Asymmetric Effects of Globalization on Environment Quality: New Evidence from the Sultanate of Oman Using a Novel NARDL Model

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Abstract

In a world where the influences of globalization are extending and diversifying across social, political, and economic dimensions, given the rise in greenhouse gas emissions, understanding the association between globalization and environmental quality has become pivotal in attaining sustainable environmental objectives. The main object of this study is to investigate the roles that globalization plays in such situations. For this purpose, the non-linear autoregressive-distributed lag model (NARDL) was employed to evaluate the asymmetric impact of globalization on environmental quality, represented by CO2 emissions, in the Sultanate of Oman. Foreign direct investment, energy consumption, and economic growth were employed as control variables. The data series spans from 1980 to 2021. Post-request tests were employed to ensure the robustness of the data series used in this study. The results identify the existence of both short-term and long-term asymmetric effects of globalization on environmental quality. Furthermore, the study found that economic growth and FDI have a statistically significant detrimental impact on environmental quality. In addition, it is detected that Energy consumption has no retarding long-run effect on environmental quality, but it plays a significant role in the short-run.

The study findings carry substantial policy implications for the Sultanate of Oman. First and foremost, employ a well-balanced mode of development that acknowledges the trade-off between economic growth strategies and clean environment requirements. Second, foreign direct investment has to promote a clean environment by driving best practice techniques, and high-tech innovation. Third, take advantage of globalization's opportunities without sacrificing the quality of the environment.

Keywords: Environmental quality, Globalization, Energy consumption, Economic Activity, Foreign direct investment.

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1. Introduction

Climate change and sustainable environment signify some of the world's most pressing issues that mankind has faced and will face in the twenty-first century. Addressing these challenges through a substantial and achievable solution is a policy priority for international organizations and governments. Hence, this study delves into the issue and scrutinizes the effects of globalization on environmental quality in the Sultanate of Oman, from 1980 to 2021. Therefore, this study can be considered a contribution to the achievement of the UN Sustainable Development Goals (SDGs), specifically Goal 17, which stresses the need for increased support on "strengthening the means of implementation and revitalizing the global partnership for sustainable development" (SDGs, 2021).

Globalization is defined as a continual process of global interaction, integration and cooperation of different national economies, such as: (i) economic integration through cross-border trade (openness), and investment; (ii) Information and communication technology (ICT); (iii) Political interaction; and (iv) Cultural exchange (Panayotou, 2000, P.1). The phenomenon of globalization has major environmental repercussions, some positive and others negative. Hence, globalization is usually seen as an economic phenomenon and therefore most of its repercussions have economic dimensions, such as flows of goods and services across borders, and international capital flows, Samimi & Jenatabadi, (2014, P1). While this viewpoint holds considerable truth, globalization as a notion encompasses broader dimensions and implications.

Globalization has the potential to positively impact the environment through increasing worldwide interconnectedness that may help to exchange innovative climate technology (green process) and best practices of managerial techniques. Moreover, a high globalization level can lead to worldwide collaboration and cooperation on environmental issues. On the other hand, the negative aspects of high globalization include the potential for increased greenhouse emissions due to expanding international trade and transportation. However, the magnitude of the positive and negative effects of various globalization drivers determines the net benefit of globalization (Panayotou, 2000, P.37).

Globalization plays a role in economic growth and subsequently affects the environment in a manner akin to the impacts of economic growth itself. Environmental degradation arises at the early stage of economic development when the income per capita is below the upper-middle-income level (Apergis, 2021, P. 33720). However, at a particular income threshold, the trade-off between production activity and the environment begins to shift in favour of environmental quality. Hence, society no longer views the environment as a luxury good, resulting in a decrease in environmental degradation, this is known as Kuznets curve hypothesis Altaee & Azeez, (2023, P.690). But as income rises, so does ecological consciousness, which is the primary driver of lessening environmental damage in later phases of economic growth Al-Jafari, & Altaee, (2023, P.5).

One positive effect of globalization is that it can aid in restructuring the economy by shifting its focus from the extraction sector to the manufacturing and services sectors. Global resource extraction has historically resulted in significant environmental changes. In contrast, the services sector is not very polluted Altaee & Azeez (2023, P 694) However, the magnitude of the positive and negative effects of various globalization drivers determines the net benefit of globalization (Panayotou, 2000, P. 2).

To the extent of our understanding, this is the first study to examine the asymmetric impact of globalization on environment quality in Oman using a relatively new development mode. It contributes to the existing literature in the following three ways. First, it employs the KOF general globalization index as a proxy for globalization. Secondly, the utilized model enabled the exploration of the short-run and long-term asymmetric relationship between

environment quality and globalization. Third, it focuses on a country described to be one of the most vulnerable countries in West Asia.

The study has four sections next to this introduction. The following provides a glance at the Sultanate of Oman. Section three reviews of the literature. Section four is devoted to the data and the specification of the econometrics model. Section 5 presents the results and its analysis. Section 6 discusses the main conclusion derived from Oman Practice and then some suggested recommendations.

2. Glance at the Sultanate of Oman

The Middle Eastern region is one of the world's most enriched areas in terms of oil reserves (Nasir et al., 2019, p.169). Oman is one of the fortunate nations endowed with a rich abundance of oil. Sultanate of Oman boasts a varied terrain encompassing a coastline extending up to 2000 kilometres in length, deserts, and mountains. Be that as it may, Oman, associated with other GCC states, faces the challenge of constrained clean water, driving to overwhelming dependence on groundwater.

Oman is the largest oil and natural gas producer in the Middle East that is not a member of the Organization of the Petroleum Exporting Countries (OPEC). According to EIA figures, Oman's oil reserves were approximately 5.4 billion barrels (EIA, 2024). In the year 2021, the hydrocarbon sector will contribute as much as 30.3 per cent to the nominal gross domestic product. Furthermore, net oil revenue made up over 50 per cent of the total revenue, whereas gas revenue represented just 23 per cent of the total revenue. The remaining 27 percent is non-hydrocarbon revenue (KPMG, 2024, p. 8).

The hydrocarbon sector, with a contribution of 73.6 per cent, remained the main driver of government revenues. The non-hydrocarbon revenues constituted 26.4 per cent of total government revenues (CBO, 2021). In 2021, Oman had the lowest per capita income rate among the GCC countries Oman has reported the lowest per capita income among the GCC states, as low as 18,301 $USA (2021=100), whereas Qatar has the highest per capita, with 61,023 $USA (2021=100), surpassing all other GCC countries (WDI, 2023).

As stated in the Second Nationally Determined Contribution (NDC), Oman is one of the most vulnerable countries in West Asia to the adverse impacts of climate change. Oman is dedicated to contributing to the Paris Agreement, to promote a more environmentally friendly world. It has committed to slow down greenhouse emission growth and reduce it by 7% in 2030. (CAA, 2021, p.4)

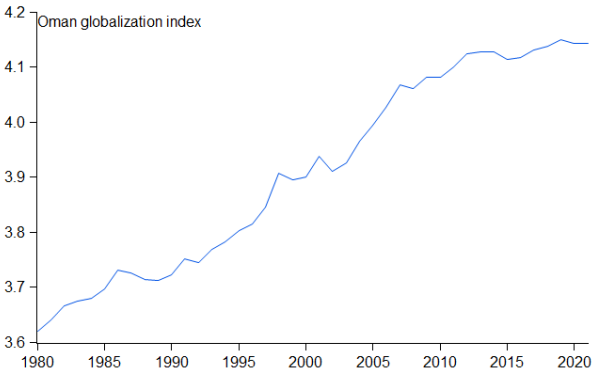

Figure 1. Oman Globalization index.

Source: KOF Swiss Economic Institute

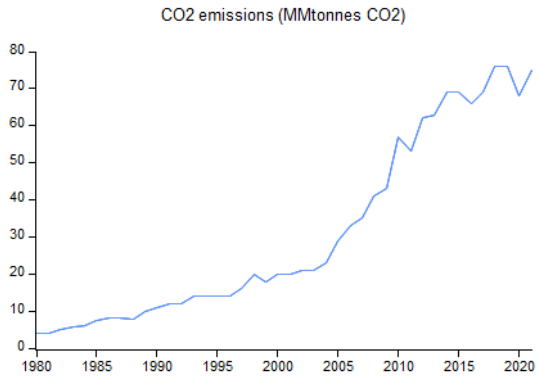

Figure 2. Oman CO2 Emission (1980-2021)

Source: EIA

To address these challenges, Oman has established an environmental preservation authority in tandem with its economic development plan. For so doing the 2040 vision focused on the necessity to enhance the economy and boost productivity through utilizing natural resources entails the advancement of non-traditional natural resources.

In 1988, Oman's per capita CO2 emission was lower than that of Egypt (a country with a population more than 24 times the population size of Oman), as shown in Figure 3. Furthermore, Oman's CO2 per capita emission is much higher than that of the rest of the world. However, these values over a period from 1980 to 2021 show that Oman's per capita CO2 has significantly higher contributions to the atmosphere in comparison with Egypt and the rest of the world. This reflects the rapid increase in Oman's per capita CO2 emission contribution to global emissions Charabi et al., (2020, p. 100548). The breakdown of CO2 emissions by fuel in Oman (2021 data) reveals that the highest percentage originates from consumed natural gas (66.7%), followed by Petroleum and other liquids at approximately 33.3 per cent.

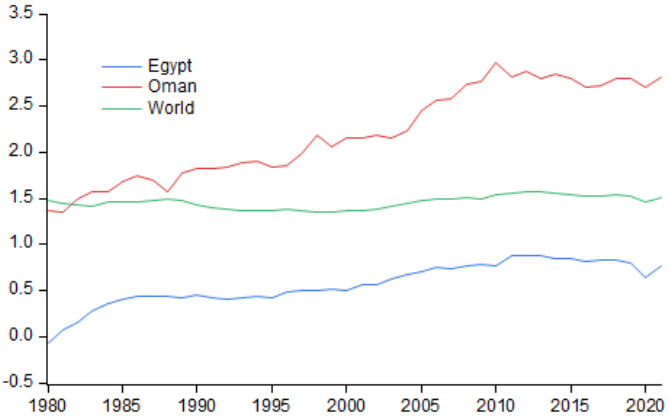

Figure. 3 CO2 in Oman (1980-2021)

Sources of data World Bank (WDI), 2024.

Oman is grappling with a challenging dilemma concerning its international pledge to reduce Greenhouse gases and the financial strain resulting from the fluctuating oil price

3. Literature Review

The relationship between globalization and environmental quality is a heated and highly debated subject in the sustainable development literature. Yet, this topic is far from being resolved. Numerous researches have been conducted in the same field in an attempt to determine the subject's peak, which would represent the level of achievement we have been striving for.

Alam et al., (2022). The marginal effects of economic growth, financial development, and low-carbon energy use on carbon Footprints in Oman, this study uses quarterly frequency data covering the period from 1984Q1 to 2018Q4 to assess the marginal effects of economic growth, financial development, and low-carbon energy use on Oman's carbon footprint levels. When structural break issues in the data are taken into account, the empirical analysis's findings support Oman's long-term environmental Kuznets curve hypothesis connected to carbon footprint.

Hamid et al., (2021) examine the symmetric and asymmetric impact of FDI Inflows, Economic growth, and capital investment on CO2 Emissions in Oman for a period from 1980 to 2019. The ARDL model was utilized to analyze the linear cointegration and the NARDL model was implemented to analyze the nonlinear cointegration between CO2 emissions, economic growth, capital investment, and foreign direct investment. The bound test demonstrates how, in both models, CO2 emissions, capital investment, economic growth, and foreign direct investment are related in a long-term equilibrium. FDI and GDP contribute positively and significantly to CO2 emissions. The asymmetric results show that positive shocks to FDI and economic growth have significant mitigation on CO2 emissions.

Baydoun and Aga, (2021) study the effect of energy consumption, financial development, and economic growth on environmental sustainability in the GCC countries The study uses a dataset that covered the years 1995 through 2018, a variety of causality techniques, including Dumitrescu and Hurlin (DH), cross-sectional dependence (CSD), slope heterogeneity (SH), Pesaran unit root, Westerlund cointegration, and cross-sectionally augmented autoregressive distributed lag (CS-ARDL), were used in an attempt to explore these correlations. The results of the CSD and SH tests showed that a long-term relationship between CO2 emissions and the regressors was found. The CS-ARDL's results demonstrated that globalization improves environmental sustainability, while economic growth and energy consumption decrease it.

Zmami and Ben-Salha, (2020) attempted to uncover the determinants of CO2 emissions in the Gulf Cooperation Council (GCC) nations between 1980 and 2017. More particular, the effects of foreign direct investments, international trade, urbanization, energy consumption, and per capita GDP on CO2 emissions are studied. The Environmental Kuznets Curve hypothesis appears to be valid in the GCC countries based on the results obtained from the PMG-ARDL Additionally, it has been shown that, although urbanization had a favorable effect on the environment, energy consumption and FDI ultimately led to greater environmental damage.

Koçak and Şarkgüneşi, (2018) explore the impact of foreign direct investment on CO2 emissions in Turkey during the period 1974 to 2013, based on the environmental Kuznets curve (EKC) model. The dynamic ordinary least square estimator (DOLS), and Hacker and Hatemi-J bootstrap test for causality method are used. The outcomes of the study validate the EKC hypothesis in Turkey, additionally. Results indicate that FDI has a positive influence on CO2 emissions.

Despite the above-mentioned studies using the NARDL approach to investigate the impact of globalization on environmental quality, there are no studies applying this approach specifically to Oman. We identify this as a gap that this study aims to fill.

4. Data, Hypothesis, and the model.

4.1. Dataset

In this study, the variables employed are environment quality $LnENVQ$, with CO2 serving as a proxy instead, energy consumption $LnENC$, and foreign direct investment $LnFDI$, $LnGDP$. The indicators comprise annual data stretching between 1980 and 2021. Energy consumption and CO2 emission were sourced from the U.S. Energy Information Administration (EIA), while GDP growth, and foreign direct investment, were extracted from Word Development Indicators (https://databank.worldbank.org). KOF globalization index is used since it's widely used in literature. Data on globalization is gathered from the KOF Swiss Economic Institute (Gygli et al., 2019). All variables were transformed into their natural logarithm form. Table 1 demonstrates definitions and their expected signs.

Table1. Variables, codes, definitions and expected signs

Variable	Symbol	Definition	Expected sign
Environment quality	$LnENVQ$	CO_2 emissions (MMtonnes CO_2) per capita	Dependent variable
Energy consumption	$LnENC$	Energy consumption (quad Btu) per capita	Positive
Economic Activity	$LnGDP$	Gross domestic product per capita	Positive
Foreign direct invest	$LnFDI$	Net inflow as a % of GDP	Positive/negative
Globalization	$LnGLOB$	KOF general globalization index	Positive/negative

4.2 Hypothesis

The primary aim of this investigation is to unveil the nature of the relationship between $LnGLOB$ and $LnENVQ$. To be more specific, our emphasis lies in determining whether the association is symmetric or asymmetric. To achieve this, the two hypotheses that follow have been stated, which will undergo testing:

H_0: There is no asymmetric relationship between globalization and environmental quality.

H_a: There is an asymmetric relationship between globalization and environmental quality.

4.3 The Mode

To investigate the asymmetry effect of globalization on environment quality in Oman. The novel non-linear Autoregressive (NARDL) approach developed by Shin & Greenwood-Nimmo, (2014) is employed. Several features make this model preferable, including: (i) it performs more effectively in identifying conintegration relationships within small sample sizes (Ullah et al., 2021, p.3), (ii) unlike some other techniques it employs only a single reduced form equation estimated by OLS method (Kripfganz and Schneider, 2023. p. 984), (iii) allows for delineating the long-term and the short-term effects separately (Palamalai & Kalaivani, 2013, P. 195) And (iv) excels in scenarios involving unforeseen and undisclosed occurrences, such as financial crises, political instability, and similar events (Bergougui, 2024, P. 5).

The following equation quantifies the functional relationship between globalization, environment quality, energy consumption, foreign direct investment, and economic growth.

$$ENVQ = f(ENC, FDI, GDP, GLOB) \quad \text{.....(1)}$$

The relationship described in Eq. 1 is delineated by the linear form econometric model can be written as:

$$LnENVQ_t = \beta_0 + \beta_1 LnENC_t + \beta_2 LnFDI_t + \beta_3 LnGDP_t + \beta_4 LnGLOP_t + \varepsilon_t \quad \text{.....(2)}$$

To examine the asymmetric long-term effects of globalization on environment quality, Eq. (2) can be expressed in logarithmic form as follows:

To investigate the asymmetric long-run effects of globalization on environment quality Eq. (2) can be reformulated in logarithmic notation as follows:

$$LnENVQ_t = \beta_0 + \beta_1 LnENC_t + \beta_2 LnFDI_t + \beta_3 LnGDP_t + \beta_4^{Post} LnGLOB^{Post}{}_t + \beta_5^{Negt} LnGLOB^{Negt}{}_t + \varepsilon_t \quad \text{.....(3)}$$

Eq. (3) is the adapted version of Eq. 2 in which the $LnGLOP$ is composed into two separate groups i.e. positive and negative groups.

Equation (3) is a modified version of Equation 2, wherein the $LnGLOP$ is subdivided into two distinct categories: negative and positive groups. Here, $\beta = (\beta_0, \beta_1, \beta_2, \beta_3, \beta_4^{Post}, \beta_5^{Negt})$ are the vector of unknown long-run coefficients. Moreover, $LnGLOB_t^{Post}$ and $LnGLOB_t^{Negt}$ are partial sum processes of positive and negative changes in $LnGLOB$ and can be expressed as:

$$LnGLOB_t^{Post} = \sum_{i=1}^{t} \Delta LnGLOB_i^{Post} = \sum_{i=1}^{t} \max(\Delta LnGLOB_i, 0),$$

$$LnGLOB_t^{Negt} = \sum_{i=1}^{t} \Delta LnGLOB_i^{Negt} = \sum_{i=1}^{t} \max(\Delta LnGLOB_i, 0)$$

The specified empirical model, as proposed by Shin et al., (2024), is represented in the asymmetric error-correction form as follows:

$$\Delta LnENVQ_t = \varphi_0 + \varphi_1 LnENVQ_{t-1} + \varphi_2 LnENC + \varphi_3 LnFDI_{t-1} + \varphi_4 LnGDP_{t-1} + \varphi_5^{Post} LnGLOB_{t-1}^{Post} + \varphi_6^{Negt} LnGLOB_{t-1}^{Negt} + \sum_{i=1}^{p} \beta_{1i} \Delta LnENVQ_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta LnENC_{t-i} + \sum_{i=0}^{R} \beta_{3i} \Delta LnFDI_{t-i} + \sum_{i=0}^{M} \beta_{4i} \Delta LnGDP_{t-i} + \sum_{i=0}^{N1} \beta_{5i}^{Post} \Delta LnGLOB_t^{Post} + \sum_{i=0}^{N2} \beta_{6i}^{Negt} \Delta LnGLOB_t^{Negt} + \varepsilon_i$$

……..(4)

To assess the presence of the asymmetric impact of globalization on environment quality levels, the following two hypotheses are formulated:

$$H_0: \varphi_5^{Post} = \varphi_6^{Negt} = 0$$

$$H_0: \sum_{i=0}^{N1} \varphi_{5i}^{Post} = \sum_{i=0}^{N2} \varphi_{6i}^{Negt} = 0$$

for all $i = 0, \ldots, N.$

In Eq. (4), φ_i are the long-run coefficients, whereas β_i are the short-run coefficients. ε_i Symbolize the error term. The positive and negative sign over the globalization variable represents the asymmetric effect of globalization on environment quality.

The ECT (error correction term) of Eq. 3 is represented as:

$$\Delta LnENVQ_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta LnENVQ_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta LnENC_{t-i} + \sum_{i=0}^{R} \beta_{3i} \Delta LnFDI_{t-i} + \sum_{i=0}^{M} \beta_{4i} \Delta LnGDP_{t-i} + \sum_{i=0}^{N1} \beta_{5i}^{Post} \Delta LnGLOB_t^{Post} + \sum_{i=0}^{N2} \beta_{6i}^{Negt} \Delta LnGLOB_t^{Negt} + \gamma_I ECT_{t-1} + \varepsilon_i$$

…….. (5)

Where ECT the error correction is term, and γ_I is the speed of adjustment.

The application of the NARDL model entails several steps. Figure 4 depicts those steps.

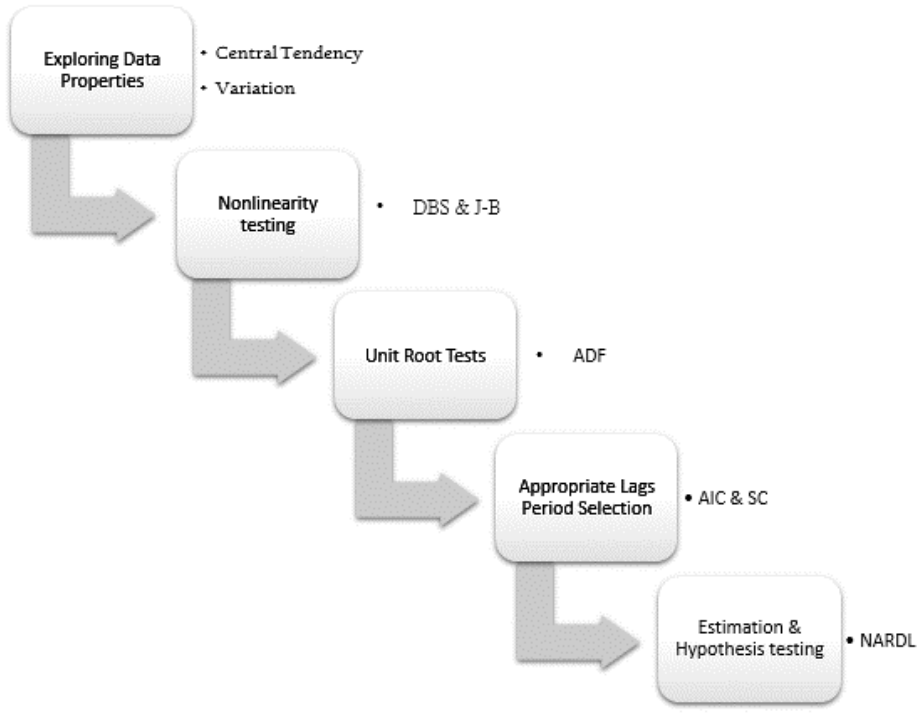

Figure 4 Econometric analysis flowchart

Source: authors' elaboration

5. Results and discussion

Before examining the long-run cointegration and conducting the estimation of the model, several preliminary tests should be conducted. The following subsections delve into the results and discussions of these tests.

5.1. Preliminary tests

5.1.1. Descriptive statistics

Before applying estimation techniques, the properties of the data should be described. The mean value of all variables, excluding energy consumption, surpasses their standard deviations, which may suggest a non-normal or skewed distribution of the variables. Table 2 illustrates that energy consumption and FDI are more volatile compared to other indicators. Economic growth has the lowest volatility, signifying that Oman's economic growth was steady from 1980 to 2021. The trends observed in CO2 closely resemble those of GDP growth and FDI, suggesting a strong degree of association between those variables and environment quality. The results display the asymmetric distribution, as indicated by the skewness. The skewness values range from -0.047 to -1.212, signifying fluctuating degrees of leftward skewness across different variables. Regarding the distribution of the variables, results don't confirm normality for at least three out of four variables at a conventional significance level (such as 0.05).

Table2.Summary statistics for LnENVQ, LnENC, LnFDI, and LnGLOB

Statistics	LnENVQ	*LnENC*	*LnFDI*	*LnGDP*	*LnGLOB*
Mean	0.212	-1.862	1.724	9.808	3.911
Maximum	0.382	-1.178	2.478	10.038	4.149
Minimum	-0.074	-2.756	0.215	9.410	3.619
Std. Dev.	0.138	0.525	0.364	0.123	0.180
Skewness	-0.963	-0.066	-1.212	-1.040	-0.047
Kurtosis	2.762	1.511	8.502	4.775	1.477
Jarque-Bera	6.585	3.909	63.252	13.080	4.077
Probability	0.037	0.142	0.000	0.001	0.130
Observations	42	42	42	42	42

5.1.2. Results of the Nonlinearity (BDS, 1996) Test statistics.

To assess the potential nonlinearity in the relevant parameters, the BDS test is utilized. The results obtained are presented in Table 3. This test was suggested by Broock et al. (pp. 197-235, 1996) to check the adequacy of the linear models in capturing the underlying structure of the data. The null hypothesis of this test is that the series are linearly dependent suggesting that the dataset doesn't violate the normal distribution. The z-statistics results for all sample variables, excluding FDI, are highly significant for the dimensions 2 to 6, providing robust evidence for rejecting the null hypothesis. This verifies the nonlinearity of the data parameters and hence provides one of the motivations to use NARDL model in the study. This finding provides corroborating evidence for the Jarque–Bera test results reported in Table 2.

Variable	*DIM* 2		*DIM* 3		*DIM* 4		*DIM* 5		*DIM* 6	
	BDS Stat.	p-value	BDS Stat.	p-value	BDS Stat.	p-value	BDS Stat.	p-value	BDS Stat.	p-value
LnENVQ	0.181***	0.000	0.309***	0.000	0.391***	0.000	0.444***	0.000	0.481***	0.000
LnENC	0.181***	0.000	0.308***	0.000	0.392***	0.000	0.449***	0.000	0.491***	0.000
LnFDI	-0.001	0.860	-0.004	0.804	-0.007	0.757	-0.012	0.713	-0.018	0.671
LnGDP	0.155***	0.000	0.255***	0.000	0.315***	0.000	0.349***	0.000	0.361***	0.000
LnGLOB	0.196***	0.000	0.327***	0.000	0.414***	0.000	0.476***	0.000	0.518***	0.000

Table 3. BDS test results.

Note: ***refer to % sig.level; DIM refers to dimension.

5.1.3. Unit root tests

The NARDL bound test requires that none of the variables integrated of order two [I (2)]. Accordingly, it is important to investigate the stationarity of the variables, in order to rule out the possibility of spurious estimates. In this study, the ADF test is used. Table 2 demonstrates the outcome of the ADF test. The results indicate that none of the variables is integrated into order two [I (2)]. This result provides legitimacy for using the NARDL approach.

Table 4.Unit root tests.

ADF				
	At level		At 1st difference	
Variable	Constant	Con.& Trend	Constant	Con.& Trend
LnENVQ	-0.4945	-1.4273	-5.0931***	-5.2005***
LnENC	-1.2603	-1.9804	-7.7841***	-7.8859***
LnFDI	-4.2198***	-5.0389***	-9.3200***	-9.2133***
LnGDP	-4.0308***	-2.8509	-4.1774***	-4.2152***
LnGLOB	-1.0997	-1.2684	-6.1782***	-6.2021***

Note: ***refer to % sig.level

5.1.4. Lag order selection

The selection of an appropriate lag length is another problem in estimating NARDL models. To determine the appropriate max lag orders $(p, q_i)$for VAR model, the automatic lag selection is performed. The results in Table 5 reveal that five criteria agree that the optimal lag order, for the series included in this study, is two-time lags.

Table 5. Optimal lag order

Lag	LogL	LR	FPE	AIC	SC	HQ
0	58.296	NA	0.004	-2.733	-2.520	-2.657
1	84.707	44.695	0.001	-4.036	-3.780	-3.944
2	87.406	4.430 *	0.001*	-4.123*	-3.8248*	-4.016*
3	87.409	0.004	0.001	-4.072	-3.731	-3.950

5.2.1. Bound test of cointegration

The asymmetric F-bounds test assesses whether the variables exhibit long-run cointegration. Table 6 presents the results of the F- bounds test alongside the Narayan (pp.1979-1990, 2005) critical values.

Table 6. Asymmetric F-bounds test of cointegration

F-Statistic	10%		5%		1%	
	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)
13.43095	3.087	4.277	3.673	5.002	5.095	6.77
(*N*=40, *k*=5)	3.032	4.213	3.577	4.923	4.885	6.55
	2.75	3.79	3.12	4.25	3.93	5.23

Note: Author's estimates (Eviews13 output)

The bound F-test statistic is 13.431, which is greater than the critical value of the upper bound and extensive at

1%. Consequently, a significant long-term relationship between environmental quality and its determinants is confirmed.

5.2.2. NARDL results and discussion

After detecting the long-run asymmetric connections between globalization and environment quality, the estimation process proceeded to estimate the long-run and short-run coefficients using the NARDL model, as illustrated in Table 7. The asymmetry in globalization is verified through the application of the Wald test. As the P-value value of both the long-run and short-run F-statistics in Table 7 part 3 are less than 0.05, the null hypothesis of no asymmetric effects is rejected. This result justifies the asymmetric analysis of the impact of short and long shocks to globalization on CO2 emissions.

Short run

Remarkably, within the long term, the coefficient of foreign direct investment demonstrates an undesirable influence on environment quality in the sultanate, suggesting that a 1% rise in FDI inflow amplifies in the long-run CO2 emission by 0.1295%. This finding echoes the result by Panigrahi et al., (p. 293, 2020), who observed a significant positive impact of FDI on CO2 emissions in Oman. These results urgently call for the need to link between the environmental requirements and FDI quality, with a focus on attracting environmentally friendly FDI.

The results also suggested that GDP per capita seem to have a significant positive impact in the long run on CO2 emissions. The positive association between economic growth and carbon emissions implies that the rise in GDP per capita is achieved at the cost of environmental degradation. As income levels rise, the demand for manufactured goods increases. Consequently, industrialization occurs, leading to environmental damage if eco-friendly production techniques are not employed. However, other studies on the impact of economic activity on environment quality in Oman give conflicting results, Panigrahi et al., (p. 193, 2020) for example found that economic growth possesses a strong negative effect on CO2 emissions, whereas Zamil et al, (p.1325, 2019) and Fatah and Altaee (p. 34, 2024) assign positive impact to GDP per capita on CO2 emissions.

The most surprising result is that of energy consumption. Indeed the study result indicates that energy consumption has no statistically significant influence on successive changes in CO2 emissions in long-run association. Indeed, there is no meaningful explanation for this result, particularly when the contribution of renewable energy is less than 5% (WDI, 2023), and all its conventional energy sources are derived from fossil fuels (coal, oil, and gas). There are, however, specific circumstances where energy sources can result in no impact on or even a decrease in CO2 emissions. For example, when natural gas replaces coal for electricity generation, or when technological advancements make the extraction, processing, and combustion of fossil fuels more efficient.

The principal focus of this study is to explore the asymmetric relationship between globalization and environmental quality. Part B of Table 7 lists the coefficients' outcomes for both negative and positive sums about the decrease and increase of the decomposed variable. The results reveal a statistically significant relationship stemming from

the positive shocks as well as the negative shocks. Regarding the positive shocks, the results signify that a 1% increase in globalization is expected to increase CO2 emissions by 2.347 short-run. Furthermore, the findings indicate that negative shocks to globalization substantially deteriorate environmental quality even more than positive shocks. In particular, a 1 per cent decrease in globalization triggers a long-run CO2 emission by 9.401 per cent in the long run. The results presented in panel A of Table 7 are related to the short-run estimate. It illustrates that the estimated result of the positive and negative globalization shocks of globalization on environment quality mirror those observed in the long run, differing only in their magnitude.

Globalization can increase CO2 emissions through heightened transportation, prolonged industrial activity, and increased energy consumption, often relying on fossil fuels. It can also drive deforestation and urbanization, both contributing to higher emissions. Additionally, relocating production to countries with lax environmental regulations and rising consumerism exacerbates the problem

In terms of the short-run influences of FDI on environmental quality, the results suggest that FDI significantly promotes CO2 in Oman. Also, the results suggest that LnENC significantly damage environmental quality. In addition, the short-run coefficient of an increase in economic activity has an unfavorable impact on environmental quality

The coefficient ECT_{t-1} is negative at -0.2296 and statistically significant at the 1% level and explains how speedily variables converge to equilibrium in reaction to the disequilibrium brought on by short-run shocks.

Table 7. Non-linear relationship environment quality and its determinants.

Coefficient	Coefficient	t-Statistic	Prob.
Part A: Short-run estimates			
ECT_{t-1}	-0.2296***	-9.8678	0.0000
$\Delta LnCO_2(-1)$	0.1142**	2.1910	0.0366
Δ_ΔLnENC	0.2050***	8.3591	0.0000
ΔΔLnFDI	-0.0139**	-2.6372	0.0133
ΔΔLnFDI(-1)	-0.0243***	-4.2612	0.0002
ΔLnGDP	0.0133	0.2605	0.7963
ΔΔLnGDP(-1)	0.2305***	4.3449	0.0002
$\Delta LnGLOB^{Post}$	0.5032***	3.4935	0.0016
$\Delta LnGLOB^{Negt}$	-0.9581**	-2.6108	0.0142
C	-1.5644***	-10.0525	0.0000
TREND	-0.0099***	-9.5166	0.0000
Part B: Long-run estimates			
LnENVQ(-1)	-0.2296**	-2.1059	0.0459
LnENC(-1)	-0.8125	-1.4589	0.1535
LnFDI(-1)	0.1295**	2.2671	0.0297
LnGDP(-1)	0.4975***	3.1823	0.0031

$LnGLOB^{Post}$	2.3470**	2.0909	0.0439
$LnGLOB^{Negt}$	-9.4006**	-2.3649	0.0237
Part C: Wald test for asymmetric relationship			
Long-run		34.0961***	0.0000
Short-run		7.1950**	0.0130
Joint (Long-Run and Short-Run)		18.0839***	0.0000
R-squared	0.949		
Adj. R-squared	0.932		
(F-stat.	54.42(0.000		
D.W	2.26		
AIC	-5.97		

Note:***indicate a 1 % sig., ** indicate a 5 % sig, and *indicate a 10 % sig

Based on the reported result in part C of Table 7, both previously posited hypotheses concerning the symmetric relationship between globalization and environment quality, whether in the short-run or long-run, should be rejected.

To assess the asymmetric adjustment in the current long-run equilibrium following a transition to a new long-run equilibrium caused by negative and positive shocks, a dynamic multiplier graph is created for the NARDL model, as portrayed in Figure 5.

Here, the asymmetric curves (solid red line) demonstrate a linear blend of dynamic multipliers showing the differences between negative and positive shocks in the globalization variable. Positive (solid blue line) and negative curves (solid blue line) offer confirmation of the asymmetric adjustment of NARDL to positive and negative globalization shocks within a designated timeframe.

Figure 5. Dynamic multiplier graph

Finally, various diagnostic tests are conducted to assess the reliability of the NARDL model. The results of the tests are reported in Table 8. The Jarque-Bera and LM diagnostic test results indicate that the model residuals are normally distributed and it is free from issues related to serial correlation. Reset and Breusch-Pagan-Godfrey tests, respectively indicate that the model is correctly specified and there is no problem of heteroskedasticity.

Table 8 Diagnostic tests

Test Type	Statistics	Probability
F-Serial Corr. (LM) test	2.7087	0.0888
F-Hetero.(BPG) test	0.7231	0.7395
χ^2 Norm.(Jarque-Bera)	0.0686	0.9963
F-RESET test	0.1935	0.6641

Furthermore, Brown et al. (pp.149-163, 1975) work is used to evaluate the stability of the model's coefficients. The results, depicted in Figure 6, suggest that the confidence and stable under both the cumulative sum of squares (CUSUMSQ) and the cumulative sum (CUSUM) tests at the 5% significance level.

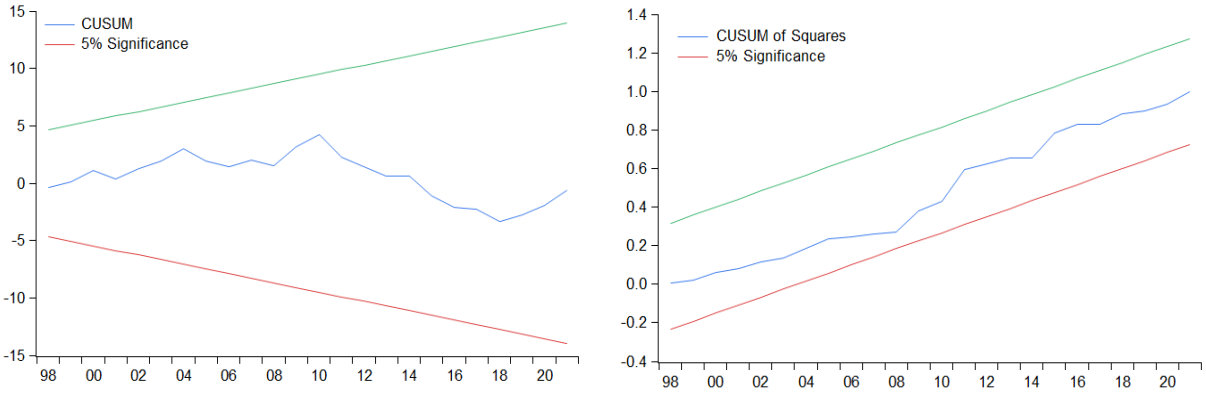

Figure 6. (CUSUMSQ) and CUSUM

6. Conclusions and policy suggestions

The main object of this study is to investigate the roles that globalization plays in such a situation. For this purpose, the non-linear autoregressive-distributed lag model is employed to evaluate the asymmetric impact of globalization on environmental quality, represented by CO2 emission, in the Sultanate of Oman. Foreign direct investment, energy consumption, and economic growth were employed as control variables. The data series spans from 1980 to 2021. This study adds to the body of literature by presenting new evidence on the long- and short-term relationships between globalization and environment quality that were obtained from a novel estimation technique.

The main finding of the study is the asymmetric impact of globalization on the environment in both long and short rums. The results also suggested that GDP per capita seem to have a significant positive impact in the long run on CO2 emissions. Foreign direct investment demonstrates an undesirable influence on environmental quality. Furthermore, results indicate that energy consumption has no statistically significant influence on successive changes in CO2 emissions in long-run association. Finally, all the various diagnostic tests that were conducted to assess the reliability of the NARDL model validate the use of the mode.

Oman is recommended to utilize a well-balanced mode of development that acknowledges the trade-off between economic growth strategies and clean environment requirements. Additionally, foreign direct investment has to promote a clean environment by driving best practice techniques, high-tech innovation, sustainable projects, and responding to environmental regulations. Moreover, Oman must reduce its dependency on the raw material extraction sector such as oil and gas production, mining, and quarrying, as it strives to attain sustainable development goals. Since environmental issues are a global matter there is a need for raising awareness and cooperation socially and among groups and individuals. At the same time, there is a necessity for promoting worthy governance and inclusion

پوختە:

لە جیهانێکدا کە کاریگەرییەکانی جیهانگیریی تیایدا فراوان و جۆراوجۆرن، ئەویش لە میانەی ڕەهەندە کۆمەڵایەتی، سیاسی و ئابورییەکانەوە، بەهۆی بەرزبوونەوەی دەرچوونی گازەکانی (قەتیسبوونی گەرمی) (الاحتباس الحراری) تێگەشتن لە پەیوەندی نێوان جیهانگیری و کوالێتی ژینگە بۆتە بابەتێکی ناوەندی لە بەدیهێنانی ئامانجە بەردەوامەکانی ژینگەدا، ئامانجی سەرەکی لەم توێژینەوەیە بریتییە لە لێکۆڵینەوە لەوەی کە دەکرێت جیهانگیری لەو جۆرە دۆخەدا ڕۆڵ بنوێنێت.

لەبەر ئەوە نموونەی پاشەکشەی خودی کەلێنە هێواشە ناهێلییەکان (NARDL) بەکارهێنراوە بۆ هەڵسەنگاندنی کاریگەری ناچونیەکی جیهانگیری لەسەر کوالێتی ژینگە، کە بە دەرچوونەکانی گازی دووەم ئۆکسیدی کاربۆن لە شانشینی عومان گوزارشتکراوە، وەبەرهێنانی بیانی ڕاستەوخۆ، بەکاربردنی وزە و گەشەی ئابووری وەکو بگۆڕەکانی دەسەڵات بەکارهێنراون، زنجیرەی داتاکان لە ساڵی ١٩٨٠وە درێژ دەبێتەوە بۆ ساڵی ٢٠٢١، هەروەها هەڵسەنگاندنی پێشوەخت بەکارهێنراوە بۆ گەرەنتی کردنی ئەو داتایانەی لە توێژینەوەکەدا بەکار هێنراون.

ئەنجامەکان جەختیان لە بوونی کاریگەریگەلی نالێکچو ی کورتمەودا و درێژمەودای جیهانگیری کردۆتەوە لەسەر کوالێتی ژینگە، سەرەڕای ئەوەی توێژینەوەکە بەوە گەیشتووە کە گەشەی ئابووری و وەبەرهێنانی بیانی ڕاستەوخۆ کاریگەری زیانگەیەنەر و خاوەن ئاماژەی ئامارییان لەسەر کوالێتی ژینگە هەیە.

وێڕای ئەوەش ئەنجامەکان دەریانخستووە کە بەکاربردنی وزە لە درێژمەودادا کاریگەریی لەسەر کوالێتی ژینگە نییە، بەڵام لە کورت مەودادا ڕۆڵێکی گرنگ دەگێڕێت.

بێگومان ئەنجامەکانی توێژینەوەکە کۆمەڵێک پێشنیاریان هێناوەتە کایە کە بە نیسبەت شانشینی عوممانەوە شیاوی جێبەجێکردنن. یەکەم و پێش هەموو شت، پێویستە شێوازێکی هاوسەنگی پەرەپێدان بەکاربهێنرێت کە پەسەندێتی نێوان ستراتیجییەتەکانی گەشەی ئابووری و خواستەکانی ژینگەی خاوێن بە هەند وەربگرێت، دووەم، پێویستە لەسەر وەبەرهێنانی بیانی ڕاستەوخۆ بەهۆی هاندانی باشترین ئەنجامکارییەکان و داهێنانە تەکنەلۆجییەکانەوە ژینگەیەکی خاوێن بەهێز بکات، سێیەم،پێدانی گوزارشتێکی گەورەتر بە بابەتی بەڕێوەبردنی جیهانگیری .

الملخص:

في عالم تتوسع فيه تأثيرات العولمة و تتنوع عبر الأبعاد الاجتماعية ، السياسية و الاقتصادية، نظراً لارتفاع انبعاثات غازات الاحتباس الحراري ، أصبح فهم العلاقة بين العولمة و جودة البيئة أمراً محورياً في تحقيق اهداف البيئة المستدامة. الهدف الرئيسي من هذه الدراسة هو التحري في ما يمكن للعولمة ان تلعب من دور في حالة كهذه.

لهذا الغرض تم استخدام نموذج الانحدار الذاتي للفجوات المبطئة غير الخطي (NARDL) لتقييم الأثر غير المتماثل للعولمة على جودة البيئة، معبراً عنها بانبعاثات غاز ثاني أوكسيد الكربون في سلطنة عمان. تم استخدام الاستثمار الأجنبي المباشر، استهلاك الطاقة و النمو الاقتصادي كمتغيرات سيطرة. تمتد سلسلة البيانات من عام 1980 إلى عام 2021، و تم استخدام اختبارات مسبقة لضمان عشوائية البيانات المستخدمة في الدراسة. اكدت النتائج وجود تأثيرات غير متماثلة قصيرة المدى و طويلة المدى للعولمة على جودة البيئة. بالاضافة الى ان الدراسة توصلت إلى أن النمو الاقتصادي و الاستثمار الأجنبي المباشر لهما تأثير ضار و ذو دلالة إحصائية على الجودة البيئية. فضلاً عن ذلك، بينت النتائج عدم وجود تأثير لاستهلاك الطاقة في المدى الطويل على جودة البيئة، و لكنه يلعب دوراً هاماً على المدى القصير.

لقد افرزت نتائج الدراسة مجموعة من الاقتراحات قابلة التطبيق بالنسبة لسلطنة عمان. أولاً و قبل كل شيء، يجب استخدام نمط متوازن من التنمية ياخذ بنظر الاعتبار المفاضلة بين استراتيجيات النمو الاقتصادي و متطلبات البيئة النظيفة. ثانياً يتعين على الاستثمار الأجنبي المباشر أن يعزز بيئة نظيفة من خلال تحفيز أفضل الممارسات و الابتكارات التكنولوجية. ثالثا اعطاء اعتبار اكبر لموضوع العولمة.

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