the level of carbon emissions.

3.2 Variable selection

3.2.1 Dependent and Mediating variable

In this research, CO_2 dioxide emissions per capita (pco2) are used to represent CO_2 emissions, and the percentage of the population living in urban region (urbanization) is utilized to represent the pace of urbanization in order to account for the influence of population size.

3.2.2 Explanatory Variable

Table 1: Evaluation system of digital economy indicators

Level 1 Indicator	**Level 2 Indicator**	**Measurements Indicator**	**Indicator Direction**
Indicators of information development	A information base	Length of fiber optic cable lines (km)	+
		Cell phone exchange capacity (10,000 households)	+
		Cell phone base stations (10,000)	+
	B Informatization impact	Total postal business (billion yuan)	+
		Total telecommunication business (billion yuan)	+
Internet development indicators	C Internet base	Internet broadband access ports (10,000)	+
		Cell phone penetration rate (min. per 100 people)	+
		Internet penetration rate (%)	+
	D Internet impact	Mobile Internet users as a percentage	+
		Internet broadband access users as a percentage	+
Digital transaction development indicators	E Digital transaction basis	Number of computers in use at the end of the period (units)	+
		Number of websites owned by enterprises (pcs)	+
		Number of websites per 100 enterprises (one)	+
	F Digital transaction impact	E-commerce sales (billion yuan)	+
		E-commerce purchases (billion yuan)	+
		Online retail sales (billion yuan)	+

The degree of development of the digital economy is represented in this study's assessment indicators, however there is disagreement on how to quantify this variable. This study uses a comprehensive set of 16 indicators to assess the level of development of the digital economy in three areas: information technology development, Internet development, and digital transaction development. It is based on the methodology of Gang-Yuan Tian and Jun Liu and considers the availability of data. Table 1 displays the indicator measuring system that was employed in this study.

3.2.3 Control Variables

This article chooses additional factors that may have an influence on carbon emissions in addition to the effect of the digital economy so as to strengthen the conclusions. The unemployment rate (unem) describes the employment situation, the proportion of each province's total imports and exports in its total value of production (open trade dependence) is reflected in the logarithm of each province's total value of production (lngdp), and the scale of coal consumption in its energy consumption is reflected in its level of economic development.

3.3 Sample selection and data sources

In order to fill in the gaps in the data, this study interpolates data from 30 provinces on the Chinese mainland (apart from the Tibet Autonomous Region) from 2012 to 2021. The China Statistical Yearbook, the statistical yearbooks of several provinces, and other public official websites provided the explanatory variables for this study (See Table 2 for descriptive statistics of this study)

Table 2 shows that the greatest and smallest values of open foreign trade dependency are 2280 and 11, respectively. The level of reliance on international commerce varied significantly. The urbanization fluctuation is rather considerable, with a significant difference between the greatest and minimum values. The digital economy is growing steadily, although there are still structural issues, as shown by the digital economy development level (digitale) values of maximum 0.904, lowest 0.026, and standard deviation 0.124.

Table 1: Statistical description of the variables.

Variable	Observations	Minimum	Maximum	Mean	Std. Dev.
pco2	300.000	0.652	43.897	8.332	5.992
digitale	300.000	0.026	0.904	0.177	0.124
unem	300.000	1.200	4.610	3.219	0.636
open	300.000	11.000	2,280.000	399.918	433.659
lngdp	300.000	7.546	11.731	9.909	0.856
energy	300.000	-0.001	2.537	0.928	0.480
urbanization	300.000	36.300	89.600	60.231	11.814
industrial	300.000	15.800	57.688	41.961	8.539
lntax	300.000	4.988	9.286	7.359	0.866
eco2	300.000	0.107	8.227	1.601	1.164

4. Empirical Results and Analysis

4.1 Unit root test

The four test techniques listed in the table are used in this research to run a unit root test on the data to prevent the problem of false regression. According to the table, only the foreign trade dependence variable has passed one test, and the rest of the variables have passed at least two tests, showing stable performance. Among them, the FISHER test, LLC test, and IPS test were processed by the second order difference, and the HADRI test was processed by the fourth order difference. Overall, the data passed the following test, and more details are shown in Table 3.

Table 3: Unit root test results

Unit root test results		**pco2**	**Urbanization**	**Digitale**	**Unem**	**Open**
FISHER	Inverse chi-squared	151.001***	101.627***	665.266***	76.639*	66.9874
	Inverse normal	-0.361	6.3847	-20.698***	2.690	3.8943
	Inverse logit t	-2.4313***	4.6854	-33.568***	2.2638	3.6968
	Modified inv. chi-squared	8.307***	3.8000***	55.253***	1.5189*	0.6379
LLC	Adjusted t*	-6.917***	-12.520***	-9.677***	-11.787***	-0.003
IPS	W-t-bar	-1.161	-0.879	-1.988	1.743	4.083
HADRI	z	20.506***	14.289***	13.593***	14.332***	14.361***
Unit root test results		lngdp	energy	industrial	lntax	eco2
FISHER	Inverse chi-squared	54.8120	301.946***	97.668***	405.001***	78.911*
	Inverse normal	3.0728	-3.909***	4.199	-9.225***	3.707
	Inverse logit t	3.2366	-10.728***	2.030	-17.975***	2.745
	Modified inv. chi-squared	-0.4736	22.087***	3.439***	31.494***	1.726**
LLC	Adjusted t*	-18.325***	-23.719***	-9.698***	12.778***	-3.370 ***
IPS	W-t-bar	-3.272***	-8.440***	-0.107	-4.374***	1.387
HADRI	z	14.462***	14.252***	14.235***	14.310***	20.716***

* p < 0.1, ** p < 0.05, *** p < 0. 01

4.2 Panel cointegration test

After the unit root test is finished and the test is successful, a further panel co-integration test is carried out to determine whether the variables have an equilibrium co-integration relationship over the long run. According to the characteristics of the data, this paper has done Pedroni test and Westerlund test, both of which have p-values of 0.0000. The null hypothesis that "there is no panel co-integration connection among panel units" is rejected at the 1% level of significance, demonstrating the existence of a long-run equilibrium cointegration relationship. More details are shown in Table 4.

Table 4: Panel cointegration test results

Panel cointegration test		**Statistic**	**p-value**
Pedroni test	Modified Phillips–Perron t	6.9947	0.0000
	Phillips–Perron t	-15.0713	0.0000
	Augmented Dickey–Fuller t	-15.7630	0.0000
Westerlund test	Variance ratio	4.9563	0.0000

4.3 Basic regression results

The digital economy's degree of development is significant at the 1% level in terms of explanatory factors, with a coefficient of 12.240. This implies that, unlike in the past, per capita carbon emissions rise by 12.240 units for every unit increase in the development level of the digital economy. The results of the study were similar and also verified the hypothesis H1. The unemployment rate, reliance on foreign trade, economic development level, and energy structure all displayed significance greater than or equal to 1% in terms of control variables, demonstrating that the calculated coefficients are more precise. Economic development level has an inhibitory effect on carbon emissions, with a coefficient of -2.987, and the energy structure has a greater impact on carbon emissions, with a coefficient of 8.009; that is, the more apparent the inhibitory effect on carbon emissions is, the higher the level of economic development, and similarity between related research results. In general, the growth of the digital economy, the rise in unemployment, the expansion of reliance on international commerce, and the deterioration of the energy structure have boosted carbon emissions to some extent, but the improvement in the level of economic development is favorable to reducing them.

In order to exclude the parameter estimation results that are not valid due to multicollinearity, therefore, certain variables with multicollinearity are excluded by VIF test which is shown in table 5 in this paper. The variance inflation factor for each variable in the table is less than 10, and the average variance inflation factor is 1.86, which is very close to 1. Therefore, there is no serious multicollinearity, and there is no need to delete the variables.

Table 5: Basic regression and VIF test results

Variable	**pco2**	**VIF**	**1/VIF**
digitale	12.240***	2.73	0.365740
	(3.451)		
unem	1.189***	1.23	0.810447
	(0.452)		
open	0.00238***	1.55	0.645599
	(0.001)		
lngdp	-2.987***	2.42	0.413133
	(0.470)		
energy	8.009***	1.36	0.736395
	(0.628)		
_cons	23.561***		
	(4.150)		
N	300		
adj. R^2	0.442		
Mean VIF		1.86	

Standard errors in parentheses
* p < 0.1, ** p < 0.05, *** p < 0. 01

4.4 Mediating effect analysis

The preceding study led this article to the conclusion that the digital economy may have an impact on CO_2 emissions through urbanization and the development of an intermediate model. For the sake of verifing whether there is a mediation effect and the robustness of the mediation effect, this research also conducted a bootstrap test as table 6, and reported the corresponding results of Bootstrap sampling 1000 times, to test whether the mediation variable can play a mediating role. The direct effect (bs2) and the indirect impact (bs1) are both significant at the 1% level and pass the mediation test, as can be shown in Table 7. In summary, the assumptions H2 and H3 are still valid.

Table 2: Sobel test and bootstrap test results

bs1	**bs2**	**Sobel**	**Goodman-1 (Aroian)**	**Goodman-2**
4.533***	7.707***	3.717***	3.717***	3.717***
(1.514)	(2.130)	(1.594)	(1.604)	(1.583)

Standard errors in parentheses
*p < 0.1, ** p < 0.05, *** p < 0. 01

Path (1) in Table 7 shows that the per capita carbon emissions regression coefficient between the digital economy development level and emissions is 12.240, which is significant at the 1% level. This demonstrates that Path (2) and Path (3), respectively, describe the influence of urbanization on per capita CO_2 emissions and the impact of digital economy development level on urbanization. The significance level is 1%, and the regression coefficients are 17.552 and 0.258, respectively. As shown in the table, urbanization will grow by 17.552 units for every unit rise in the digital economy, and per capita carbon emissions will grow by 0.258 units for every unit increase in urbanization. When the test results from the table are added together, it is demonstrated that the growth of the digital economy has encouraged the rise in CO_2 emissions by fostering the growth of urbanization. Combined with the results of the Bootstrap test, the hypothesis H1, hypothesis H2 and hypothesis H3 of this article are verified.

Table 7: Mediating effect regression results.

Variable	**Path(1) Y=pco2**	**Path (2) Y=urbanization**	**Path (3) Y=pco2**
urbanization			0.258^{***}
			(0.030)
digitale	12.240^{***}	17.552^{***}	7.707^{**}
	(3.451)	(5.937)	(3.142)
unem	1.189^{***}	2.008^{**}	0.670
	(0.452)	(0.778)	(0.411)
open	0.002^{***}	0.0203^{***}	-0.003^{***}
	(0.001)	(0.001)	(0.001)
lngdp	-2.987^{***}	-0.961	-2.739^{***}
	(0.470)	(0.809)	(0.423)
energy	8.009^{***}	1.167	7.708^{***}
	(0.628)	(1.081)	(0.565)

Standard errors in parentheses
*p < 0.1, ** p < 0.05, *** p < 0. 01

4.5 Robustness test

Table 8: Robustness test results

	Add control variable	**Replace the explained variable**	**Least square method**
Variable	**pco2**	**eco2**	**pco2**
digitale	11.54^{***}	1.974^{***}	12.83^{***}
	(3.473)	(0.529)	(4.123)
unem	1.353^{***}	0.147^{**}	1.219^{**}
	(0.463)	(0.069)	(0.516)
open	0.00176	0.0000173	0.00297^{**}
	(0.001)	(0.000)	(0.001)
lngdp	-3.438^{**}	-0.791^{***}	-3.564^{***}
	(1.386)	(0.072)	(0.574)
energy	8.159^{***}	1.470^{***}	7.989^{***}
	(0.673)	(0.096)	(0.697)
industrial	-0.0508		
	(0.036)		
lntax	0.742		
	(1.543)		
_cons	24.40^{***}	7.241^{***}	29.26^{***}
	(4.445)	(0.637)	(5.014)
N	300	300	240
adj. R^2	0.443	0.652	0.451

Standard errors in parentheses
* p < 0.1, ** p < 0.05, *** p < 0. 01

We executed the robustness test as given in Table 8 to confirm the validity of the experimental data. In the first column of the table, test whether the regression coefficient is significant by adding control variables. The structural effect (industrial) of each one of them indicates the percentage of the secondary industry, and the tax revenue (lntax) is defined as the taxation's logarithm. In the second column of Table 8, the stability is checked by replacing the explained variable, and the explained variable per capita CO_2 emissions (pco2) is replaced by CO_2 emission intensity (eco2). The issue of endogeneity of the data assessed using the least square approach is shown in Table 8's third column. The findings are similar with the previous article in that the coefficient of digital economy development level's significance and sign have not altered much.

5. Conclusions and Policy Recommendations

First, the findings indicate that the digital economy has a considerable impact on the rise in CO_2 emissions. Additionally, the rise in unemployment, the expansion of reliance on foreign trade, and the deterioration of the energy structure have all contributed to a certain extent to the increase in CO_2 emissions; however, the improvement in the level of economic development is helpful in reducing carbon emissions. Moreover, we discovered that the digital economy has greatly helped the growth of urbanization and consequently carbon emissions. According to the test, urbanization serves as a mediator in the connection between the digital economy and CO_2 emissions. Urbanization growth is positively impacted by the development of the digital economy. By speeding the rate of urbanization, the growth of the digital economy has the potential to slightly raise per capita CO_2 emissions.

Our recommendations are based on the findings of the aforementioned research. To create the groundwork for lowering carbon emissions, the first priority is to accelerate the construction of green infrastructure for the digital economy. Promote the upgrading of traditional digital economy infrastructure, use new energy to empower digital infrastructure, innovate power generation facilities, limit carbon emissions at the source and cut back on the amount of coal used to generate electricity without slowing the growth of the digital economy. Second, emphasize the beneficial contribution of the digital economy to the cause of urbanization. In addition, we will strengthen the monitoring of carbon emissions and improve the low-carbon awareness of the corporate masses. National government departments can restrain enterprises from reducing carbon emissions by collecting resource taxes and other taxes, set reasonable prices for carbon exchanges, and effectively curb corporate carbon emissions through market adjustment mechanisms. The national government actively publicizes knowledge about carbon emissions, brings energy saving and emission reduction to the public's attention, and builds a new trend of green development. In addition, as the digital economy is promoted to support the green and sustainable development of the economy, economic growth has a certain carbon emission reduction effect, thus slowing the pace of expansion of the high-carbon digital economy. Accelerate the research and development of new energy sources, adjust my country's energy structure, and promote CO_2 emission reduction structurally. Promote integral development of agriculture, industry and services. The state provides policy support and preferential arrangements for disadvantaged industries to improve the country's self-sufficiency, minimize unnecessary exports and imports, reduce dependence on foreign trade, reduce long-distance transportation, and effectively reduce CO_2 emission. The state encourages enterprises to increase jobs, further expand employment, increase employment rates, promote effective use of resources, and reduce carbon emissions by reducing taxes, improving social welfare for employees, and improving labor-related laws.

The research in this paper also has the following limitations. To begin with, since the data gathering is limited, so the data are only from 2012 to 2021, across 30 Chinese provinces, which has a small sample size and is limited to China, and can only analyze how China's political climate has affected urbanization when probing into the function of the digital economy on CO_2 emissions. Moreover, it treats all provinces and cities equally, without considering individual characteristics and spatial effects. In addition, the choice of urbanization indicators based on the proportion of urban population has some bias, and does not adopt multi-level variables to reflect the new urbanization in a comprehensive manner, which is not comprehensive enough. Furthermore, despite the fact that the development level of the digital economy is measured by 16 multi-level indicators, some of them are challenging to assess precisely because the digital economy is so vast and it is challenging to correctly represent its effects. In conclusion, this work examines how to reduce emissions from the viewpoint that urbanization is influenced by the digital economy, which in turn impacts carbon emissions. Other factors that affect carbon emissions still require additional study.

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