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Does Globalization Asymmetrically Affect CO₂ Emissions in Pakistan? A New Evidence through NARDL Approach

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ARTICLE DETAILS	ABSTRACT
History: Accepted 12 Dec 2020 Available Online 31 Dec 2020	<i>The study examines the impact of globalization and institutional quality on environmental degradation in Pakistan. The study employs symmetric and asymmetric Autoregressive Distributed Lag Model (ARDL) at a time to check the linear and nonlinear effect of globalization on the environment over 1985 to 2017. The long-run findings of linear ARDL shows globalization affect positively to the environment and all other control variables FDI, GDP are significant with a positive sign while institutional quality and the interaction term of globalization and institutional quality is significant with a negative sign. The study also finds the marginal effect of interaction term and found that globalization has a different effect on the environment with different level of institutional quality. The linear ARDL model is not suitable to check the asymmetric behaviour of globalization on the environment. For this, the study applied a nonlinear ARDL estimation method. The findings of the nonlinear ARDL model showed the asymmetric behaviour of globalization on the environment. This study provides a new direction by proving the asymmetric relationship of globalization on environment quality that is more beneficial for policymakers and government officials.</i>
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1. Introduction

In the past few decades, there is an indicator of climate change and global warming, which is increasing and contributing to the awareness of increasing environmental degradation (Majeed and Ozturk, 2020). Same as there is the economic activity which is affecting environmental degradation become the most popular topic for the researchers. In this aspect, there is the hypothesis of Kuznets curve and pollution hypothesis (Halo & Haven) on the environment is the many time surveyed

hypothesis that shows the relation of level of income as well as a foreign direct investment with the environment. Pollution haven hypothesis states that foreign direct investment degrades the environment, which is empirically proved in recent literature (Nathaniel et al., 2020; Nadeem et al., 2020). In pollution halo hypothesis opponents claimed that foreign direct investment cleans the environment that also proved in studies (Salehnia et al., 2020; Zhao et al., 2020).

Globalization can be stated as a modification from independent and secluded economies at the national level with trade and the barriers in investment, rules and regulation, and merge a cultural difference, depending on each other in the global economy (Hill-2008). The overall social, economic, political globalization shows positive as well as adverse effect on the environment from the recent decades between the nations (Lv and Xu, 2018; Shahbaz et al., 2018; Bilgili et al., 2020; Saud et al., 2020; Suki et al., 2020). Globalization has some economic features which affect the environment by the trade and FDI networks. In this case, the investor from foreign shall hire the new and latest technology through initiating or for growing their business projects that will reduce the consumption of energy and will improve the quality of the environment (Assamoi et al., 2020). The cost of production will be decreased and also reduce the consumption resources by using the latest and advanced technology that will give the idea to businesses at domestically to use the latest technology. Despite this all, the environmental quality will decline, if the foreign companies depend on straight and out old dated technologies (Shahbaz et al-2016). The globalization effect on the environment by trade openness can be defined as scale, effective technique and composition. Globalization will increase the consumption of energy and emission by rapid growth in economic activities. Globalization combines effect carries the changes in the structure of the economy (Anwar et al., 2016).

Apart from the globalization other factors also affect the environment like economic growth, foreign direct investment and institutional quality which already proved in the previous empirical literature. There are many studies which define the relation of economic growth and institutional quality with environmental degradation as utilization of CO₂ emission (Salahuddin et al., 2015; Ali et al., 2019; Chaudhry et al., 2020).

The study contributes to the literature in many ways: (1) this study uses the unique methodologies ARDL and NARDL at a time to show the linear and nonlinear effect of globalization on CO₂ emission; (2) our study uses interaction term (globalization*Institutional quality) and also finds the marginal effect of interaction term that shows globalization has a different effect on the environment with different level of institutional quality; (3) Finally, the study provides the new direction by proving the asymmetric relationship of globalization on environment quality that is more beneficial for policymakers in the formulation of policy.

The rest of the paper structures as following: the next section provides the literature of previous studies. Section 3 and 4 gives information about data and methodology and discussion about results, respectively. The last section provides concluding remarks and policy recommendations.

2. Literature Review

Lv and Xu (2018) show a relationship which is negative between the CO₂ emission and globalization by using the panel estimation techniques for the panel of 15 countries against the cross-sectional and heterogeneity dependence for the time period of 1970-2012. Same as You and Lv (2018) propose a negative relationship for 83 countries panel between the CO₂ emission and globalization. According to the discussion, Twerefou et al. (2017) show the relationship between CO₂ emission and the globalization by applying the technology named GMM for the panel of 36 economies of Africa. The

results reveal that in particular African countries environment degraded by the globalization. Same as Shahbaz et al. (2018) examine the consequences of CO₂ emissions by globalization for the panel of developed 25 countries. The results disclose that there is a positive effect of globalization on the carbon dioxide emissions in the economies which are developed. Salahuddin et al. (2019) show that there are the 44 SSA countries in which the effect on Carbon Dioxide emission effected by the globalization by applying the techniques of panel estimation. The results reveal that there is no significant impact on carbon dioxide from the globalization and also there is a positive impact of the urbanization on the carbon dioxide emission. Suki et al. (2020) revealed the association of globalization and environment by using quantile ARDL method over quarterly date from 1970-2018 in Malaysia. The findings showed that globalization degrades the environment. Xu et al. (2018) claims no effect of globalization on the carbon dioxide emission in Saudi Arabia. By adding all, researcher analysis the impact of globalization on various environmental signs and the findings changes throughout the countries. Globalization has both effects as negative and positive on political, economic and social aspects. Many of the recent studies apply the panel data with non-conclusive results.

More recently, Nasir et al. (2019) found supporting results for PHH hypothesis by indicating that FDI enhances economic growth at the cost of CO₂ emissions in ASEAN-5 countries (Singapore, Thailand, Malaysia, Philippines and Indonesia) by using the data covering the period 1982–2014. The study used quantitative techniques for panel data analysis which involved Fully Modified OLS (FMOLS) and Dynamic Ordinary Least Squares (DOLS) methods. Similarly, Hanif et al. (2019) confirmed the PHH hypothesis for 15 Asian countries, for the period 1990–2013. The study of Mohammed et al., (2019) discovered the change in the carbon dioxide CO₂ emission and its driving factors in the top 10 emitting economies. The method used for this study was The Logarithmic mean Divisia index (LDMI) which analysed that due to CO₂ emissions, there is significant change in the per capita income, energy intensity, carbon intensity effects and population. The data used for these countries was from 1991 to 2014. The results show that due to the increased CO₂ emission, there is a significant effect in these emitting countries, especially in China and the United States by income and population. Opoku and Boachie (2020) investigated the effect of foreign direct investment and industrialization environment. In this study were used data time period from 1980 to 2014. The investigation applied to 36 selected African countries. We examined Environmental proxies with a variety of variables, including carbon dioxide, nitrous oxide, methane, and complete and the Emissions of Greenhouse Gases. Pooled Mean Group technique was used to check the significance level of variables. The results showed that industrial environmental have a significant effect on foreign direct investment. Nadeem et al (2020) results showed that a positive long-term model is a positive relationship between the inflow of FDI and CO₂ emissions, solid fuel CO₂ emissions, and GHG and CO₂ emissions. The long-term negative relationship between the inflow of FDI and emissions of SO₂. Overall, we did not find any definitive proof of the life for Pakistan. Ali et al. (2019) estimates the effect of quality of institutions on the emission of carbon throughout the 47 countries which are developing. The results uncover that the quality of institutions issues for the environment.

3. Methodology

The finest and well-known sources of data are used to collect the data. These are data collection sources as “Statistical Review of World Energy” for CO₂ emissions, International country risk guide (ICRG) for institutional quality and “World Development Indicators” for FDI and GDP. The study uses overall globalization and data sourced from KOF index of globalization. The study uses data that covers 1985-2017 on data availability.

The previous literature used different econometric methodologies to check the effect of

globalization on different macroeconomic indicators. This study uses Autoregressive distributed lag model (ARDL) to prove hypothesis on the behalf of stationary results. The mixed order of integration leads to apply the method of ARDL. Prior to this, this is necessary to identify the long run existence in the model. There ought to be the co-integration for this between the variables that will be perceived by F-test. Subsequent attaining these tests and the presence of long-run clearance, the following significant step is to exercise the technique of ARDL. By this, the technique of ECM is formulated on the model empirically to identify the impact of the short run to the long run and equilibrium stability of long run. Toward the conclusion, diagnostic tests are experienced on the empirical model to detect the model is unrestricted from all problems with respect to hetero, normality, stability. The ARDL model is not sufficient to check asymmetric behaviour of globalization therefore, the study uses a nonlinear ARDL model, which was introduced by Shin, Yu, and Greenwood-Nimmo (2014).

This study examines the effect of globalization, gross domestic product, foreign direct investment, institutional quality and the interaction term of globalization and institutional quality on the degradation of the environment in Pakistan. Here,

$$CO_2 = f(GLOB, GDP, FDI, INSQ, (GLOB*INSQ)) \quad (1)$$

The equation (1) defines that the carbon emission is the function of globalization, growth of the economy, foreign direct investment, institutional quality and the interaction term of (GLOB*INSQ).

Following is the model specification based on the previous studies,

$$CO_{2t} = \beta_0 + \beta_1 GLOB_t + \beta_2 GDP_t + \beta_3 FDI_t + \beta_4 INSQ_t + \beta_5 (GLOB * INSQ)_t + \mu_t \quad (2)$$

The ARDL formulation as follows:

$$\begin{aligned} \Delta CO_{2t} = & \alpha_0 + \sum_{i=1}^l a_{1i} \Delta CO_{2t-i} + \sum_{i=0}^p \alpha_{2i} \Delta GLOB_{t-i} + \sum_{i=0}^q \alpha_{3i} \Delta GDP_{t-i} + \sum_{i=0}^r \alpha_{4i} \Delta FDI_{t-i} + \sum_{i=0}^s \alpha_{5i} \Delta INSQ_{t-i} + \\ & + \sum_{i=0}^l \alpha_{6i} \Delta (GLOB * INSQ)_{t-i} + \beta_1 CO_{2t-1} + \beta_2 GLOB_{t-1} + \beta_3 GDP_{t-1} + \beta_4 FDI_{t-1} + \beta_5 INSQ_{t-1} + \beta_6 (GLOB * INSQ)_{t-1} + \mu_t \end{aligned} \quad (3)$$

So, ECM model estimation as :

$$\begin{aligned} \Delta CO_{2t} = & \alpha_0 + \sum_{i=1}^l a_{1i} \Delta CO_{2t-i} + \sum_{i=0}^p \alpha_{2i} \Delta GLOB_{t-i} + \sum_{i=0}^q \alpha_{3i} \Delta GDP_{t-i} + \sum_{i=0}^r \alpha_{4i} \Delta FDI_{t-i} + \sum_{i=0}^s \alpha_{5i} \Delta INSQ_{t-i} \\ & + \sum_{i=0}^l \alpha_{6i} \Delta (GLOB * INSQ)_{t-i} + \lambda ECT - 1 + vt_t \end{aligned} \quad (4)$$

λ expresses the speed of adjustment parameter in equation (4) and the residuals from the model is denoted by ECT.

We take partial derivatives of equation (4) to confine the marginal effects of changes in the two variables with respect to the globalization, as follows:

$$\partial CO_{2t} / \partial GLOB_t = \alpha_2 + \alpha_6 INSQ_t \quad (5)$$

In the partial derivative if (α_2 and α_6) are positive that shows a high level of globalization and

the high level of institutional quality would improve the environment. But if these two coefficients have different signs that indicate the threshold effect exists that environmental impact of globalization varies with the level of the institutional quality. So, there is compulsory to evaluate marginal effect within the sample. Similarly, this would be applied in the nonlinear model.

The above ARDL model can be written as NARDL (Shin, Yu, and Greenwood-Nimmo (2014)) formulation as follows:

$$\begin{aligned} \Delta CO_{2t} = & \alpha_0 + \sum_{i=1}^l a_{1i} \Delta CO_{2t-i} + \sum_{i=0}^{p1} \alpha_{2i}^+ \Delta GLOB_{t-i}^+ + \sum_{i=0}^{p2} \alpha_{2i}^- \Delta GLOB_{t-i}^- + \sum_{i=0}^q \alpha_{3i} \Delta GDP_{t-i} + \sum_{i=0}^r \alpha_{4i} \Delta FDI_{t-i} + \sum_{i=0}^s \alpha_{5i} \Delta INSQ_{t-i} + \sum_{i=0}^t \alpha_{6i} (\Delta GLOB_{t-i} * \Delta INSQ_{t-i}) \\ & + \beta_1 CO_{2t-1} + \beta_2^+ GLOB_{t-1}^+ + \beta_2^- GLOB_{t-1}^- + \beta_3 GDP_{t-1} + \beta_4 FDI_{t-1} + \beta_5 INSQ_{t-1} + \beta_6 (GLOB_{t-1} * INSQ_{t-1}) + \mu_t \end{aligned} \quad (6)$$

β_2^+ and β_2^- , α_2^+ and α_2^- measures asymmetry by taking following hypotheses in the long run and short run:

$$H_0: \beta_2^+ = \beta_2^- = 0$$

$$H_0: \sum_{i=0}^{p1} \alpha_{2i}^+ = \sum_{i=0}^{p2} \alpha_{2i}^-$$

for all $i=0, \dots, p$.

4. Results and Discussion

4.1 Descriptive Statistics and Correlation Matrix

The result of descriptive statistics shows the mean value of CO₂, Globalization, INSQ, FDI, GDP, (GLOB*INSQ) are 105.6861, 46.63502, -0.012951, 1.006286, 1.35E+11 and (GLOB*INSQ) 2.510603 respectively. The maximum value of CO₂ 195.7069, Globalization 55.34643, Institutional quality 2.754684, FDI 3.668323, GDP 2.54E+11 and (GLOB*INSQ) 122.1868 respectively. The minimum value of CO₂ 36.51237, Globalization 34.35223, Institutional quality -6.062273, FDI 0.178192, GDP 5.60E+10 and (GLOB*INSQ) -208.5540 respectively. The standard deviation value of CO₂ 44.96726, Globalization 7.403649, Institutional quality 1.393037, FDI 0.813576, GDP 5.57E+10 and (GLOB*INSQ) 55.52804 respectively. The correlation matrix shows the association between the variables. The high value of the coefficient of correlation shows the high association between the variables.

Table 4.1: Descriptive Statistics& Correlation Matrix

	CO2	GLOB	INSQ	FDI	GDP	(GLOB*INSQ)
Mean	105.6861	46.63502	-0.012951	1.006286	1.35E+11	2.510603
Median	98.88407	47.65687	0.084339	0.764443	1.20E+11	3.475800
Maximum	195.7069	55.34643	2.754684	3.668323	2.54E+11	122.1868
Minimum	36.51237	34.35223	-6.062273	0.178192	5.60E+10	-208.5540
Std. Dev.	44.96726	7.403649	1.393037	0.813576	5.57E+10	55.52804
Skewness	0.201170	-0.339351	-1.995431	2.065990	0.469302	-1.104099
Kurtosis	1.977772	1.690547	11.72234	6.608571	2.141473	7.703930
Jarque-Bera	1.759959	3.172317	134.1758	43.88860	2.359651	39.37951
Probability	0.414792	0.204710	0.000000	0.000000	0.307332	0.000000
Sum	3699.014	1632.226	-0.453278	35.22001	4.71E+12	87.87109
Sum Sq. Dev.	68749.86	1863.677	65.97882	22.50478	1.06E+23	104834.4
CO2	1					
GLOB	0.9452	1				
INSQ	0.2585	0.3108	1			
FDI	0.3644	0.4659	0.1513	1		
GDP	0.9906	0.9119	0.2249	0.2815	1	
(GLOB*INSQ)	0.2329	0.2881	0.9886	0.1221	0.2020	1

4.2 Unit Root Test

The findings of the unit root test express that all variables have a mixed order of integration. The variable CO2, globalization, GDP, FDI and (GLOB*INSQ) are non-stationary at the level, and it becomes stationary at first differences, while institutional quality and (GLOB*INSQ) is stationary at the level as well as at first difference.

Table 4.2: Unit Root Test

Variable	ADF		PP	
	Level	First Difference	Level	First Difference
CO2	1.063	-3.095**	1.009	-3.095**
GLOB	-1.848	-4.435***	-1.739	-4.435***
INSQ	-3.964***	-2.272**	-5.576***	-9.028***
GDP	3.533	-4.176***	4.018	-4.201***
FDI	-2.823	-3.867***	-1.933	-3.842***
(GLOB*INSQ)	-3.920***	-2.438**	-4.559***	-7.274***

4.3 ARDL Bound Test

Table 4.3 shows the bound test a result which clearly indicates F-stat is equal to 6.5755 is higher than upper bounds that show the long-run association between the variables.

Table 4.3: Bound Test (ARDL)

	1%	5%	10%
Lower Bound	4.257	3.037	2.508
Upper Bound	6.040	4.443	3.763
F-Stat	6.5795		

4.4 ARDL Short Run and Long Run Results

In table 4.4, diagnostic test results show our model is free from hetero problem, auto problem normal and stable. The value of R^2 is 0.89, and the value of Durbin Watson is 2.073. The coefficient of globalization is 0.093 and 0.062, which is positively significant which means a 1% increase in globalization will degrade the environment by 0.09% and 0.062% in long run and short run. The variable FDI is significant with the positive sign which validates the pollution haven hypothesis (PHH). The variable GDP is significant with a positive sign in the short-run and long run. While institutional quality and the interaction term (GLOB*INSQ) is significant with a negative sign in the long run only. Error correction term ECM (-1) is significant with a negative sign that insures the long-run stability.

Table 4.4: ARDL RESULTS

Long Run Results			
	Coefficient	Std. Error	t-stat
GLOB	0.093**	0.036	2.583
INSQ	-0.132*	0.077	-1.722
FDI	0.037*	0.019	1.939
GDP	1.112***	0.205	5.430
(GLOB*INSQ)	-0.003*	0.002	-1.815
Constant	-10.076***	1.957	-5.148
Short Run Results			
D(GLOB)	0.062**	0.029	2.085
D(INSQ)	-0.034	0.023	-1.481
D(FDI)	0.012***	0.004	3.227
D(GDP)	0.287***	0.075	3.821
D(GLOB*INSQ)	-0.0008	0.0005	-1.60
ECM(-1)	-0.258***	0.093	-2.779
Diagnostic Test			
J.B Test	0.541 (0.763)	HETERO Test	1.093 (0.391)
LM Test	0.298 (0.589)	RAMSEY Test	2.272 (0.143)
R^2	0.89	D.W	2.073

Note: *, **, *** shows significance level at 10%, 5% and 1%, respectively.

The following figures 4.1 and 4.2 represent the graph of CUSUM and CUSUMSQ for stability test.

Figure 4.1: CUSUM graph

Figure 4.2: CUSUMSQ Graph

It is necessary to compute the marginal effect within the sample by using the estimated coefficients of the ARDL model as the sign of the estimated coefficients are different as shown in table 4.4.

Table 4.5 shows the marginal effect at a different level of institutional quality.

$$\delta CO_{2t} / \delta GLOB_t = 0.093 - 0.003INSQ_t$$

Moreover, the marginal effect of globalization on the environment is analyzed at minimum, the mean and maximum level of institutional quality is 0.111186, 0.093039 and 0.084735, respectively.

Table 4.5: Marginal Effect

		Minimum	Average	Maximum
Pakistan	Institutional Quality	-6.062273	-0.012951	2.754684
	Marginal Effect	0.111186	0.093039	0.084735

The following graph expresses the marginal effect of globalization on different level institutional quality which shows the environment improve on a high level of institutional quality.

Figure 4.3: Marginal Effect Graph

4.5 NARDL Bound Test

Table 4.6 shows the bound test results which clearly indicate F-stat is higher than upper bounds that validate the long-run association between variables.

Table 4.6 Bound Test Results (NARDL)

	1%	5%	10%
Lower Bound	4.016	2.864	2.387
Upper Bound	5.797	4.324	3.671
F-Stat	9.23		

4.6 NARDL Short Run and Long Run Results

In table 4.9, diagnostic test results show NARDL model is free from hetero problem, auto problem normal and stable. The value of R² is 0.881, and the value of Durbin Watson is 2.036. In tables 4.7 and 4.8, coefficients of GLOB-POS and GLOB-NEG are 0.018, 0.006 and 0.050, 0.015 which is statistically significant in the long run and short run, respectively. It means that a 1% increase in positive globalization will increase CO₂ emission by 0.018% and 0.006% in the long and short run. On the other hand, a 1% decrease in globalization will decrease in CO₂ emission by 0.050% and 0.015% in the long and short run, respectively. Other control variables like FDI and GDP are significant with a positive sign while INSQ and interaction term are significant with a negative sign in long run. Error correction term ECM (-1) is significant with a negative sign that insures the long-run stability.

Table: 4.7 NARDL RESULTS

Long Run Results			
	Coefficient	Std. Error	t-stat
GLOB-POS	0.018*	0.009	1.898
GLOB-NEG	0.050**	0.022	2.271
INSQ	-0.014**	0.006	-2.339
FDI	0.126**	0.056	2.251
GDP	2.030***	0.498	4.079
(GLOB*INSQ)	-0.021***	0.005	-3.822
Constant	-20.179***	5.361	-3.764

Note: *, **, *** shows significance level at 10%, 5% and 1%, respectively.

Table: 4.8 NARDL RESULTS

Short Run Results			
D(GLOB-POS)	0.006**	0.002	2.537
D(GLOB-NEG)	0.015**	0.007	2.225
D(INSQ)	-0.015	0.023	-0.676
D(FDI)	0.004	0.004	0.935
D(GDP)	0.625***	0.155	4.027
D(GLOB*INSQ)	-0.0004	0.0005	-0.751
ECM(-1)	-0.308***	0.088	-3.504

Note: **, *** shows significance level at 5% and 1%, respectively.

Table: 4.9 DAIGNOSTIC RESULTS

Diagnostic Test			
J.B Test	0.103 (0.949)	HETERO Test	0.681 (0.687)
LM Test	1.659 (0.209)	RAMSEY Test	1.392 (0.249)
R ²	0.881	D.W	2.036
W _{LR}	3.386 (0.049)	W _{SR}	0.487 (0.038)

W_{LR}, W_{SR}: Wald test for the null hypothesis of the long run and short run symmetry, respectively.

The study employed the Wald test for long-run (W_{LR}) and short-run (W_{SR}) to check the appropriateness of the nonlinear model, and results are presented in Table 4.9. The findings are in favour of asymmetry of globalization on the environment. The asymmetric behaviour of positive and negative changes of globalization on environment articulated by following the dynamic multiplier graph.

Figure 4.4: Dynamic Multiplier Graph

5. Concluding Remarks and Policy Suggestions

The study examines the impact of globalization and institutional quality on environmental degradation in Pakistan. The study employs symmetric and asymmetric Autoregressive Distributed Lag Model (ARDL) at a time to check the linear and nonlinear effect of globalization on the environment over 1985 to 2017. The long-run findings of linear ARDL, globalization affect positively to the environment and all other control variables FDI, GDP are significant with a positive sign while institutional quality and the interaction term of globalization and institutional quality is significant with a negative sign. The study also finds the marginal effect of interaction term and found that globalization has a different effect on the environment with different level of institutional quality. The linear ARDL model is not suitable to check the asymmetric behaviour of globalization on the environment. For this, the study applied a nonlinear ARDL estimation method. The findings of the nonlinear ARDL model showed the asymmetric behaviour of globalization on the environment. This study provides a new direction by proving the asymmetric relationship of globalization with environment quality that is more beneficial for policymakers in the formulation of policy.

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