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The Effect of Energy Consumption and Economic Growth on Environmental Sustainability in the GCC Countries: Does Financial Development Matter?

Hala Baydoun [1,2,3,*] and Mehmet Aga [1]

1 Department of Accounting and Finance, Faculty of Economics and Administrative Sciences, Cyprus International University, North Cyprus, Mersin 10, Haspolat 99040, Turkey; maga@ciu.edu.tr
2 Department of Accounting Information Systems, School of Business, Lebanese International University, Beirut, Lebanon
3 Department of Banking and Finance, School of Business, Lebanese International University, Beirut, Lebanon
* Correspondence: hala.baydoun@liu.edu.lb

Abstract: Achieving environmental sustainability whilst minimizing the climate change effect has become a global endeavor. Thus, this study examined the effect of energy consumption (EC), economic growth (GDP), globalization (GLO), financial development (FD) on CO_2 emissions in the GCC countries. The research utilized a dataset stretching from 1995 to 2018. In a bid to investigate these associations, this study applied cross-sectional dependence (CSD), slope heterogeneity, Pesaran unit root, Westerlund cointegration, cross-sectionally augmented autoregressive distributed lag (CS-ARDL), and Dumitrescu and Hurlin (D–H) causality approaches. The outcomes of the CSD and slope heterogeneity tests indicated that using the first-generation techniques will produce misleading results. The panel unit root analysis unveiled that the series are I (1). Furthermore, the outcomes of the cointegration test revealed a long-run association between CO_2 and the regressors, suggesting evidence of cointegration. The findings of the CS-ARDL showed that economic growth and energy consumption decrease environmental sustainability, while globalization improves it. The study also validated the environmental Kuznets curve (EKC) hypothesis for the GCC economies. In addition, the results of the D–H causality test demonstrated a feedback causality association between CO_2 and GDP and between financial development and CO_2. Moreover, there is a one-way causality from energy use and globalization to CO_2 emissions in the GCC economies. According to the findings, environmental pollution in the GCC countries is output-driven, which means that it is determined by the amount of energy generated and consumed.

Keywords: CO_2 emissions; economic growth; energy consumption; financial development; environmental sustainability

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1. Introduction

Substantial economic expansion and industrialization have resulted in rising energy consumption and environmental deterioration, posing challenges to sustainable development [1]. In 2019, global primary energy consumption grew by 1.3% [2]. Energy is a requirement for economic growth as well as the primary cause of environmental deterioration, and climate change is connected to the utilization of energy and greenhouse gas (GHGs) emissions [3]. Numerous environmental researches have emphasized the need of reducing GHGs, specifically CO_2 emissions, which account for the largest chunk of GHGs [4]. Understanding the reasons for rising CO_2 emissions and developing suitable mitigation plans is vital for all governments, but it is specifically important for Gulf Cooperation Council (GCC) nations due to their unique features. The six Gulf countries of the Gulf Cooperation Council (GCC) are Kuwait, Oman, Bahrain, United Arab Emirates (UAE), Qatar, and Saudi Arabia, are rich in resources and control 19.8% of natural-gas holdings globally [2]. Saudi Arabia, UAE, and Qatar are amongst the globe's leading emitters [5]. Fossil fuels are the foundation of these nations, which rely on earnings from fossil fuel exports to fund industrial activities that have a negative impact on environmental quality [6]. Although renewable energy sources account for a tiny portion of these economies' energy mix, they are heavily dependent on fossil fuels. The energy consumption in this region is increasing as a result of expanding population, fast urbanization, and economic expansion, presenting a severe challenge to the sustainability of the environment [7]. These nations generate 2.4% of global GHGs, more than the EU. These nations are likewise anticipated to see a large upsurge in energy utilization as income grows as well as the demand for luxury goods [7].

This research investigates the links between CO_2 emissions (CO_2), economic growth (GDP), financial development (FD), and globalization (GLO). Many researchers have focused on globalization in recent years since the globalization process can impact sustainability. Dreher [8] created the globalization index, which is made up of economic, social, and political variables. It is a combination of political, social, and economic indices in the first dataset; nevertheless, subsequent research by [9] included some more sub-indices for a better understanding of this process. The association between GLO and CO_2 has been investigated by prior studies; however, their outcomes are mixed. For instance, the studies of [10] for the top 10 electricity consuming countries, [11] for 23 African countries, and [12] established a negative CO_2–GLO connection, while the studies of [13] for BRICS, [14] for WAME countries, and [15] found a positive CO_2–GLO connection.

Furthermore, financial development (FD) is a big component that can impact levels of environmental deterioration. FD may have an impact on environmental deterioration in a variety of ways. For instance, financial institutions' lending can lead to company development, which can increase energy use, land use, and the creation of waste. Individuals' financial demands are also supported by financial institutions, and a rise in purchasing power can increase resource consumption, resulting in more damage to the environment. On the other hand, financial institutions may encourage technical progress that reduces the utilization of energy and therefore decreasing environmental damage [16]. Furthermore, financial institutions may play a beneficial role in supporting initiatives that may lead to technological innovation because innovation is unachievable without adequate investment in research and development. There are conflicting data on the FD–CO_2 relationship. For instance, the research of [17,18] established a negative FD–CO_2 connection, while the works of [19,20] found a positive FD–CO_2 connection.

The different perspectives of these research studies suggest that globalization, energy usage, economic expansion, and financial development have varying effects on environmental deterioration. GCC countries are presently confronted with increased globalization processes as well as increased utilization of energy and GDP, posing a considerable challenge in the context of ecological quality. As a result, the current study will assist policymakers in pursuing more pragmatic planning and maximizing decision-making linked to environmental abatement in general, and particularly in the GCC nations. This study offers several major contributions to the existing studies. First, it investigates the impact of globalization, energy usage, economic growth, and financial development on CO_2 in the particular context of the GCC countries, whilst incorporating factors that are essential to the region's economic prosperity. Second, to address the issue of CSD and heterogeneity, this study utilizes an advanced panel data estimate approach. Additionally, the present research contributes by utilizing a novel CS-ARDL model to solve the problems of heterogeneity and CSD of panel data, which are ignored by previous studies.

The remainder of the paper includes different sections. Section 2 is a review of the literature, and Section 3 involves the research methodology with an explanation of the empirical models, data, and methods. Section 4 presents the study results and the findings along with the discussion of these findings. Finally, Section 5 depicts the conclusion and the policy path.

2. Literature Review

This section of the paper discusses in detail past research conducted regarding the association between CO_2 emissions (CO_2), financial development (FD), energy consumption (EC), globalization (GLO), and economic growth (GDP).

2.1. CO_2, Energy Consumption, and Economic Growth

In the empirical literature, it is generally acknowledged that there is a connection between energy consumption or utilization (EC), economic growth (GDP), and CO_2 emissions (CO_2). Energy is needed for production, which spurs economic expansion and stimulates degradation of the environment. The study of [21] in Tunisia, utilizing impulse response and cointegration approaches between 1971 and 2005, unveiled an EC–CO_2 positive connection. Likewise, in the GCC economies, [22] assessed the CO_2–GDP–EC connection utilizing PMG and panel causality from 1980 to 2012. The investigators applied PMG and causality approaches, and their empirical outcomes unveiled an insignificant connection between GDP and CO_2, while energy utilization impacts CO_2 positively. Furthermore, feedback causality linkage surfaced between EC and CO_2. Using Toda–Yamamoto Causality, [23] assessed the CO_2–EC–GDP connection in India utilizing a dataset between 1971 and 2011. The outcomes of the study disclosed feedback causality linkage between energy utilization and CO_2 and between EC and CO_2. The study of [24], in 170 economies utilizing data from 1980 to 2011 and VECM, uncovered that both GDP and EC triggers CO_2. Furthermore, feedback causality linkage exists between EC and CO_2, while there is evidence of one-way causality from GDP to CO_2. In the United States, using panel OLS and data from 1997 to 2016, [25] established that GDP and EC impact CO_2 positively. Moreover, the environmental Kuznets curve (EKC) hypothesis is validated. Utilizing Dynamic ARDL, and Frequency Domain Causality approaches, [26] assessed the CO_2–GDP–EC in Pakistan using data covering the period from 1972 to 2018. Their outcomes unveiled that both GDP and EC contribute to the degradation of the environment, and GDP Granger causes CO_2. The positive CO_2–GDP–EC association is validated by the study of [27]. Moreover, [28] assessed the CO_2–GDP–EC connection in Brazil utilizing datasets from 1990 to 2018. The investigators utilized FMOLS, DOLS, and frequency domain causality approaches, and the study outcomes showed that an upsurge in energy utilization and GDP contributes to the degradation of the environment. Similarly, the study of Adebayo et al. (2021) in South Korea, using a dataset from 1980 to 2018 and the ARDL approach, disclosed that an upsurge in growth and utilization of energy mitigate the quality of the environment in South Korea. Likewise, a study conducted by [29] found that an upsurge in GDP triggers emissions levels in Australia. Moreover, the study of [30] using a dataset from 1980 to 2017 for the case of Nigeria revealed that degradation of the environment is caused by an upsurge in both energy utilization (EC) and economic growth (GDP).

2.2. CO_2 and Financial Development

The study of [31] on the association between CO_2 emissions (CO_2) and financial development (FD) in G8 and D8 countries, which utilized data from 1999 to 2013 and used PMG-panel ARDL, showed that there is a positive connection between CO_2 and FD in both G8 and D8 economies. In addition, there is a one-way causal linkage from FD to CO_2. Similarly, [32] looked at the connection between FD and CO_2 in 184 nations from 1990 to 2017. The investigator used the GMM to explore this association, and the outcome disclosed a negative FD–CO_2 connection suggesting that FD contributes to the sustainability of the environment in the 184 countries. On the contrary, the study of [33] in China, utilizing data from 1980 to 2016 and ARDL, revealed a negative FD–CO_2 association which demonstrates that FD contributes to the degradation of the environment. Similarly, the study of [34] on the FD–CO_2 association utilizing the South Asian economies as a case study from 1990 to 2014 disclosed FD–CO_2 positive linkage. In addition, FD Granger causes CO_2. Likewise, [18] assessed the FD–CO_2 connection in South Africa utilizing data from the period 1980 and 2017. They utilized ARDL, FMOLS, DOLS, and the novel spectral causality approaches. The outcomes from the FMOLS and DOLS disclosed an FD–CO_2 negative connection whilst the causality test revealed a one-way causality from FD to CO_2 in the short run and the long run. Similarly, [35] scrutinized the FD–CO_2 linkage in Turkey utilizing FMOLS and DOLS and data stretching from 1960 to 2014. The study outcomes showed a positive connection between FD and CO_2, while the Granger causality outcome uncovered a unidirectional causality from FD to CO_2 in Turkey. Moreover, using a yearly dataset spanning from 1970 to 2016, [36] assessed the financial development emissions nexus in Thailand using the novel wavelet coherence and ARDL approaches. The findings of the study uncovered that an upsurge in financial development does not have a substantial influence on the level of emissions in Thailand.

2.3. CO_2 and Globalization

Over the years, many studies on the connection between CO_2 emissions (CO_2) and globalization (GLO) have been conducted; nonetheless, there is no consensus on the influence of GLO on CO_2. For instance, using the top 10 electricity-consuming nations, [10] assessed the GLO–CO_2 connection using data from 1971 to 2013. The investigators applied both FMOLS and DOLS to explore the linkage between the series, and their findings disclosed that GLO negatively impacts CO_2 suggesting that an upsurge in GLO improves the quality of the environment. Furthermore, there is a one-way causal linkage from GLO to CO_2. Likewise, the study of [37] on the GLO–CO_2 association utilizing 31 developed and 155 developing economies between 1991 and 2018 showed a negative linkage between CO_2 and GLO, which implies that an upsurge in GLO mitigates degradation of the environment. Utilizing 23 African countries, [38] examined the GLO–CO_2 connection by employing the Driscoll–Kraay estimator and data from 1999 to 2017. Their outcome disclosed a negative GLO–CO_2 association. Likewise, [12] looked into the GLO–CO_2 association utilizing ARDL, Dual Gap Approach, and Frequency Domain Causality, and their outcomes revealed a negative GLO–CO_2 association and that GLO causes CO_2. On the contrary, the research of [15] on the dynamics between FD and CO_2 in Turkey using data from 1971 to 2016 as well as Fourier ADL cointegration and Fourier Causality tests disclosed that there is a CO_2–FD connection. Furthermore, the causality test unraveled unidirectional causal linkage from GLO to CO_2. This outcome is supported by the study of [6] in WAME economies utilizing data from 1990 to 2017. The study of [39] on the interrelationship between emissions and globalization using advanced time-series approaches found that an upsurge in globalization aids in mitigating emissions levels in Argentina.

Table 1 presents a synopsis of the linked studies discussed above.

Table 1. Summary of seminal studies.

Author(s)	Nations(s)	Time-Frame	Method(s)	Finding(s)
		Effect of EC and GDP on CO_2		
[21]	Tunisia	1971–2005	Cointegration, impulse response	GDP ⇨ CO_2 (+) EC ⇨ CO_2 (+)
[22]	GCC economies	1980–2012	PMG, causality	GDP ≠ CO_2 EC ⇨ CO_2 (+) EC ⇔ CO_2
[40]	One hundred and eighty-eight countries	1993–2010	PMG, causality	GDP ⇨ CO_2 (+) GDP ⇨ CO_2 EC ⇨ CO_2 (+) EC ⇔ CO_2
[23]	India	1971–2011	Toda–Yamamoto causality	EC ⇨ CO_2 GDP ⇨ CO_2 EC ⇔ GDP

Table 1. *Cont.*

Author(s)	Nations(s)	Time-Frame	Method(s)	Finding(s)
		Effect of EC and GDP on CO_2		
[24]	One hundred and seventy countries	1980–2011	Panel VECM	GDP ⇨CO_2 (+) GDP ⇨CO_2 EC ⇨CO_2 (+) EC ⇔ CO_2
[20]	ASEAN-5 countries	1980–2016	Panel causality	In Malaysia and Singapore GDP ⇨CO_2 In Thailand EC ⇨GDP
[25]	United States	1997–2016	Panel OLS	GDP ⇨CO_2 (+) EC ⇨CO_2 (+) GDP^2 ⇨CO_2 (−)
[26]	Pakistan	1972–2018	Dynamic ARDL, frequency domain causality	GDP ⇨CO_2 (+) EC ⇨CO_2 (+) GDP ⇨CO_2
[41]	Thirty Chinese provinces	2000–2017	VECM	EC ⇨CO_2 GDP ⇨CO_2
[42]	Spain	1970–2018	Threshold vector autoregression (TVAR)	REC ⇨CO_2 (−) GDP ⇨CO_2 (+)
		Effect of FD on CO_2		
[31]	G8 and D8 countries	1999–2013	PMG-Panel ARDL	FD ⇨CO_2 (+) FD ⇨CO_2
[32]	184 countries	1990–2017	GMM	FD ⇨CO_2 (−)
[33]	China	1995–2017	CS-ARDL	FD ⇨CO_2 (+)
[43]	Bangladesh	1980–2016	ARDL	FD ⇨CO_2 (−)
[34]	South Asian economies	1990–2014	FMOLS, DOLS, D–H Causality	FD ⇨CO_2 (+) FD ⇨CO_2
[18]	South Africa	1980–2017	ARDL, FMOLS, DOLS	FD ⇨CO_2 (−) FD ⇨CO_2
[35]	Turkey	1960–2014	FMOLS, DOLS	FD ⇨CO_2 (−) FD ⇨CO_2
		Effect of GLO on CO_2		
[10]	Top 10 electricity-consuming countries	1971–2013	FMOLS, DOLS	GLO ⇨CO_2 (−) GLO ⇨CO_2
[17]	Thirty-one developed and 155 developing economies	1991–2018	GMM	GLO ⇨CO_2 (−)
[11]	Twenty-three African countries	1999–2017	Driscoll–Kraay estimator	PGLO ⇨CO_2 (−) EGLO ⇨CO_2 (−)
[44]	Sweden	1990–2018	Quantile-on-quantile	GLO ⇨CO_2 (−) GLO ⇨CO_2
[13]	BRICS	1971–2016	Fourier ADL cointegration, Fourier causality	GLO ⇨CO_2 (+) GLO ⇨CO_2
[45]	Turkey	1971–2016	Dual gap approach, FMOLS	GLO ⇨CO_2 (+) GLO ⇨CO_2
[14]	WAME countries	1990–2017	Panel techniques	GLO ⇨CO_2 (+) GLO ⇨CO_2

3. Research Methodology

3.1. Theoretical Underpinning and Model

Economic expansion can impact CO_2 in three different ways, namely scale, composite, and technique effects. The scale effect states that economic expansion pollutes the environment at first because it necessitates more resources and energy, resulting in greater pollution and waste [46]. The degree of pollution and the materials utilized in the production process, on the other hand, are determined by a nation's sectoral structure. As a result, the composition effect expects the structural transition of countries from the industrial to the service sector to minimize the adverse effects of economic development on the environment. Finally, the technique effect shows that when a country's affluence rises, it adopts new and sophisticated technology that boosts production while mitigating emissions [47].

Energy is a critical input in an economy's production process, given the enormous increase in the use of alternative energy sources, because it is the cornerstone of transportation, agricultural production, industry, and home, and therefore, energy dependency will keep growing as the global population grows, and development and economic growth continue [48]. Urbanization and an interconnected global economy will exacerbate energy consumption and reliance as a result of increased telecommunications and mobility. Increasing energy use has a negative impact on the environment, health, safety, lifestyle, and communications, as history has proven.

Furthermore, financial development may contribute to environmental quality through investing in green technology and greener energy products. Financial development, on the other side, may stimulate economic activity, resulting in higher energy consumption and CO_2 emissions [18]. Scholars have disproportionately concentrated on the links between energy utilization, globalization, and their use in recent years. Theoretically, this relationship is simple; as countries become more international, their energy needs increase as well. It is commonly assumed that as globalization develops, trade barriers will decrease, resulting in increased output and income for a nation. Increases in wealth and output are connected to increases in energy usage [49]. As it is often assumed that growing globalization is related to greater levels of GDP, it is commonly assumed that GLO is a source of rising energy consumption. Based on this debate, the current study investigates the link between GDP, EC, FD, and CO_2 using the following model.

This research follows the works of [50] by incorporating globalization into the model.

$$C0_{2i,t} = \alpha_0 + \theta_1 GDP_{i,t} + \theta_2 EC_{i,t} + \theta_3 FD_{i,t} + \theta_4 GLO_{i,t} + \varepsilon_{i,t} \quad (1)$$

where "i" illustrates the cross-sections, i.e., the GCC countries. The period of time (1995–2018) is depicted by t. The intercept term is denoted by α. Moreover, ε and θ' s stand for parameters and error terms, respectively. Carbon emission is illustrated by CO_2 which is calculated as per capita emissions. Economic growth (GDP) is measured as GDP per capita (constant $2010 USD) is utilized in measuring the degradation of the environment. The energy utilization is represented by EC, and it is calculated as energy use per capita (Kwh). The financial development (FD) is measured as domestic credit to the private sector, and it is depicted by FD. Finally, globalization (GLO) is measured as an index based on FDI, trade, and portfolio investment. In this study, both EC and CO_2 are obtained from the database of British petroleum (BP). Furthermore, GDP and FD are gathered from the World Bank database and the IMF database. Lastly, GLO is gathered from [9].

In terms of the anticipated signs of the indicators' coefficients, it is generally believed that increasing output leads to environmental deterioration via growing resource and energy usage. The continuous growth of GCC economies presents a severe danger to the environment due to unsustainable development practices. Thus, it is anticipated that the relationship between CO_2 emissions and economic growth is positive $\left(\theta_1 = \frac{\delta CO_2}{\delta GDP} > 0\right)$. A large proportion of the GCC energy utilization comes from nonrenewable energy sources. Therefore, the connection between utilization of energy and CO_2 is expected to be positive $\left(\theta_2 = \frac{\delta CO_2}{\delta EC} > 0\right)$. Besides, a negative association is expected to appear between financial development and CO_2 emissions $\left(\theta_3 = \frac{\delta CO_2}{\delta FD} < 0\right)$; otherwise, it is deemed positive when it is not eco-friendly $\left(\theta_3 = \frac{\delta CO_2}{\delta FD} > 0\right)$. Lastly, GLO is included in the empirical model of CO_2. Globalization has boosted competitiveness by expanding the flow of products and services, posing a serious danger to the environment. As a result, GLO is anticipated to positively impact CO_2 $\left(\theta_4 = \frac{\delta CO_2}{\delta GLO} > 0\right)$; otherwise, it is deemed negative when it is eco-friendly $\left(\theta_4 = \frac{\delta CO_2}{\delta GLO} < 0\right)$.

3.2. Data

The research used panel data for the GCC nations from 1995 to 2018 to assess the dynamic connection between CO_2 and the regressors. The variables employed in this empirical analysis are economic growth (GDP), globalization (GLO), CO_2 emissions (CO_2), energy consumption (EC), and financial development (FD). Table 2 comprises the variables, the signs, the measurements, and the data sources.

Table 2. Variables, signs, measurements, and data sources.

Variable	Sign	Measurement	Data Source
Carbon emissions	CO_2	Per capita emissions	BP
Economic growth	GDP	Per Capita (constant 2010$)	WDI
Energy consumption	EC	Per capita energy use	BP
Financial development	FD	Domestic credit to the private sector	WDI
Globalization	GLO	Index based on FDI, trade, and portfolio investment	[9]

3.3. Estimation Approaches

3.3.1. Cross-Sectional Dependence (CSD) Test

This study commenced by examining cross-sectional dependence (CD) because nations are linked via numerous economic, social, and cultural networks that may produce spillover effects. Consequently, the present research utilized both the Pesaran Scaled LM and [51] CD tests to ascertain the cross-sectional dependence. The CSD test equation is stipulated as follows:

$$CSD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \quad (2)$$

where pairwise correlation is illustrated by $\hat{\rho}_{ij}$.

3.3.2. Slope Homogeneity (SH) Test

The next phase assessed the existence of slope heterogeneity amongst the cross-sectional units. The issue of heterogeneity must be determined because, due to differences in developing nations' economic and demographic structure, there is a possibility of slope heterogeneity, which can potentially affect the consistency of panel estimators. For this reason, this study utilized the slope homogeneity method. The [52] test is illustrated below:

$$\widetilde{\Delta}_{SH} = (N)^{\frac{1}{2}}(2k)^{-\frac{1}{2}}\left(\frac{1}{N}\widetilde{S} - k\right) \quad (3)$$

$$\widetilde{\Delta}_{ASH} = (N)^{\frac{1}{2}}\left(\frac{2k(T-k-1)}{T+1}\right)^{-\frac{1}{2}}\left(\frac{1}{N}\widetilde{S} - 2k\right) \quad (4)$$

where $\widetilde{\Delta}_{SH}$ and $\widetilde{\Delta}_{ASH}$ stand for delta tilde and adjusted delta tilde, respectively.

3.3.3. Stationarity Test

Understanding the stationarity characteristics of series is critical in empirical analysis. To capture the stationarity features of the series under consideration, we used both the cross-sectionally augmented ADF (CADF) and the cross-sectionally augmented IPS (CIPS). This method works well, especially when the slope is heterogeneous and the CSD. The equations for these tests are as follows:

$$\Delta Y_{i,t} = \gamma_i + \gamma_i Y_{i,t-1} + \gamma_i\, \overline{X}_{t-1} + \sum_{l=0}^{p} \gamma_{il} \Delta \overline{Y_{t-1}} + \sum_{l=1}^{p} \gamma_{il} \Delta Y_{i,t-1} + \varepsilon_{it} \quad (5)$$

where the first differences averages and the lagged are illustrated by $\Delta\overline{Y_{t-1}}$ and $\overline{Y}_{t-1}$, respectively. Moreover, by taking the average of each CADF, the CIPS is obtained as illustrated in the following equation:

$$\widehat{CIPS} = \frac{1}{N} \sum_{i=1}^{n} CADF_i \quad (6)$$

3.3.4. Cointegration Test

It is critical to capture the long-term relationship between the variables of interest. As a result, the [53] cointegration test was used in this study to capture the long-run relationship between CO_2 and the regressors. Unlike the traditional cointegration tests (e.g., Kao and Pedroni), this test offers impartial outcomes in the presence of CD and heterogeneity. The cointegration test is presented as follows:

$$\alpha i(L)\Delta y_{it} = y2_{it} + \beta_i (y_{it} - 1 - \acute{\alpha}_i x_{it}) + \lambda_i (L) v_{it} + \eta_i \quad (7)$$

where $\delta_{1i} = \beta_i(1)\hat{\vartheta}_{21} - \beta_i \lambda_{1i} + \ \beta_i \hat{\vartheta} 2_i$ and $y2_i = -\beta_i \lambda 2_i$

The Westerlund cointegration statistics are presented as follows:

$$G_t = \frac{1}{N} \sum_{i-1}^{N} \frac{\acute{\alpha}_i}{SE(\acute{\alpha}_i)} \quad (8)$$

$$G_\alpha = \frac{1}{N} \sum_{i-1}^{N} \frac{T\acute{\alpha}_i}{\acute{\alpha}_i(1)} \quad (9)$$

$$P_T = \frac{\acute{\alpha}}{SE(\acute{\alpha})} \quad (10)$$

$$P_\alpha = \ T\acute{\alpha} \quad (11)$$

where G_a and G_t stand for group means statistics, while P_a and P_t pertain to panel statistics.

3.3.5. Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL)

The CS-ARDL test, developed by [54], was used in this work for both long-run and short-run estimates. This test is more reliable and efficient than other approaches such as mean group (MG), pooled mean group (PMG), augmented mean group (AMG), and common correlated effect mean group (CCMG). The problems of homogeneity slope coefficients, CSD, non-stationarity, unobserved common variables, and endogeneity are all addressed by this technique. This is due to the fact that ignoring unobserved common variables will result in incorrect estimation results, as stated by Wang et al. (2021). The equation below depicts the CS-ARDL:

$$Y_{it} = \sum_{i=1}^{py} \pi_{it} Y_{i,t} + \sum_{i=0}^{pz} \theta_{i1}^{\iota} Z_{i,t-1} + \sum_{i=0}^{pT} \phi_{i1}^{\iota} Z_{i,t-1} + e_{it} \quad (12)$$

where $X_{t-1}^{-} = \left(Y_{t-1}^{-}, Z_{t-1}^{-}\right)\iota$, $\overline{Y_t}$ and $\overline{Z_t}$ illustrate average cross-sections. Moreover, X_{t-1}^{-} illustrates the averages of both dependent and regressors:

$$\hat{\vartheta}_{CS-ARDL,i} = \frac{\sum_{i=0}^{pz} \hat{\theta}_{iI}^{\iota}}{1 - \sum_{I=1}^{py} \hat{\pi}_{iI}} \tag{13}$$

$$\hat{\vartheta}_{mean\ group(MG)} = \frac{1}{N}\sum_{i=1}^{N} \hat{\vartheta}_i \tag{14}$$

3.3.6. Dumitrescu and Hurlin Causality

The study used a causality test established by Dumitrescu and Hurlin (2012), to evaluate the causative relationship between CO_2 emissions and GLO, EC, FD, and GDP. This test is appropriate if T is larger than or equal to N. This approach is also beneficial for a balanced and diverse panel data collection. This approach can also be used to deal with cross-sectional dependency. Equation (15) depicts the Dumitrescu and Hurlin Causality test as follows:

$$z_{i,t} = \alpha_i + \sum_{j=1}^{p} \beta_i^j z_{i,t-j} + \sum_{j=1}^{p} \gamma_i^j T_{i,t-j} \tag{15}$$

where the lag length is illustrated by j, and the autoregressive parameters are depicted by β^j (j). The alternative and null hypotheses postulate causal association and no causal association, respectively.

4. Findings and Discussion

4.1. Findings

The empirical analyses of this study are depicted in this section. First, we conducted a CSD test on the variables of interest. The outcome of the CSD test is presented in Table 3. The findings unveiled that all the series of interests have the issue of CSD. The outcomes demonstrated that we failed to reject the alternative hypothesis. The importance of the CD is derived from the fact that in today's globalized world, nations are intertwined. This means that any change in one GCC nation's fundamental variable might affect other GCC nations. As a result of spillover effects, the variables are cross-sectionally dependent. Moreover, Table 4 shows that the GCC nations have different levels of technological advancement and growth. As a consequence, the findings confirmed the occurrence of heterogeneity slope coefficients. Furthermore, we assessed the series stationarity characteristics of the series which are depicted in Table 5, and the outcomes revealed that series are I (1) variables.

Table 3. Cross-sectional dependence (CSD).

	CO_2	GDP	EC	FD	GLO
Breusch–Pagan LM	227.24 *	99.257 *	162.43 *	227.24 *	410.54 *
Pesaran scaled LM	38.749 *	15.383 *	26.918 *	38.749 *	72.216 *
Bias-corrected scaled LM	38.646 *	15.279 *	26.815 *	38.646 *	72.113 *
Pesaran CD	14.512 *	4.3758 *	−1.7779 ***	14.512 *	20.261 *

Note: * and *** depict $p < 1\%$ and $p < 10\%$, respectively.

Table 4. Slope homogeneity (SH).

	Test Value	*p*-Value
Delta tilde	4.352	0.000 *
Delta tilde adjusted	4.972	0.000 *

Note: * depicts $p < 1\%$.

Table 5. Cross-sectionally augmented IPS (CIPS).

	Level	First Difference
CO_2	−2.103	−5.867 *
GDP	−1.828	−4.474 *
EC	−1.722	−5.234 *
FD	−1.741	−3.527 *
GLO	−2.586	−5.300 *

Note: * depicts $p < 1\%$.

It is crucial to capture the long-run connection between CO_2 and EC, FD, GDP, and GLO in the GCC economies. In doing so, we applied the Westerlund (2007) cointegration test which is depicted in Table 6. The outcomes of the cointegration test are shown in Table 6. The outcome of the test unveiled the presence of a long-run association between CO_2 and EC, FD, GDP, and GLO. Furthermore, as a robustness check, we applied the Pedroni and Kao cointegration tests. The outcomes of the tests are presented in Table 7. The outcomes disclosed evidence of a long-run connection between CO_2 and EC, FD, GLO, and GDP. Thus, the outcomes of the Pedroni and Kao cointegration tests validate the Westerlund (2007) cointegration test.

Table 6. Cointegration.

Statistic	Value	Z-Value	*p*-Value
Gt	−3.275 *	−3.087	0.001
Ga	−6.022	1.328	0.908
Pt	−6.423 **	−1.944	0.026
Pa	−6.257	−0.048	0.481

Note: * and ** depict $p < 1\%$ and $p < 5\%$, respectively.

Table 7. Kao and Pedroni outcomes.

Panel A: Kao				
	T-Stat	Prob		
ADF	−4.4890 *	0.0000		
Residual-variance	0.0018			
HAC variance	0.0014			
Panel B: Pedroni				
			Weighted	
	Stat	Prob	Stat	Prob
Panel v-stat	1.1438	0.1263	1.1543	0.1242
Panel rho-stat	0.2267	0.5897	0.2645	0.6043
Panel PP-stat	−2.3354 *	0.0098	−2.0974 **	0.0180
Panel ADF-stat	−2.3855 *	0.0085	−2.1508 **	0.0157
Group rho-stat	1.1387 *	0.8726		
Group PP-stat	−3.1699 *	0.0008		
Group ADF-stat	−4.5722 *	0.0000		

Note: * and ** depict $p < 1\%$ and $p < 5\%$, respectively.

After we affirmed the long-run interrelationship between CO_2 and the regressors, we proceeded to the estimation of the long-run and the short-run connection between CO_2

emissions and the regressors after the long-run cointegration between CO_2 and EC, FD, GLO, and GDP has been established. In doing so, we applied the CS-ARDL to capture both short-run and long-run connections between CO_2 and the regressors. The outcomes of the long-run CA-ARDL are presented in Table 8. The outcomes revealed the following: the influence of CO_2 on GDP growth is positive and significant, suggesting that a 1.829% upsurge in CO_2 is attributed to a 1% upsurge in GDP in the GCC economies when other indicators are kept constant. Besides, we also affirmed the EKC hypothesis since the coefficient of GDPSQ is negative (0.127) and statistically significant. Furthermore, the connection between CO_2 and energy use is positive and significant which implies that keeping other factors constant, a 1% upsurge in utilization of energy triggers CO_2 by 0.028%. Moreover, the CO_2–FD association is positive and insignificant. Lastly, the CO_2–GLO connection is negative and significant illustrating that a −0.922% decrease in CO_2 is linked with a 1% upsurge in globalization keeping other factors constant.

Table 8. Cross-sectionally augmented autoregressive distributed lag (CS-ARDL) outcomes.

Panel A: Short-Run Results				
Regressors	**Coefficient**	**StdErr.**	**Z-Stat.**	***p*–Value**
ECM (−1)	−0.801 *	0.2901	−4.017	0.002
GDP	1.080 *	0.362	4.669	0.000
GDPSQ	−0.053 **	0.018	−1.903	0.014
EC	0.038 ***	0.013	1.886	0.064
FD	1.170	0.609	0.727	0.468
GLO	−1.835 *	0.049	−3.929	0.000
Panel B: Long-Run Results				
	Coefficient	**StdErr.**	**Z-Stat.**	***p*–Value**
GDP	1.829 ***	0.030	1.886	0.062
GDPSQ	−0.127 *	0.045	−2.784	0.006
EC	0.028 *	0.004	6.252	0.000
FD	−1.679	0.133	−1.480	0.141
GLO	−0.922 *	0.538	−4.699	0.000

Note: *, **, and *** depict $p < 1\%$, $p < 5\%$, and $p < 10\%$, respectively.

After confirming the association between CO_2 and the regressors (FD, EC, GLO, and GDP) in the long run, we also estimated the short-run association which is represented in Table 8. In the short run, the outcomes of the CS-ARDL showed findings that are similar to the long-run outcomes. In the short run, the influence of GDP and EC on CO_2 is positive, while GLO impacts CO_2 negatively. As anticipated, the ECM (–0.801) is negative, which illustrates that corrections made in past periods can be rectified in succeeding periods.

The present study takes a step further by assessing the causal connection between CO_2 and EC, GLO, and GDP in the GCC countries. The outcomes of the causal association between CO_2 and the regressors are presented in Table 9. The outcomes from the D–H causality test uncovered a one-way causal linkage from the utilization of energy to CO_2. This demonstrates that EC can predict CO_2. Moreover, there is bidirectional causality between FD and CO_2, which implies that FD can predict CO_2 and vice-versa. Furthermore, there is a feedback causality association between GDP and CO_2, which implies that both GDP and CO_2 can predict each other. Lastly, there is a unidirectional causal linkage from GLO to CO_2, which disclosed that GLO can predict CO_2 emissions. Figure 1 illustrates the graphical findings of the empirical analysis.

Table 9. Dumitrescu and Hurlin (D-H) causality outcomes.

Direction of Causality	W-Stat.	Zbar-Stat.	Prob.	Decision
EC → CO_2	2.78598 **	2.54193	0.0110	One-way causality
CO_2 → EC	0.81241	−0.40790	0.6833	
FD → CO_2	6.68909 *	8.31375	0.0000	Feedback causality
CO_2 → FD	4.03315 *	4.37064	0.0000	
GDP → CO_2	4.00496 *	4.38192	0.0000	Feedback causality
CO_2 → GDP	7.64135 *	9.83586	0.0000	
GLO → CO_2	7.36713 *	9.37155	0.0000	One-way causality
CO_2 → GLO	0.67537	−0.47251	0.5953	

Note: * and ** depict $p < 1\%$ and $p < 5\%$, respectively.

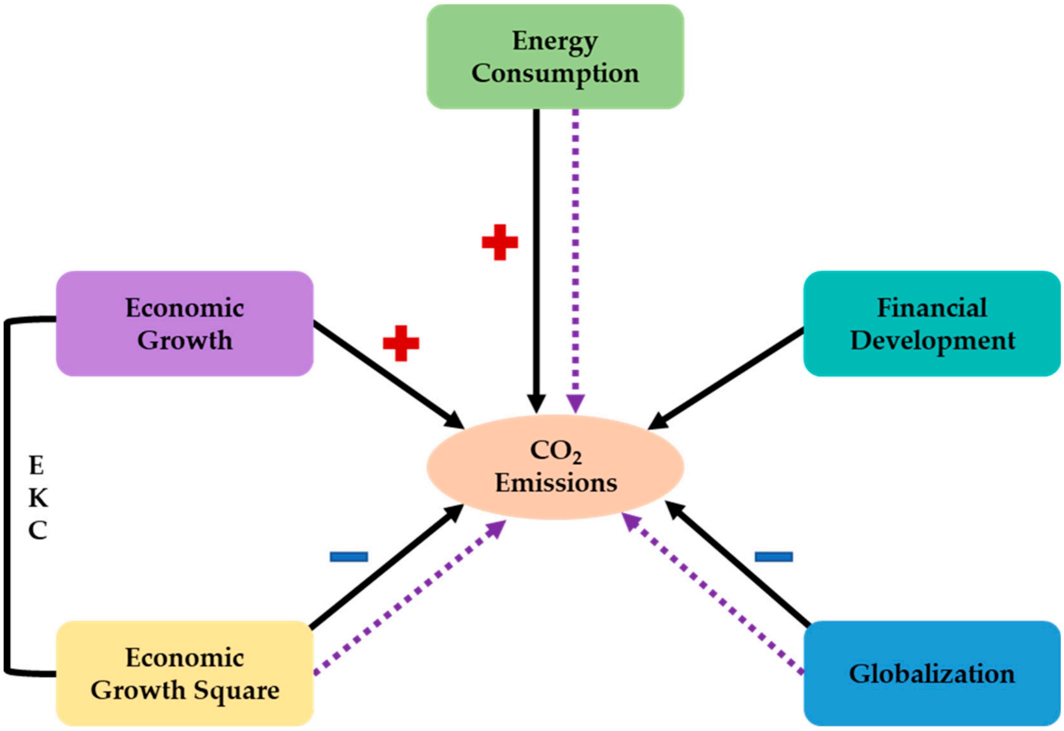

Figure 1. Graphical findings.

4.2. Discussion of Findings

This section of the empirical analysis discusses in detail the findings mentioned above. With the aim of investigating the influence of globalization (GLO), energy utilization (EC), economic growth (GDP), and financial development (FD) on CO_2 in the GCC countries, we applied both the CS-ARDL and panel causality techniques. The outcomes from the CS-ARDL disclosed that economic growth contributes to an upsurge in the degradation of the environment in the GCC economies. This simply means that the GCC nations are majorly pro-growth economies. Thus, they favor economic expansion at the expense of the quality of the environment. As a result, economic growth in the GCC economies stimulates the consumption of energy, which leads to a rise in environmental deterioration. This further implies that, in the pursuit of rapid economic expansion, GCC economies' environmental quality has deteriorated. The study also affirmed the EKC hypothesis which indicates that the GCC economies are on the right part towards environmental sustainability. This outcome is consistent with the study of [55] who found that an upsurge in CO_2 in Malaysia is attributed to an upsurge in economic expansion. Moreover, the studies of [28] for Brazil, [16] for highly decentralized economies, and [39] for Argentina comply with this finding by establishing a positive growth–emission interrelationship.

Furthermore, we established a positive emissions–energy use interrelationship in both the long run and the short run. This outcome is not surprising given the fact that energy consumption is necessary for economic growth which also triggers degradation of the environment. Thus, utilization of nonrenewable energy triggers economic expansion which, in turn, mitigates the quality of the environment of the GCC nations. This outcome concurs with the works of [12] for Mexico who established positive emissions–energy use interconnection. The study of [56] for selected Latin American countries also complies with this finding. Additionally, our finding is consistent with the studies of [45] for India and [57] for Chile.

Moreover, the short-term and the long-term financial development–emissions association is positive and insignificant. This finding is unsurprising given that financial development may not mitigate environmental degradation in emerging countries such as the GCC countries, where the structural transition of the financial sector is still in its infant phase. This outcome concurs with the works of [12] for Mexico and [14] for emerging nations; however, it contradicts the outcomes of Oluwajana et al. (2021) for South Africa and [58] for Malaysia who established a negative CO_2–FD negative association.

We also found that there is a negative globalization–emissions interrelationship, which implies that globalization plays a vital role in abating emissions levels in the GCC economies. One possible reason for the negative connection between globalization and CO_2 is that globalization through trade also enables technical advancement and leads to an increase in economic activity. According to the research of [59] on Andean nations (e.g., Colombia, Peru, Bolivia, and Ecuador), trade openness stimulates industrialization via the capacitive effect, scale effect, comparative advantages effect, and technique effect, and it stimulates investment, which, in turn, affects economic activity, energy consumption, and, ultimately, environmental degradation. This outcome conforms with the studies of [37] for Japan, [60] for APEC economies, and [61] for the 15 highest emitting countries. Nonetheless, the outcome contradicts the findings of [62] for South Africa, [63] for Australia and [15] who found a positive CO_2–globalization association.

To capture the causal influence of financial development, globalization, and growth on CO_2 in the GCC economies, we applied the panel causality approach. The outcomes from the causality test disclosed that energy utilization or consumption, globalization, and economic growth (GDP) play a vital role in predicting the level of emissions in the GCC economies. This outcome infers that any policy directed towards energy utilization, globalization, and GDP will have a substantial influence on emissions of CO_2 in the GCC nations. The above findings have significant policy consequences for the GCC countries regarding CO_2 emissions.

5. Conclusions and Policy Path

This research study assesses the effect of financial development and globalization on CO_2 emissions as well as the role of energy consumption and economic growth in the GCC nations by utilizing a dataset stretching between 1995 and 2018. In a bid to investigate these connections, the study utilized cross-sectional dependence, slope heterogeneity, Pesaran unit root, Westerlund cointegration, CS-ARDL, and the D–H causality approaches. The outcomes of both CSD and SH tests disclosed that using the first-generation techniques will produce incorrect results. Thus, the present study is centered on the second-generation approaches. The outcomes of the panel unit root test unveiled that the series are I (1). Furthermore, the outcomes of the cointegration test unveiled a long-run association between CO_2 and the regressors, suggesting evidence of cointegration. The outcomes of the CS-ARDL showed that economic growth and energy consumption decrease the sustainability of the environment, while globalization improves the sustainability of the environment. Furthermore, we applied the D–H causality test, and the outcomes disclosed feedback causality association between CO_2 and GDP and between FD and CO_2. In addition, there is a one-way causality from energy use and globalization to CO_2 emissions in the GCC economies.

To achieve environmental quality, present energy regulations must be changed to support green energy sources and other energy-efficient technology. Furthermore, this research showed that there is a negative link between GLO and CO_2, and as a result, GCC economies should implement the following policy suggestions. Openness to new markets and business partners will aid in the improvement of environmental quality. Environmental deterioration may be reduced by establishing possibilities and flexibility for imports of renewable technology and clear environmental regulations and rules. Policymakers in the GCC economies may also strengthen relationships with their foreign commercial partners in order to relieve poverty, create new job opportunities, and increase exports and imports. If these steps are adopted, global trading partners will recognize the value of doing business with the GCC countries. Interestingly, financial development has little effect on CO_2 emissions in the GCC economies. FD may not enhance environmental protection in developing economies, such as the GCC nations and other developing countries where the financial sector is still in the early stages of structural transformation. This proposes the need to broaden the financial basis, specifically in terms of PPP in clean and renewable energy usage to promote clean energy (Sustainable Development Goal-7) (SDG-7) and a clean environment (SDG-13). Besides, increased CO_2 emissions from economic expansion reduce environmental sustainability. This implies that policymakers in the GCC economies should exercise caution when enacting policies that promote economic expansion at the price of environmental deterioration. As a result, there is a need to create effective energy conservative policies that strike a balance between the GCC countries' energy mix, environmental plans, and macroeconomic aims. This will promote long-term economic growth without jeopardizing energy efficiency; instead, a paradigm shift to renewables such as thermal, hydro, wind, and solar energy may be undertaken.

Though this research assessed the association between CO_2 and financial development, globalization, economic growth, and energy use, further studies should be conducted by using an asymmetric approach and by also including additional variables. Moreover, other metrics of environmental degradation should be considered in future studies.

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References

1. Shan, S.; Ahmad, M.; Tan, Z.; Adebayo, T.S.; Man Li, R.Y.; Kirikkaleli, D. The role of energy prices and non-linear fiscal decentralization in limiting carbon emissions: Tracking environmental sustainability. *Energy* **2021**, *234*, 121243. [CrossRef]
2. BP. British Petroleum. 2021. Available online: https://www.bp.com/en/global/corporate/careers/professionals/locations/sweden.html#/ (accessed on 25 January 2021).
3. Awosusi, A.A.; Kirikkaleli, D.; Akinsola, G.D.; Adebayo, T.S.; Mwamba, M.N. Can CO_2 emissions and energy consumption determine the economic performance of South Korea? A time series analysis. *Environ. Sci. Pollut. Res.* **2021**, *28*, 38969–38984.
4. Orhan, A.; Adebayo, T.S.; Genç, S.Y.; Kirikkaleli, D. Investigating the Linkage between Economic Growth and Environmental Sustainability in India: Do Agriculture and Trade Openness Matter? *Sustainability* **2021**, *13*, 4753. [CrossRef]
5. Luciani, G. *Business Politics in the Middle East*; Hurst Publishers: London, UK, 2013.

6. Kihombo, S.; Vaseer, A.I.; Ahmed, Z.; Chen, S.; Kirikkaleli, D.; Adebayo, T.S. Is there a tradeoff between financial globalization, economic growth, and environmental sustainability? An advanced panel analysis. *Environ. Sci. Pollut. Res.* **2021**. [CrossRef] [PubMed]
7. Zmami, M.; Ben-Salha, O. An empirical analysis of the determinants of CO_2 emissions in GCC countries. *Int. J. Sustain. Dev. World Ecol.* **2020**, *27*, 469–480. [CrossRef]
8. Dreher, A. Does globalization affect growth? Evidence from a new index of globalization. *Appl. Econ.* **2006**, *38*, 1091–1110. [CrossRef]
9. Gygli, S.; Haelg, F.; Potrafke, N.; Sturm, J.-E. The KOF Globalisation Index–revisited. *Rev. Int. Organ.* **2019**, *14*, 543–574. [CrossRef]
10. Rahman, M.M. Environmental degradation: The role of electricity consumption, economic growth, and globalization. *J. Environ. Manag.* **2020**, *253*, 109742. [CrossRef] [PubMed]
11. Villanthenkodath, M.A.; Ansari, M.A.; Shahbaz, M.; Vo, X.V. Do tourism development and structural change promote environmental quality? Evidence from India. *Environ. Dev. Sustain.* **2021**, *4*, 1–32. [CrossRef]
12. He, X.; Adebayo, T.S.; Kirikkaleli, D.; Umar, M. Consumption-based carbon emissions in Mexico: An analysis using the dual adjustment approach. *Sustain. Prod. Consum.* **2021**, *27*, 947–957. [CrossRef]
13. Pata, U.K. Linking renewable energy, globalization, agriculture, CO_2 emissions and ecological footprint in BRIC countries: A sustainability perspective. *Renew. Energy* **2021**, *173*, 197–208. [CrossRef]
14. Kihombo, S.; Ahmed, Z.; Chen, S.; Adebayo, T.S.; Kirikkaleli, D. Linking financial development, economic growth, and ecological footprint: What is the role of technological innovation? *Environ. Sci. Pollut. Res.* **2021**, 1–11. [CrossRef]
15. Kirikkaleli, D.; Adebayo, T.S.; Khan, Z.; Ali, S. Does globalization matter for an ecological footprint in Turkey? Evidence from dual adjustment approach. *Environ. Sci. Pollut. Res.* **2021**, *28*, 14009–14017. [CrossRef]
16. Tufail, M.; Song, L.; Adebayo, T.S.; Kirikkaleli, D.; Khan, S. Do fiscal decentralization and natural resources rent curb carbon emissions? Evidence from developed countries. *Environ. Sci. Pollut. Res.* **2021**, 1–12. [CrossRef]
17. Baloch, M.A.; Danish Qiu, Y. Does energy innovation play a role in achieving sustainable development goals in BRICS countries? *Environ. Technol.* **2021**, *2*, 1–10. [CrossRef]
18. Oluwajana, D.; Adeshola, I.; Kirikkaleli, D.; Akinsola, G.D.; Adebayo, T.S.; Osemeahon, O.S. Coal Consumption and Environmental Sustainability in South Africa: The role of Financial Development and Globalization. *Int. J. Renew. Energy Dev.* **2021**, *10*, 527–536.
19. Xu, Z.; Baloch, M.A.; Danish Meng, F.; Zhang, J.; Mahmood, Z. Nexus between financial development and CO_2 emissions in Saudi Arabia: Analyzing the role of globalization. *Environ. Sci. Pollut Res.* **2018**, *25*, 28378–28390. [CrossRef]
20. Salahuddin, M.; Alam, K.; Ozturk, I.; Sohag, K. The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO_2 emissions in Kuwait. *Renew. Sustain. Energy Rev.* **2018**, *81*, 2002–2010. [CrossRef]
21. Chebbi, H.E. Long and Short–Run Linkages between Economic Growth, Energy Consumption and CO_2 Emissions in Tunisia. *Middle East Dev. J.* **2010**, *2*, 139–158. [CrossRef]
22. Salahuddin, M.; Gow, J. Economic growth, energy consumption and CO_2 emissions in Gulf Cooperation Council countries. *Energy* **2014**, *73*, 44–58. [CrossRef]
23. Nain, M.Z.; Ahmad, W.; Kamaiah, B. Economic growth, energy consumption and CO_2 emissions in India: A disaggregated causal analysis. *Int. J. Sustain. Energy* **2017**, *36*, 807–824. [CrossRef]
24. Wang, S.; Li, Q.; Fang, C.; Zhou, C. The relationship between economic growth, energy consumption, and CO_2 emissions: Empirical evidence from China. *Sci. Total Environ.* **2016**, *542*, 360–371. [CrossRef] [PubMed]
25. Salari, M.; Javid, R.J.; Noghanibehambari, H. The nexus between CO_2 emissions, energy consumption, and economic growth in the U.S. *Econ. Anal. Policy* **2021**, *69*, 182–194. [CrossRef]
26. Abbasi, K.R.; Lv, K.; Radulescu, M.; Shaikh, P.A. Economic complexity, tourism, energy prices, and environmental degradation in the top economic complexity countries: Fresh panel evidence. *Environ. Sci. Pollut. Res.* **2021**, 1–15. [CrossRef]
27. Xu, X.; Huo, H.; Liu, J.; Shan, Y.; Li, Y.; Zheng, H.; Guan, D.; Ouyang, Z. Patterns of CO_2 emissions in 18 central Chinese cities from 2000 to 2014. *J. Clean. Produc.* **2018**, *172*, 529–540. [CrossRef]
28. Su, Z.-W.; Umar, M.; Kirikkaleli, D.; Adebayo, T.S. Role of political risk to achieve carbon neutrality: Evidence from Brazil. *J. Environ. Manag.* **2021**, *298*, 113463. [CrossRef]
29. Acheampong, A.O.; Adams, S.; Boateng, E. Do globalization and renewable energy contribute to carbon emissions mitigation in Sub-Saharan Africa? *Sci. Total Environ.* **2019**, *677*, 436–446. [CrossRef]
30. Ayobamiji, A.A.; Kalmaz, D.B. Reinvestigating the determinants of environmental degradation in Nigeria. *Int. J. Econ. Policy Emerg. Econ.* **2020**, *13*, 52–71. [CrossRef]
31. Shoaib, H.M.; Rafique, M.Z.; Nadeem, A.M.; Huang, S. Impact of financial development on CO_2 emissions: A comparative analysis of developing countries (D8) and developed countries (G8). *Environ. Sci. Pollut. Res.* **2020**, *27*, 12461–12475. [CrossRef]
32. Khan, M.S.; Butt, U.U. *Asymmetric Impact of Globalization on Economic Growth in Pakistan by Using ARDI Model [Internet]*; Report No.: ID 3860498; Social Science Research Network: Rochester, NY, USA, 2021; Available online: https://papers.ssrn.com/abstract=3860498 (accessed on 9 August 2021).
33. Shen, Y.; Su, Z.-W.; Malik, M.Y.; Umar, M.; Khan, Z.; Khan, M. Does green investment, financial development and natural resources rent limit carbon emissions? A provincial panel analysis of China. *Sci. Total Environ.* **2021**, *755*, 142538. [CrossRef]

34. Bekhet, H.A.; Matar, A.; Yasmin, T. CO_2 emissions, energy consumption, economic growth, and financial development in GCC countries: Dynamic simultaneous equation models. *Renew. Sustain. Energy Rev.* **2017**, *70*, 117–132. [CrossRef]
35. Katircioglu, S.; Gokmenoglu, K.K.; Eren, B.M. Testing the role of tourism development in ecological footprint quality: Evidence from top 10 tourist destinations. *Env. Sci Pollut Res.* **2018**, *25*, 33611–33619. [CrossRef] [PubMed]
36. Odugbesan, J.A.; Adebayo, T.S.; Akinsola, G.D.; Olanrewaju, V.O. Determinants of Environmental Degradation in Thailand: Empirical Evidence from ARDL and Wavelet Coherence Approaches. *Pollution* **2021**, *7*, 181–196.
37. Ahmed, Z.; Nathaniel, S.P.; Shahbaz, M. The criticality of information and communication technology and human capital in environmental sustainability: Evidence from Latin American and Caribbean countries. *J. Clean. Prod.* **2021**, *286*, 125529. [CrossRef]
38. Leal, P.H.; Marques, A.C. The environmental impacts of globalisation and corruption: Evidence from a set of African countries. *Environ. Sci. Policy* **2021**, *115*, 116–124. [CrossRef]
39. Yuping, L.; Ramzan, M.; Xincheng, L.; Murshed, M.; Awosusi, A.A.; BAH, S.I.; Adebayo, T.S. Determinants of carbon emissions in Argentina: The roles of renewable energy consumption and globalization. *Energy Rep.* **2021**, *7*, 4747–4760. [CrossRef]
40. Chen, Y.; Wang, Z.; Zhong, Z. CO_2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. *Renew. Energy* **2019**, *131*, 208–216. [CrossRef]
41. Zhang, J.; Patwary, A.K.; Sun, H.; Raza, M.; Taghizadeh-Hesary, F.; Iram, R. Measuring energy and environmental efficiency interactions towards CO_2 emissions reduction without slowing economic growth in central and western Europe. *J. Environ. Manag.* **2021**, *279*, 111704. [CrossRef] [PubMed]
42. Piłatowska, M.; Geise, A.; Włodarczyk, A. The Effect of Renewable and Nuclear Energy Consumption on Decoupling Economic Growth from CO_2 Emissions in Spain. *Energies* **2020**, *13*, 2124. [CrossRef]
43. Khan, Z.; Ali, S.; Umar, M.; Kirikkaleli, D.; Jiao, Z. Consumption-based carbon emissions and International trade in G7 countries: The role of Environmental innovation and Renewable energy. *Sci. Total Environ.* **2020**, *730*, 138945. [CrossRef]
44. Adebayo, T.S.; Rjoub, H.; Akinsola, G.D.; Oladipupo, S.D. The asymmetric effects of renewable energy consumption and trade openness on carbon emissions in Sweden: New evidence from quantile-on-quantile regression approach. *Environ. Sci. Pollut. Res.* **2021**, 1–12. [CrossRef]
45. Kirikkaleli, D.; Adebayo, T.S. Do public-private partnerships in energy and renewable energy consumption matter for consumption-based carbon dioxide emissions in India? *Environ. Sci. Pollut. Res.* **2021**, *28*, 30139–30152. [CrossRef]
46. Grossman, G.M.; Krueger, A.B. *Environmental Impacts of a North American Free Trade Agreement [Internet]*; (Papers). Report No.: 158; Woodrow Wilson School-Public and International Affairs: Princeton, NJ, USA, 1991; Available online: https://ideas.repec.org/p/fth/priwpu/158.html (accessed on 24 July 2021).
47. Alibašić, H. Examining the Intersection of Sustainability and Resilience. In *Sustainability and Resilience Planning for Local Governments: The Quadruple Bottom Line Strategy [Internet]*; Sustainable Development Goals Series; Alibašić, H., Ed.; Springer International Publishing: Cham, Switzerland, 2018. [CrossRef]
48. Akinsola, G.D.; Adebayo, T.S.; Kirikkaleli, D.; Bekun, F.V.; Umarbeyli, S.; Osemeahon, O.S. Economic performance of Indonesia amidst CO_2 emissions and agriculture: A time series analysis. *Environ. Sci. Pollut. Res.* **2021**, 1–15. [CrossRef]
49. Adebayo, T.S. Revisiting the EKC hypothesis in an emerging market: An application of ARDL-based bounds and wavelet coherence approaches. *SN Appl Sci.* **2020**, *2*, 1945. [CrossRef]
50. Adebayo, T.S.; Kirikkaleli, D. Impact of renewable energy consumption, globalization, and technological innovation on environmental degradation in Japan: Application of wavelet tools. *Environ. Dev. Sustain.* **2021**, 1–26. [CrossRef]
51. Pesaran, M.H. Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure. *Econometrica* **2006**, *74*, 967–1012. [CrossRef]
52. Hashem Pesaran, M.; Yamagata, T. Testing slope homogeneity in large panels. *J. Econom.* **2008**, *142*, 50–93. [CrossRef]
53. Westerlund, J. Testing for Error Correction in Panel Data*. *Oxf. Bull. Econ. Stat.* **2007**, *69*, 709–748. [CrossRef]
54. Chudik, A.; Pesaran, M.H. Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. *J. Econom.* **2015**, *188*, 393–420. [CrossRef]
55. Zhang, L.; Li, Z.; Kirikkaleli, D.; Adebayo, T.S.; Adeshola, I.; Akinsola, G.D. Modeling CO_2 emissions in Malaysia: An application of Maki cointegration and wavelet coherence tests. *Environ. Sci. Pollut. Res.* **2021**, *28*, 26030–26044. [CrossRef]
56. Ramzan, M.; Adebayo, T.S.; Iqbal, H.A.; Awosusi, A.A.; Akinsola, G.D. The environmental sustainability effects of financial development and urbanization in Latin American countries. *Environ Sci Pollut Res* **2021**, 1–14. [CrossRef]
57. Udemba, E.N.; Adebayo, T.S.; Ahmed, Z.; Kirikkaleli, D. Determinants of consumption-based carbon emissions in Chile: An application of non-linear ARDL. *Environ. Sci. Pollut. Res.* **2021**, 1–15. [CrossRef]
58. Khan, Z.; Hussain, M.; Shahbaz, M.; Yang, S.; Jiao, Z. Natural resource abundance, technological innovation, and human capital nexus with financial development: A case study of China. *Resour. Policy* **2020**, *65*, 101585. [CrossRef]
59. Koengkan, M.; Fuinhas, J.A. Exploring the effect of the renewable energy transition on CO_2 emissions of Latin American & Caribbean countries. *Int. J. Sustain. Energy* **2020**, *39*, 515–538.
60. Zaidi, S.A.H.; Zafar, M.W.; Shahbaz, M.; Hou, F. Dynamic linkages between globalization, financial development and carbon emissions: Evidence from Asia Pacific Economic Cooperation countries. *J. Clean. Prod.* **2019**, *228*, 533–543. [CrossRef]
61. Usman, O.; Iortile, I.B.; Ike, G.N. Enhancing sustainable electricity consumption in a large ecological reserve–based country: The role of democracy, ecological footprint, economic growth, and globalisation in Brazil. *Env. Sci Pollut Res.* **2020**, *27*, 13370–13383. [CrossRef]

62. Usman, O.; Akadiri, S.S.; Adeshola, I. Role of renewable energy and globalization on ecological footprint in the USA: Implications for environmental sustainability. *Environ. Sci. Pollut. Res. Int.* **2020**, *27*, 30681–30693. [CrossRef]
63. Adebayo, T.S.; Acheampong, A.O. Modelling the globalization-CO_2 emission nexus in Australia: Evidence from quantile-on-quantile approach. *Environ. Sci. Pollut. Res.* **2021**, *10*, 11–26.