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Corresponding Author: Muhammad Arif (Email: dr.arif@uoswabi.edu.pk)

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The Effects of Financial Inclusion and Institutional Quality on the Environmental Sustainability: Evidence from Top 30 High Greenhouse Gas Emitter Countries

Faid Ali [a] Said Shah [b] Muhammad Arif [c]

Abstract: *The study investigates the effects of financial inclusion (FIN) and institutional quality (INQ) on the environmental sustainability (ES) in the highest 30 greenhouse gas (GHG) emitter countries from 2004 to 2021. The study created composite indexes from the facets of the FIN and INQ, using principal component analysis (PCA). In the preliminary analysis the study conducted cross-sectional dependency (CSD), slope homogeneity, structural breaks and unit root test for ultimate review of the dataset. The study adopted 3rd generation cross-sectional autoregressive distributed lag model (CS-ARDL) to estimate long and short run relationships. The empirical findings of the study reveal that the FIN is significantly reducing environmental pressures. However, the INQ increases environmental dilapidation. Further, the findings of the interactive nexus of FIN and INQ on the ES is not momentous. Finally, the study recommends valuable policy suggestions for the policymakers of the developing and developed world for endorsing their ES.*

Keywords: Financial Inclusion, Institutional Quality, Environmental Sustainability, Greenhouse, Emission

Introduction

Global warming and climate change are burning topics worldwide, as indicated by the exponential growth in academic literature, political dialogues, media coverage, regulatory and legal responses (Ozturk & Acaravci, 2013). On flip side, the persistent GHG emission caused environmental degradation, as a result jeopardized the global climate system. The success of the Paris club agreement and other environmentally friendly policies are mainly dependent on the INQ of an economy (Salman et al., 2019). Institutions can be of four types; administrative, political, social and economic (Nguyen et al., 2018; Goel et al., 2013) thus the quality of each type of institution relates with its target's achievement.

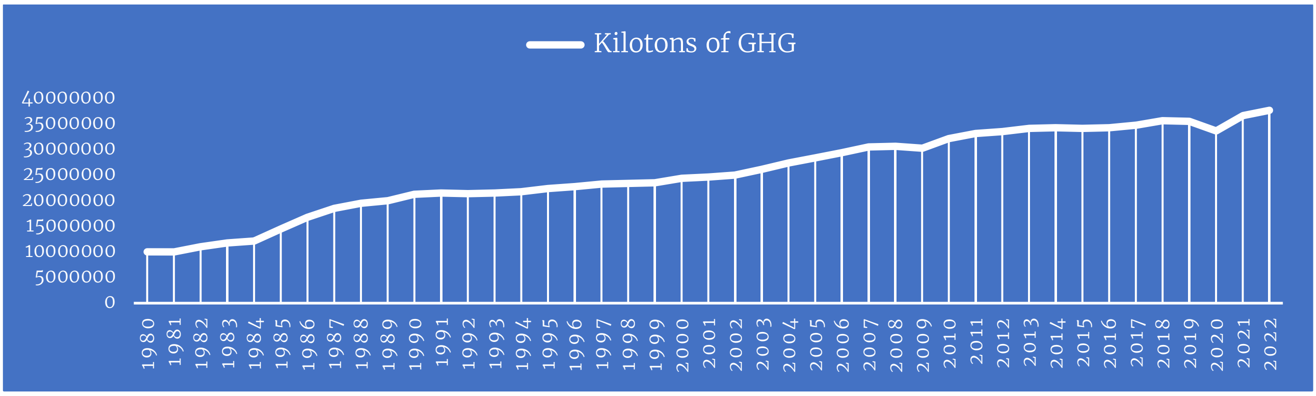
An active and dynamic institutional structure assists in framing and implementing environmentally friendly regulations. Contrary to the above, an incapable and weak institutional structure allow individual and organization to breach laws and rules in respect of environmental quality for profit maximization (Welsch, 2004). Besides, the robust institutional framework assists in reducing environmental pollution, which is beneficial for local community as well as for adjoining countries through the spillover effects (Hosseini & Kaneko, 2013).

In the last two decades the GHG emission shown enormous increase, in 2022, the global GHG emission (excluding emission from soil) continued to rise at the rate of 1.10%, reaching global GHG emission to 56.70 gigatons of CO_2 equivalent (Wawrzyniak & Doryn, 2020). The growth rate of 1.10% of the global GHG emission is twofold that of 2018.

[a] PhD Scholar, Department of Management Sciences, University of Swabi, Khyber Pakhtunkhwa, Pakistan.
[b] Assistant Professor, Department of Management Sciences, University of Swabi, Khyber Pakhtunkhwa, Pakistan.
[c] Assistant Professor, Department of Management Sciences, University of Swabi, Khyber Pakhtunkhwa, Pakistan.

Figure 1

Global GHG Emission Trend from 1980 to 2022

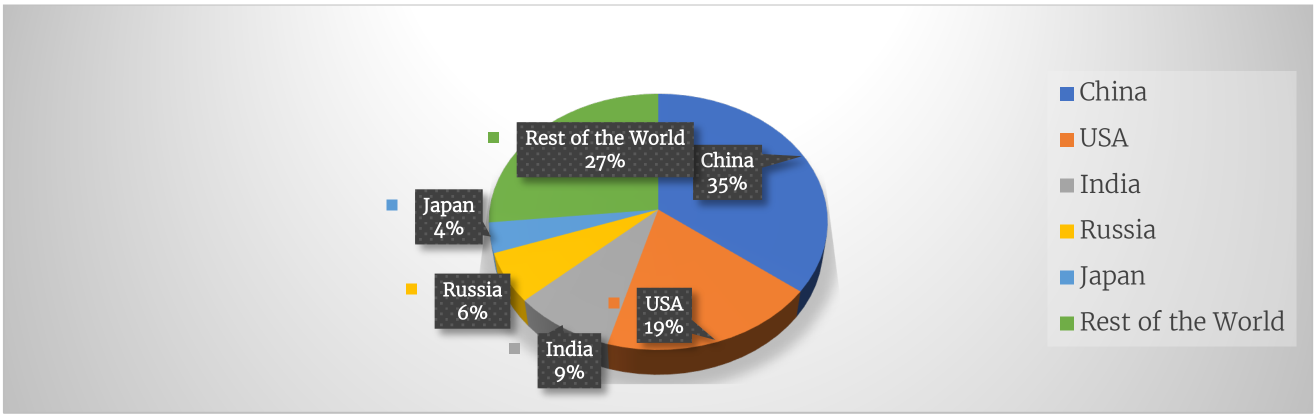


Author Own Calculation, EPA Report 2022

The countries which significantly contributed in global GHG emission are China, America, India, Russia, Japan, which contribute about 73%, while the rest of the world contribution is about 27% (Hosseini & Kaneko, 2013).

Figure 2

Global GHG Emission by Country

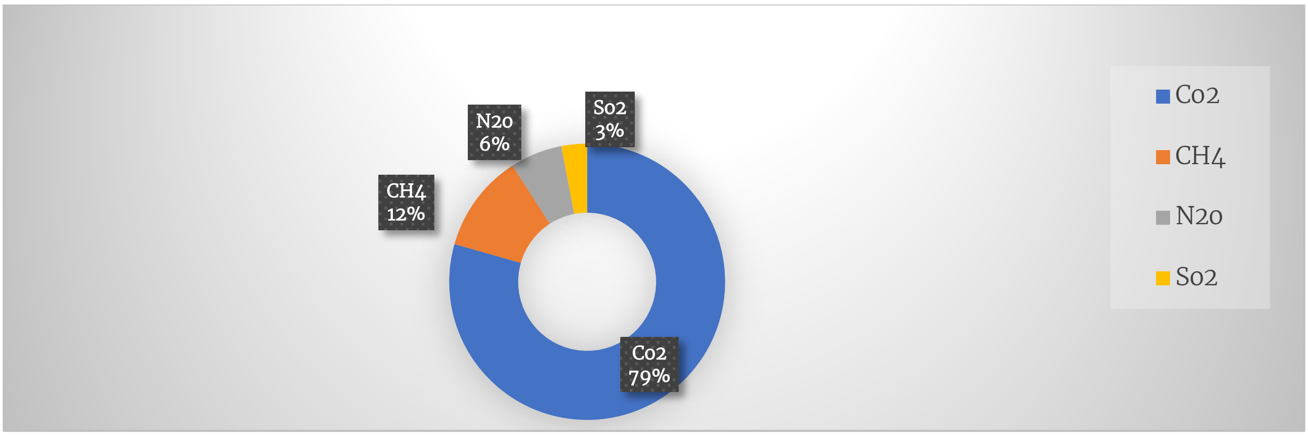


Author Own Calculation from WPR 2022

The GHG emission is composed of methane (CH_4), nitrous oxide, (N_2O), carbon dioxide CO_2 and sulfur dioxide (SO_2) wherein, the ratio of CO_2 in the atmosphere is significantly higher than the other gases (Laegreid & Povitkina, 2018).

Figure 3

Global GHG Emission by Gases 2022



Author Own Calculation from EPA, Report 2022

This study is different from the existing literature in the three different aspects; first, numerous studies have used only CO_2 emission as a GHG indicator for ES however, the study has taken novel proxies for ES such as N_2O, SO_2, CH_4 and CO_2 (Wang & Luo, 2020; Khattak et al., 2020; Bhattacharya et al., 2017). Second, the existing literature has mainly focused on single domain of FIN (financial access) however, this study has taken all proxies of FIN (Khan & Rana, 2021; Wawrzyniak & Doryn, 2020; Acheampong et al., 2021). Third, the existing literature neglected the combined role of institutional factors in determining ES and only focused on either one or two proxies of INQ that is, control of corruption and rule of law but this study has taken all proxies of INQ (Ozturk, 2020; Arminen & Menegaki, 2019; Yasin et al., 2021; Godil et al., 2021). The study came to fill research gap by analyzing the interactive nexus of FIN and INQ on the ES of the top 30 high GHG emitter countries for the period 2004 to 2021.

The macroeconomic modelling of the study FIN over GHG emission is purely based on the theoretical underpinnings of the Financial Kuznets Curve (FKC) hypothesis. The theory described that, at the initial stage of economic growth the financial development boosts up the demand for energy consumption, as in the initial stage the economies are more inclined towards growth, which results in higher GHG emission. However, in the later stages of economic development, the efficient policies and structural changes may lead to the deployment of green and clean technology, consequently reduce GHG emission (Baloch & Meng, 2019). The theoretical underpinning at the backend of nexus between INQ and ES is based on the standard helping hand or public interest theory. The theory argued that the regulatory rules and government interventions in response to market imperfection and failure in the best interest of the public.

The study is important in four perspectives: first, it is projected that due to the curtailment of the energy intensive operations, the global GDP will be reduced 25% (Stern, 2007). Thus, the study will highlight the significance of the FIN and INQ in reducing the GHG emission without curtailing global GDP. Second, the developing nations are facing dilemma between economic performance and reduction in GHG emission in midst of economic development. Hence, responding to the serious effects of GHG emission the developing world will adopt measures of FIN and INQ to curb CO_2 emission. Third, the developed economies while responding to global warming will pose negative effect on the global economic growth. Thus, the FIN and INQ will be used to strike balance between it, that the GHG emission will not hurt economic performance. Fourth, In the policymaking perspective this study is important to recommend policy implication in reduction of GHG emission.

Review of Literature

The financial development became prerequisite for sustainable long term economic growth (Le, Chuc & Taghizadeh-Hesary, 2019). While the FIN played important role in the progress of financial institution and financial sector. The area of FIN is not very old and it was developed by Chibba (2009) however, in 2000 it was found that the main cause of poverty was financial exclusion. Thus, FIN became important for economic development, which implies that the public at large in an economy have easy access to large scale financial services and products. Although, the effects of FIN on ES are at infantry stage in the literature (Li, Chen & Sohail, 2022; Boutabba, 2014). Thus, the effects of FIN on ES needs to be further investigated. Theoretically, FIN can either degrade, improve or neutral in aspect of environmental quality. First, the FIN through depth, stability, accessibility and efficiency makes financial products and services easier and more affordable for individuals and organization, which further enables them to efficiently invest in green and clean technologies. Hence, the FIN can pose positive effects on ES (Le, Le & Taghizadeh-Hesary, 2020). Second, increase in FIN enhance individuals and firm access to numerous financial services and products, as a result promote manufacturing and industrial activities in the country thereby increasing GHG emission (Wang et al., 2022). In the demand perspective, an inclusive financial system enable easy access of consumers to variety of financial services and products thereby increasing the demand for energy intensive goods, i-e. air condition, microwaves, refrigerators, dishwashers, washing machines and automobiles as a result increase GHG emission (Frankel & Romer, 1999). To sum up, financial inclusiveness and GHG emission nexus can be either optimistic or pessimistic (Le et al., 2020). According to the Innovation for Poverty Action (2017) the effects of FIN on ES will be favorable, if the inclusive financial system enhance adoption, accessibility and affordability of the environmentally friendly practices, which reduce contribution to environmental challenges (Zeraibi et al., 2023; Jingpeng et al., 2023). While the inclusive financial system triggers economic activities, consequently enhance demand for energy intensive products thereby increase GHG emission (Frankel & Romer, 1999; Akram et al., 2020; Li et al., 2022). In the different stages of economic growth, the effects of FIN are different; first in the developing stage the inclusive financial system enhance access to financial services thereby trigger GHG emission. While in the growth stage the FIN fosters economic activities and GHG emission. However, in developed stages, the FIN leads to the development of financial markets thereby investors expect environmentally sustainable measure from corporations, which reduce CO_2 emission (Murshed et al., 2023; Wang et al., 2022).

INQ in terms of regulatory quality, quality of bureaucracy, political stability, rule of law, voice and accountability, government effectiveness and control of corruption are important although somewhat neglected aspect in the literature which significantly effects ES (Wang & Yang, 2022). Although institutional failure may lead to environmental degradation while, well-functioning effective institutions improve environmental quality even if the income of an economy is low (Pata, 2021). Literature evidenced that if the government institutions are effective to adopt environmental regulations and standards then the quality of ecological system will be improved (Jahanger et al., 2022; Hussain & Dogan, 2021). If the government institutions prioritize elements like sufficient budgetary resources, political and legal framework, availability of feedback mechanism, motivated public, which enhance citizen engagement in respect of creating significant value from Open Government Data (OGD) and public perceived ease of engagement to solve the societal problems, in this case the quality of institutions will be improved (Liu et al., 2021). The policymakers need to ensure the significance of main factors, which are; quality, efficiency, usefulness, end user satisfaction and ease of use that will enhance environmental quality and GHG emission will be reduced (Bakhsh et al., 2021). The area of INQ is at infantry stage in the literature therefore the effects of INQ on ES needs to be further investigated.

In short, the effects of INQ on GHG emission can be either favorable or unfavorable; the first school of thought evidenced that INQ, measured through legislation in respect of green technology, good governance and control of corruption are the core factors that control environmental challenges (Bakhsh et al., 2021). Governance system, civil liberties and democracy level of an economy control environmental hazards as well as improve ES of neighboring economies due to spillover effect (Hosseini & Kaneko, 2013). The INQ through strong policies implement to launch green technologies, moderate the environmental disclosure (Uzar, 2021). The second school of thought evidenced that the nexus between INQ and CO_2 emission is positive (Mehmood et al., 2021). According to Teng et al., (2021) electricity consumption, INQ and economic growth adversely affect ES. Further, according to Gyamfi et al., 2022 INQ and ICT penetration degrade environmental quality and did not mitigate environmental challenges. Besides, Azam et al (2021) evidenced that INQ degrades environmental quality by increasing CH_4 and CO_2 emission.

Dataset and Methodology

The research approach is quantitative, based on the secondary data of the top 30 high GHG emitter countries. The study collected panel data of the INQ from the Worldwide Governance Indicators, 2022, FIN data from the World Bank, Global Financial Development Database, 2022, and the ES data from the World Developmental Indicators, 2022, for the period from 2004 to 2021.

Table 1

Data of the Highest Emitter Countries

Column 1	Column 2	Column 3	Column 4
China	South Korea	United Kingdom	Pakistan
USA	Indonesia	Italy	Ukraine
India	Canada	Poland	Iraq
Russian	Brazil	Kazakhstan	Spain
Japan	South Africa	France	Argentina
Iran	Turkey	Malaysia	Algeria
Germany	Australia	Thailand	
Saudi Arabia	Mexico	Vietnam	

** Highest emitter countries presented in the table from 1st in the column 1st to lowest in column 4*

The variables which were not in the index or percentage form are converted into log form so that to attain data smoothness. The research models of the study are below:

$$LNCO_{2it} = \beta_0 + \beta_1 FIN_{it} + \beta_2 INQ_{it} + \beta_3 (FIN_{it} * INQ_{it}) + \beta_4 LNGDP_{it} + \beta_5 LNPOP_{it} + \beta_6 TPI_{it} + \beta_7 IVA_{it} + \beta_8 REC_{it} + B_9 UPP_{it} + \varepsilon_{it} \; \ldots\ldots\ldots Equ.(1)$$

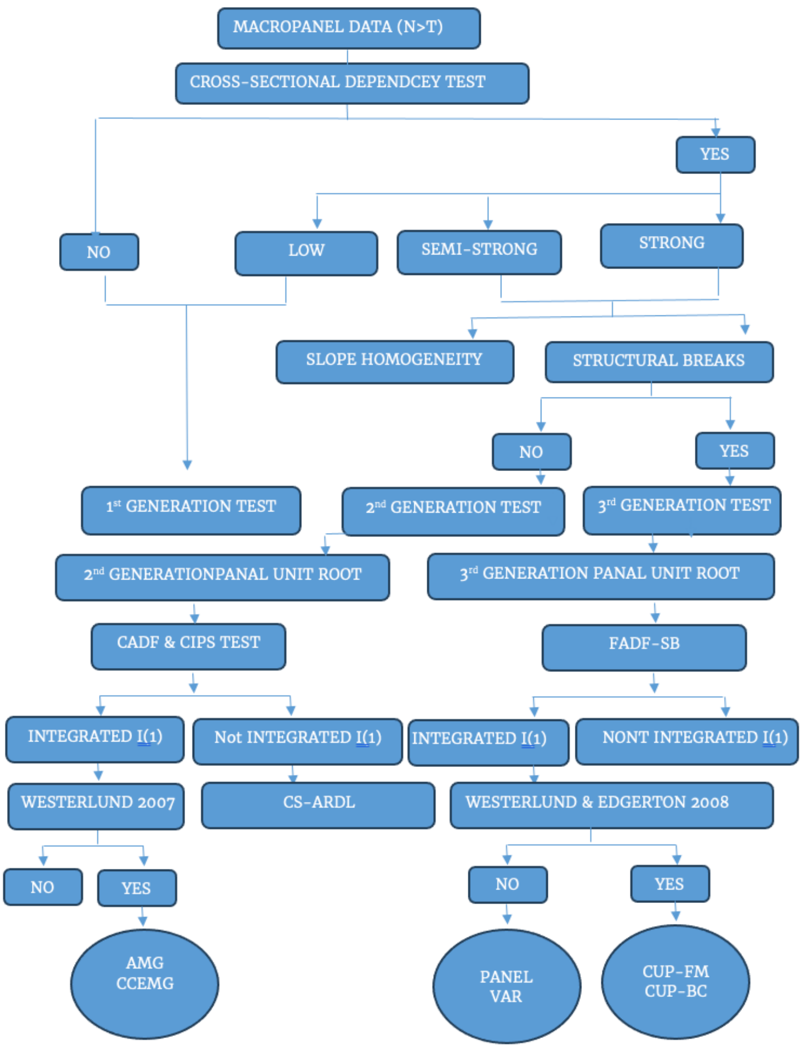
$$LNCH_{4it} = \beta_0 + \beta_1 FIN_{it} + \beta_2 INQ_{it} + \beta_3 (FIN_{it} * INQ_{it}) + \beta_4 LNGDP_{it} + \beta_5 LNPOP_{it} + \beta_6 TPI_{it} + \beta_7 IVA_{it} + \beta_8 REC_{it} + B_9 UPP_{it} + \varepsilon_{it} \; \ldots\ldots\ldots (Equ.2)$$

$$LNN_2O_{it} = \beta_0 + \beta_1 FIN_{it} + \beta_2 INQ_{it} + \beta_3 (FIN_{it} * INQ_{it}) + \beta_4 LNGDP_{it} + \beta_5 LNPOP_{it} + \beta_6 TPI_{it} + \beta_7 IVA_{it} + \beta_8 REC_{it} + B_9 UPP_{it} + \varepsilon_{it} \; \ldots\ldots\ldots (Equ.3)$$

Wherein, the ES proxies are; $LNCO_2$ stands for carbon dioxide, $LNCH_4$ is methane and LNN_2O is nitrous oxide. FIN stands for financial inclusion index, INQ is the institutional quality index. LNGDP is GDP per capita, LNPOP is the total population, TPI is trade openness index, IVA is industry value added (including construction), REC is renewable energy consumption, and UPP is the percentage of urban population in the total population.

Figure 4

Flow of Analysis



Analytical Techniques

Principal Component Analysis

PCA is multivariate analysis used to reduce large number of proxies of a variable into a standalone single indicator by converging dataset into linear weighted index of the primary variables like x1, x2, x3 and so on (Vyas & Kumaranayka, 2006). The 1st component y1, that explain largest part of variation in the dataset is selected as an index (Mckenzie, 2005; Sahn & Stifel, 2003).

It is two-step process; where, in the 1st step various factors are determined, which reflect maximum variation in original variables with minimum correlation between the components. In the 2nd step an index is ascertained on the factors having eigenvalue >1 (Gujarati & Porter, 2009). A weighted index can be constructed using PCA through the following formula:

$$X = \frac{w_1 * ln \dots \dots \dots \dots W_k * l_{nk}}{n}$$

Bartlett's Test

Bartlett's test is used to validate the PCA results, it is used to ascertain that the variance of dataset is equal, and normally distributed. Bartlett test is effective when data is nearly normal or normally distributed (Arsham & Lovric, 2011). The H0 of the Bartlett test states that all the variances are equal. According to Snedecor & Cochran (1967) the statistical equation of the Bartlett test is as below:

$$x^2 = \frac{(n-k)\ln(s_p{}^2) - \sum^{k}{}_{i=1} (n_i - 1)\ln(s_p{}^2)}{1 + \frac{1}{3(k-1)}\left(\sum^{k}{}_{i=1}\left(\frac{1}{(n_i-1)}\right) - \frac{1}{N-1}\right)}$$

Kaiser-Meyer-Olkin Test

The Kaiser-Meyer-Olkin (KMO) test check data appropriateness for the PCA analysis. It validates sampling adequacy for the entire model and each variable in the model. The KMO test measure proportion of variation among variables which is known is common variance. The lower is proportion of variance, the more data is suited for factor analysis. The results of test lie between 0 to 1.0 hence, the results lie between 0.5 to 1.0 is better for further analysis (Hill, 2011). The formula of the test is as below:

$$M0j = \frac{\sum_{i\_j} r_{ij}^2}{\sum_{i\_j} r_{ij}^2 + \sum_{i\_j} u}$$

Cross-Sectional Dependency Test

The globalization has caused to enhance the global economic integration, as a result the economic shock in one economy effects the other economy, is termed as CSD. The CSD can be determined through the Breusch-Pagan CD_{LM1} (1980) CD_{LM2} (Pesaran, 2004) and LM_{adj} (Pesaran & Yamagata, 2008). The Breusch-Pagan CD_{LM1} (1980) was the 1st test for the assessment to CD. The hypothesis of the technique holds that, there is no CD relationship where T→ ∞ N is constant, the Breusch-Pagan CD_{LM1} (1980) chi-square has asymptotic distribution at $N(N-1)/2$ degree of freedom, when T > N. The other test CD_{LM2} can be used when both the time and cross-section dimension are large in a model. The 2nd test of CD if N > T the CD_{lm2} indicate large deterioration and deviations in the level and deviations are increasing with increase in N. The CD_{lm2} test is based on the sum of correlation coefficients between cross-section residuals. The 3rd test of CD, wherein the deviation is corrected in case N > T is LM_{adj} which equation is given below:

$$LMadj = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \cdot \sum_{j=i+1}^{N} TP_{ij} \quad \frac{T - K\, P_{ij}^2 - uT_{ij}}{\sqrt{v^2}}$$

Slope Homogeneity Test

The heterogeneity problem assessment is crucial due to demographic and economic disparities among the selected countries because slope parameters variations may affect the panel estimator's consistency (Pesaran & Yamagata, 2008). The first slope homogeneity test proposed by Swamy (1970) which required fixed cross-section (N) and relative time period (T). Thereafter, Pesaran and Yamagata (2008) developed modified version of the standard delta test which is suitable in case of N, T→∞. The test assumes that the error term is normally distributed. The standard delta test equation is as below:

$$\bar{\Delta}_{adJ} = \sqrt{N}\left(\frac{N^{-1}\,\tilde{S} - E(\bar{z}_{it})}{\sqrt{var\ (\bar{z}_{it})}}\right)$$

The standard delta test needed error term not to be autocorrelated, then the heteroskedastic and autocorrelation (HAC) robust version of the (Blomquist & Westerlund, 2013) was developed. The robust HAC test of slope homogeneity equation Δ_{HAC} and (Δ_{HAC})adj are as below:

$$\Delta_{HAC} = \sqrt{N}\left(\frac{N^{-1}s_{HAC} - k}{\sqrt{2k}}\right) \sim x_k^2$$

$$(\Delta_{HAC})_{adJ} = \sqrt{N}\left(\frac{N^{-1}s_{HAC} - k}{v(T,k)}\right) \sim N(0,1)$$

Structural Breaks

The modern economists are concerning about the structural changes in the data, particularly panel data is suspected to have structural breaks, as the time period in panel data is long enough, so the larger is the time dimension the higher will be the probability of structural breaks in the data. The problem incurs if the coefficients of all or some of the regressors may be subject to structural breaks, as the historical major events can cause relationship to change overtime. The structural breaks test Ditzen et al., (2021) is feasible under the condition N>T.

Panel Unit Root

The conventional unit root tests; Choi test, Pesaran and Shin, Levin-Lin-Chu and Fisher ADF in the presence of slope homogeneity and CSD will not perform well, because these conventional tests assume cross-sectional independence. Thus, to cater for the above-mentioned issues, the study will proceed to 2nd generation unit root test; Cross-Section Im-Pesaran (CIPS) (Pesaran, 2007) and Cross-sectionally Augmented Dickey Fuller (CADF) to test for order of integration and problem of unit root in the series. Thus, the CIPS statistics are as below:

$$CIPS = \frac{1}{N}\sum_{t=0}^{n} CDF_{\mathrm{i}},$$

Cross-sectional Autoregressive Distributed Lag CS-ARDL

The matter of CSD and slope heterogeneity can be resolved through (Westerlund, 2007; Westerlund & Edgerton, 2008) techniques. However, if the order of regressors are I(0) and I(I) or combination of both, along-with CSD, structural breaks and slope heterogeneity then it can be only dealt through the CS-ARDL approach proposed by (Chudik & Pesaran, 2015). The advantages of CS-ARDL approach are; (1) handle the issue of panel non-stationary series (2) It provides robust results even in presence of CSD. (3) handle the problem of endogeneity and heterogeneous slope coefficient. (4) handle the common correlation bias. (5) capable to handle serial correlation problem in panel series. (6) rectify model mis-specification bias. The CS-ARDL is also known as dynamic common correlated effect DCCE CS-ARDL. The panel ARDL by Chudik and Pesaran (2013) equation is modified with additional lags for cross-sectional averages of regressors. The modified equation of CS-ARDL is as below:

$$\hat{\lambda}_{CS-ARDL} = \frac{\sum_{j=0}^{q} \hat{\Omega}_{ij}}{1 - \sum_{j=1}^{p} \hat{g}_{ij}}$$

The error correction equation of CS-ARDL is given below:

$$\Delta CO_{2i,t} = \vartheta_i\left[CO_{2i,t-j} - \lambda_{ij}\varkappa_{i,t}\right] - \sum_{j=1}^{P-1} \delta_{i,j}\Delta_I CO_{2i,t-1} + \sum_{j=0}^{q} \Omega_{ij}\Delta X_{i,t} + \sum_{j=0}^{r} B_i I\bar{z}_{t-1} + \omega_i + \mu_{it}$$

Results and Discussion

The study is conducted with a view to analyze the effects of FIN and INQ on the ES of the top 30 high GHG emitter countries, for the period from 2004 to 2021. The study constructed the indexes of the FIN and INQ through PCA, in the table 2-3.

Table 2

PCA Analysis Institutional Quality

Institutional Quality	Eigenvalues	% of Variance	Cumulative Variance
1	1.256	0.314	0.314
2	1.135	0.284	0.598
3	0.951	0.238	0.836
4	0.655	0.164	1.000
Bartlett's Test: 4808.957[a],	Kaiser-Meyer-Olkin Test: 0.920		

Table 3

PCA Analysis Financial Inclusion

Institutional Quality	Eigenvalues	% of Variance	Cumulative Variance
1	5.129	0.854	0.854
2	0.408	0.068	0.922
3	0.308	0.051	0.974
4	0.074	0.012	0.986
Bartlett's Test: 57.814[a],	Kaiser-Meyer-Olkin Test: 0.427		

Indicate significance at 1% significance level

The results of the PCA are presented in the Table 2-3 The PCA results are duly confirmed by the Bartlett's test and Kaiser-Meyer-Olkin test, as evidenced from the statistics of the KMO and Bartlett's test. The normality test results in Table 4 indicates small difference between minima and maxima values, which is a sign of normality. Table .5 present the results of the pairwise correlation, the respective signs of coefficients shows positive and negative nexus between variables. The results shows that there is strong positive nexus between $LNCH_4$ with LNN_2O and LNGDP with INQ. Table .6 portray the results of the CSD, the P-values of the respective models are significant, hence, the null hypothesis of the CSD test is accepted, consequently CSD is detected in the dataset. The study further investigated for assessment of the weak, semi-strong and strong from of CSD through the cross-sectional exponent (alpha).

Table 4

Descriptive Statistics

Description	Mean	Std Dev.	Minima	Maxima
CO2	6.802	4.491	0.693	19.597
LNCH4	11.512	1.050	9.916	13.986
LNN2O	10.398	1.101	8.101	13.220
FIN	-1.640	1.120	-1.931	4.184
INQ	1.530	2.264	-5.455	4.184
MFIQ	0.427	1.935	-6.287	6.857
LNGDP	9.318	1.027	6.794	4.184
LNPOP	18.226	1.052	16.578 I	21.069
TPI	65.600	33.753	22.105	210.374
IVA	31.012	10.594	16.087	66.429
REC	13.583	13.350	0.010	50.050
UPP	68.360	17.058	7.000	92.229

Table 5

Correlation Matrix

Variable	CO2	LNCH4	LLN2O	FIN	INQ	MFIQ	LNGDP	LNPOP	TPI	IVA	REC	UPP
CO2	1											
LNCH4	-0.01	1										
LNN2O	-0.05	0.80	1									
FIN	0.37	0.14	0.02	1								
INQ	0.48	-0.24	0.13	0.16	1							
MFIQ	0.10	0.19	0.22	-0.35	-0.01	1						
LNGDP	0.62	-0.22	-0.00	0.29	0.78	0.00	1					
LNPOP	-0.30	0.74	0.82	0.08	-0.10	0.11	-0.27	1				
TPI	-0.09	-0.44	-0.49	-0.02	-0.11	-0.17	-0.29	-0.37	1			
IVA	-0.00	0.01	-0.40	0.23	-0.51	-0.31	-0.40	-0.31	0.40	1		
REC	-0.59	0.38	0.48	-0.12	-0.19	0.02	-0.36	0.54	-0.13	-0.25	1	
UPP	0.47	-0.23	-0.14	0.20	0.49	0.00	0.69	-0.38	-0.29	-0.21	-0.54	1

Table 6

Cross-Sectional Dependency Test

	Model No. 01		Model No. 02		Model No. 03	
Description	Statistics	P-Value	Statistics	P-Value	Statistics	P-Value
LM	3303.00	0.000	3695.00	0.000	3672	0.000
LM adj*	315.90	0.000	357.00	0.000	354.70	0.000
LM CD*	57.200	0.000	60.59	0.000	60.21	0.000

Cross-Sectional independence, show significance at 1%

Table 7

Cross-Sectional Exponent Alpha

Variable	alpha	std. Error	[95% Conf.	Interval]
CO2	1.006	0.437	0.920	1.092
LNCH4	1.006	0.041	0.925	1.086
LNN2O	1.006	0.028	0.951	1.061
FIN	1.006	0.023	0.960	1.051
INQ	1.006	0.039	0.928	1.083
MFIQ	1.006	0.032	0.942	1.070
LNGDP	1.006	0.056	0.896	1.116
LNPOP	1.006	0.028	0.949	1.062
TPI	1.006	0.230	0.554	1.458
IVA	1.006	0.142	0.727	1.284
REC	1.006	0.135	0.741	1.270
UPP	1.006	0.091	0.826	1.186

0.5 <= alpha < 1 implies strong cross-sectional dependence

The results presented in Table .7 evidenced that the alpha value of all respective variables are >1, which indicates high degree of CSD among all series in dataset. Hence, the null hypothesis of no CSD is rejected. In the next step of the preliminary analysis the study tested for the slope heterogeneity through standard delta test and HAC Robust test.

Table 8

Slope Homogeneity Test

	Model No. 01		Model No. 02		Model No. 03	
Description	Statistics	P-Value	Statistics	P-Value	Statistics	P-Value
Delta_tilde	-6.822	0.000	-7.823	0.000	-7.701	0.000
Delta_tilde_adj	-8.756	0.000	-10.040	0.000	-9.884	0.000

Significance level at 1%

The results of the slope homogeneity presented in the Table .8. The P-value and T-statistics of the respective models are less than the .05%. Hence, the null hypothesis of the test is rejected, which means that the slope parameters are heterogeneous at 1% significance level. The robustness of the standard delta test is checked through the HAC robust test and confirmed the results of the standard delta test. In the flow of analysis, the study tested for the structural breaks through the Ditzen, Karavias & Westerlund, 2021, in the Table .8. The results of the T-statics compared with the critical values at 1%, 5% and 10%, which evidenced that there are no structural breaks in the dataset. Thus, the null hypothesis of the structural breaks is rejected while alternate hypothesis is accepted. As a prerequisite for the cointegration analysis the study tested for unit problem in the series. The results of the CIPS and CADF test in the Table 10 indicated that all series were found stationary on 1(0) at the significance level of 1%. Thus, the null hypothesis of no unit root is rejected. In last, the study proceeded to the final analysis through CS-ARDL approach.

Table 9

Structural Break Test

	Model 01	Model 02	Model 03			
Description	T-Statistics	T-Statistic	T-Statistic	1%Critical-Value	5%Critical-Value	10%Critical Value
F(1|0)	0.18	0.21	0.21	3.40	2.85	2.56
F(2|1)	-0.00	0.00	0.00	3.59	3.07	2.84
F(3|2)	-2.85	0.00	0.00	3.72	3.21	2.96
F(4|3)	-10.15	-26.22	-13.14	3.81	3.30	3.07
F(5|4)		-20.89	-105.84	3.88	3.39	3.14

Critical values at 1%, 5% and 10%

Table 10

Unit Root Test

Variable	CIPS	CADF	Order
CO2	-4.668	-4.184	1(0)
LNCH4	-4.992	-2.941	1(0)
LNN2O	-3.760	-2.558	1(0)
FIN	-5.106	-4.214	1(0)
INQ	-4.019	-3.291	1(0)
MFIQ	-4.772	-3.408	1(0)
LNGDP	-5.061	-4.269	1(0)
LNPOP	-5.697	-2.806	1(0)
TPI	-4.229	-3.510	1(0)
IVA	-5.149	-4.086	1(0)
REC	-3.322	-2.485	1(0)
UPP	-4.968	-2.947	1(0)

[a] *Significance level at 1% and order mean order of integration*

[b] *Critical Values of CIPS: -2.4, -2.21 and 2.1 on 1%, 5% and 10% respectively*

[c] *Critical values of CADF: -2.40, -2.21 and -2.10 on 1%, 5% and 10% respectively*

The results of the CS-ARDL approach in the Table 11 evidenced that both in short and long run there is significant negative association between FIN and ES. Thus, the null hypothesis of the study is accepted at 1% significance level. The results further evidenced that both in short and long run the INQ is positively associated with the ES at 1% significance level. Thus, the null hypothesis of the study is rejected. Furthermore, the interactive nexus between FIN and INQ indicated no association with ES. Hence, the null hypothesis of the study is rejected. It can be inferred from the results that increase in FIN reduce GHG emission while increase in the INQ enhance GHG emission. Further, the effects of the interactive association of the FIN and INQ on the ES is not momentous.

Table 11

CS-ARDL

Long Run						
	Model No. 01		Model No. 02		Model No. 03	
Description	Statistics	P-Value	Statistics	P-Value	Statistics	P-Value
FIN	-0.836**	0.022	-0.185***	0.001	-0.139**	0.018
INQ	1.521***	0	0.186***	0	0.292***	0
MFIQ	-0.815*	0.094	-0.014	0.755	0.075*	0.06
LNPOP	-3.371***	0	1.000***	0	1.067***	0
IVA	0.086**	0.025	-0.024	0.536	0.058***	0
REC	-0.220***	0	-0.009***	0	0.008**	0.018
LNGDP	16.469**	0.052	-0.295**	0.018	-0.306**	0.017
TPI	-0.002	0.974	-0.008***	0	0.004	0.652
UPP	-0.03	0.346	0.017	0.743	-0.318*	0.079

			Short Run			
Description	Statistics	P-Value	Statistics	P-Value	Statistics	P-Value
FIN	-0.707**	0.013	-0.308***	0.002	-0.147**	0.057
INQ	1.326***	0	0.318***	0	0.336***	0
MFIQ	-0.462	0.117	-0.007	0.918	0.102*	0.094
LNPOP	-0.892***	0	0.856***	0	0.603***	0
IVA	0.097***	0.003	-0.041	0.506	0.065***	0
REC	-0.148***	0	-0.015***	0	0.014***	0
LNGDP	7.683	0.337	-0.546**	0.017	-0.470**	0.017
TPI	0.068	0.296	-0.014***	0	-0.005	0.659
UPP	-0.012	0.67	0.032	0.578	-0.226*	0.091

*, **, *** indicated 10%, 5% and 1% significance level respectively

Conclusion and Policy Implication

The study is conducted with a view to analyse effects of FIN and INQ on the ES in the top 30 high GHG emitter countries, by applying 3rd generation econometric techniques i.e. CS-ARDL for the period from 2004 to 2021. Further, the study analysed the interactive nexus of FIN and INQ on the ES. The study creates composite indexes from the four facets of the FIN, six facets of the INQ through PCA.

The empirical finding indicat that there is significant negative relationship between FIN and ES in long and short run. Thus, it is inferred from the results that increase in FIN will reduce $CO_{2,}$ CH_4 N_2O emission and vice versa. However, the INQ indicated significant positive relationship with ES in both long and short run. Thus, it is inferred from the results that increase in the INQ will further increase $CO_{2,}$ CH_4 N_2O emission and vice versa. Further, the effects of the interactive nexus of FIN and INQ on the ES indicated insignificant results.

This article concluded with significant policymaking recommendations; which are: policymaking is required to establish compelling linkage between environmental administration and environmental justice to enhance the role of institutions in improving ES. The linkage mechanism of environmental justice and environmental administration is the extensive utilization of environmental administrative law enforcement powers, judicial powers, legislative powers, so that to mobilize and coordinate it fully. Second, the government environmental administrative powers should be exercised for the establishment of coercive force to prevent environmental pollution. Third, the environmental protection policies should be reviewed to enhance institutional role in the environmental protection. Fourth, on the national level carbon tax should be imposed on the non-eco-friendly practices of the corporations and stringent policies should be formulated for local and foreign investors to establish ecofriendly manufacturing structure. While on the international level tariffs should be imposed on those trade activities which comes of non-eco-friendly technologies. Fifth, an environmental protection fund should be established for environmental clean-up as well as for the environmental justices with those communities which are not involved in the environmental degradation.

The study significantly contributes to the existing horizon of knowledge; however, this study still has some limitations which are guidelines for future research. This study can be extended to the other sub-domains of the facets of FIN in context of ES along with pollution haven and halo hypothesis.

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