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Impact of Financial Inclusion, Globalization, Renewable Energy, ICT, and Economic Growth on CO_2 Emission in OBOR Countries

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Abstract: This study examines the short-term and long-term effects of various important determinants such as financial inclusion (FI), information and communication technology (ICT), renewable energy (RE), globalization (GOB), and economic growth (EG) on CO_2 emissions in the top 10 emitter countries in the OBOR region based on the collected data for the years 2004 to 2019. This study employed the CS-ARDL technique. Findings demonstrate a strong relationship between FI, ICT, and CO_2 emissions in both the long-term and short-term. Renewable sources of energy have been found to have a CO_2 emission reduction effect, both in the long and short term. In the long run, there is a negative connection between globalization and CO_2 emissions; however, in the short run, this connection is inconsequential, while economic growth (EG) has a positive association with CO_2 emission. The development of ICT infrastructure carries the potential to directly mitigate the detrimental effects of CO_2 emissions while also playing an important role in raising people's environmental consciousness. OBOR countries should welcome and encourage clean and green foreign investment that provides technical skills, environmental technology development, and carbon-free processes.

Keywords: CO_2 emission; financial inclusion; information communication technology; renewable energy; globalization

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1. Introduction

Climate change and global warming pose great danger to the long-term viability of life on the planet Earth. Rising global warming and the resulting destruction in worldwide populations may be traced back to greenhouse gas emissions, more specifically to emissions of carbon dioxide [CO_2] [1]. In response to this perilous scenario, world leaders convened at UNCOP21 and resolved to take comprehensive actions under the sustainable development goals (SDGs) required by the 70th session of the United Nations General Assembly. The goal of these actions is to reduce carbon dioxide emissions caused by the exponential integrations of energy needs, the polluting environment, and the expansion of global economic development [2], but doing so will require first establishing a thorough familiarity with the factors that have an impact in each geographical area and the dynamics that will be required to be effective [3].

Scholars have carefully studied all variables that directly or indirectly preserve environmental protection. For instance, ref. [4] observed that deteriorating environmental prominence threatens human existence due to GDP, economic decentralization, globalization, innovation, and technology. Fuel-efficient technology might reduce global carbon emissions [5]. Eco-friendly goods and techniques, infrastructure modernization, capturing and conserving carbon, electricity production, sustainable power, and eco-friendly grid operations and power conservation have major environmental impacts [6]. Another school of research has examined aspects including industrial production, technical progress, natural resources, and human resources [7], whereas the latest research has proven the importance of financial growth and monetary inclusion [8] (see for example [8] or [9]).

Technological advances have spread worldwide in the 21st century. Global and regional collaboration and coordination efforts are overlapping geographical boundaries, offering a glimpse of win–win commerce, prosperity, and coordination. The rise of global temperature and worsening climate conditions affect even the developing nations despite their negligible share of these industrial waste productions [3]; however, technological influences and green energy usage can ultimately reduce CO_2 emissions creating hope for things to improve. Scholars want to know how these contributing factors impact both developed and developing nations in various areas in the short and long term [10]. One belt one road (OBOR) is a potential worldwide regional cooperation and coordination initiative. Globalization, economic growth, financial inclusion, renewable energy, and technological advances in communication and information affect short-term and long-term CO_2 emissions for the top 10 CO_2 emitters under the One Belt One Road consortia. The One Belt, One Road (OBOR) initiative, launched by China in 2013, is the largest major initiative by a single country and can dramatically impact global markets and development. The proposed project includes over two-thirds of the world's population, one-third of the global GDP, and 25% of worldwide commerce. It has two primary parts: The Belt, or new Silk Road, is a land-based initiative including ports, shipping lanes, and marine development linking China's east coast to south Asia and Europe across the Indian Ocean. Ports, trade channels, and marine infrastructure link Inner China to Europe via Central Asia and the Middle East [11].

The OBOR project, which also originally implicated a direct engagement from the 65 countries in Europe, Asia (including regions such as East Asia, Southeast Asia, Central Asia, and South Asia), and the MENA region, has broad economic objectives to accomplish including integrated and liberalized trade throughout the areas, infrastructural development and unification, and effective resource utilization. This belt and road regime is predicted to grow beyond 65% of the worldwide population and a predicted investment of USD 6 trillion, which represents more than 34% of the global GDP [12].

Given the increasing relevance of multidimensional issues for regional commerce and collaboration from regional communities throughout the globe, researchers are studying regional organizations such as One Belt One Road [13]. Since most of these nations are transitioning, massive infrastructure initiatives and international investment in energy and related businesses are harming the environment [14]. Most OBOR countries' non-renewable energy usage is rising rapidly, causing massive greenhouse gas emissions. China's massive investments may lead to environmental damage due to the OBOR nations' lack of green funding or other methods. OBOR will provide for 60% of global infrastructure expenses and more than half of greenhouse gas emissions in the next decades [11]. Furthermore, many current researchers have analyzed regional communities from the viewpoint of environmental issues and how different features of these cooperative structures may influence the global environmental condition in the OBOR nations [15]. Institutional quality, human resources, capital formation, financial globalization, trade flexibility, economic expansion, energy usage, energy efficiency, and renewable sources are some of the relevant dimensions being studied from the perspective of OBOR nations [11]. This research examines how globalization (GOB), economic growth (EG), renewable energy (RE), financial inclusion (FI), and information and communication technology (ICT) affect CO_2 emissions from the top 10 OBOR consortium emitters. This research addresses the following main research questions.

1. How do the five main factors, including financial inclusion, globalization, renewable energy, ICT, and economic growth, create short-term and long-term effects on the CO_2 emissions for the top 10 emitter countries in the OBOR region?
2. How does the renewable energies factor influence the emissions for the top 10 emitter countries in the OBOR region?

This work is innovative in several dimensions. Firstly, the extant literature has extensively focused on the top 10 emitter countries across the globe; however, given the changing regional dynamics and upcoming transformational trade and infrastructural developments, not many studies have covered the impact of the top 10 emitter countries in the OBOR region. This research attempts to fill this void in the literature by investigating the influence of various drivers on CO_2 emissions over 15 years i.e., from 2004 to 2019. Secondly, this study makes use of the cross-sectional dependence approach for the assessment of cross-sectional dependence in the data. In doing so, the cross-sectional dependence was employed [16,17] along with Im, Pesaran, and CIPS testing methods, in addition to the Westerlund panel cointegration approach. Further, the CS-ARDL method was employed to confirm the robustness check of our results. According to the CS-ARDL study, financial inclusion (FI) has a positive long-term and short-term relationship with CO_2 emissions in the top 10 OBOR countries. Furthermore, ICT has a long-term and short-term positive relationship with CO_2 emissions. Globalization has a long-term negative relationship with CO_2 emissions, but it is insignificant in the short run. Long-term economic growth is associated with lower CO_2 emissions. Our findings establish useful implications for the theorists and practitioners interested in policymaking and practices for environmental protection and conservation in the light of the United Nations' sustainable development goals.

This study continues with an overview of the literature and the research framework for this research in Section 2. Section 3 covers the methodology. Section 4 includes the discussion about the results. Section 5 ends with a conclusion and policy recommendations.

2. Literature Review

The present research attempts to evaluate the role of various contributor factors on the environment in terms of CO_2 emissions for the top 10 emitter countries in the OBOR region. For the factors responsible, the framework presented in Figure 1 will present the details of the independent and dependent variables of this study.

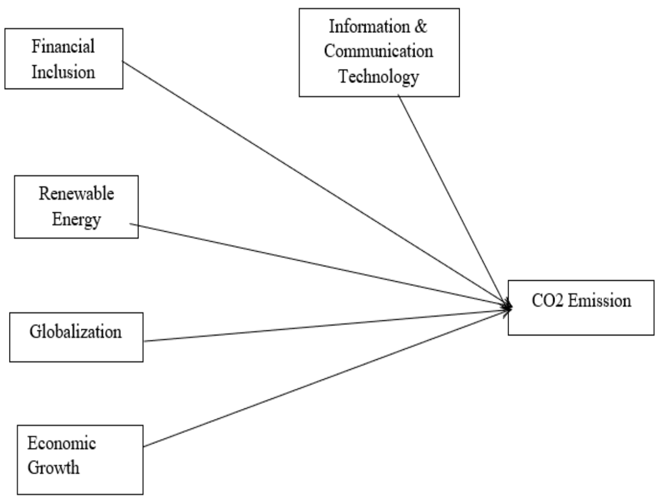

Figure 1. Research framework of the study.

In this section, prior work in the areas of financial inclusion, renewable energy, globalization, economic growth, information and communication technology, and carbon emissions are critically evaluated. This section will help us fully comprehend how each of the mentioned factors contributes to CO_2 emissions. The literature on each topic is reviewed in the following paragraphs, starting with the illustration of recent facts related to CO_2 emission.

2.1. CO_2 Emission

Emissions of CO_2, which make up the majority of greenhouse gases, significantly contribute to global warming leading to catastrophic impacts on life on the planet. CO_2 emissions have increased by 31.79% between the period of 2003 and 2018 and account for 72% of emitted greenhouse gases [18,19], forcing many nations to set reduction targets for carbon emissions.

The relative share of carbon emissions is 3.6% for South and Central America, 3.8% for the African region, 6.2% for the Middle Eastern countries, 6.3% for the Commonwealth of Independent States, 11.2% for the European countries, 16.5% for the North American region, and 52.3% for the Asia Pacific region. During the last decade, South and North American countries and European nations were able to reduce emissions by 1.2, 0.1, and 1.9% respectively due to their effective strategies [20].

Several attempts have been made to identify the major determinants of carbon emissions. Initial work associated numerous energy usage/consumption-related measures with carbon emissions; various measures of economic and financial activity were then linked, and in recent literature we find the role of renewable energy, globalization, and ICT to be the more prominent causes of carbon emissions. Carbon emissions have been measured as consumption-based carbon emissions and territory-based carbon emissions [21] and are normally measured in Kilotons [22]. We have combined both measures to ensure a comprehensive measure of carbon emissions.

After extensively reviewing the literature, we have tried to combine the most prominent causes of carbon emissions in a single study that includes financial inclusion, renewable energy, globalization, and economic growth. Additionally, a graph is provided in Figure 2 to help understand the CO_2 emissions in the top 10 OBOR nations. It shows that the Czech Republic had the greatest CO_2 emissions at the beginning of the examination period and that they then began to decline. The trend is consistent in Luxembourg.

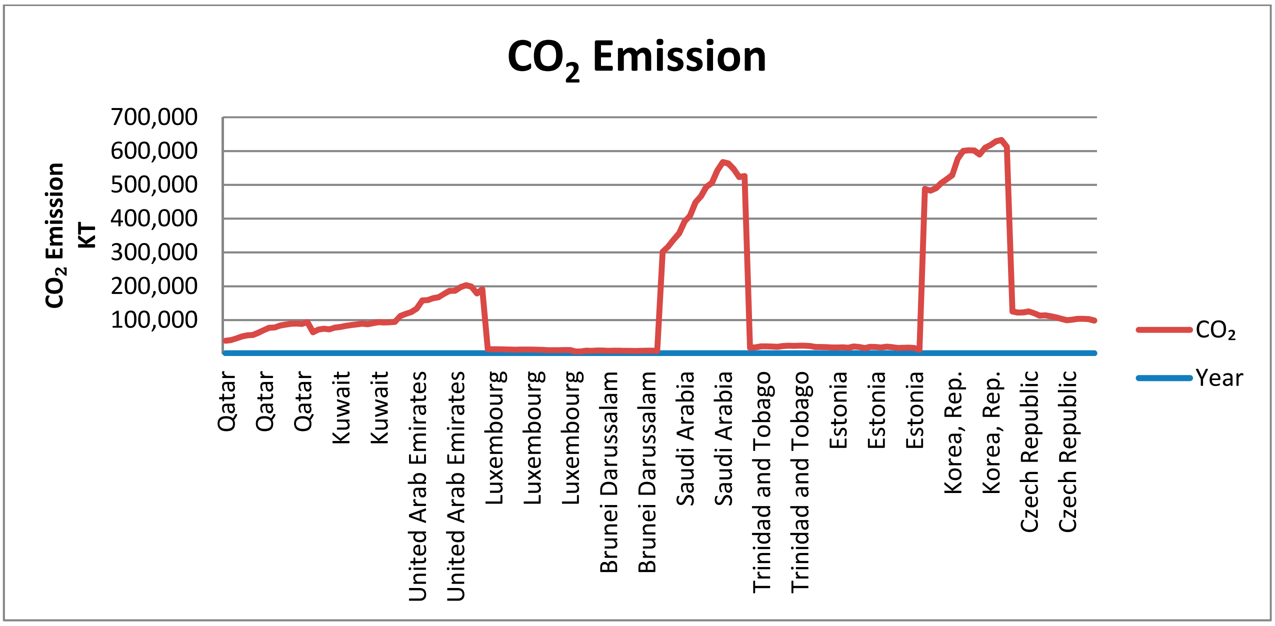

Figure 2. Top 10 emitter OBOR Countries CO_2 Emission.

2.2. Financial Inclusion

One of the credible definitions of financial inclusion states "financial inclusion means that individuals and businesses have access to useful and affordable financial products and services that meet their needs–transactions, payments, savings, credit, and insurance–delivered in a responsible and sustainable way" [8]. Financial inclusion represents the economic stability of a country; however, high economic activity leads to high energy consumption which negatively affects the environmental quality through the emission of carbon dioxide.

Before the introduction of financial inclusion and carbon emissions, financial stability or financial instability has been studied with carbon emissions or with environmental quality [23–27]. Financial inclusion is a more appropriate measure as compared to financial stability since financial inclusion is achieved after financial stability and it is an overarching concept that truly reflects the financial health of a country's businesses and individuals by measuring the ratio or percentage of the population having access to financial products/services [9,28].

Within the limited literature available, we see mixed results of financial inclusion and carbon emissions. Some studies claim that financial inclusion decreases carbon emissions [29]; however, from the data collection of 31 countries by Le [30] financial inclusion came out to be the most important contributor of carbon emissions as compared to the other four contributing factors. These findings strongly suggest probing the relationship between financial inclusion and carbon emissions. Financial inclusion has been previously measured in terms of bank accounts per 1000 adults [31,32], percentage of bank credit to bank deposits [32], percentage of life insurance premium volume to GDP [33], and percentage of non-life premiums to GDP [34].

2.3. Economic Growth

Economic growth requires energy, and to the extent that this energy is produced using fossil fuels, it results in carbon emissions. A crucial topic for climate change is the nature of this connection between the expansion in economic activity and carbon emissions. The quest to increase economic activity without an increase in carbon emissions is a global challenge. There are parts of the world that also demonstrate an inverse relationship between economic growth and carbon emissions due to which there does not appear to be a widespread consensus among researchers on this relationship. The studies that have concluded a positive relationship between economic growth or energy consumption with carbon emissions include the work of Ehigiamusoe and Lean [35], Mensah et al. [36], and Musah et al. [37].

The studies with an inverse relationship between economic activity and carbon emissions include the work of Sun et al. [38] and Ozcan [39]. A group of academics have asserted a link between CO_2 emissions and economic development, claiming that CO_2 emissions rise during the early phases of economic development but fall after a particular level of economic development is reached [40–42].

These contradicting results could also be the consequence of differences in time and place. Mensah et al. [39] focused on African economies, Musah et al. [37] selected West Africa, Ozcan [39] selected Middle Eastern countries, Sun et al. [38] worked on China and Xu et al. [42] focused their study on G20 countries. There are still many regions of the planet that are not covered, indicating an ongoing discussion on the relationship between economic activity and carbon emissions and the requirement for additional research.

In consideration of the above gap and discussion, we have selected the top 10 countries of the OBOR region for this study. These countries have not been studied for CO_2 emissions in particular, and represent an upcoming global classification that needs due attention for research and policy implementation.

2.4. Renewable Energy

Renewable energy in the form of wind, solar, and water is taken very seriously as a source of reducing carbon emissions. The use of renewable energy has been studied in various studies for the reduction in carbon emissions and improvement in the air quality for developing nations [43–48] and as well as for developed nations [37–39] or for both of them [40,41].

Various techniques have been used to establish the relationship between renewable energy and carbon emissions including panel pooled mean group-autoregressive distributive lag model [39], modified ordinary least squares and vector error correction [42], and the AMG approach [43]. The findings of these techniques and research work complement each other, and in most of the literature renewable energy is claimed to have mitigated carbon emissions. Furthermore, the renewable energy trend is provided in the top 10 OBOR countries below in Figure 3.

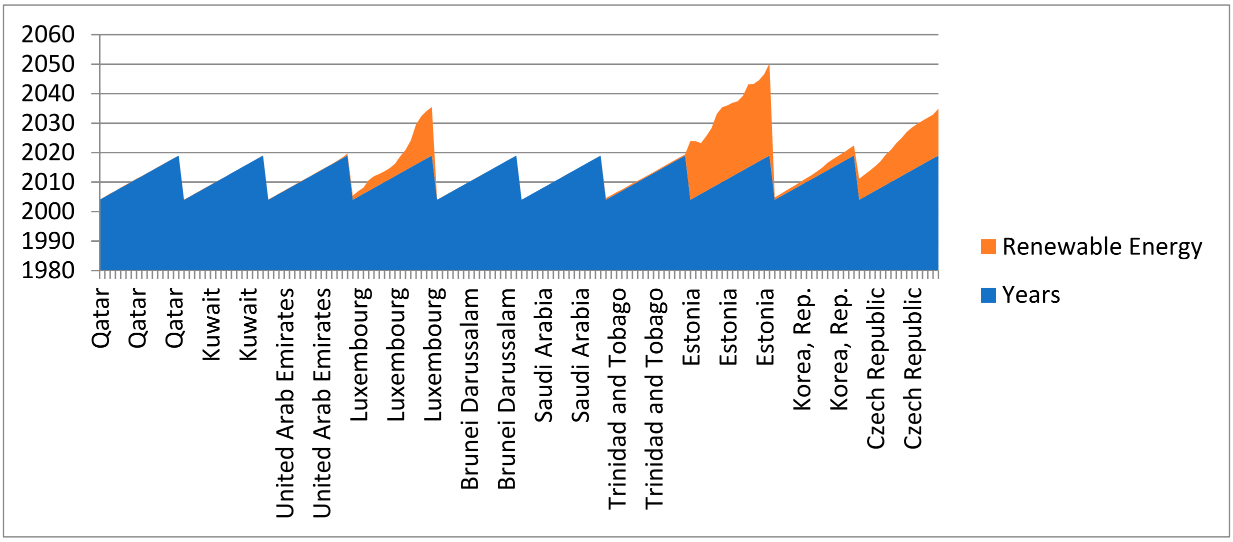

Figure 3. Top 10 emitter OBOR Countries Renewable Energy.

2.5. Globalization

Increased cross-border trade in products and services, increased international money flows, and increased labor flows are all signs of globalization, the ongoing process of greater economic interdependence among nations [44]. Several studies have attempted to study the impact of globalization on CO_2 emissions and environmental quality. In their investigation of 40 developed and developing nations, Antweiler et al. [45] found that trade liberalization enhances environmental quality. According to research conducted by Sinha and Shahbaz [46] for India between 1971 and 2015, trade is negatively related to carbon dioxide emissions. Acheampong [47] showed how decreased global carbon emissions resulted from trade openness and improved environmental quality.

Although there is a consensus that globalization reduces carbon emissions and improves environmental quality, the relative impact of this relationship is varied across the globe. This was concluded in the research conducted by Shahbaz et al. [48] in which a general trend showed a reduction in carbon emissions due to globalization but with varying effects from country to country in the African region. Trade liberalization decreases carbon dioxide and sulfur dioxide pollutant emissions in OECD countries while increasing emissions in non-OECD countries [49].

Chang et al. [50] attributed the varying effect to the income level of an economy. They concluded that trade liberalization only improved environmental quality in high-income countries while increasing carbon emissions in low-income economies. An improved understanding of this phenomenon is the result of the study by Shahbaz et al. [51] that concluded a bidirectional relationship for middle-income counties between trade and carbon emissions and a unidirectional one for high-income and low-income level countries. Another explanation of the varying effect is provided by Farhani et al. [52], who claimed that trade liberalization's impact on environmental quality is based on the scale of trade growth, the techniques shared for environmentally friendly technologies, and the techniques of production employed by the host country. These results open avenues for research in upcoming global regions, alliances, and partnerships that believe in trade liberalization and lifting hurdles that hamper globalization.

2.6. Information and Communication Technology

Information and communication technologies (ICTs) have been shown to have a wide range of effects on important global mechanisms. Prior studies have documented the impact of ICT on different environmental and development aspects. ICT has been studied for economic prosperity and development [53,54], sustainable development [55,56], and alongside carbon emissions [57,58]. It has been documented that these technologies increase productivity, lower energy intensity, and may even facilitate production of cheaper renewable energy. Each one of these effects has different implications for CO_2 emissions, causing a lack of agreement on how ICTs will affect carbon emissions [59,60].

Some advocate the use of ICT as a strategy to slow down the effects of climate change by enhancing energy efficiency [61,62] and lowering the price of renewable energy sources [63]. Other studies support the significant link between ICT development and economic expansion [64–66] which would raise energy consumption and carbon dioxide emissions.

There are different results of ICT on environmental quality in different parts of the world. ICT has been proven to reduce environmental damage and carbon emissions in the BRICS region [67], Pakistan [68], and China [69]. ICT has been associated with increased carbon emissions in sub-Saharan African countries [70]. Comparative studies conclude that ICT increases carbon emissions in low-income countries while the opposite is true for middle and high-income countries [71]. Finally, the studies by Higón et al. [72] and Faisal et al. [73] claim that ICT increases pollution up to a certain level and eventually reduces it later on. Hence, a generally agreed-upon finding on the overall effect of ICTs on the environment has not yet been achieved.

3. Research Methodology

The OBOR top 10 emitter countries were selected based on world bank data available online and retrieved from [74]. The top 10 OBOR emitting countries were identified based on the following criteria: First, all high-income countries participating in the OBOR were picked. Furthermore, the top 10 countries with study variable data were chosen based on CO_2 emissions data from 2004 to 2019 on a per capita basis. An econometric equation is presented. CO_2 emission was used as the dependent variable, FI, ICT, RE, and GL were used as the independent variables, and EG was used as the control variable (Table 1).

Econometric Equation:

$$CO_2 = \alpha + \beta 1(FI) + \beta 2(ICT) + \beta 3(RE) + \beta 4(GL) + \beta 5(EG) + \mu it \quad (1)$$

where

CO_2—Carbon dioxide emission
FI—Financial inclusion
ICT—Information Communication Technology
RE—Renewable Energy
GOB—Globalization
EG—Economic Growth

Table 1. Variable information.

Symbols	Variables	Measurement	Source	Time Period
CO_2	Carbon Dioxide Emission	Carbon dioxide emission (Kt)	World Development Indicators	2004 to 2019 Retrieved on 27-10-2022
FI	Financial Inclusion	Commercial bank branches (per 100,000 adults)	World Development Indicators	2004 to 2019 Retrieved on 27-10-2022
ICT	Internet Communication Technology	Individuals using the Internet (% of the population)	World Development Indicators	2004 to 2019 Retrieved on 27-10-2022
RE	Renewable Energy	Renewable energy consumption (% of total final energy consumption)	World Development Indicators	2004 to 2019 Retrieved on 27-10-2022
GOB	Globalization	GOF Index	KOF Globalisation Index	2004 to 2019 Retrieved on 27-10-2022
EG	Economic Growth	GDP 2015 Constant	World Development Indicators	2004 to 2019 Retrieved on 27-10-2022

3.1. Cross-Sectional Dependency Test

A cross-sectional dependency issue may arise with the data due to the economic, cultural, and social ties that exist between a select number of neighboring regional countries that are included in the cross-sectional data. As a result, it is not completely impossible to speculate on how a specific macroeconomic event in one of these countries would impact the economies of the others. If the issue of cross-sectional dependency is overlooked, the findings of unit root, cointegration, regression, and causality analyses may be biased. We used the cross-sectional dependency test recommended by [75] for cross-sectional dependence to determine whether or not cross-sectional dependence exists within the OBOR top 10 emitter countries panel data set that is being considered in this study. This was done to determine whether cross-sectional dependence does exist. This methodology gives accurate findings when applied to datasets with finite cross-sectional units and time dimensions. This technique calculates an estimate of a test statistic while taking into consideration the alternative hypothesis of cross-sectional dependence.

$$CD = \sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i=0}^{n} T_{ij}p^2 \rightarrow N(0,1) \quad (2)$$

Breusch and Pagan developed the Lagrange Multiplier test in 1980, which is used to assess the validity of results about cross-sectional dependency. This conclusion is backed by the fact that the selected OBOR top 10 emitter countries are linked geographically, by socioeconomic engagements and cultural links, and through similarities in several OBOR countries' macroeconomic policies. Additionally, this conclusion is supported by the fact that the OBOR top 10 emitter countries have similar cultural ties. In addition, these countries are recognized as high-income countries by the World Development Index, which lends credence to the idea that cross-sectional reliance exists.

3.2. Homogeneity Test

Another significant issue with panel data is the availability of differing slope coefficients across different cross-sectional units, which can lead to biased results if not considered in the regression analysis [76,77]. The disparities in the EF levels of the Top 10 OBOR emitter countries are most likely to blame for the slope heterogeneity issues in the data set investigated in this study. The slope homogeneity test developed by Dong, Dong, and Jiang [78]. This test recommends to explore slope homogeneity changes for large panel datasets as per [79] to account for bias and with fixed sample sizes and time dimensions.

The approach of [78] predicts two test statistics that are comparable to the test statistic (and) coefficients of the cross-sectional unit slope under the homogeneous null hypothesis. This statistic resembles the predicted test statistic of, except it has been modified for bias [79]. Due to the finite features of the panel dataset analyzed in this study, slope heterogeneity is determined by the statistical significance of the projected statistic.

3.3. Unit Roots Test

Before developing an appropriate regression technique, the suitable integration order between the variables in the relevant model must be determined. Furthermore, non-stationary data increases the likelihood of anticipating erroneous regression parameters [80]. Conventional unit root estimate procedures cannot be applied to cross-sectionally dependent data sets because they assume cross-sectional independence [81]. The Im–Pesaran–Shin (IPS) method is effective in the absence of cross-sectional dependency concerns. Consequently, it is necessary to research methods of the future able to manage cross-sectionally dependent datasets [82]. Consequently, the Cross-sectionally Augmented IPS (CIPS) approach provided by [16] is a superior option for our data set. As seen below, the CIPS test statistic can be predicted using a generalized regression model.

$$\Delta y_{it} = \partial_i + \delta_{iy_{i,t-1}} + c_i\ y\ t - 1 + \sum_{j=0}^{S} d_{ij} \Delta yt - j + \sum_{j=0}^{S} \delta_{ij} \Delta yt - j + e_{it} \quad (3)$$

where δ and ∂ represent the cross-sectional means of first differences and delayed levels, respectively; and *j* is the operator for first differences [75]. Using the following equation, the CIPS test statistic is derived:

$$CIPS(N,T) = N^{-1} \sum_{i=1}^{N} t_i(\mathrm{N},\ \mathrm{T}) \quad (4)$$

All of the aforementioned methods are utilized in this study to compute the unit root properties.

3.4. Cointegration Analysis by Panel

Typical cointegration techniques, such as those created by [83], perform poorly when applied to cross-sectionally dependent data [82]. In contrast, the proposed panel cointegration estimator of [84] performs better under cross-sectional dependence. [82] state that the method of [84] predicts four distinct test statistics (Gt, Ga, Pt, and Pa), where Gt and Ga represent two group-mean test statistics and Pt and Pa represent two panel-mean test statistics.

$$GT = \frac{1}{N} \sum_{i=1}^{N} \hat{\alpha_i} / SE\hat{\alpha_i} \quad (5)$$

$$G_{a=} \frac{1}{N} \sum_{i=1}^{N} T\hat{\alpha_i} / \hat{\alpha_i} \quad (6)$$

$$P_t = \hat{\alpha_i} / SE\hat{\alpha_i} \quad (7)$$

$$P_{a=}\ \mathrm{T}\ \hat{\alpha} \quad (8)$$

In addition, because the technique proposed by [84] necessitates slope homogeneity and no structural break, it is inapplicable to data sets with the aforementioned issues, following [82].

3.5. Cross-Sectional of the ARDL Model

We calculated Chudik and Pesaran's Cross-sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) model for the examination of long- and short-run coefficients [85]. Whether the series is co-integrated or not, and whether the repressors are I_0, I_1, or a combination of both, the CS-ARDL estimator yields reliable results [86]. It takes cross-sectional dependence into account because it is an ARDL variant of the Dynamic Common Correlated Estimator and is based on individual estimations with lagged dependent variables and lagged cross-section averages [85]. Variable slope coefficients allow for the estimation of group means. The mean group variation of the CS-ARDL model is based on supplementing each cross-ARDL section's estimations with cross-sectional averages that serve as surrogates for unobserved common components and their lags [86]. This technique also outperforms the moderate endogeneity issue that occurs when the lagged dependent variable is incorporated into the model. The authors contend that augmenting the model with lagged cross-section averages substantially eliminates the endogeneity issue. Using the subsequent regression, the CSARDL is estimated.

4. Result and Discussion

To select more reliable estimates, we employed the cross-sectional dependency and homogeneity assumptions in the first step of the empirical study. The findings of the dependency study with a cross-sectional approach are presented in Table 2. The null hypothesis of cross-sectional independence is rejected at both the 1% and 5% significance levels by the statistical significance of the test statistics from the procedures of [16], which confirms that there are cross-sectional dependency issues in the data. Table 3 displays the results of the slope homogeneity test performed by [78]. At a 1% level of significance, the anticipated test statistic can be proved to be statistically significant. As a result, the null hypothesis that slope homogeneity exists among cross-sectional units cannot be accepted. As a result, the slope heterogeneity problem must be considered in the analysis, as it implies that the panel dataset used in this study is heterogeneous. Then, a panel unit root analysis is performed.

Table 2. Cross-sectional dependency test.

Variable	Pesaran (2004)	Breusch and Pagan (1980)
CO_2	2.87 ***	21.11 **
EG	19.15 ***	44.23 ***
ICT	21.44 ***	41.15 ***
RE	4.69 ***	18.34 ***
GOB	19.48 ***	23.61 **
FI	8.48 ***	22.50 **

, * represents 5%, and 1% significance level, respectively.

Table 3. Homogeneity Test.

Dependent Variable: CO_2	
Statistics	**Value Prob**
Delta	4.440 *** (0.000)
Adjusted Delta	5.921 *** (0.000)

*** represents 1% significance level.

In the second step, a unit root test was employed. The results of the unit root test are shown in Table 4. Except for globalization and economic growth, all variables are stationary at first differences. Globalization and economic growth are stationary at this level. Further, cointegration analysis was employed to check the cointegration between variables. Table 5 indicates that Gt, Ga, Pt, and Pa are significant at a 1% significance level. It shows that all variables are cointegrated. Moreover, the CS-ARDL approach is employed in Table 6. The CS-ARDL approach is suitable when the data showed stationary at several levels. This study's initial investigation finds multiple orders of stationarity, cross-sectional dependence, and slope heterogeneity which confirm the robustness of the CS-ARDL approach.

Table 4. Unit root test.

	CIPs				Im-Pesaran-Shin			
Var	**Level**	***p*-Value**	**1st Diff**	***p*-Value**	**Level**	***p*-Value**	**1st Diff**	***p*-Value**
CO_2	−2.238	>0.10	−2.215	<0.050 **	−1.5751	0.3642	−2.4368	0.007 ***
EG	−0.949	<0.05 **	−0.949	<0.050 **	−1.4677	0.032 **	−2.2701	0.041 **
ICT	−1.794	>0.10	−1.894	<0.050 **	−1.1613	0.123	−1.9461	0.025 **
RE	−0.912	>0.10	−0.912	<0.050 **	7.4388	0.111	4.8625	0.021 **
GOB	−1.984	<0.05 **	−2.238	<0.050 **	−2.1476	0.016 **	−3.5324	0.002 ***
FI	−2.328	>0.10	−2.467	<0.050 **	1.5255	0.936	8.1188	0.032 **

, * represents 5%, and 1% significance level respectively.

Table 5. Westerlund test.

Dependent Variable: CO_2		
Statistics	**Value**	***p*-Value**
GT	−2.144	0.000
G_a	−3.660	0.000
P_t	−11.444	0.000
P_a	−5.164	0.000

Table 6. CS-ARDL.

	Short Run		
Variables	**Coefficient**	**Stand Error**	***p*-Value**
FI	0.987 **	0.503	**0.050**
ICT	0.003 ***	0.488	**0.004**
RE	1.197 **	1.170	**0.050**
GOB	−5.151	5.565	**0.355**
EG	4.710	1.530	**0.758**
	Long Run		
FI	1.062 **	0.460	**0.021**
ICT	0.003 **	0.002	**0.054**
RE	−0.034 **	0.541	**0.050**
GOB	−1.968 ***	1.930	**0.008**
EG	6.840 *	4.120	**0.097**
ECM	−0.944 ***	0.545	**0.000**

*, **, *** represents 10%, 5%, and 1% significance level respectively.

Table 6 depicts that financial inclusion (FI) has a 5% positive significance with CO_2 emissions in the top 10 OBOR countries in both the long and short run. This means that an increase in financial inclusion also increases CO_2 emissions. This result is consistent with [9,87] This finding suggests that citizens in the top 10 OBOR countries purchased more items during the investigation period, such as automobiles, refrigerators, air conditioners, and television sets, owing to increased access to finance, and whose widespread use accelerates domestic fossil-fuel energy use, resulting in higher CO_2 emissions in the top 10 OBOR countries. It also indicates that the Top 10 OBOR countries allocate their financial resources to achieve their targeted outcomes. In other words, the resources of the Top 10 OBOR countries are still in their beginning stage. Furthermore, in the long run, ICT has a 5% positive significance with CO_2 emissions and a 1% positive significance in the short term. This means that an increase in ICT also increases CO_2 emissions. The expansion of ICT infrastructure and the use of ICT goods can help to boost economic growth by increasing productivity and energy efficiency, lowering transportation costs, and reducing CO_2 emissions. The results are consistent with [68,71]. According to the data, the top 10 OBOR countries' corporate operations are based on technology. These countries have high CO_2 emissions due to their usage of cutting-edge technologies. To reduce CO_2 emissions, renewable energy sources must be used.

Renewable energy has a 5% negative significance with CO_2 emissions in both the long and short run. This indicates that renewable energy decreases CO_2 emissions. This result is in line with [88,89]. Recent study findings have discovered a negative association between renewable energy and CO_2 emissions, referring to the fact that renewable energy allows for the reduction of climate change and greenhouse gas emissions in the top 10 emitter countries [90,91].However, OBOR countries still lag in use of RE as also depicted in Table 7; where the mean value of RE represents the lowest of the figures; thus indicating a need to focus on that more. Furthermore, globalization has a negative 1% significance level association with CO_2 emissions in the long run, while it is insignificant in the short run. According to [62], globalization greatly reduces CO_2 emissions. Globalization has had a significant detrimental impact according to [11] and Shahbaz et al. [48]. Long-term economic growth has a positive 10% significance threshold with CO_2 emissions, but short-term economic growth is irrelevant. These findings are consistent with Ehigiamusoe and Lean [35], Mensah et al. [36], and Musah et al. [37]. A group of researchers asserted a connection between CO_2 emissions and economic development, suggesting that CO_2 emissions rise during the early stages of economic development but decline after a certain level of economic development is attained [26–28]. The findings suggest that the majority of top 10 emitter countries are in the early stages of economic expansion. This is the cause of rapid economic expansion and huge CO_2 emissions. The top 10 emitting countries must establish measures to minimize CO_2 emissions.

Table 7. Descriptive statistics.

Variable	Mean	Std. Dev.	Min	Max
FI	3.030283	0.1931515	2.59961	3.364495
ICT	37.65441	35.67006	9.0481	99.70149
CO_2	4.488163	0.5245749	3.513218	5.752194
RE	0.4771623	1.120934	−2.0442	1.495406
GOB	4.0732	0.2589	3.1223	4.4624
EG	10.70289	0.5249382	9.88947	11.83195

5. Conclusions and Policy Recommendation

The top 10 emitters of CO_2 in the OBOR region were examined in this study to determine the short- and long-term impacts of various factors, including financial inclusion, information and communication technology, renewable energy, globalisation, and economic growth. Results from 2004 to 2019 were examined using data from the OBOR top 10 emitter countries. In the top 10 OBOR countries, financial inclusion (FI) has a positive long- and short-term relationship with CO_2 emissions, according to the CS-ARDL research. ICT also has a long- and short-term favourable relationship with CO_2 emissions. Although globalisation has little impact on CO_2 emissions in the short term, it has a negative impact on them over time. Long-term economic expansion is positively related to CO_2 emissions.

A lack of investment in renewable energy could explain the rise in CO_2 emissions in OBOR countries. The adoption of modern ICT applications such as online shopping, mobile apps, online funds transfer and payments, and efficient power usage will result in further reducing CO_2 emissions. Furthermore, several legislative measures should be studied to improve economic advancement and environmental quality while sustaining long-term sustainability. The construction of ICT infrastructure has the potential to strengthen the power of policies while also playing an essential role in boosting people's environmental consciousness. OBOR countries should promote green and eco-friendly FDA along with technical support and training facilities for the workforce that will enhance the ownership among the workforce to adopt green human practices and closed-loop production practices in the industry.

In many aspects, this study provides a wide range of opportunities for future researchers. For instance, additional research might be conducted by including other variables that have an impact on CO_2 emissions. Second, future research may employ all OBOR countries; this analysis only used the top 10 emitter countries. Third, researchers may also employ other econometric methods.

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