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Income Inequality and CO_2 Emissions in Developing Countries: The Moderating Role of Financial Instability

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Abstract: This paper studies the effects of income inequality and financial instability on CO_2 emissions in the presence of fossil fuel energy, economic development, industrialization, and trade openness. Moreover, the present study is the first to examine the moderating role of financial instability between income inequality and CO_2 emissions. We utilized panel data of forty-seven developing countries for the period 1980–2016 by utilizing the stochastic impacts by regression on population, affluence, and technology (STIRPAT) model. The empirical outcomes in all models indicate that income inequality and industrialization significantly reduce environmental degradation, while fossil fuel, trade openness, and economic growth decrease the quality of the environment. However, financial instability (with interaction term) shows no significant link to environmental quality, whereas (with interaction term) it shows a significant negative effect on CO_2 emissions. In addition, the result of the interaction variable reveals that an increase in inequality, ceteris paribus, in combination with the rise in financial instability, is expected to increase pollution. Furthermore, there exists a bidirectional causal association among income inequality, financial instability, fossil fuel, trade openness, industrialization, economic growth, and the interaction variable with CO_2 emissions.

Keywords: income inequality; financial instability; CO_2 emissions; developing countries; STIRPAT

1. Introduction

During the last decades, a dramatic increase has been observed globally in carbon footprints due to anthropogenic activities such as burning of gas, coal, and petrol [1,2]. The continuing surge in carbon dioxide (CO_2) emissions, along with changes in climate, is causing an environmental threat to the mental and physical health of humankind. Notably, worldwide global warming, triggered by huge emissions of greenhouse gases (GHG), has now turned into one of the main problems confronting humans. Therefore, this topic has gained increased attention among researchers and policymakers to examine whether there is a sustainable linkage between CO_2 emissions, greenhouse gases, and economic progress [3]. It is essential to identify the causes that are disturbing the atmosphere severely. In this framework, the current study investigates the effect of income inequality (INE) and financial instability (FIS) on the environmental performance of the developing nations.

The latest research focused on environmental quality has acknowledged plenty of crucial elements, except aggregate income, inducing environmental contamination. However, the pivotal role of income imbalance (inequality) has consistently been ignored. The economic projects instigating environment contamination mostly generates winners and losers. The winners will get the advantage of the activity, while losers bear the loss. We can suppose that the winners can pressurize the administration to ease the rules and regulations if they are significantly rich, therefore causing the degradation of the environment. Correspondingly, if the losers are wealthy, they can deal with the winners and influence the policymakers to establish stringent eco-friendly restrictions. Thus, environmental degradation depends on both the level of income and income imbalance [4]. Therefore, CO_2 emissions can be simulated by income discrimination in several ways, creating multiple methods. Krueger and Grossman [5] indicated that these theoretical relations could be set up through environmental guidelines, industrial composition, and technology. In this context, we can safely deduce that the relationship between economic progress and environmental degradation is contingent on the technological, scale, and composition effects [5,6].

Torras and Boyce [7] stated that developments in technological enhancements generate a special effect and confirm that eco-friendly equipment is used in the production method. Therefore, areas that have a large consumption of energy generated by fossil fuels like oil and coal will see lesser adverse environmental effects utilizing clean energy technologies. Mohapatra, Adamowicz, and Boxall [8] define the scale effect, which is referred to as a rise in output and consumption when the level of income starts to surge in the first step, *ceteris paribus*, and it causes environmental contamination due to excessive utilization of natural resources and energy. Lastly, for the composition effect, Barra and Zotti [9] express that higher income levels create essential conversions in the economy. A change in the economy from highly polluted areas to low contamination areas decreases environmental pollution by generating a composition effect. Increased CO_2 emissions and other contaminant factors that generally go with economic growth are a few of the leading reasons for environmental pollution. The losses of the forests, excessive usage of fossil fuel, and various other elements have raised the emission of CO_2 and other pollutants, which leads to increased degradation of the environment [10].

Baek and Gweisah [11] specified that primary research works in the environment literature have utilized only per capita income level to describe the performance of the environment. In this framework, by ignoring indicators that are significant factors of environmental issues, omitted variable bias could create a severe issue in prior research works [12]. The latest research studies indicate that financial development (FD), urbanization (UR), energy consumption (EC), trade openness (TOP), and foreign direct investments (FDI) are factors that affect environmental performance [13–15]. However, financial instability and income distribution, which have notable economic and social effects, are usually not utilized as factors in ecological investigations and, thus, have been overlooked [7,16,17]. Hence, financial instability and income distribution are not incorporated in the model, and possible linkage among environmental degradation, financial instability, and income distribution cannot be generalized [18,19].

Income inequality signifies that revenue made in a state and span cannot be divided equally among persons, areas, or social classes. Although the mistreatment of income distribution has been made in the energy and economics studies, yet an extensive set of studies indicate that expanding INE has become a crucial socio-economic issue in both advanced and emerging economies in recent years [20]. Mainly since 1980, a substantial decline in the individual and functional distribution of the income has arisen in the United States (US), in other advanced economies of Organization for Economic Cooperation and Development (OECD), and also in several emerging nations [21]. A rise in income imbalance can cause significant social and financial complications; INE can decrease overall demand, which could harmfully affect economic development and the levels of employment [22]. Furthermore, the rise in poverty and the rate of violent crime can cause a collapse of the community [23]. Income disparity has become an important issue that has raised the attention of the researchers in the causes and outcomes of income imbalance. In this framework, examining the impacts of income imbalance on poverty, economic development, crime, and employment (but ignoring environmental effects, i.e., CO_2 emissions) is an essential scarcity in ecological economics studies.

Schumpeter [24] confirmed an association between financial development and economic progress by underlining the significance of the financial sector in the development of economic progress. The financial system performs a dynamic role in organizing investments and distributes savings to fruitful activities. This increases national productivity and enhances economic development. King and Levine [25] also reported that a stable financial sector is a driver of economic development in a country. A reliable and advanced financial sector offers more access to financial facilities by decreasing monitoring, transaction, and information costs [26]. This improves the efficiency of distributed funds, which in turn triggers economic growth. The financial system also boosts investing activities by providing credits at a low cost and distributes funds to creative projects, organizes investments, allowing trading, proposing hedging, checking the firms working, diversifying the threats, and guides the corporations to utilize clean and green technology to improve the level of national production.

The advanced and robust financial system prompts economic development and also decreases energy contaminants. Frankel and Romer [27] indicated that established financial markets could assist in inviting FDI and encouraging the speed of economic progress. Financial progress works as a network for the latest eco-friendly technology [28]. Besides, financial development has a significant and direct influence on energy consumption (e.g., [29,30]) and so on CO_2 emissions [31]. A robust financial sector decreases the rate of credit and stimulates investment projects [26], and reduces energy emissions by improving proficiency in the energy zone [32]. In general, the low rate of credits empowers domestic, provincial, and local administrations to start eco-friendly activities. A developed financial sector can stimulate industrial revolutions in the energy sector and therefore supports in decreasing the energy contaminants.

Nasreen et al. [33] stated that a robust financial sector enhances economic growth as well as the performance of the environment. Thus, countries with a strong financial system are likely to have a pleasant environment rather than those nations which do have not a robust financial system. A developed financial sector encourages economic development by inviting investors from other countries. Imported plants are energy-saving as related to local plants. Also, financial sector stability not only stimulates financing projects by making resources economical but also penalizes those companies that damage the atmosphere by applying penalty and restricting their access to credit. Morris [34] also indicated that a developed financial sector raises the level of financing by giving finances at a discounted amount, boosts the capital market, mitigates risk, enhances the working of the firms, and encourages them to employ environmentally friendly machinery. Furthermore, an advanced financial sector is a mode of entry for the latest sustainable technology that affects the atmosphere [35]. So, the financial sector performs a vital role in pollution controlling by motivating the latest equipment in the energy zone [19].

The above discussion encourages us to study the linkages among income inequality, financial instability, and carbon emissions. The significant characteristics of this study are stated as follows. Firstly, this study analyzes the income inequality-environmental degradation nexus in developing countries by adding financial instability. Second, we examine the interactive (moderating) role of financial instability between income inequality and CO_2 emissions. As reported by Richard [36], in the phase of financial instability, the association between economic development and the environment becomes compromised because of the inaccessibility of symmetric data. Furthermore, we extend the work of Shahbaz and Islam [37] who stated that financial instability increases income inequality, but their study failed to address the critical issue of environmental degradation. Rasiah et al. [38] argue that economic inequities (i.e., income imbalance) and the degradation of the environment have a reciprocal association. Therefore, considering these arguments, we expect that financial instability and income inequality have significant effects on environmental quality. So, it is essential and innovative to check the interactive impact of income inequality and financial instability upon CO_2 emissions in forty-seven developing countries. Third, this study focuses on developing countries, because emerging economies are more vulnerable to the degradation of the environment

[39]. After a thorough and comprehensive assessment and review of literature, we can confidently claim that it is the first study that examines the association between income inequality, financial instability, and CO_2 emissions for forty-seven developing countries. Lastly, for stronger and influential policy preparation, consistent and authentic findings are needed based on the advanced econometric modelling. Therefore, we use the cross-section dependency approach, cross-sectional augmented Dickey-Fuller (CADF) and cross-sectional Im-Pesaran (CIPS) panel unit root tests, and the Pedroni, Westerlund, and Kao cointegration approaches to confirm the dependency, stationarity, and co-integration amongst the variables, respectively. In addition, for long-run estimates and to confirm the causal link between variables, we employ the Dynamic Seemingly Unrelated Regression (DSUR), and the Dumitrescu-Hurlin (DH) panel causality approaches, respectively.

The study is set as follows. "Literature review" summarizes the theoretical underpinnings and also summarizes relevant studies about the relationship between environmental measures, income distribution, and financial instability. "Model construction and data collection" contains the data collection and methodology. The discussion of the empirical outcomes is presented in the "Empirical results." Finally, "Conclusion" summarizes the paper and offers suggestions for policy formulation.

2. Literature Review

2.1. Theoretical Background

This section contains the theoretical understanding of how financial instability and income distribution affect the environment.

The theoretical literature regarding income imbalance and the environment includes several conflicting perspectives. Boyce [40] theoretically examined the linkage between income imbalance and environmental performance, and it is established on the political-economy approach (POE). Based on the POE, the study tried to answer the questions regarding whether protection of the environment overlays with the benefits of a specific class; which group will formulate political requests for the quality of the environment, and how to settle these issues amongst groups and generate ecological guidelines. Boyce [40] indicated that if a significant gap among income and power occurs, the particular quality of the environment will be compromised. In a group with a large level of income imbalance, political pressure will support the developments that are damaging to the atmosphere, leading to the destruction of the atmosphere [7]. Therefore, for many projects that have environmental impacts, those with political influence could burden people with the developments' environmental consequences. Political influence and income inequality in people cause ecological strategies to support the benefits of the political privileged rather than society as a whole [4]. Boyce [40] explains this condition as the power biased social decision regulation, wherein the power imbalance among the wealthy and the inferior leads to the financial advantage for the well-off people and environmental destruction for the poor people. Magnani [41] defines that the decline in income inequality can boost the opinion of the comparatively powerless and allow them to be extra productive in the political procedure. Besides, the fair distribution of the income increases the call for environmental performance by making ecological awareness.

Another perspective that describes the association between income distribution and environment emphasizes on the economic performance of households and on the marginal properties to emit (MPPE). In this perspective, Heerink et al. [42] and Berthe and Elie [43] stated that households' financial performance is established on the utilization of goods and services that arise, and their effect on the atmosphere is analyzed. The demand for consumption is the leading factor of MPPE. Studies proved that MPPE differs according to income level, and findings indicated that a rise in income reduces MPPE [18]. Scruggs [44] clarified three diverse conditions, contingent on the development of the relationship between income inequality and environmental degradation. If the income-pollution relationship is concave, the movement of income from higher groups to smaller groups will raise the average deprivation of the environment. On the contrary, if the relationship between income and environment is convex, the movement of income will reduce environmental pollution [42]. Lastly, if the relationship between income and pollution shows a linear trend, there will be no impact on the environmental degradation of income distribution [43].

The last approach regarding the link between income distribution and the environment is established on the Emulation Theory (EMT) of Veblen [45], which is recognized by the phenomena of inequality and environment [46]. EMT method can be driven in the context of the nexus between income inequality and environmental quality (EQ). In this framework, high-income disparity disturbs status consumption. Individuals with low income emulate the consumption standards of high-income society, and they tend to expend extra. Therefore, an increase in demand for luxurious products, which causes environmental pollution, such as an increase in the need for automobiles. Besides, the extra working times in societies with high-income imbalance have higher energy consumption and, thus, high CO_2 emissions because of better household consumption and economic progress [46].

Although, the theoretical literature about financial instability (FIS) and the environment comprises different schools of thought. One major school of thought proposes that the financial sector performs a double responsibility for decreasing environmental degradation. On one side, it can increase economic progress and reduce CO_2 emissions by distributing more financial funds for sustainable developments. However, a robust financial sector could control access to secure funding for those companies which discharge extra waste in the atmosphere [47]. Furthermore, significant investments in credit markets can perform a vibrant role in supporting the company's environmentally friendly structure by proposing extra inducements. It is also noticed that satisfactory or unsatisfactory performance of the environment of the companies is connected with the worth of their shares in the stock market where it listed [19].

However, there is one more school of thought that recommends that the stability of the financial sector prompts environmental deterioration. A developed financial sector assists in decreasing the credit restrictions and expands economic development, which affects high energy use and so decreases environmental quality. Moreover, financial progress makes it convenient and accessible for customers to obtain easy credits and purchase luxury items such as cars, air conditioners, etc., which raises the level of pollution [48]. Furthermore, progress in the stock market permits the companies to get low-cost funding and increase their production, which results in higher energy consumption and, thus, high emissions level of CO_2 [23].

2.2. Empirical Literature

Alongside the progress of the economy, the worldwide environmental issues are becoming stern. The stability between economic progress and environmental protection is essential for ecological development. Since environmental degradation, financial instability, and income inequality are the most critical issues nowadays, it has increased importance in the relationship between these factors [10,16,49,50]. Several environmental measures such as biodiversity, water and soil pollution, CO_2 emission, nitrogen oxide (NOx), and sulfur dioxide (SO_2) emission have been utilized in this subject. The absence of a broad range of income distribution indicators and complications in finding data has popularized the Gini coefficient as a preference in the research studies. The range of research works in the literature is diverse from one another. The research studies focused on data availability, in some cases concentrated on single countries, whereas several studies tried cross-country analysis [3,10,16,33,46,50]. Therefore, to investigate the nexus among environmental degradation, financial instability, and income inequality, studies can be estimated in two groups. The first strand of the literature concluded the nexus between income inequality and environmental performance, whereas the research works in the second group concluded the association between financial instability and quality of the environment.

Scientific works in the first category concluded the impact of income inequality on environmental performance. Torras and Boyce [7] examined the influence of political rights, income disparity, literacy, and several other variables on the measures of the environment. The outcomes showed that political rights and literacy are essential in defining the performance of the environment, particularly in low-income nations. This study also highlighted that the progress in income distribution possibly would raise the performance of the environment. Holland, Peterson, and Gonzalez [51] investigated the associations between biodiversity, income inequality, and other variables in selected nations from 1980–1984. The results indicated that the decline in inequality hindered biodiversity loss. Clement and Meunie [52] studied the association between income distribution, water pollution, and SO_2 emissions in 83 transition and emerging nations from 1988 to 2003. The outcomes revealed that the impact of the Gini is insignificant on SO_2 emissions, but in the transition countries' rise in the Gini coefficient increased water contamination. Similarly, Jorgenson et al. [46] examined the association between the Gini coefficient and carbon emissions in the United States of America. The outcomes showed no significant association between income disparity and CO_2 emissions. Kasuga and Takaya [53] investigated the associations between income inequality and several pollution measures in eighty-five cities of Japan from 1990 to 2012. The findings revealed that a rise in income distribution increases air pollution, SO_2, and NOx emissions. Knight, Schor, and Jorgenson [54] studied the link between income distribution and CO_2 emissions from 2000 to 2010 in 26 advanced nations. Outcomes of the study show that the rise in inequality increases environmental degradation.

Unlike the above studies, several studies have established that an increase in income disparity would increase environmental performance. The findings of Ravallion et al. [55] revealed that there is a positive association between income distribution and environmental quality. They conclude that higher income inequality reduces carbon emissions in developing and advanced countries. Heerink et al. [42] conclude that a rise in inequality cuts CO_2 emissions significantly. Brännlund and Ghalwash [56] examined the linkage between income distribution and several environmental measures by utilizing the Swedish household data in 1984, 1988, and 1996. They found that the decline in income distribution reduces CO_2, SO_2, and NOx emissions. Coondoo and Dinda [57] tested the nexus between inequality and carbon dioxide in eighty-eight nations for the period 1960 to 1990. They revealed that income imbalance decreases the emission level. Grunewald et al. [18] confirmed the relationship between income imbalance and CO_2 emissions for the period 1980–2008. For the low and middle-income nations, the outcomes of the study revealed a negative linkage between income disparity and CO_2 emissions. However, in the high-income and upper-middle and nations, the opposite association is confirmed.

On the other hand, there are very scarce scientific studies existing on the linkage between financial instability (FIS) and environmental performance. For example, Richard [36] tested the nexus between financial volatility and CO_2 emissions using a panel data of developed and developing countries. The outcomes of the study indicated that a rise in financial volatility raises the level of CO_2 emissions. However, Brussels [58] stated that financial instability is not harmful to the atmosphere. The study reported that the financial crisis in the economies of Estonia, Italy, Spain, Romania, and the United Kingdom, reduced the level of CO_2 emissions by 24%, 16%, 16%, 22%, and 13%, respectively. Besides, Enkvist, Dinkel, and Lin [59] stated that the financial crisis has a minor effect on CO_2 emissions globally. Shahbaz [19] tested the link between financial fragility and environmental degradation in Pakistan. The results show that financial fragility reduces the quality of the environment. The empirical study led by Nasreen et al. [33] shows that financial stability increases environmental performance. Baloch et al. [16] tested the relationship between financial instability and CO_2 emissions with other variables in Saudi Arabia from 1971 to 2016. They found an insignificant influence of financial instability on CO_2 emissions. Recently, Yang, Ali, Nazir, Ullah, and Qayyum [50] analyzed the nexus between financial instability and CO_2 emission in 54 emerging economies cover the period 1980–2016. The outcomes of the study revealed that a decrease in financial instability would increase the performance of the environment.

It is essential to note that the existing literature on the income inequality-environment relationship has ignored a significant role of financial instability in this nexus. The financial sector is an important pillar in any economy. It can surge economic development and decrease CO_2 emissions by issuing more capital for ecological developments. Also, there are limited research studies on the association between income inequality and environmental degradation for developing countries. By adding financial instability into the income inequality-environment linkage, we could possibly get reliable, consistent outcomes and also solve the question of problem specification.

3. Model Construction and Data Collection

3.1. Data

The objective of this paper is to offer an inclusive investigation of the association between income inequality and financial instability on CO_2 emission for the panel of 47 developing nations. In this study, strongly balanced panel data of 47 developing economies from the period 1980–2016 is used. However, the selection of the sample and the period of the analysis were constrained by data availability. Thus, it decreased our sample size to 47 countries. The names of the countries have been documented in the Appendix A.

CO_2 emission is our dependent variable, which is measured to be the main kind of GHG and the leading source of worldwide warming [3]. CO_2 emission data is measured as metric tons per capita and obtained from the database of the World Bank's website (http://data.worldbank.org). In the analysis, our main variables are income inequality and financial instability. Therefore, income inequality data, considered by the famous Gini coefficient, disclose the range to which the distribution of the income between people differs from absolutely equal distribution. This data of Gini, which varies from 0 (or 0%) to 1 (or 100%), is downloaded from the website of Standardized World Income Inequality Database (SWIID) [60]. The Gini coefficients of 0 show complete equality, and 1 represents complete disparity. The author uses multiple methods to estimate Gini coefficients (for example, net income, consumption expenses, and gross income), this paper utilizes net income measure for inequality, which is consistent with Kotschy and Sunde [61] and Grunewald et al. [18]. We use SWIID because of the following reasons. This indicator can maximize the resemblance of the comprehensive range of countries and periods examined [60]. Moreover, it is developed to increase the global comparability of data on INE, therefore allowing more reliable analysis [60]. Due to its advantages, this indicator is intensively useful in several regions of research studies [62,63].

Regarding the financial instability, we develop a composite financial instability index (FIS) with the support of four financial market-based and bank-based indicators: (1) domestic credit to the private sector (DOP), (2) domestic credit to the banking sector (DOB), (3) liquid liabilities (LLS), and (4) broad money (BMY) [16,50]. The data of these variables are taken from the famous World Development Indicators (WDI) of the World Bank. We generate FIS by employing the principal component analysis (PCA). By using PCA, we can transform a vast number of interrelated variables into a few uncorrelated variables without dropping original variation in the numbers [64,65]. Table 1 presents the PCA for FIS. Table 1 shows that only the first component has an eigenvalue higher than 1 (2.98614). This component is useful as it describes 74.65% of the standardized variance. Thus, we take out the first component of this analysis for FIS because other components are showing small and negative values (presented in the second part of Table 2). We create an index for financial instability following Baloch et al. [16], and Figure A1 demonstrates the scree plot of the eigenvalues of the index (see Appendix A).

$$FIS = (\text{Change in DOP} \times 0.4989) + (\text{Change in DOB} \times 0.5033) + (\text{Change in BMY} \times 0.5275) + (\text{Change in LLS} \times 0.4686).$$

where the FIS is the cumulative value of four financial instability indicators after multiplying the respective coefficient of every component.

Table 1. Principal component analysis (PCA) for composite financial instability index.

Eigenvalues of Matrix				
Component	Eigenvalue	Difference	Proportion	Cumulative

1	2.98614	2.43205	0.7465	0.7465
2	0.554093	0.285396	0.1385	0.8851
3	0.268697	0.0776305	0.0672	0.9522
4	0.191066	-	0.0478	1.0000
Eigenvectors (loadings)				
Variables	Comp1	Comp2	Comp3	Comp4
DOP	0.4989	−0.4485	0.7206	−0.1751
DOB	0.5033	−0.4699	−0.5174	0.5081
BMY	0.5275	0.2283	−0.3970	−0.7156
LLS	0.4686	0.7252	0.2354	0.4462

Note: DOP represents domestic credit to the private sector, DOB is domestic credit to the banking sector, BMY denotes broad money, and LLS shows liquid liabilities.

Table 2. Variable definition and source of the data.

Variables	**Definition**	**Source**
CO_2	Carbon dioxide emissions (Metric tons per capita)	WDI
INE	Gini coefficient of income inequality	SWIID
FIS	Financial instability index (domestic credit to the private sector (% of GDP), domestic credit to the banking sector (% of GDP), liquid liabilities (% of GDP), broad money (% of GDP))	WDI
FOS	Fossil fuel energy consumption (Kilograms of oil equivalent)	WDI
IND	Industrialization, value added (% of GDP)	WDI
GDP	GDP per capita (constant 2010 US$)	WDI
TOP	The ratio of imports plus exports to GDP (% of GDP)	WDI

Note: SWIID is Standardized World Income Inequality Database, and WDI is World Development Indicators.

We also include other essential variables to evade an omitted variable bias. Following the prior literature, fossil fuels, industrialization, gross domestic product (GDP) per capita, and trade are incorporated [3,4,66,67]. All these variables are gathered from the WDI for the period 1980–2016. Detailed information of the variables and their sources are depicted in Table 2. The present study indicates the summary statistics of all the incorporating variables from 1980 to 2016 through box-plot (see Figure 1). Table 3 contains descriptive statistics and a pair-wise correlation for all the indicators (in log form). The CO_2 emission ($LnCO_2$) is significantly associated with all the variables (i.e., LnFIS, LnINE, LnFOS, LnIND, LnGDP, and LnTOP). Moreover, CO_2 emission is positively correlated with all the regressors except income inequality. Income inequality is negatively associated with carbon emissions in developing countries. The higher level of income disparity is linked with improving environmental quality in these countries. On the other hand, financial instability has a positive and significant relationship with pollution. A higher degree of environmental degradation could be attached to a highly unstable and volatile financial system. The other variables, such as fossil fuel consumption, industrialization, economic growth, and trade openness, have a positive and significant association with CO_2 emissions. The greater use of non-renewable energy in developing countries could cause environmental damage. The industrial growth in these countries could be attributed to more pollution as the industrial sector is considered to be the most polluting sector in the economy; factories and production sites require extensive use of energy consumption, which may adversely affect the environment. The higher economic growth in developing economies could also put immense pressure on the environment as GDP and carbon emissions are positively linked in the analysis. Lastly, trade openness is also another significant factor attached to environmental degradation in developing economies.

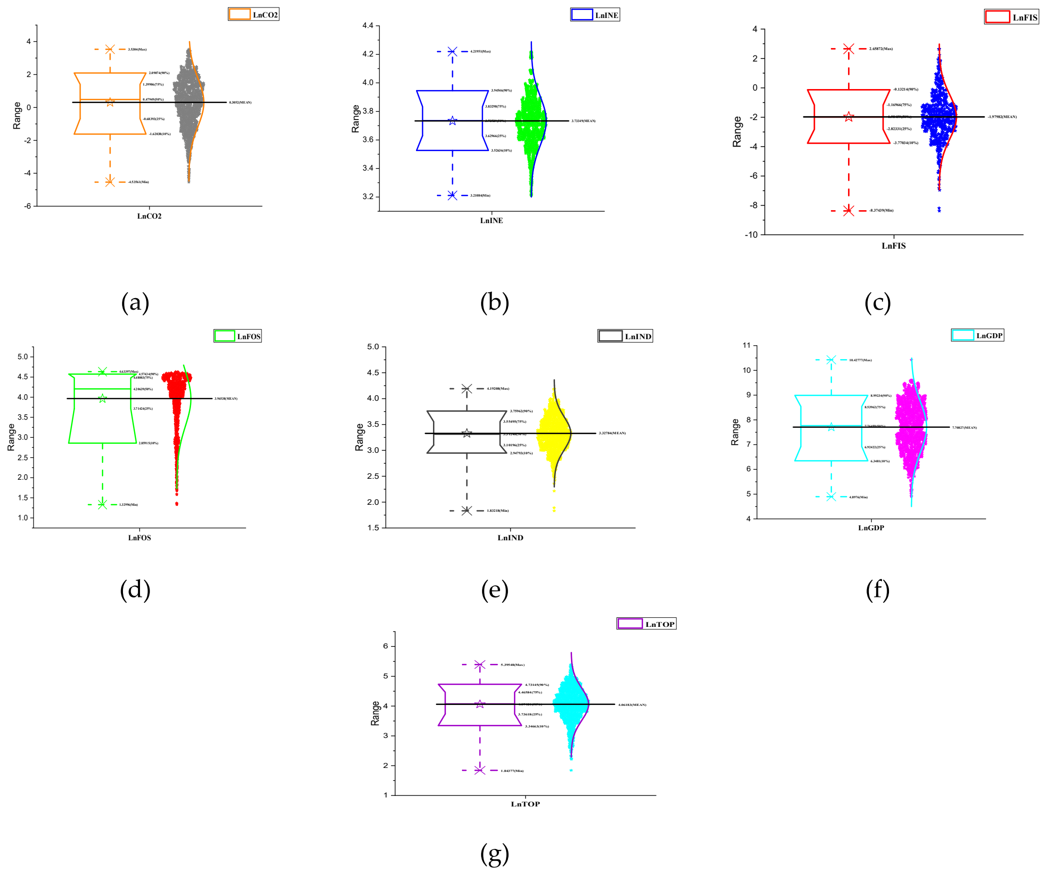

Figure 1. Box plot summary statistics of the variables; (a) $\ln CO_2$; (b) lnINE; (c) lnFIS; (d) lnFOS; (e) lnIND; (f) lnGDP; and (g) lnTOP.

Table 3. Descriptive statistics and pair-wise correlation.

	$LnCO_2$	LnINE	LnFIS	LnFOS	LnIND	LnGDP	LnTOP
Mean	0.3052006	3.733488	−1.979819	3.965378	3.327835	7.708275	4.061826
Std. Dev.	1.465712	0.1704037	1.522674	0.6884935	0.3182225	1.0043	0.5431738
Maximum	3.5304	4.219508	2.658716	4.633966	4.192081	10.42777	5.395477
Minimum	−4.535612	3.210844	−8.374393	1.329957	1.832177	4.897597	1.843773
Observations	1739	1739	1739	1739	1739	1739	1739
$LnCO_2$	1						
LnINE	−0.2830 [a]	1					
LnFIS	0.1570 [a]	−0.1432 [a]	1				
LnFOS	0.4532 [a]	0.2564 [a]	−0.2197 [a]	1			
LnIND	0.1615 [a]	0.0551	−0.0377	0.4963 [a]	1		
LnGDP	0.3052 [a]	0.1527 [a]	0.2482 [a]	0.6351 [a]	0.4380 [a]	1	
LnTOP	0.1799 [a]	0.1706 [a]	−0.0975 [a]	0.1258 [a]	0.0064	0.0316	1

Note:[a] Indicates the level of significance at 1%.

Furthermore, Figures 2–4 indicate the changes in the CO_2 emissions, income inequality, and the index of financial stability across forty-seven developing countries during the sample periods, respectively. To sum up, these illustrations display that the CO_2 emissions show an upward trend from 2001 to 2012 despite fluctuations throughout several sample periods and then start showing a downward trend for the remaining period. Income inequality depicts an upward trend with some fluctuation and then starts declining from 2002 to onwards. Financial instability indicates a mixed trend with various variations throughout the period, but then it starts rising speedily later in 2015.

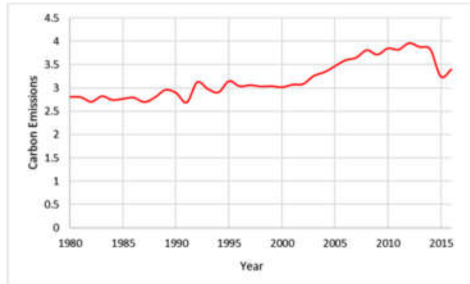

Figure 2. Changes in the CO_2 emissions in forty-seven developing countries.

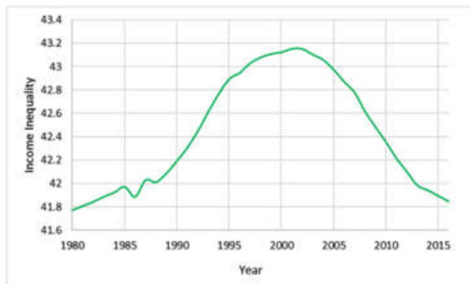

Figure 3. Changes in income inequality in forty-seven developing countries.

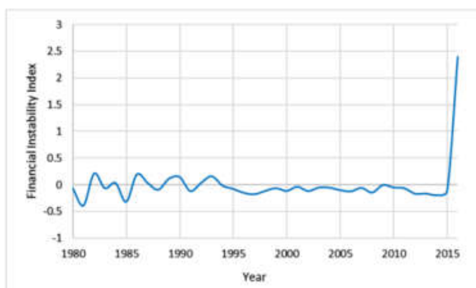

Figure 4. Changes in financial instability in forty-seven developing countries.

3.2. Model

The present study aims to examine the influence of income inequality, financial instability, fossil fuel, industrialization, economic growth, and trade openness on carbon emissions for a panel of 47 emerging nations. To achieve this objective, we used the extended stochastic impacts by regression on population, affluence, and technology (STIRPAT) model. Ehrlich and Holdren [68] recommended the IPAT model, which emphasizes three main factors affecting the environment; the environmental impact (I) is associated to population (P), affluence (A), and technology (T) Thus, IPAT examines the outcome of human activities on the quality of the environment. Based on the conventional IPAT model, York et al. [69] proposed the STIRPAT model, which has been extensively used in previous research studies [70–73]. The specification of the STIRPAT model can be specified as:

$$I_{it} = \alpha P_{it}^{\beta} A_{it}^{\gamma} T_{it}^{\lambda} \mu \quad (1)$$

where I denote the element of the environmental pressure, P is the population of a country, A indicates the affluence, and T represents the technology. Further, β, γ, and λ, are the exponential powers for the independent variables to be projected, α denotes the coefficient of the model, i shows the number of nations; t represents the number of years, and μ is the error term.

After converting both sides of Equation (1) into logarithmic form, we get the following equation:

$$\ln I_{it} = \alpha_0 + \alpha_1 \ln P_{it} + \alpha_2 \ln A_{it} + \alpha_3 \ln T_{it} + \mu_{it} \quad (2)$$

Since our baseline model includes the effect of income disparity (income inequality) and financial instability on CO_2 emissions, we have modified and extended STIRPAT model in the following form:

$$\ln CO_{2it} = \alpha_0 + \alpha_1 \ln INE_{it} + \alpha_2 \ln FIS_{it} + \alpha_3 \ln FOS_{it} + \alpha_4 \ln IND_{it} + \alpha_5 \ln GDP_{it} + \alpha_6 \ln TOP_{it} + u_{it} \quad (3)$$

where CO_2 denotes the carbon emissions, *INE* indicates the income inequality, *FIS* is the financial instability index, *FOS* represents the fossil fuel, *IND* is industrialization, *GDP* indicates the economic growth, and *TOP* denotes the trade openness.

This study proposes that financial instability (*FIS*) and income inequality might have an interaction role besides its direct effect on CO_2 emissions in 47 developing countries. Therefore, focusing on this issue, this paper attempts to examine the interaction role of *FIS* on the linkage between income inequality and CO_2 emission. Thus, to empirically examine the moderating effect of *FIS* and *INE* interaction term on CO_2 emissions, we include an interaction term in Equation (3) and get a new following equation:

$$\ln CO_{2it} = \alpha_0 + \alpha_1 \ln INE_{it} + \alpha_2 \ln FIS_{it} + \alpha_3 \ln FIS^{*} \ln INE_{it} + \alpha_4 \ln FOS_{it} + \alpha_5 \ln IND_{it} + \alpha_6 \ln GDP_{it} + \alpha_7 \ln TOP_{it} + u_{it} \quad (4)$$

The moderating impact will be established once the interaction variable will demonstrate a statistically significant association [74]. Therefore, we also assume that if the coefficient (α_3) is statistically significant, it will validate the moderating function of *FIS* in the analysis.

3.3. Econometric Methodology

The current study used the advanced five econometric approaches for the analysis: Firstly, we confirm the cross-sectional dependency by using the four well-known methods. Secondly, we check the stationarity level of the variables. Thirdly, the Kao, Westerlund, and Pedroni heterogeneous panel cointegration approaches are used to check cointegration amongst the variables. Fourthly, for the long run estimations, we employed the DSUR technique. Finally, we also determine the causality association among the including variables.

3.3.1. Cross-Sectional Dependence Test

In the panel dataset, cross-sectional dependency problems occur most of the time, and without handling these problems, the data could mislead biased prediction. Following Shujah-ur-Rahman et al. [75], we applied the following four prominent and frequently used approaches: (i) Breusch and Pagan [76] established LM (Langrage Multiplier) test; (ii) Pesaran [77] recommended scaled LM test; (iii) bias-corrected scaled LM test proposed by Baltagi et al. [78]; and (iv) Pesaran [77] suggested CD test. The null hypothesis (H_0) for all these tests assumes that variables are cross-sectionally independent.

3.3.2. Panel Unit Root Process

Since our data contain the issue of cross-sectional dependence, we cannot apply the first-generation unit root tests because they could lead to biased outcomes. Thus, the present study has applied second-generation unit root techniques to evaluate the data stationary of panel data of 47 developing countries. The second-generation unit root tests such as Cross-sectional Im-Pesaran (CIPS) and Cross-sectional augmented Dickey-Fuller (CADF), as devised by Pesaran [79], are more appropriate to provide consistent results even when the data has the problem of cross-sectional dependence [80]. The simple linear equation of Pesaran [79] CADF unit root is normally expressed as follows:

$$\Delta y_{it} = \alpha_i + \rho_i y_{it-1} + \beta_i \overline{y}_{t-1} + \sum_{j=0}^{k} \gamma_{ij} \Delta \overline{y}_{it-1} + \sum_{j=0}^{k} \delta_{ij} y_{it-1} + \varepsilon_{it} \quad (5)$$

where $\sum_{j=0}^{k} \gamma_{ij} \Delta \overline{y}_{it-1}$ indicated the lagged terms of cross-sectional averages and $\sum_{j=0}^{k} \delta_{ij} y_{it-1}$ indicates the first difference value of individual time series. The equation of the CIPS stationarity test can be stated by obtaining t-value from the mean values of individual CADF.

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

3.3.3. Heterogeneous Panel Cointegration Approaches

To measure the cointegration between the variables we used three diverse econometric techniques: (a) Pedroni [81,82] recommended a two-step process to ensure cointegration among variables; (b) Kao [83] introduced a test in which data were obtained from panel analysis known as a least-squares dummy variable (LSDV) method. Kao t-statistic commences homogeneity in panels based on the framework of ADF; (c) Westerlund [84] proposed a heterogenous panel co-integration with error-correction adjustment, which is a very appropriate technique in the con-integration analysis. Therefore, following Shujah-ur-Rahman et al. [75], and You et al. [3], this study used Westerlund's [84] co-integration test, alongside Kao [83] and Pedroni [81,82] co-integration tests, because it addresses cross-sectional dependency and delivers unbiased outcomes. Since our data has the problem of cross-sectional dependence, we have applied the advanced technique of Westerlund [84] to incorporate the issue of cross-dependency to have more consistent and reliable findings.

3.3.4. Long-Run Estimations

Moreover, to measure the long run estimations between all the variables while handling the other econometric issues relating to the panel data, we used the second generation econometric method proposed by Mark et al. [85], the "Dynamic Seemingly Unrelated Regression" (DSUR). They extend the single-equation estimator Dynamic Ordinary Least Square (DOLS), and by incorporating the issues of heterogeneity, endogeneity, and cross-sectional dependency in the panel dataset, they propose multiple-equation cointegration regression. Second-generation analysis can control cross-sectional dependence and other problems associated with panel statistics and deliver fair and more reliable results. Thus, following Saud et al. [80] and Rua [86], the present study employed the DSUR method to measure the long-run estimates of the variables.

3.3.5. Panel Causality Test

To examine the causal nexus between our variables of interest and determine the direction of causality, the current study applies the advanced approach developed by Dumitrescu and Hurlin [87] non-Granger causality test. This approach is more advanced and addresses the issue of heterogeneity, which was ignored by the traditional Granger causality approach [88,89]. This approach is based upon *W*-bar and *Z*-bar statistics which could be stated as follows:

$$W_{N,T}^{HNC} = \frac{1}{N}\sum_{i=1}^{N} W_{i,t}; Z_{N,T}^{HNC} = \frac{\sqrt{N}\left[W_{N,T}^{HNC} - \sum_{i=1}^{N} E(W_{i,t})\right]}{\sqrt{\sum_{i=1}^{N} Var(W_{i,t})}} \quad (7)$$

where $W_{i,t}$ indicates Wald statistics, and Z bar is measured from the mean and variance values of Wald statistics. The null hypothesis tests the non-homogenous causality of data.

4. Results and Discussion

Firstly, we check the cross-sectional dependency issue in the variables by using the scaled LM, bias-corrected LM, B-P LM, and Pesaran-CD tests. The outcomes of all the tests stated above conclude that cross-sectional dependence is present in the economies. All the regressors (i.e., $LnCO_2$, LnFIS, LnINE, LnFOS, LnIND, LnGDP, and LnTOP) are statistically significant at 1% significance level (see Table 4). It shows that disturbance in one economy will damage the other developing countries in the panel.

Table 4. Outcomes of cross-section dependence test.

Variables	Breusch-Pagan LM		Pesaran Scaled LM		Bias-Corrected Scaled LM		Pesaran CD	
	Statistic	**Prob.**	**Statistic**	**Prob.**	**Statistic**	**Prob.**	**Statistic**	**Prob.**
$LnCO_2$	10,713.11 [a]	0.0000	206.1434 [a]	0.0000	205.4906 [a]	0.0000	32.35966 [a]	0.0000
LnINE	19,340.30 [a]	0.0000	391.6850 [a]	0.0000	391.0322 [a]	0.0000	11.38751 [a]	0.0000
LnFIS	15,728.48 [a]	0.0000	314.0069 [a]	0.0000	313.3541 [a]	0.0000	57.08336 [a]	0.0000
LnFOS	14,575.39 [a]	0.0000	289.2079 [a]	0.0000	288.5551 [a]	0.0000	12.69639 [a]	0.0000
LnIND	9576.092 [a]	0.0000	181.6899 [a]	0.0000	181.0371 [a]	0.0000	2.734521 [a]	0.0062
LnGDP	20,234.00 [a]	0.0000	410.9056 [a]	0.0000	410.2528 [a]	0.0000	112.9696 [a]	0.0000
LnTOP	7683.117 [a]	0.0000	140.9784 [a]	0.0000	140.3256 [a]	0.0000	43.60008 [a]	0.0000

Note: [a] Denotes 1% significance level..

Secondly, we examine the stationarity or unit root of the variables by applying the two second-generation panel unit root tests (i.e., CADF and CIPS). The results are reported in Table 5. The outcomes of CIPS reveal that LnINE, LnFOS, LnIND, and LnGDP are not stationary at levels. So, we cannot decline the null hypothesis. All the variables turn out to be stationary at the first difference at 1% significance level. The outcomes of CADF indicate that LnINE, LnFOS, LnIND, and LnGDP are non-stationary at levels. All the variables become stationary when enumerated at the first difference at 1% significance level. Thus, the results of all the two approaches confirm that all the variables have the order of integration I(1) because they become stationary at first difference.

Table 5. Panel unit root results.

Variables	Cross-sectional Im-Pesaran (CIPS)		Cross-sectional augmented Dickey-Fuller (CADF)	
	At Level	**1st Difference**	**At Level**	**1st Difference**
$LnCO_2$	−2.366 [a]	−5.604 [a]	−1.951 [c]	−4.479 [a]
LnINE	−1.152	−3.555 [a]	−1.767	−2.724 [a]
LnFIS	−4.101 [a]	−5.692 [a]	−3.546 [a]	−5.129 [a]
LnFOS	−1.832	−5.437 [a]	−1.829	−4.366 [a]
LnIND	−1.654	−5.360 [a]	−1.680	−4.221 [a]
LnGDP	−1.571	−4.446 [a]	−1.772	−3.730 [a]
LnTOP	−2.275 [a]	−5.438 [a]	−2.347 [a]	−4.364 [a]

Note: [a] Denotes 1% significance level. [c] Signifies 10% significance level.

Thirdly, after checking the integration order in the variables, we then examine the long-run equilibrium relationship among the variables. The outcomes of all the three-panel co-integration investigations are reported in Table 6. Empirical confirmation of all the panel co-integration tests indicates that we can refute the null hypothesis (i.e., H_0 = no cointegration) at a 1% critical level (see Table 6). Thus, we establish that co-integration and long term relationships prevail between the investigated variables. Next, we can continue to the DSUR technique by using the models specified in Equations (3) and (4)Equation (3); Equation (4).

Table 6. Outcomes of panel co-integration test.

Test	Cointegration Test	Stat. Value	*Z* Value	*p*-Value
Westerlund ECM				
	G_t	−3.517 [a]	−4.862	0.000
	G_a	−15.296	1.365	0.914
	P_t	−28.197 [a]	−9.785	0.000
	P_a	−19.112 [a]	−4.412	0.000
Pedroni				

		Within dimension	
	Panel v	−0.172922	0.5686
	Panel rho	−1.687155 [b]	0.0458
	Panel PP	−16.17323 [a]	0.0000
	Panel ADF	−14.26978 [a]	0.0000
		Between dimension	
	Group rho	1.706286	0.9560
	Group PP	−20.64025 [a]	0.0000
	Group ADF	−11.57220 [a]	0.0000
Kao			
	ADF	3.889659 [a]	0.0001

Note: [a] Denotes 1% significance level [b] Signifies 5% significance level.

The DSUR econometric technique was utilized to obtain the regression coefficients of LnINE, LnFIS, LnFISXLnINE, LnFOS, LnIND, LnGDP, and LnTOP concerning with LnCO_2. The documented results in Table 7 conclude that all the variables have a significant impact on the environment (CO_2) at 1%, 5%, and 10% significance level except LnFIS in model 1. Regarding income inequality, which is also our core variable in this study, we notice that income inequality negatively influences environmental degradation. It implies that a 1% increase in inequality is linked with a 0.0968% reduction in CO_2 emission level and vice versa. These outcomes are also contrary to the theoretical stance of Boyce [40], who posited that spreading income disparity generates a power gap among poor and rich in the society that can raise environmental pollution. While the wealthy persons grasp the benefit of the atmosphere, the less-privileged bear the cost of the atmospheric deterioration. Therefore, these results urge that alleviating income inequality may reduce environmental quality by increasing CO_2 emissions. Our outcomes stand with the results of Demir et al. [90] for Turkey and Grunewald et al. [18] for low and middle-income economies. Therefore, a better imbalance in the community creates less cumulative consumption and wastage in the economy due to the lesser tendency to emit by the wealthier households resulting in enhanced environmental quality. However, these findings are opposing to those of Zhang and Zhao [91] for Chinese regions, Knight et al. [54] for high-income countries, and Liu et al. [92] for China. We assume that this inconsistency with the present study is because we have heterogeneous data of forty-seven developing countries having different economic and political dynamics, and we have employed the DSUR estimation to get the generalized outcomes for the whole sample.

Table 7. Results of long-run estimations through Dynamic Seemingly Unrelated Regression (DSUR).

Dependent Variable = LnCO_2						
	Model 1			**Model 2**		
Variables	**Coefficient**	***t*-Value**	***p*-Value**	**Coefficient**	***t*-Value**	***p*-Value**
LnINE	−0.0968 [a]	−6.40	0.000	−0.0965 [a]	−6.39	0.000
LnFIS	−0.1292	−1.28	0.202	−1.8663 [b]	−2.17	0.030
LnFOS	0.0314 [a]	6.53	0.000	0.0313 [a]	6.53	0.000
LnIND	−0.0541 [a]	−4.36	0.000	−0.0541 [a]	−4.36	0.000
LnGDP	0.0001 [c]	1.88	0.061	0.0001 [c]	1.89	0.059
LnTOP	0.0208 [a]	6.74	0.000	0.02081 [a]	6.76	0.000
LnFISXLnINE				0.0445 [b]	2.03	0.042

Note: [a] Denotes 1% significance level [b] Signifies 5% significance level [c] Shows 10% significance level.

The long-run link between FIS and pollution in model 1 is negative but not significant. It indicates that financial instability does not promote CO_2 emissions, and it is not detrimental to the atmosphere in 47 emerging economies. The outcomes are acceptable because it is possible that throughout the difficult financial period, people become more aware of their expenses. They restrict their activities (i.e., drive less, fly less notion) and eventually use less energy to get through in the phase of a financial dilemma. Therefore, due to the sensible expenditures of the people, no significant rise can be noticed in GHG emissions throughout the time of financial instability. The outcomes of the model are consistent with Brussels [58] and Baloch et al. [16], who stated that FIS is not detrimental to the atmosphere.

The DSUR analysis signifies that fossil fuel depicts a positive and statistically significant relationship with CO_2 emission. The coefficient of FOS concludes that 1% increase in energy use due to the consumption of fossil fuel leads to increase emissions by 0.0314% in 47 developing countries. Energy from FOS is degrading the environmental quality by releasing high carbon emissions. The findings of FOS consumption support the conclusions of [66,93]. They found that the increase in non-renewable energy usage upsurges the emissions level of CO_2. The coefficient of IND is statistically significant at the 1% level. One percent decrease in industrialization causes a 0.0541% decrease in CO_2 emissions in 47 developing countries. The outcomes are in line with the conclusion of Sarkodie and Owusu [94]. Increasing the availability and accessibility of green energy resources can stimulate industrialization, which would consequently increase economic development in these developing countries. Regarding economic growth, there is a significant positive linkage between GDP and CO_2 emissions at 10% significance level. It denotes that a 1% increase in GDP causes a 0.0001% increase in the emission level of carbon dioxide in 47 emerging nations per annum. Our findings support the conclusion of [14,95]; they have stated a positive and significant effect of GDP on environmental degradation. Because the development of the economy is intensely associated with high usage of energy, therefore, countries consume more energy to increase their economic growth by producing more units of output, which eventually raises the level of CO_2 emissions. Moreover, TOP is positively linked to carbon emissions at a 1% statistical level. The coefficient of TOP signifies that the level of CO_2 emissions raises by 0.0208% due to a 1% increase in TOP. The results of TOP is congruent to the outcomes of Danish et al. [35] and Hashmi et al. [96]; they confirm the existence of a significant association between TOP and CO_2 emissions. The outcomes for 47 emerging economies can be vindicated that the size of economic growth is expanding through scale effect, which may raise the deterioration of the environment. The manufacturing of less carbon-intensive goods has contained more emissions. In recent years, the study of driving force authenticates that trade volume is presenting as the leading driver in increasing emissions activities [97].

The model 2 of Table 7 includes the interaction variable (LnFISXLnINE) to check the moderating effect on CO_2 emissions. We have found some exciting outcomes regarding the coefficient of the interaction term. The result shows the significant and positive effect of the interaction term on CO_2 emissions at a statistical 1% level. It reveals that a rise in inequality, ceteris paribus, in integration with the increase in financial instability is likely to increase pollution. It implies that a robust financial sector is inevitable for reducing inequality and, thus, CO_2 emissions in developing countries. When the financial sector in the country starts rising through different channels, such as the financial and banking services sector, it not only affects the economic development pattern but also influences the environment, and, subsequently, affects the distribution of income. Therefore, the distribution of income, which is characterized by excessive economic development, is directly affected by the progress of the financial sector. So, countries should improve their financial sector to overcome the issues of income disparity and environmental pollution.

The indications of all the variables remain the same as reported in model 1, except the financial instability indicator. The coefficient of FIS shows a significantly negative association with CO_2 emissions at a statistically 5% level. A 1% increase in FIS lowers environment degradation by 1.8663% in 47 developing nations. Our result of FIS is consistent with the outcomes of the work of Yang et al. [50], which reported that FIS increases the quality of the environment. However, these outcomes are contradicted with the findings of Richard [36] for a panel of 36 countries, and with Shahbaz [19] in the case of Pakistan. The possible justification for this outcome is that during the period of financial instability in an economy, the production of luxury goods which consume high energy becomes slow; firms produce fewer products because people are not willing to buy these expensive things in the time of financial instability. Also, in the time of financial catastrophes, investors did not invest their money into highly expensive projects (i.e., energy-related) due to asymmetric information. Therefore, the shortage of financing in the energy sector throughout the period of financial fragility can also be the cause of decreasing CO_2 emissions.

Lastly, the direction of causality would help the policymakers to set suitable economic strategies besides environmental policies in the selected developing countries. Therefore, for this purpose, we employ the D-H causality technique to confirm the causal association between the model parameters, i.e., CO_2 emissions, INE, FIS, FOS, IND, GDP, and TOP. The sign and direction of causality can be recognized from the coefficients of significant levels of the required variables. The outcomes reveal that in the long-run bidirectional causality was noticed between income inequality (INE) and CO_2 emissions. These outcomes show a strong relationship between INE and CO_2 emissions in the forty-seven developing countries, which indicates that INE plays a significant role not only in environmental quality but also in the economic development of the country. However, these outcomes are contradicted with the previous study, i.e., Demir et al. [90], who report a unidirectional causal relation between income inequality and CO_2. Similarly, financial instability (FIS) and CO_2 emissions also indicate a bidirectional causal association. These outcomes depict a strong link between FIS and CO_2. However, the findings of Baloch et al. [16] are opposed to our outcomes. They find no causal relation between financial instability and CO_2. The bidirectional causality also exists between GDP and CO_2. Saud et al. [15] also reveal similar findings. The direction of causality demonstrates that GDP causes CO_2 and vice versa. The bidirectional association is also noticed between FOS and CO_2. Nasreen et al. [33] also confirm a similar causal association for India, Bangladesh, and Srilanka. Industrial growth and CO_2 also have a bidirectional causal relation, which is consistent with the study of Uzar and Eyuboglu, [49]. Two-way causal linkage is also observed between trade openness (TOP) and CO_2, which is parallel to the conclusion of Saud et al. [80]. The interaction term (FISXINE) also evidences a two-way causality towards CO_2. The results of the interaction term imply a pollution-enhancing role of financial instability and income inequality when their multiplying or joint effect is accounted for. Similarly, two-way causal associations were noticed between; INE and FIS, INE and FOS, INE and IND, INE and GDP, INE and TOP, INE and FISXINE, FIS and IND, FIS and GDP, FIS and FISXINE, FOS and IND, FOS and GDP, and FOS and TOP, GDP and TOP, GDP and FISXINE; however, unidirectional causality is running from TOP to FIS and TOP to FISXINE. Moreover, no causal relationship was tested between FIS and FOS and FISXINE and FOS. The outcomes of the D-H panel causality test are listed in Table 8.

Table 8. Dumitrescu-Hurlin panel causality.

Variables	$LnCO_2$	LnINE	LnFIS	LnFOS	LnIND	LnGDP	LnTOP	LnFISXLnINE
		3.5742 ^{a}	1.7664 ^{a}	3.5894 ^{a}	3.6397 ^{a}	4.3453 ^{a}	2.1791 ^{a}	1.7526 ^{a}
$LnCO_2$	-	(12.4790)	(3.7150)	(12.5528)	(12.7963)	(16.2169)	(5.7157)	(3.6483)
		0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0003
	6.7222 ^{a}		1.4916 ^{b}	6.4620 ^{a}	5.5339 ^{a}	7.7738 ^{a}	12.3318 ^{a}	1.5211 ^{b}
LnINE	(27.7393)	-	(2.3831)	(26.4779)	(21.9789)	(32.8374)	(54.9328)	(2.5260)
	0.0000		0.0172	0.0000	0.0000	0.0000	0.0000	0.0115
	2.0313 ^{a}	1.6458 ^{a}		1.0870	1.5875 ^{a}	2.0825 ^{a}	1.2070	2.3463 ^{a}
LnFIS	(4.9995)	(3.1307)	-	(0.4217)	(2.8481)	(5.2475)	(1.0033)	(6.5265)
	0.0000	0.0017		0.6732	0.0044	0.0000	0.3157	0.0000
	1.9917 ^{a}	2.9176 ^{a}	0.9979		2.5326 ^{a}	2.1834 ^{a}	1.8246 ^{a}	0.9667
LnFOS	(4.8076)	(9.2959)	(−0.0101)	-	(7.4296)	(5.7366)	(3.9976)	(−0.1615)
	0.0000	0.0000	0.9919		0.0000	0.0000	0.0000	0.8717
	1.8737 ^{a}	2.1018 ^{a}	2.8159 ^{a}	2.7000 ^{a}		2.1103 ^{a}	1.9529 ^{a}	2.8305 ^{a}
LnIND	(4.2355)	(5.3414)	(8.8027)	(8.2412)	-	(5.3821)	(4.6194)	(8.8736)
	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000
	3.9512 ^{a}	4.3489 ^{a}	3.5379 ^{a}	2.6998 ^{a}	3.4712 ^{a}		4.3878 ^{a}	3.5581 ^{a}
LnGDP	(14.3065)	(16.2344)	(12.3027)	(8.2399)	(11.9796)	-	(16.4230)	(12.4006)
	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000
	1.7609 ^{a}	2.8006 ^{a}	1.8703 ^{a}	1.9252 ^{a}	2.3344 ^{a}	1.5084 ^{b}		1.9227 ^{a}
LnTOP	(3.6887)	(8.7288)	(4.2191)	(4.4851)	(6.4686)	(2.4645)	-	(4.4729)
	0.0002	0.0000	0.0000	0.0000	0.0000	0.0137		0.0000
LnFISXLnINE	2.0178 ^{a}	1.6293 ^{a}	2.3177 ^{a}	1.0874	1.5977 ^{a}	2.0852 ^{a}	1.2152	

	(4.9341)	(3.0506)	(6.3877)	(0.4236)	(2.8975)	(5.2605)	(1.0432)	-
	0.0000	0.0023	0.0000	0.6719	0.0038	0.0000	0.2968	

Note: H_0: No causality. Top values indicates w-stat. ( ) shows z-stats. [a] Signifies 1% significance level. [b] Denotes 5% significance level.

5. Conclusion

Greenhouse gas emissions, climate change, and global warming have become critical risk factors to our environment. Previous works on the environment conclude that high consumption of energy is one of the leading sources of low environmental quality. In this situation, worldwide economies are doing their best to make the environment sustainable for their upcoming generations and masses. This unique study examines the effect of income inequality, financial instability, fossil fuel consumption, industrialization, economic growth, and trade openness with the interaction variable (LnFISXLnINE) on CO_2 emissions in 47 emerging countries. This scientific study utilizes panel data of 47 emerging countries from 1980–2016. For authentic results, this paper uses second-generation advanced econometric techniques to confirm cross-sectional dependence, stationarity, and co-integration amongst variables. Further, this study employs the DSUR to examine the long-run association and the DH non-Granger panel causality approach to confirm the causal link amongst the variables.

The outcomes from DSUR indicate that income inequality is increasing the environmental quality of 47 developing nations in the long run, as this study found a significantly negative impact of income inequality on CO_2 emissions in both the models with and without the interaction term. However, the results of the financial instability index are fascinating because, without interaction term, it shows the no significant effect on CO_2 emissions, whereas, after adding the interaction term which is our main contribution in the model, the coefficient of financial instability depicts a significantly negative impact on environmental degradation. These findings are consistent with the conclusion of Demir et al. [90], Grunewald et al. [34], and Yang et al. [50]. The results of financial instability imply that the broad and established financial sector is essential for increasing the environmental quality in developing economies in the long-run. The outcomes of income inequality support the argument of Ravallion et al. [55], that poor populations in a country have higher marginal properties to emit than wealthy people; higher inequality in a country helps to generate lesser emissions as underprivileged households are becoming omitted from carbon economy due to the lower-income level. However, the results of the interaction term (LnFISXLnINE) reveals a significant positive effect on CO_2. The interactive effect of both income inequality and financial instability enhances environmental degradation in developing countries. Financial instability plays a moderating role between income inequality and CO_2 emissions. These findings imply that the social inclusion agenda of respective governments should be tightly linked with their financial development policies to improve the environmental quality in these countries; otherwise, stand-alone policies would not provide potential benefits of sustainable development. Our empirical findings also conclude that economic growth, fossil fuel consumption, and trade openness raises environmental degradation while industrialization enhances the quality of the environment. The outcomes of the D-H panel causality test found a bidirectional causal linkage between CO_2 and income inequality, CO_2 and financial instability, CO_2 and fossil fuel, CO_2 and industrialization, CO_2 and economic growth, $CO_{2,}$ and trade openness, CO_2 and FISXINE.

Based on the above outcomes, the subsequent policy suggestions may be implemented to increase the performance of the environment of these 47 emerging countries. First, income inequality should be well-synchronizedwith financial instability to reduce environmental degradation by lowering carbon emissions in the atmosphere. We can state that reducing the imbalance between the wealthy and the poor can raise the quality of the environment. Second, the Sustainable Goals of the United Nations can work as a framework that might connect protection measures of the environment and acquire inclusive progress through the decreasing of inequality. Third, the results of our study also proposed that the existing strategies of developing economies to support the financial sector are not dangerous to the atmosphere, and it is advised that the continuousness of this strategy would be passed on. Moreover, the present outcome also motivates the policymakers to reconsider the strategy framework about energy consumption. Lastly, the outcomes of the analysis disclose that the consumption of fossil fuel is the crucial element behind increasing degradation of the environment. In this regard, it is extensively advised that the administration of these countries should stimulate financial institutions to help the department of research and development in carrying eco-friendly technology (i.e., biogas, biomass, and solar). However, this study utilizes a sample containing 47 developing economies from different parts of the world with diverse economic and political dynamics; our findings, therefore, do not suggest the same policy proposal for all 47 countries. Thus, individual countries should evaluate and tailor the recommended policy proposals according to their country-specific factors.

Furthermore, the issue of income inequality and financial instability may also have some severe effects on developed countries. Therefore, these findings have some implications for developed nations. First, it is suggested to the administrations of the developed countries to institute a balanced income growth approach and inclusive development strategy for low and middle-income citizens while regulating the distribution of the income. Policymakers should confirm that the increase in the income of a poor does not transform into higher emissions. Hence, the pressure of the environment can be condensed when dispensing income more justifiably. Second, environmental changes for carbon emission should be reviewed in policy preparation and execution. The motive of policies must be acknowledged to increase the overall prosperity of the public and decouple the underlying linkage between carbon emissions and economic expansion stages across areas. Lastly, encouraging a green lifestyle along with policy direction and enhancing environmental awareness in public are excellent ways to decrease carbon emissions. The administration should introduce the latest green technologies so that citizens could raise their demand for sustainable products.

Though this research gives several new understandings on the linkage between income inequality, financial instability, and environment,, yet it has certain constraints. This study cannot investigate the indirect effect of income inequality and financial instability on the environment. Besides, these economies have diverse cultural backgrounds; if the statistics related to culture can be obtained, we can incorporate cultural differences into analysis and examine their impacts on the environment, which might deliver various novel outcomes. Moreover, there is still room for regional and country-level analysis by applying other proxies of income inequality and making a comparative assessment of developed and developing countries.

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Appendix A

Table A1. Names of the countries with their geographic region.

No.	Geographic Region	Name of Country
1	East Asia & Pacific	China
2		Indonesia
3		Malaysia
4		Philippines
5		Thailand
6		Vietnam
7	Europe & Central Asia	Albania
8		Armenia
9		Azerbaijan
10		Bosnia and Herzegovina
11		Kyrgyz Republic

12		Moldova
13		Tajikistan
14		Ukraine
15	Latin America & Caribbean	Argentina
16		Brazil
17		Chile
18		Colombia
19		Dominican Republic
20		Guatemala
21		Mexico
22		Nicaragua
23		Peru
24		Suriname
25		Uruguay
26		Venezuela, RB
27	Middle East & North Africa	Algeria
28		Egypt
29		Iran
30		Jordan
31		Lebanon
32	South Asia	Bangladesh
33		India
34		Pakistan
35		Sri Lanka
36	Sub-Saharan Africa	Benin
37		Cote d'Ivoire
38		Ghana
39		Kenya
40		Mauritius
41		Mozambique
42		Namibia
43		Niger
44		Nigeria
45		South Africa
46		Togo
47		Zambia

Source: International Monetary Fund (IMF) and World Bank.

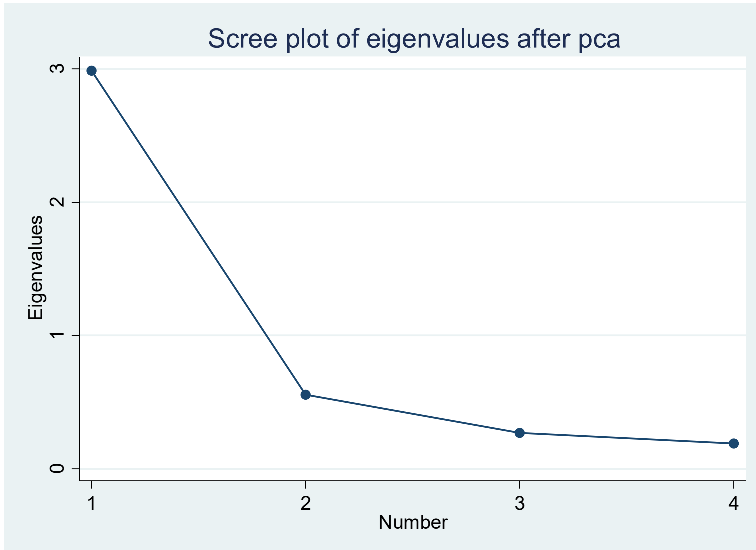

Figure A1. This graph shows the variance reported by the different indicators.

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