https://doi.org/10.52131/joe.2024.0601.0204

*i*RASD Journal of Economics

Volume 6, Number 1, 2024, Pages, Pages 229 – 241

Journal Home Page:
https://journals.internationalrasd.org/index.php/joe

The Impacts of Digital Trade on Environmental Quality in Case of Developing Countries

Anita Pariyar[1], Ping Guo[2], Guoqin Pan[3], Awais Dastgeer[4]

[1] PhD Scholar, School of Economics and Trade, Hunan University, Changsha 410006, China.
Email: pariyaranita03@gmail.com
[2] Professor, School of Economics and Trade, Hunan University, Changsha 410006, China.
Email: gping1963@163.com
[3] Assistant Professor, School of Economics and Trade, Hunan University, Changsha 410006, China.
Email: guoqinpan@126.com
[4] Master Scholar, School of Economics and Trade, Hunan University, Changsha 410006, China.
Email: awaisdastgeer105@gmail.com

ARTICLE INFO

Article History:

Received:	December	05, 2023
Revised:	March	15, 2024
Accepted:	March	18, 2024
Available Online:	March	20, 2024

Keywords:
Digital Trade
Environmental Quality
Carbon Emission Reduction
Developing Economies

JEL Classification Codes:
B26, E25, F64

Funding:
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Digital trade (DT) raises the incentives for developing economies, like China, India, Bangladesh, Brazil and Turkey's economic growth, to attain environmental quality, which is assessed by lowering carbon emissions, within the framework of the dual carbon targets. This study investigates the impact of DT development on carbon emissions by empirical means and their heterogeneity using panel data. Regression result shows that DT development considerably lowers the carbon emissions in the surrounding area. Utilizing its influence on upgrading industrial structure, fostering the development of green technologies, and growing economic size, DT can lower regional carbon emissions. The impact of DT on reducing carbon emissions will diminish as trade liberalization rises and carbon intensity declines. The study's conclusions are crucial from a practical perspective to effectively address climate change, achieve the carbon neutrality target, and promote better economic development.

Corresponding Author's Email: awaisdastgeer105@gmail.com

Citation: Pariyar, A., Guo, P., Pan, G., & Dastgeer, A. (2024). The Impacts of Digital Trade on Environmental Quality in Case of Developing Countries. *IRASD Journal of Economics*, *6*(1), 229–241. https://doi.org/10.52131/joe.2024.0601.0204

1. Introduction

Using cheap labour and a cornucopia of natural coffers, the addition of rising countries in the global value chain has significantly increased profitable growth (Teng et al., 2023). Still, adding environmental problems brought about by this integration include melting glaciers, rising ocean situations, and global warming, demonstrating the mischievous consequences of the hothouse effect on mortal weal. To offset climate change, nations across the globe, particularly developing bones, are working to encourage the shift to low-carbon frugality and reduce hothouse gas emigrations (Wang, Zhang, & Li, 2023). Developing economies is laboriously redefining its profitable development model and laboriously sharing in global climate change governance, as the world's largest developing country. Developing economies set aggressive pretensions in 2020, saying that carbon dioxide emigration would peak by 2030, that carbon emigration intensity would drop by further than 65 from 2005 situations by 2030, and that carbon impartiality would be attained by 2060. DT has been necessary in enabling notable progress in low-carbon profitable development and artificial elevation, indeed in the face of obstacles from strict carbon reduction programs that have affected global profitable development, especially in poor countries.

Environmental economics has long studied the relationship between commerce and the environment (Cherniwchan, 2017; Copeland, 2013; Gozgor & Ongan, 2017). Traditional trading patterns have altered as a result of the development of digital technology; it is worth more study to see whether these changes affect how commerce affects the environment (Tushman & Anderson, 2018). DT is a term used to describe a new type of online commerce that makes use of digital exchange technology. It is the outcome of research and development, cross-border trade, consumption, and production. The easy exchange of digital goods and services for traditional physical commodities is made possible by e-commerce and other online platforms. Apart from bringing about modifications to the worldwide industrial labour division and resource reallocation, digital trade has emerged as a noteworthy new form of economic expansion.

Due to the abecedarian element of digital technology that DT possesses; it presents notable benefits over traditional commerce. This element not only stimulates artificial restructuring and profitable growth, but it also fosters the development of low-carbon technology, so aiding in the mitigation of carbon emigrations and offering creative answers to climate governance problems. Digital trading is ecologically benign since it has a lower impact on the terrain than conventional trade. likewise, low-carbon inventions are encouraged to arise by the advancement of digital technology. DT's capacity to streamline procedures, boost productivity, and encourage the relinquishment of greener technologies across diligence is how it helps reduce carbon emigration. Organizations can reduce their carbon footmark by using DT to streamline operations and use lower coffers. Digital technologies also make it possible to produce intelligent systems and renewable energy sources, which helps in the fight against emigration. Because of the effectiveness advancements and creative implicit handed by digital technologies, digital trade reduces carbon emigrations else than traditional approaches. More accurate resource operation and emigration monitoring are made possible by DT through real-time data analysis, robotization, and connection, which results in further successful carbon reduction plans. Developing economies' carbon targets can be met and digital structure can be advanced by gaining a theoretical foundation and policy perceptivity from an understanding of the relationship between DT and carbon reduction. Policymakers can successfully address climate change enterprises while promoting high-quality profitable development by exercising DT's eventuality for carbon mitigation.

The following two categories can be used to generally categorize the research that is closely related to this article. Research on carbon emissions falls under the first category; it mostly measures the amount of carbon emissions from various businesses or geographical areas Shan et al. (2017) and investigates the variables that affect carbon emissions. The second category of study mostly focuses on talking about the economic repercussions, ramifications, and measurement of DT (Yi, Liu, Sheng, & Wen, 2022). A few academics have talked about how the digital economy affects carbon emissions (Cheng et al., 2023; Frenken & Schor, 2019). Others have investigated the connection between DT and carbon emissions, such as the impact of DT on reducing carbon emissions from both the production and consuming sides Zhang et al. (2022), examining the global effects of DT products on carbon emissions in various nations and the dynamic relationship between financial development and DT and environmental sustainability. Generally speaking, though, the economic implications of digital commerce have received greater attention, whereas the environmental effects of DT are still the subject of less research. More empirical study is particularly needed to supplement existing knowledge on the mechanism underlying the effect of DT on regional carbon emissions and regional heterogeneity. In contrast to earlier research, the discussion of the impact of DT on carbon reduction is the main objective of this study. It investigates how DT affects carbon reduction, starting with theoretical research. It analyzes the variability of the carbon reduction impacts of DT based on regional variations, trade openness variations, and carbon intensity variations.

Data of studied variables of developing economies are collected from WDI annual reports from 2004 to 2023. These variables include InCO2, DT, GLOB and GI. This provided the starting point for a study of the mechanism and variability of DT's impact on carbon emissions. According to research, developing economies' growing digital technology may help to successfully lower regional carbon emissions and encourage regional carbon reduction; however, the influence of DT on carbon reduction differs throughout locations. While inland regions outperform coastal regions, central and western regions have a bigger impact on lowering carbon emissions than do eastern regions. The carbon reduction benefit of DT reduces with increased trade openness; the effect increases with increasing carbon emission intensity. By encouraging the development of green technologies, modernizing the industrial structure, and expanding the scope of economic development, DT also indirectly affects the carbon emissions of the region.

The following is this article's possible contribution. First, this article examines the possible environmental effects of DT by looking at how DT affects regional carbon emissions. Second, this paper integrates digital technology and carbon emissions into a single study framework, providing a theoretical basis for developing economies' carbon reduction practices. This contributes to the theoretical study of DT's effects on carbon reduction in a little way. Third, the heterogeneity of DT on carbon emissions is examined based on differences in trade openness, geographic locations, and carbon emission intensity. Fourthly, practically speaking, it offers factual backing for advancing the growth of DT and creating a digital developing economies, as well as a scientific foundation for the nation to meet its carbon reduction goal.

This is how the rest of the article is organized. The literature review is examined in the second section. The methods part is the third one. Results and interpretation are explained in the fourth part. The conclusion and policy recommendations are illustrated in Section Five.

2. Literature Review

Digital frugality, frequently known as DT, has attracted a lot of interest from experts and scholars in the United States and away as a new profitable model. Before the" binary carbon" targets were put into place, the maturity of scholarly exploration was concerned with the high-quality development, job creation, product effectiveness, and technological invention effectiveness of the digital frugality (Wang et al., 2023). Still, experimenters and professionals have shifted their focus towards examining the impact of digital frugality on carbon emigration situations since the government established strategic carbon impartiality pretensions, which aim for carbon impartiality by 2060 and a peak in carbon emigrations by 2030 (Sun et al., 2023). Three major shoes within the academic community regarding digital frugality's part in reducing carbon emigration are shown by a thorough analysis of the literature presently in publication. First, it's generally known that the rise of digital frugality has resulted in a drop in carbon emigration. Digital frugality makes indigenous modernization, networking, development, and governance easier through channels like artificial intelligence and big data (Yi et al., 2022). By optimizing resource application and reducing energy consumption, big data and digital technologies can greatly ameliorate the effectiveness of businesses, governance, and operations within a fiefdom. This can eventually lead to increased productivity and a reduction in indigenous carbon emigration (Wang et al., 2023).

Secondly, there's a perceptible upward trend in carbon emigration as a result of the expansion of digital frugality. The top cause of this is the rise in energy operations linked to the objectification of digital technologies into diligence like electricity (Kuzior, Grebski, Kwilinski, Krawczyk, & Grebski, 2022). For illustration, developing economies's urbanization and industrialization trends are adding to energy demand and, as a result, carbon emigration (Zhang et al., 2022). Carbon emigration situations and the expansion of digital frugality have a nonlinear relationship, as demonstrated by Li et al. (2016), who, using panel data from Developing economies metropolises, discovered an inverse" U" shaped association between the two. This means that although digital frugality helps to increase carbon emigration in the early phases of development, in the after stages it becomes an interference. Last but not least, perfecting artificial structures results in a steady decline in energy operation and carbon emigration in the artificial and manufacturing sectors, which ultimately helps to lower carbon emigrations in the region (Cheng et al., 2023). Environmental restrictions, still, encourage small increases in energy effectiveness and have a U-shaped nonlinear impact on a country's green profitable growth (Dzwigol, Kwilinski, Lyulyov, & Pimonenko, 2023).

2.1. Hypotheses Development

2.1.1. Digital Trade and Carbon Emission

According to Zugravu-Soilita (2018), the body of research highlights the growing concerns for DT to facilitate trade without the need for transportation, foster technological innovation to reduce pollution and accelerate economic growth. DT eliminates the need for expensive transportation in place of traditional means of selling products and services. Access to information technology applications has changed many aspects of human living, and digitalization has increasingly changed information distribution methods. But if digitalization's qualities aren't fully acknowledged, exploitation and abuse of it will lead to several problems (Dasgupta & Robinson, 2022). Automated processes and operations, such as converting data between formats, are referred to as digitization. Low-cost features on digital platforms contribute to the prosperity of the DT. According to Jiang, Ergu, Liu, Cai, and Ma (2022), trade between individuals increases with transportation; however, DT has solved transportation-related issues. Because of their high replicability and low marginal cost, digital products are relatively inexpensive in terms of product attributes (Jiang et al., 2022). DT, according to González and Jouanjean (2017), lowers prices, speeds up supply-demand matching, and lessens knowledge asymmetry. Digital payment systems facilitate the transfer of a broad spectrum of economic processes. Information technology platforms are therefore effective tools and strategies for economic expansion. The current payment options would not be possible without the advancement of technology.

Present approaches aim to increase financial inclusion by eliminating the barriers that the general public encounters. Aligning the goals and combining fresh ideas with preexisting ones to create original solutions can improve stakeholder involvement and connection while also fostering stronger relationships and teamwork. Digital technology enables better information flows, greater flexibility, adaptability, and productivity in investment initiatives. The rapid rise of innovative digital technology business models can be attributed to Developing economies' R&D capabilities, industrial vigour, and infrastructure (Neligan, 2022).

Developing economies has led the globe in 5G rollout, with a notable acceleration and continues to prioritize digital technology, promote international trade, and develop new DT models as a result Zhang et al. (2022) demonstrating that Developing economies is the global leader in artificial intelligence (Jiang et al., 2022). Major environmental problems like food waste, agricultural waste, e-waste, and solid waste can be solved by digitalization (Wen, Zhang, Wang, Weinan, & Srolovitz, 2022). It also supports sustainable urbanization, sustainable production, and environmental management. Digital technology is essential for solving environmental problems. According to Cenci et al. (2022), digital businesses use eco-friendly technology. Therefore, partner interactions, computing, and promotion all contribute to the improvement of environmental quality. The following factors are taken into account: production variables, organizational structure, work location, payment systems with other businesses, and staff communication strategies. Based on the above discussion we created the following hypothesis.

H1: *Digital trade has a significant effect on environmental quality in developing economies.*

2.1.2. Globalization and Carbon Emission

Since increasing interconnectedness and integration of economies, civilizations, and cultures are characteristics of globalization (GLOB), there are significant implications for EQ. According to Fischer (2003) GLOB is viewed as a way to improve labor mobility, open markets, free commerce, information transfer, and foreign investment in order to increase economic interdependence across governments. This strategy affects the environment globally since it is connected to the Industrial Revolution. According to some analysts, GLOB is to blame for the cross-border spread of energy-intensive technologies and polluting industries, which has significantly increased CO2 emissions in developing nations (Mair, Wolf, & Seelos, 2016).

Mixed results came from the empirical study of the relationship between GLOB and environment. Numerous studies have shown that in developing nations, GLOB enhances environmental sustainability (Warsame, Abdi, Amir, & Azman-Saini, 2023). Zhang et al. (2022) looked at the impact of GLOB on environmental deterioration. Results demonstrated that GLOB significantly lowers CO2 emissions. Ayad (2023) found that GLOB has a negative effect on long-term ecological sustainability. Bibi, Bibi, Abu-Dieyeh, and Al-Ghouti (2023) investigated the effects of GI and GLOB on CO2 emissions in developing economies. The Dynamic-ARDL findings indicate that GLOB and EQ are positively correlated. Huo et al. (2023) claim that financial innovation and economic GLOB both directly and indirectly benefit developing economies' EQ.

On the other hand, when Ali, Yan, Razzaq, Khan, and Irfan (2023) investigated the dynamic elements of GLOB, they found that although social and political GLOB enhances the environment, economic GLOB deteriorates it. Ahmad, Saraswat, and El Gamal (2023) assessment of GLOB's impact on CO2 emissions in OECD nations was conducted. The CS-ARDL and AMG long-term elasticities show that GLOB raises pollution indices. According to Wang et al. (2023), in a sample of 128 BRI countries, financial GLOB significantly encourages environmental degradation. Nevertheless, Danish and Ulucak (2022) identified a neutral effect on pollution and proposed that it serve as a catalyst for innovation in energy systems for developing nations. The scientific literature suggests conducting additional study in this area to generate suitable policy suggestions, as the evaluation of the GLOB-environmental nexus has yielded inconclusive results. The following hypothesis is also supported by current research, which shows a favorable link between these variables.

H2: *Globalization has a signifcant positive infuence on environmental quality in developing economies.*

2.2. Theoretical Framework

It is essential for creating and maintaining an environment that benefits both the present and the future generations and is resilient, healthy, and sustainable. For the sake of ecological benefits, biodiversity conservation, human well-being, moral considerations, and general sustainable development, high environmental quality is necessary. It encompasses a wide range of environmental features and components, including ecosystems, biodiversity, air, water, and land, as well as general sustainability. One of the main components of long-term growth is EQ. It is the essential component for achieving SDG 13 UN (2023) and involves striking a balance between environmental concerns and social and economic elements in order to foster long-term well-being and prosperity.

Environmental degradation may occur during the early stages of economic expansion, but eventually sustainable development where economic expansion and EQ coexist may take hold. Making the shift to a green economy has the potential to both improve environmental quality and spur economic growth (Javaid, Haleem, & Singh, 2023). By installing clean manufacturing facilities to reduce pollution and improving resource efficiency, green growth can be promoted (Zhao, Ma, Chen, Shang, & Song, 2022). Through eco-innovation and green technology, green growth can be accomplished while reducing resource use, pollution, and adverse environmental effects. The link between economic growth and EQ is strengthened by this decoupling. Additionally, employing scientific and technical advancements, communities worldwide have stepped up their efforts to address pollution (Li et al., 2016).

Conventionally created products have inherent flaws; DT overcomes these by bringing sophisticated technology, cheap cost, innovation, and a green environment. DT drives GI by supporting sustainable practices and efficient resource management in all business sectors. Since DT facilitates the monitoring and optimization of energy use, waste reduction, and the switch to renewable sources, it is easier to integrate smart grids and digital solutions. Similarly, GI makes renewable energy technologies more accessible and reasonable substitutes for fossil fuels by increasing their efficiency and affordability. For this reason, GI is essential to the shift towards a sustainable economy and carbon neutrality. These discoveries have the potential to promote green growth and improve environmental quality while reducing climate change, maintaining ecosystems, safeguarding resources, and generating green jobs. GI has the power to boost business morale, which will boost production and competitiveness. As a result, businesses will produce eco-friendly or green products and advocate for environmental preservation and emission reduction at the same time. Liu et al. (2023) assert that because GI has both technological and environmental effects, it is considered a great tool for ecological modernization.

The most common type of international trade carried out using digital technology is DT, which is another factor. Firms are forced to increase their levels of invention and production by DT, which enables them to manufacture their final products in a competitive setting. Corporations are then forced to engage in e-trading or e-commerce, which is a more environmentally friendly form of trade than traditional trading, as a result of this good competition. People can transact digitally using DT, and goods can be delivered internationally without the need for extra transportation, both of which eventually minimize pollution in the environment. DT is becoming more and more important in today's globalized world since it enables businesses to access foreign markets, increase customer choice, and advance economic growth (Doğan, Chu, Ghosh, Diep Truong, & Balsalobre-Lorente, 2022). Through process optimization, waste reduction, and increased efficiency, DT enables businesses to optimize their distribution networks. Businesses can reduce the environmental damage caused by trash disposal and wasteful resource consumption by digitizing their manufacturing and supply chains. It is therefore possible to reduce ecological effects and improve environmental quality by taking use of the opportunities provided by DT and upholding sustainable practices in the digital world.

In addition, global labor markets are seen as a driving force behind technical developments, ecological innovation, and greater economic ties between nations. If GLOB is combined with technical advancement, know-how, the exchange of green technology and eco-innovation, and environmentally beneficial strategies resulting from MNC competition, pollution may be reduced (Liu et al., 2023). Environmental sustainability is the consequence of countries sharing green environmental technologies through GLOB.

3. Methodology

3.1. Data

For developing economies, this study collects annual data on factors (such as DT, GLOB, GI, and InCO2) for the years 2004 through 2023. The scope and availability of data determine the estimated series, period, and economy. To allay worries about normalcy, variables are converted to a natural logarithmic form (Chishti & Patel, 2023). To quantify EQ, InCO2 variables are employed. The data is taken from WDI Bank (2023) and includes InCO2 in metric tons per capita and DT in digital goods and services traded. The information is from the OECD OECD (2023) and includes GI in patent environment technologies and REC in the contribution of RE to the overall primary energy supply. These econometric strategies are used in the study together with sophisticated econometric methodologies. A preliminary analysis of the chosen series is conducted at the start of the study. Once stationarity has been determined, sectional dependence (CSD) is examined and unit root tests (CIPS and CADF) are run. It is possible to confirm a long-term relationship between variables using second-generation cointegration tests. Regression analysis makes use of sophisticated techniques like Panel FMOLS and DOLS.

3.2. Econometric Model

This study has examined the association between the stated variables using this econometric model.

$$InCO2_{it} = \beta_0 + \beta_1 DTit + \beta_2 RECit + \beta_3 GLOBit + \beta_4 GIit + \varepsilon_{it} \qquad (1)$$

Where,
InCO2= Carbon Emission Reduction
DT= Digital Trade
REC= Renewable Energy consumption
GLOB= Globalizations
GI=Green Innovation

4. Results
4.1. Descriptive Statistics

Table 1
Descriptive Statistics

Variable	Observation	Mean	SD	Min	Max
InCO2	100	1.39	0.86	−0.13	1.97
DT	100	29.31	19.58	8.01	59.33
REC	100	16.69	13.90	2.41	43.59
GLOB	100	3.13	0.18	3.84	4.31
GI	100	8.79	2.54	3.89	15.89

The variables' descriptive statistics are displayed in Table I. There are no outliers in the current data because the mean values for every variable are all within their ranges. Each variable's SD value indicates that there is enough variety in the data.

4.2. Correlation Result

Table 2
Correlation Statistics

Variables	InCO2	DT	REC	GLOB	GI
InCO2	1				
DT	−0.39	1			
REC	−0.56	0.05	1		
GLOB	-0.61	0.51	0.56	1	
GI	−0.29	0.38	0.12	0.17	1

Table II presents the correlation results of independent and control variables. It indicate that aa the variables has negative impact on carbon emission. It means that these all variables reduce the carbon emission and increases EQ.

4.3. Cross sectional dependence (CDS) test

Table 3
Pesaran cross sectional dependence (CDS) test

Variables	CD-test	p value	corr	abs(corr)
InCO2	9.48*	0.000	0.39	0.61
DT	6.37*	0.000	0.29	0.50
REC	24.10*	0.000	1	1
GLOB	17.01*	0.000	0.68	0.69
GI	19.70*	0.000	0.93	0.97

Note: *** p<0.01, ** p<0.05, * p<0.1

The findings of a statistical analysis that used two techniques, a test for cross-sectional dependence (CSD) and correlations between the relevant variables, are shown in Table III. The research results indicate that the panel series under study has obvious cross-sectional dependence. The degree of correlation between each variable is shown in the corr column, where correlation coefficients range from 0.29 to 1. Notably, the absolute values of the correlation coefficients, which show the strength of the associations between the variables regardless of direction, are displayed in the abs (corr) column. The results indicate that cross-sectional dependence is present in the dataset significantly. Furthermore, there is a strong association between every variable in the panel series, with some particularly noteworthy correlations found between InCO2, DT, REC, GLOB, and GI. These results highlight the interdependence of the examined factors and stress the significance of considering their combined effects in further analytical or modeling endeavors.

4.4. Unit Root Results

Table 4
Unit Root Results

	CADF				CIPS	
	Level		First Difference		Level	First Difference
Variable	t-bar	P-value	t-bar	P-value	bi-values	bi-values
InCO2	2.31	0.49	3.029*	0.000	-2.791	-4.510*
DT	1.51	0.791	2.712*	0.001	-3.101	-5.590*
REC	2.61	1	2.06*	0.000	1.07*	1.06*
GLOB	1.802	1	3.590*	0.002	1.801*	2.59*
GI	1.713	0.610	2.602*	0.003	-0.090	-4.561*

Note: *** p<0.01, ** p<0.05, * p<0.1

The outcomes of unit root tests conducted on a few chosen series, such as InCO2, DT, REC, GLOB and GI, are shown in Table IV. The results provide significant new information about the stationarity characteristics of these series. Result indicate that all test statistics exceed critical values at all levels, and non-significant P-values suggest that none of the series are stationary in their level form. This means that there are probably unit roots in these series, indicating long-term trends. As such, these series might not be appropriate for some statistical analyses that rely on stationary data. Overall, the results show how crucial it is to consider time series data stationarity qualities, especially when doing statistical analysis or modeling, and how appropriate first difference transformations are for establishing stationarity in the chosen series.

4.5. Westerlund Cointegration Test

Table 5
Westerlund Cointegration Test

Statistics	G_t	G_a	P_t	P_a
Model	-3.219	-4.491	-16.801	-4.891

Note: *** p<0.01, ** p<0.05, * p<0.1

Table V shows the cointegration results for this, as reported by Westerlund (2007). The results validate a long-term relationship between InCO2, DT, REC, GLOB, and GI and show that the assumptions are accepted, which further encourages this study to perform long-run coefcient calculations.

4.6. Long Run Regression Estimates

Table 6
Panel FMOLS and DOLS Regression Results for CO2 Emissions

Dependent Variable: InCO2				
Methods	**FMOLS**		**DOLS**	
Variables	**beta**	**t-statistics**	**Beta**	**t-statistics**
DT	-0.117 ***	-5.20	-0.159 ***	-2.31
REC	-0.019 **	-2.09	-0.130 **	-2.89
GLOB	1.020***	2.31	0.629***	2.09
GI	-0.291**	-2.91	-0.030*	-2.70

This study employs panel FMOLS and DOLS techniques. The ordinary least squares technique, commonly called OLS, cannot provide reliable estimates for variables with a unique order of integration. The FMOLS estimator is known for producing reliable estimates and is not significantly affected by issues such as endogeneity and heterogeneous dynamics. Ramirez (2007) highlights the benefits of the FMOLS estimator. Hence, in light of the unique characteristics of FMOLS, we employ this methodology to address the potential issues of endogeneity and serial correlation in our research. Moreover, DOLS is suitable for looking at dynamic links in panel datasets because it deals with endogeneity using lagged dependent variables. DOLS also gives accurate and consistent estimates even when endogeneity and serial correlation are present. This makes it a potent method for estimating panel data models like this.

The results of the panel FMOLS and DOLS methods are reported in Table VI. Result shows that DT has negative significant effect on carbon emission. It can also be interpreted that a 1% rise in renewable energy consumption will reduce CO2 emissions per capita by 0.117% in the panel. The result indicate that REC has also negative impact on carbon emission but GLOB has positive impact. It shows that GLOB increase carbon emission. GI has negative significant impact on InCO2 with coefficient value 0.291. It shows that 1% rise in GI will 0.291% decreases CO2 emission.

5. Conclusions and Policy Recommendations

In addition to looking into creative styles of reducing carbon in the age of digital carbon frugality, this essay goes into DT to examine its function in coordinating the commerce between low-carbon sustainable development and indigenous profitable openness. A comprehensive evaluation of the state of DT in several developing economies businesses was carried out, covering a range of factors including the DT terrain, status, digital network structure, specialized position, trade eventuality, digital artificial trade, and trade in digital industrialization. The benefits of developing economies's DT development on lowering carbon emigration were empirically tested, and the results showed a variety of goods depending on trade openness, indigenous differences in carbon emigration intensity, and the compass, structure, and technology of the design. A detailed disquisition was conducted on the theoretical process that underlies the correlation between indigenous carbon emigration and DT development. The study's conclusions indicate that DT vastly lowers carbon emigration in Developing economies at the indigenous position. Although trade openness, the intensity of carbon emigration, and different structural and specialized dynamics can all have an impact on indigenous carbon emigration, DT can also have a direct impact.

The exploration makes several policy recommendations to optimize the impact of DT on reducing carbon emigration. It first highlights how pivotal it is to coordinate the creation of a digital structure and use digital technologies to reduce carbon emigration. To support DT's structure, governments are advised to encourage the development of slice-edge information structures, including data centres, artificial intelligence, and 5G base stations. Second, the report promotes increased trade openness as a means of integrating digital technology with profitable trade. To effectively reduce carbon emigration, it emphasizes the necessity of embracing new trends in digital trade, promoting profitable digital metamorphosis, and optimizing the use of artificial coffers. Thirdly, the report emphasizes how important it is to support green technology invention and optimize the structure of the artificial sector. Governments are prompted to help companies be more environmentally and carbon-competitive by using DT as a catalyst for new developments in green technology and advancements to artificial structures. Eventually, the study emphasizes how critical it is to take indigenous differences into account and produce integrated indigenous plans for low-carbon development. To completely realize their eventuality for low-carbon growth, it recommends that the western and central regions aggressively engage in digital trade and increase trade openness. There are still colourful data and index system limitations, indeed with the thorough exploration carried out in the study. The study recognizes the necessity of perfecting applicable data by adding abecedarian information reflecting the current position of digital development in diligence like the internet and e-commerce, intelligent services, and related sectors, as well as the need to modernize the indicator system regularly grounded on factual trading situations.

The essay makes several policy proffers targeted at optimizing the capability of DT to successfully reduce carbon emigration in light of these findings. The most important of them is the necessity of aligning coordinated sweat to reduce carbon emigration with the development of digital structure. This means that the development of vital factors of the digital structure data centres, AI, and 5G networks, for illustration that form the foundation of digital metamorphosis, needs strong government support. also, the objectification of digital technology into profitable commerce is emphasized as a pivotal pathway to ameliorate the results of low-carbon growth. Achieving meaningful carbon emigration reductions will bear embracing new trends in digital trade and exercising digital metamorphosis programs to enhance product operations. The paper also emphasizes how critical it is to support green technology invention and optimize artificial structures to support DT's sweat to reduce carbon emigration. It's believed that the relinquishment of green technology and the stimulation of invention by the government are essential for promoting sustainable artificial metamorphosis. The composition's conclusion highlights the necessity of technical indigenous tactics to take use of the special openings presented by DT and accommodate a variety of experimental situations. The creation of trade openness and active engagement in digital trade have been honoured as critical tactics for enabling low-carbon development, especially in underserved areas. Although the exploration is thorough, the paper notes several essential limitations in the data and index systems that are presently accessible. To give further nuanced knowledge of digital development patterns across different diligence, it calls for the addition of applicable data sources and emphasizes the necessity of continuously enriching the indicator system to fit with changing realities.

Author's Contribution:
Anita Pariyar: writing original draft, literature reviewing & editing, data analysis & interpretations.
Ping Guo: Supervision.
Guoqin Pan: Conceptualization, review, and editing.
Awais Dastgeer: Data curation, methodology, visualization, revising the draft & editing

Conflict of interest/ Disclosures:
The authors declared no potential conflicts of interest w.r.t the research, authorship and/or publication of this article.

References

Ahmad, A., Saraswat, D., & El Gamal, A. (2023). A Survey on Using Deep Learning Techniques for Plant Disease Diagnosis and Recommendations for Development of Appropriate Tools. *Smart Agricultural Technology, 3*, 100083. doi:https://doi.org/10.1016/j.atech.2022.100083

Ali, S., Yan, Q., Razzaq, A., Khan, I., & Irfan, M. (2023). Modeling Factors of Biogas Technology Adoption: A Roadmap Towards Environmental Sustainability and Green Revolution. *Environmental Science and Pollution Research, 30*(5), 11838-11860. doi:https://doi.org/10.1007/s11356-022-22894-0

Ayad, F. (2023). Mapping the Path Forward: A Prospective Model of Natural Resource Depletion and Sustainable Development. *Resources Policy, 85*, 104016. doi:https://doi.org/10.1016/j.resourpol.2023.104016

Bank, T. W. (2023). Inco2 in Metric Tons Per Capita and Dt in Digital Goods and Services Traded.

Bibi, A., Bibi, S., Abu-Dieyeh, M., & Al-Ghouti, M. A. (2023). Towards Sustainable Physiochemical and Biological Techniques for the Remediation of Phenol from Wastewater: A Review on Current Applications and Removal Mechanisms. *Journal of Cleaner Production, 417*, 137810. doi:https://doi.org/10.1016/j.jclepro.2023.137810

Cenci, A., Macchia, I., La Sorsa, V., Sbarigia, C., Di Donna, V., & Pietraforte, D. (2022). Mechanisms of Action of Ozone Therapy in Emerging Viral Diseases: Immunomodulatory Effects and Therapeutic Advantages with Reference to Sars-Cov-2. *Frontiers in Microbiology, 13*, 871645. doi:https://doi.org/10.3389/fmicb.2022.871645

Cheng, J., Novati, G., Pan, J., Bycroft, C., Žemgulytė, A., Applebaum, T., . . . Sargeant, T. (2023). Accurate Proteome-Wide Missense Variant Effect Prediction with Alphamissense. *Science, 381*(6664), eadg7492. doi:https://doi.org/10.1126/science.adg7492

Cherniwchan, J. (2017). Trade Liberalization and the Environment: Evidence from Nafta and U.S. manufacturing. *Journal of International Economics, 105*, 130-149. doi:https://doi.org/10.1016/j.jinteco.2017.01.005

Chishti, M. Z., & Patel, R. (2023). Breaking the Climate Deadlock: Leveraging the Effects of Natural Resources on Climate Technologies to Achieve Cop26 Targets. *Resources Policy, 82*, 103576. doi:https://doi.org/10.1016/j.resourpol.2023.103576

Copeland, B. R. (2013). Trade and the Environment. In *Palgrave Handbook of International Trade* (pp. 423-496): Springer.

Danish, & Ulucak, R. (2022). Analyzing Energy Innovation-Emissions Nexus in China: A Novel Dynamic Simulation Method. *Energy, 244*, 123010. doi:https://doi.org/10.1016/j.energy.2021.123010

Dasgupta, S., & Robinson, E. J. (2022). Attributing Changes in Food Insecurity to a Changing Climate. *Scientific Reports, 12*(1), 4709. doi:https://doi.org/10.1038/s41598-022-08696-x

Doğan, B., Chu, L. K., Ghosh, S., Diep Truong, H. H., & Balsalobre-Lorente, D. (2022). How Environmental Taxes and Carbon Emissions Are Related in the G7 Economies? *Renewable Energy, 187*, 645-656. doi:https://doi.org/10.1016/j.renene.2022.01.077

Dzwigol, H., Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023). Renewable Energy, Knowledge Spillover and Innovation: Capacity of Environmental Regulation. *Energies, 16*(3), 1117. doi:https://doi.org/10.3390/en16031117
Fischer, S. (2003). Globalization and Its Challenges. *American Economic Review, 93*(2), 1-30. doi:http://doi.org/10.1257/000282803321946750
Frenken, K., & Schor, J. (2019). Putting the Sharing Economy into Perspective. In *A Research Agenda for Sustainable Consumption Governance* (pp. 121-135): Edward Elgar Publishing.
González, J. L., & Jouanjean, M.-A. (2017). Digital Trade: Developing a Framework for Analysis. doi:https://doi.org/10.1787/18166873
Gozgor, G., & Ongan, S. (2017). Economic Policy Uncertainty and Tourism Demand: Empirical Evidence from the USA. *International Journal of Tourism Research, 19*(1), 99-106. doi:https://doi.org/10.1002/jtr.2089
Huo, X., Ma, G., Tong, X., Zhang, X., Pan, Y., Nguyen, T. N., . . . Wei, M. (2023). Trial of Endovascular Therapy for Acute Ischemic Stroke with Large Infarct. *New England Journal of Medicine, 388*(14), 1272-1283. doi:http://doi.org/10.1056/NEJMoa221337
Javaid, M., Haleem, A., & Singh, R. P. (2023). Chatgpt for Healthcare Services: An Emerging Stage for an Innovative Perspective. *BenchCouncil Transactions on Benchmarks, Standards and Evaluations, 3*(1), 100105. doi:https://doi.org/10.1016/j.tbench.2023.100105
Jiang, P., Ergu, D., Liu, F., Cai, Y., & Ma, B. (2022). A Review of Yolo Algorithm Developments. *Procedia Computer Science, 199*, 1066-1073. doi:https://doi.org/10.1016/j.procs.2022.01.135
Kuzior, A., Grebski, W., Kwilinski, A., Krawczyk, D., & Grebski, M. E. (2022). Revitalization of Post-Industrial Facilities in Economic and Socio-Cultural Perspectives—a Comparative Study between Poland and the USA. *Sustainability, 14*(17), 11011. doi:https://www.mdpi.com/2071-1050/14/17/11011#
Li, J., Galley, M., Brockett, C., Spithourakis, G. P., Gao, J., & Dolan, B. (2016). A Persona-Based Neural Conversation Model. *arXiv preprint arXiv:1603.06155*. doi:https://doi.org/10.48550/arXiv.1603.06155
Liu, P., Yuan, W., Fu, J., Jiang, Z., Hayashi, H., & Neubig, G. (2023). Pre-Train, Prompt, and Predict: A Systematic Survey of Prompting Methods in Natural Language Processing. *ACM Computing Surveys, 55*(9), 1-35. doi:https://doi.org/10.1145/3560815
Mair, J., Wolf, M., & Seelos, C. (2016). Scaffolding: A Process of Transforming Patterns of Inequality in Small-Scale Societies. *Academy of Management Journal, 59*(6), 2021-2044. doi:https://doi.org/10.5465/amj.2015.0725
Neligan, P. C. (2022). The Future of Plastic Surgery. *Archives of Plastic Surgery, 49*(01), 1-2. doi:http://doi.org/10.5999/aps.2021.02278
OECD. (2023). The Organization for Economic Cooperation and Developmen.
Ramirez, R. K. (2007). *Native Hubs: Culture, Community, and Belonging in Silicon Valley and Beyond*: Duke University Press.
Shan, Y., Guan, D., Liu, J., Mi, Z., Liu, Z., Liu, J., . . . Zhang, Q. (2017). Methodology and Applications of City Level Co2 Emission Accounts in China. *Journal of Cleaner Production, 161*, 1215-1225. doi:https://doi.org/10.1016/j.jclepro.2017.06.075
Sun, Y., Wu, J., Tan, M., Xu, X., Li, Y., Morandotti, R., . . . Moss, D. J. (2023). Applications of Optical Microcombs. *Advances in Optics and Photonics, 15*(1), 86-175. doi:https://doi.org/10.1364/AOP.470264
Teng, S., Hu, X., Deng, P., Li, B., Li, Y., Ai, Y., . . . Zhu, F. (2023). Motion Planning for Autonomous Driving: The State of the Art and Future Perspectives. *IEEE Transactions on Intelligent Vehicles*. doi:https://doi.org/10.1109/TIV.2023.3274536
Tushman, M. L., & Anderson, P. (2018). Technological Discontinuities and Organizational Environments. In *Organizational Innovation* (pp. 345-372): Routledge.
UN. (2023). Striking a Balance between Environmental Concerns and Social and Economic Elements in Order to Foster Long-Term Well-Being and Prosperity.

Wang, Q., Zhang, F., & Li, R. (2023). Revisiting the Environmental Kuznets Curve Hypothesis in 208 Counties: The Roles of Trade Openness, Human Capital, Renewable Energy and Natural Resource Rent. *Environmental Research, 216*, 114637. doi:https://doi.org/10.1016/j.envres.2022.114637

Warsame, A. A., Abdi, A. H., Amir, A. Y., & Azman-Saini, W. N. W. (2023). Towards Sustainable Environment in Somalia: The Role of Conflicts, Urbanization, and Globalization on Environmental Degradation and Emissions. *Journal of Cleaner Production, 406*, 136856. doi:https://doi.org/10.1016/j.jclepro.2023.136856

Wen, T., Zhang, L., Wang, H., Weinan, E., & Srolovitz, D. J. (2022). Deep Potentials for Materials Science. *Materials Futures, 1*(2), 022601. doi:http://doi.org/10.1088/2752-5724/ac681d

Westerlund, J. (2007). Testing for Error Correction in Panel Data. *Oxford Bulletin of Economics and statistics, 69*(6), 709-748. doi:https://doi.org/10.1111/j.1468-0084.2007.00477.x

Yi, M., Liu, Y., Sheng, M. S., & Wen, L. (2022). Effects of Digital Economy on Carbon Emission Reduction: New Evidence from China. *Energy Policy, 171*, 113271. doi:https://doi.org/10.1016/j.enpol.2022.113271

Zhang, H., Wu, C., Zhang, Z., Zhu, Y., Lin, H., Zhang, Z., . . . Manmatha, R. (2022). *Resnest: Split-Attention Networks.* Paper presented at the Proceedings of the IEEE/CVF conference on computer vision and pattern recognition.

Zhao, X., Ma, X., Chen, B., Shang, Y., & Song, M. (2022). Challenges toward Carbon Neutrality in China: Strategies and Countermeasures. *Resources, Conservation and Recycling, 176*, 105959. doi:https://doi.org/10.1016/j.resconrec.2021.105959

Zugravu-Soilita, N. (2018). The Impact of Trade in Environmental Goods on Pollution: What Are We Learning from the Transition Economies' Experience? *Environmental Economics and Policy Studies, 20*(4), 785-827. doi:https://doi.org/10.1007/s10018-018-0215-z