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Article

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Exploring the Nexus between CO_2 Emissions, Trade, and Sustainable Economic Growth: A Novel NARDL Approach

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ABSTRACT

This study investigates the nexus between CO_2 emission, trade, GDP, and tourism in Pakistan during 1990-2019. We examined the asymmetric relationship between CO_2 emission, international trade, GDP, and international tourism number of arrivals in Pakistan. Data Stationarity has been tested using the Augmented Dicky Fuller (ADF), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and Phillips-Perron (PP) tests for unit roots. We used the NARDL technique and Granger Causality to estimate the relationship between these environmental variables. The ARDL technique can potentially explore the dynamic nexus between CO_2 emission, tourism, GDP, and trade. Our findings suggest a dynamic relationship between tourism, trade, CO_2 emission, and GDP from Pakistan's perspective. The outcomes reveal that negative and positive shocks to trade, GDP, and tourism affect CO_2 emissions in the short and long term. The Granger Causality findings also determined that causality is directed from Tourism toward CO_2 emission, while unidirectional causality was found between CO_2 emission and tourism. In this study, the graphs of the CUSUM and CUSUMQ determined the functional stability of the established relationship. This indicates that this model is a suitable and valuable strategy tool. The finding benefits macro-level policymakers and will provide important insight for the relevant stakeholders.

Keywords: CO_2 Emission, International Tourism Number of Arrival, Gross Domestic Product, Trade, Non-Linear Autoregressive Distributed Lags, Pakistan

JEL Classifications: Q56, C58

1. INTRODUCTION

In the modern era, development efforts are geared toward achieving eco-friendly economic growth by focusing only on growth. The existing literature shows a strong association between economic growth activities and their negative impacts on environmental quality. There is a consensus among research scholars that economic activity triggers environmental degeneration (Tang et al., 2017). In various emerging and developed economies, extensive efforts are being made to overcome the problem of high CO_2 emissions. Over the past few years, the growing issue of global warming has emerged as an important element of national and international policy debate. Reducing global CO_2 emissions is the main goal of global efforts to mitigate the harmful effects of global climate change (Tamazian and Rao, 2010). Pakistan is gradually shifting from an agriculture-based economy to an industrial economy. This industrial development has increased the demand for energy, which has resulted in increased pollution in the country. Carbon emission is also increasing, and the country is facing the adverse effect of climate change (Cheema et al., 2015). Pakistan tackles environmental degradation through National Environmental Policy the main reasons for increasing CO_2 emissions in Pakistan are the high consumption of petroleum, coal, and gas in the industrial sector and transportation. Although Pakistan accounts for 0.4% of total global carbon emissions globally, it is growing slowly. Furthermore, carbon emissions increased from 0.86 metric tons to 98 metric tons from 2005 to 2018, respectively. Most literature focuses primarily on CO_2 emissions, tourism, GDP, and trade

(Martinho, 2016). However, trade is also an important variable that affects environmental quality. Theoretically, there are three main trade-offs affecting CO_2 emission, the composition effect, the scale effect, and the technique effect (Dritsakis, 2004). This scale effect occurs when trade liberalization, aggregate industrial output, and intensive economic activities increase; this results in increased carbon emissions. For example, it is confirmed that pollution originates in one country, whereas the goods produced are consumed in another country.

Furthermore, (Mohsin et al., 2022) confirmed that importing goods also cause CO_2 emissions. This explanation is particularly true of the import of industrial inputs used in production. Structure results in a proportional gain from trade, with production, with industrial structures, resulting in the production of specific goods for which a country has comparative advantages. The composition's actual impact on the environment depends on the country's defining comparative benefits (Cole and Elliott, 2003). Along With structural effects, trade also affects carbon emissions due to technology adoption in manufacturing processes. The "Technique effect" is the use of advanced technology in the production process, leading to carbon emission into the environment. Nonetheless, trade liberalizations will reduce carbon emissions if the government makes some regulations to encourage the usage of green technology at the manufacturing level. In general, trade liberalization affects export, all increasing industrial production, thereby increasing carbon emissions into the atmosphere. Past studies have also highlighted the relationship between trading volume, carbon emission, GDP, and tourism, with varying results recognized (Rehman et al., 2021). Therefore, identifying the major contributors to environmental degradation is the primary objective of Environmental Economists' disk. The tourism industry is therefore considered an integral part of regional, national, and local development and economic modernization at various scales. The tourism industry is now considered a heritage and cultural link and economic growth mechanism. Tourism plays an important role in economic growth, having multiple linkages with adjacent economic sectors, thereby contributing through an optimistic multiplier effect and catalyzing economic improvement ability to work (Naseem et al., 2020).

With industrialization, globalization, and developments in transportation and communication grids, tourism has become one of the world's largest industries. It contributes about 11% to the global GDP, enabling global economic growth (Qiu et al., 2020). Tourism promotes 6% of global trade in goods, export, and services globally, accounting for 30% of international trade in services. The tourism industry is worth trillions of dollars and accounts for approximately 1 in 10 of all employment (Dwyer and Forsyth, 2008). it was found that the tourism sector accounts for 5% of global CO_2 emissions. The UN designated 2017 as the year to address the various obstacles and challenges to the progress of sustainable development goals and the year of sustainable tourism (Pulido-Fernández and Rodríguez-Díaz, 2016). Recently, tourism has grown rapidly and recognized itself as one of the greatest industries in developed and developing countries (Paramati et al., 2017). This rapid economic growth is considered a key factor (Tan et al., 2015). Conversely, increased international tourists not only stimulate economic growth but also increase energy consumption. This results in high consumption of non-renewable energy in the form of direct or indirect burning of fossil fuels for electricity use, particularly from oil, gas, and coal production during tourism activities (Robaina-Alves et al., 2016). Tourism is the main source of foreign exchange earnings and generates export earnings (Eugenio-Martin et al., 2004). Service, revenue, foreign exchange incomes, and income are the main benefits resulting from tourism activities (Archer and Archer, 1995).

Tourism in Pakistan continues to grow and has reached 1,750,000 in the last decade. In 2017, the tourism industry's total contribution to Pakistan's GDP was estimated at $22,286 million, which is 7.4% of the total GDP. While 2018, it reached $39851.6 million, and 5.4% annual growth will be 5.8% of GDP (WTTC, 2019). But, during the same period in 2017, the country's CO_2 emission also increased and reached 198830.00 metric tons per capita. WTO revealed in 2017 that the tourism industry accounts for 5% of carbon emissions worldwide and contributes 4.6% to global warming. According to WTO 2018 report, a total of $1.3 billion per day was spent by tourists in 2001, contributing to a total of $462 billion. In the south Asian region, Pakistan is famous for tourism. Pakistan Tourism Development Corporation (PTDC) reported in 2017 that 1.9 million tourists worldwide visited Pakistan. However, about 90% of tourists in Pakistan travel by road, with smaller numbers traveling by train or air. The WTTC reported in 2017 that tourists generated $19.4 million in income from tourism, which is about 7% of GDP and contributes 6.3% to total employment. WTTC also expects this amount to increase to $361 million by 2030.

The aim of this research is to investigate the nexus between CO_2 emission, Trade, Tourism, and GDP in the perspective of Pakistan. The rest of the study is structured as follows; section two summaries out the details with an in-depth review of the previous literature that is already available. Section three explained the model and mentioned the sources of data collection. The 4th section explains the results followed by a discussion, and the last one section 5 draws conclusions based on the results. Limitations and upcoming directions for research in this area.

2. LITERATURE REVIEW

Although previous literature focuses on the overall positive role of tourism in economic development and prosperity, the negative environmental impacts resulting from excessive tourism activities cannot be denied. The linkage among GDP, tourism, CO_2 emissions, and trade has been well examined in this concern. This part of the study further divides the available literature into four sub-area, as discussed below. Economic, Social, and environmental costs are connected with the tourism industry. Tourism activities are an energy-related industry and emit greenhouse gases such as CO_2 (Hart, 2005). The increase in the number of tourists provides social and cultural opportunities and results in environmental factors. by (Deike, 2003). High economic growth also requires high energy consumption resulting in the high level of CO_2 emission (Arouri et al., 2012). a descriptive study by (Hwang et al., 2023) reported that the reason for the rapid growth of the Korean economy is the increase in tourism. Similarly, developing countries can earn foreign exchange from the tourism industry and promote sustainable growth and development. Economic growth and prosperity can be maximized by encouraging tourism activities, which are a mainstay in a developing economy. Despite the different opinions of researchers on how tourism has created economic growth and employment in many different developed and developing countries.

The literature on the role of tourism in economic growth and CO_2 emissions is largely divided into two different schools of thought has been distributed. One's preference is that tourism has a direct effect on the CO_2 emissions volume. Similarly, (Katircioglu, 2009) also addressed the short and long-term association between tourism activities and CO_2 emissions in the case of Turkey. Their empirical results show that carbon emissions increase with the arrival of tourism. The similarity of (Ragab and Meis, 2016) also concludes that 464.3 tons of CO_2 are emitted directly by tourists. Another researcher analyzed that CO_2 emissions are indirectly affected by tourism (Lee and Brahmasrene, 2013) and added that tourism not only stimulates the economy but also helps in reducing CO_2 emissions. likewise, in the example of Cyprus (Katircioğlu, 2014), noting the results of his study, he investigated the association between energy consumption and tourism mobility as an indicator of carbon emission. Their research also found that tourism increases energy demand and alters CO_2 emissions. But, (Naseem et al., 2020) claimed that the primary objective of many countries is the tourism industry and development for overall economic prospects. Furthermore, a hypothesis of tourism-based economic development in Singapore, turkey, and Malta has been confirmed in several studies (Katircioglu, 2009). However, there is bidirectional causality between tourism and economic development that has been proven in previous literature. (Apergis et al., 2010) in nine Caribbean countries likewise, (Ekanayake and Long, 2012) few studies have examined the non-causality of tourism and economic development (Choudhury et al., 2013) no cause was found in even 140 developing countries either.

Sustainable development and regeneration of natural resources can be aided whenever tourism activities are based on natural potential and focus only on future productivity (Bramwell and Lane, 1993). (Gao et al., 2019) Examining tourism income and GDP in Guizhou, China, revealed the relationship between tourism and GDP. Phillips-head, Granger causality, and Co-integration tests demonstrated a formal relationship between tourism and economic variables. A VAR model is used to analysis of Turkish data from 1985 to 2007 to identify the long-run correlations between economic growth and tourism. The growing importance of the tourism industry in the economy raises new questions for policymakers and management to stimulate economic growth. The overall cost of carbon emission is associated with climate change, which accounts for about 5% of GDP each year. But, 20% of the steps have not been taken yet (Sarfraz et al., 2022). However, energy needs and demand, thereby reducing carbon emissions at the cost of macroeconomic variables at the national level (Azam et al., 2023). Reducing carbon emissions is an attempt to reduce energy consumption, which in turn will have a negative impact on economic growth, as the ground reality is that energy plays a key role in the productive work (Al-Mulali and Sab, 2012). Even the environment Kuznets curve (Aydin and Karaman, 2008) observes that initial increases in economic growth will initially result in higher CO_2 emissions and that CO_2 eventually falls as economic growth increases. Several studies focus on variables that explain economic growth and the existence of pollution, but (Azam et al., 2016), (Dogan and Aslan, 2017), (Jardón et al., 2017) findings an alliance with an adversary. Some studies focus on the nexus of a country's energy consumption and economic growth.

Although some correlational studies have focused on more sophisticated multivariate models and time series mechanisms, the results from these studies have been diverse (Muhammad et al., 2019). Similarly, (Alam et al., 2023) claims that CO_2, economic growth variables, and energy consumption are interrelated. Avoiding misspecification and examining their relationship within a more coherent and systematic framework. But, despite the considerable available literature on ecology and economic growth, few or no empirical studies attempt to bring together the two distinct strands of literature to investigate the causality of the relationship. Similarly, research has shown a positive correlation between CO_2 emissions and GDP (Mikayilov et al., 2018). Another factor that is the most important and main pillar of the economy is international trade. Which plays a vital and key role in the country's prosperity and economy. Indeed, trade is an important factor in ensuring economic growth. In the long term, international trade helps increase the economic growth of a country through access to imports and exports. Trade also helps to allocate natural or other resources and increase factor productivity. Because trade can increase income and output, it affects emission through technique and scale effect (Ghouse et al., 2021). International trade which is significant variable and also affect the environment and carbon emissions. There are three types of effect of trade on environments i.e., scale effect, technology and composition effects (Salamat et al., 2020). In the effect of technology, it helps to improve when trade increases technology, reducing carbon emissions. According to scale consequence, when the volume of trade and production increases, which in turn has adverse impacts on the environment. In the conclusion, in composition effects, developing economies tend to attract polluting industries the latter contribute to environmental degradation. This suggests that composition and scale have a negative effects while technology has a positively effects on the environment and carbon emissions. For our developing country Pakistan, we discuss that financial development and trade both have positive impacts with carbon emission. Because, more focus is on investment growth and job creations.

Moreover, (Farhani and Ozturk, 2015) found confirming the asymmetric effects of trade on CO_2 volume. They also point out, the effect of trade increases and decreases is found to be insignificant and positive with CO_2 emissions, correspondingly. Trade agrees more acquire and utilized new technology, which lowers the volume of CO_2 emissions in investor countries. Their finding determine that trade determinants positively with CO_2 in China (Farhani et al., 2014). (Mutascu and Sokic, 2020) they also explored the correlation between trade and CO_2 emission and suggested that countries should choose short- and long-term trade-offs to reduce CO_2 volume. Furthermore, the consequences of (Yang et al., 2022), (Naiwen et al., 2021) determine that an increasing trend in trade correspondence to an increasing trend in CO_2 emission. This positive declining period does not hold declining in trade. An increase in trade will also increase carbon dioxide per capita.

3. METHODOLOGY AND DATA SOURCES

3.1. Data Collection and Sampling Technique

In the data collection process, we collect the annual time series data of carbon dioxide (chemical formula CO_2), Gross Domestic Product (GDP), international trade, and tourism (international tourism number of arrival) of Pakistan from 1990 to 2019. All figures are taken from the world development indicator (WDI), one of the utmost authentic and globally wise reliable databases organized by the World Bank (Alam et al., 2023). All variables were converted into a log form. The data sources, process, and variable features are declared in Table 1. The selected data series are presented in graphical form in Figure 1 which further sectoried A, B, C & D subsections for covering individuality of variables.

3.2. Model Specification and Research Methodology

This pragmatic research study is the asymmetric associations among CO_2 emission, trade, tourism, and GDP in the perspective of Pakistan utilizing the non-linear autoregressive distributed lags (NARDL) model. We hypothesized the following linear equations to investigate the long-run associations of these variables.

For practical calculation, we recommended the subsequent.

$$\ln CO_{2t} = f(\ln GDP_t, \ln TR_t, \ln TO_t) \quad (1)$$

The following Equation is for linear form

$$\ln CO_{2t} = \beta_0 \, \beta_1 \ln GDP + \beta_2 \ln TR + \beta_3 \ln TO + \mu_t \quad (2)$$

According to the principles of the econometric technique, the ARD, Granger Causality, or ECM methodology is utilized to determine the long-run association among the variables. These econometric models redirect the asymmetrical assort of data direction. Otherwise, linear relationships are planned amongst the variables more than linear model regression, which is unsuccessful in recompensing for the non-linear variable's performances. In the current view of the non-linear variables difficulty, (Shin et al., 2014) described the structure of ARDL of (Pesaran et al., 2001) and the co-integration technique to Auto Regressive Distributed Lag asymmetric of (Pesaran et al., 1999). This method can apprehend the structure breaks and uncertainties of the short-run. We perceived the asymmetric effect of GDP, tourism, and Trade on CO_2 emission.

Table 1: Variables descriptions

Variables	Descriptions	Detail	Sources
LN CO_2	CO_2 emissions	metric tons per capita	WDI
LN GDP	Gross domestic product	per capita (current US$)	WDI
LN TR	Trade	% Of GDP	WDI
LN TO	Tourism	International tourism	WDI

GDP: Gross domestic product

The long-term factual asymmetric Equation of CO_2 emission is the following:

$$CO_{2t} + \alpha_0 + \alpha_1 \ln GDP_t^+ + \alpha_2 \ln GDP_t^- + \alpha_3 \ln TR_t^+ + \alpha_4 \ln TR_t^- + \alpha_5 \ln TO_t^+ + \alpha_6 \ln TO_t^- + \varepsilon_t \quad (3)$$

Where CO_2 denotes the carbon dioxide emission Gross Domestic product is GDP, TR is specified Trade and TO represent Tourism (number of international tourism arrival), and the co-integration matrix to be determined as $\alpha = (\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6)$. In Equation (3), $GDP_t^+ + GDP_t^-$, $TR_t^+ + TR_t^-$, $TO_t^+ + TO_t^-$ are insignificant sums of positive (+) and negative (−) of GDP, Tourism, Trade and consequently CO_2 emission.

$$\ln GDP_t^+ + \sum_{i=1}^{t} \ln GDP_t^+ \sum_{i=1}^{t} \max(\ln GDP_i, 0) \quad (4)$$

$$\ln GDP_t^- + \sum_{i=1}^{t} \ln GDP_t^- \sum_{i=1}^{t} \min(\ln GDP_i, 0) \quad (5)$$

$$\ln TR_t^+ + \sum_{i=1}^{t} \ln TR_t^+ \sum_{i=1}^{t} \max(\ln TR_i, 0) \quad (6)$$

$$\ln TR_t^- + \sum_{i=1}^{t} \ln TR_t^- \sum_{i=1}^{t} \min(\ln TR_i, 0) \quad (7)$$

$$\ln TO_t^+ + \sum_{i=1}^{t} \ln TO_t^+ \sum_{i=1}^{t} \max(\ln TO_i, 0) \quad (8)$$

$$\ln TO_t^- + \sum_{i=1}^{t} \ln TO_t^- \sum_{i=1}^{t} \min(\ln TO_i, 0) \quad (9)$$

The asymmetric Auto Regressive Distributed Lag System, which is acknowledged by (Shin et al., 2014), discuss in the following Equation.

$$\begin{aligned} CO_2 &= \beta_0 + \beta_1 CO_{2t-1} + \beta_2 \ln GDP_{t-1}^+ + \beta_3 \ln GDP_{t-1}^- \\ &+ \beta_4 \ln TR_{t-1}^+ + \beta_5 \ln TR_{t-1}^- + \beta_6 \ln TO_{t-1}^+ \\ &+ \beta_7 \ln TO_{t-1}^- + \sum_{i=1}^{m} \delta_{1i} \ln CO_{2t-1} + \sum_{i=0}^{n} \delta_{2i} \ln GDP_{t-1}^+ \\ &+ \sum_{i=0}^{p} \delta_{3i} \ln GDP_{t-1}^- + \sum_{i=0}^{q} \delta_{4i} \ln TR_{t-1}^+ \\ &+ \sum_{i=0}^{r} \delta_{5i} \ln TR_{t-1}^- + \sum_{i=0}^{s} \delta_{6i} \ln TO_{t-1}^+ + \sum_{i=0}^{t} \delta_{7i} \ln TO_{t-1}^- + \mu_i \end{aligned} \quad (10)$$

We suggested in the above Equation an order of the lags as m, n, p, q, r, s. But, $\beta1$, $\beta2$, $\beta3$, $\beta4$, $\beta5$, $\beta6$ and $\beta7$ signify the long-run positive and negative shocks which are carried by Trade, Tourism, and GDP on CO_2 emission. Exposes both the positive and negative results of the short run, which affect CO_2 emission by tourism, trade, and GDP, respectively. In this research study, the long-run relationship of non-linear is taken as a result of utilizing the non-linear autoregressive distributed lag approach. For the initial stages, we utilized for asymmetric ARD model as the following, Augmented Dicky Fuller (ADF), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and Phillips Perron (PP) unit root tests for all variable stationarity. The stationarity assessment is not essential for ARDL techniques. While all variables are severely stationary at level 1(0), first difference 1(1), or a combination of both, we applied the ARDL model (Ivascu et al., 2021). But, there are almost some restrictions as the ARDL model cannot continue in the existence series in the model (Aminu et al., 2015). Accordingly, we check out the variable stationarity to avoid unreliability in consequences. In the 2nd part, Equation (10) has been appropriately estimated by Ordinary Least Square (OLS).

Furthermore, we utilized the general-to-specific and SIC information criterion as a trailed base technique. In 3rd phase, bound tests are applied to know the prevailing and confirmation of co-integration. After confirming co-integration, we employ the asymmetric autoregressive distributed lags (ARDL) model. The dynamic increase of asymmetric multiplier impacts is removed by a change of 1% in this stage.

$$\ln GDP_t^{+} + \ln GDP_t^{-} + \ln TR_t^{+} + \ln TR_t^{-} + \ln TO_t^{+} + \ln TO_t^{-}$$

Accordingly, as

$$S_h^{+} + (GDP) = \sum_{j=0}^{h} \frac{\partial CO_{2t+1}}{\partial GDP_{t-1}^{+}} \quad (11)$$

$$S_h^{-} + (GDP) = \sum_{j=0}^{h} \frac{\partial CO_{2t+1}}{\partial GDP_{t-1}^{-}} \quad (12)$$

$$S_h^{+} + (TR) = \sum_{j=0}^{h} \frac{\partial CO_{2t+1}}{\partial GDP_{t-1}^{+}} \quad (13)$$

$$S_h^{-} + (TR) = \sum_{j=0}^{h} \frac{\partial CO_{2t+1}}{\partial GDP_{t-1}^{-}} \quad (14)$$

$$S_h^{+} + (TO) = \sum_{j=0}^{h} \frac{\partial CO_{2t+1}}{\partial GDP_{t-1}^{+}} \quad (15)$$

$$S_h^{-} + (TO) = \sum_{j=0}^{h} \frac{\partial CO_{2t+1}}{\partial GDP_{t-1}^{-}} \quad (16)$$

4. EMPIRICAL ANALYSIS AND RESULTS

Table 2 demonstrates the different statistical data information and its relevant classes, and the descriptive statistic shows the trend shown by the data. All series show structural changes and economic growth. Also, the skewness and kurtosis of the data are observed, wherever skewness estimates the degree of patchiness of data and relatively calculated the kurtosis peaked inferences to measure dispersion. Three basic formats elaborate on the skewness value; regular = 0, positive = long extended right tails (extreme value), and negative = long extended left tails (nominal value). Similarly, there are three similar states of kurtosis as; first of all, mesokurtic denotes the normal dispersion, where kurtosis is 3. Second, the arc of the leptokurtic crest forms where the positive kurtosis value is >3. And last, the platykurtic determined the flattened arc where the negative kurtosis value is under 3. The Jerque-Bera test (JB) claims the normality of the data series in the analysis under study, and all variables appear to be normally distributed because of their little probability.

For applying the necessary form of the ARDL bound test technique (Table 2), the number should be stationary in arrangement number one. Similarly, (Alam et al., 2023). The argument that the outcome of ARDL will be inappropriate in case some of the variables consist of in the research mentioned model. Hereafter, it is essential to describe all of the variable's stationarity. For this ambiguity, we applied the unit roots test of ADF, PP, and KPSS, and found the outcomes revealed in Table 3. The unit-roots test outcomes show that CO_2 emission, GDP, Tourism, and Trade are not stationary at level but at first difference (Khan et al., 2018). Moreover, not a single series is showing stationarity at a 2nd difference or over,

The auto-regressive distributed lag (ARDL) bound test technique is applied according to the data stationarity. Similarly, (Bahmani-Oskooee and Bohl, 2000) pushed into a long-run relationship that is at variance going on optimal lags. It was further observed that neither minimum lags nor implementing many lags could avoid important information of the model or report any trivial computation. Furthermore, since there is a possibility of suggesting a maximum optimal lag, we used only two types of lags SIC information criteria and optimum lag. The bound test outcomes in Table 4 designate non-linear reports. The F-Statistics calculates whether a value exceeds the upper and lower bound values. According to (Pesaran et al., 2001) The significance values are at the 5% level, and the calculated F-statistic value for the NARDL is 6.039924, which is greater than the lower I(0) and upper I(1) bound as defined. This result eliminates and verifies asymmetric co-integration.

According to these facts, we utilize the asymmetrical autoregressive distributed lag model (ARDL). We concentrate the Equation no # (8), properly focusing and applying using the p = q = 2 methodology the general-to-specific, being the span of optimum lags. Likewise, the same methodology was also authorized by (Shin et al., 2014). Based on general to specific techniques, we eliminated repressors through immaterial prominence from the present model. Subsequently (Alam et al., 2023) discussed that the irrelevant elimination of

Table 2: Descriptive statistics

Particulars	LNCO$_2$	LNGDP	LNTO	LNTR
Mean	0.296793	6.608162	13.47595	3.465661
Med	0.277072	6.576729	13.3133	3.491686
Max	0.008214	7.301292	15.06827	3.651135
Min	0.603829	5.919159	12.55947	3.231051
Std. Dev.	1.151706	1.462525	1.66347	1.12427
Skew	0.040371	0.104426	0.901755	-0.411485
Kurt	2.48754	1.460981	3.097627	2.117024
Jar-Bera	0.336418	3.015247	4.077724	1.82116
Prob	0.84518	0.22144	0.130177	0.402291
Observations	30	30	30	30

Table 3: Unit root tests

Test	LN CO$_2$	LN GDP	LN TR	LN TO
ADF				
I (0)	−0.53	−0.909	−1.939	0.386
I (1)	−4.866***	−4.82***	−5.332***	−5.17***
PP				
I (0)	−0.641	−0.914	−1.939	0.738
I (1)	−4.914***	−4.741***	−5.334***	−5.169***
KPSS				
I (0)	0.686418**	0.688304**	0.352798*	0.681333**
I (1)	0.069134	0.16143	0.063064	0.190397

Note: *** display implication at 1%, ** 5%, and *, 10% of a level, respectively

Table 4: Bound test

Test statistic	Value	K
F-statistic	5.039924	5
Critical bounds value		
Significance	**I (0) Bound**	**I (1) Bound**
10%	2.12	2.23
5%	2.45	2.61
2.50%	2.75	2.99
1%	3.15	3.43

Note: **** show significance at 1,**2.5, and * and 10% levels respectively

Table 5: Non-linear ARDL estimation results

Variable	Coefficient	Std. error	t-statistic	Prob.*
C	0.038662	0.092311	0.418825	0.6822
LNCO2(−1)	1.005697	0.177283	5.672846	0.0001
LNGDP_POS	−0.230228	0.162132	1.420005	0.1791
LNGDP_NEG	0.848817	0.244446	3.472407	0.0041
LNGDP_NEG(−1)	−0.582409	0.493593	1.179938	0.2592
LNGDP_NEG(−2)	−1.682094	0.571366	2.943988	0.0114
LNTO_POS	0.142469	0.031187	4.568242	0.0005
LNTO_NEG	−0.018239	0.042908	−0.42507	0.6777
LNTR_POS	−0.5943	0.238681	−2.48993	0.0271
LNTR_POS(−1)	1.139625	0.239534	4.757671	0.0004
LNTR_POS(−2)	−0.534924	0.165039	−3.24119	0.0064
LNTR_NEG	0.392003	0.161806	2.422677	0.0308
LNTR_NEG(−1)	−0.4221	0.155827	−2.70877	0.0179
LNTR_NEG(−2)	0.441121	0.137267	3.213595	0.0068

lagged repressors could handle the noise issue in the dynamic multipliers. Table 5, outcomes, determines that no such problem happens in data analysis. According to these facts and figures, we apply the NARDL models. It is most important to discuss the structural breaks of 2008 that were measured for the adverse effects on the economy. The variable's long-run asymmetric relationship is explained in Table 6. The outcomes reveal a long-term nexus between GDP, Tourism, and trade with CO_2. According to positive shock in GDP, CO_2 is increased by 25% or 0.25-unit and decreases with negative shock by 48% 0r 48-unit change. Furthermore, it has been pragmatic that GDP has both positive and negative shock asymmetric effects on CO_2 emissions volume. Tourism has positive shocks of 15% or CO_2 increase by tourism 0.15 units, and negative shocks of 17% mean decrease with 0.17 units, respectively. The Trade positive shocks to CO_2 are 35% and negative shocks by 26 %, and the asymmetric results confirm that CO_2 emissions increase by 35 units and decrease by 26 units. All of these kinds of shocks influence CO_2 emissions volume in Pakistan. The outcomes reveal that GDP, Tourism, and Trade have asymmetric associations and larger effects on CO_2 emissions. Several previous diagnostic tests validated a recent application of this ARDL asymmetry model.

There are also tested numerous regression issues like serial correlation and residual normality by utilizing the Breusch-Godfrey serial correlation LM test, heteroscedasticity, Jarque-Bera, and Breusch-Pagan-Godfrey test. CUSUM and CUSUMQ test for the model consistency. All of these outcomes of the examination are confirmed in Table 7. The X^2 (P-values) of Breusch-Pagan-Godfrey and serial correlation LM tests are 10.57929 and 0.1685, which underline the significance of the model, which is based on serial correlation and heteroscedasticity. Furthermore, the Jarque-Bera value is 1.432369, which is insignificant and further confirms residual normal. ARCH heteroscedasticity result materialized the X^2 value 1.385595 statistics respectively. Ramsey Reset X^2 value 0.127989 is also insignificant and defines that our model has been expressed properly. All figure shows the model at a steady state. Thus, the portfolio and coefficients of the model parameters are constant (Table 7).

Table 6: Long run coefficient

Variable	Coefficient	Std. error	t-statistic	Prob.
LNGDP_POS	0.25221	1.519755	0.485248	0.6325
LNGDP_NEG	−0.486822	1.968546	−0.502632	0.6205
LNTO_POS	0.154972	1.109697	1.412732	0.1724
LNTO_NEG	0.173946	1.19799	0.410835	0.6854
LNTR_POS	0.356932	1.742922	0.480443	0.6359
LNTR_NEG	−0.268491	1.507651	−0.528889	0.6024

Table 7: Diagnostic test result

S. No	Test	χ^2 (P-value)	Prob
1	Jarque-Bera	1.432369	0.48861
2	Breusch-Godfrey Serial Correlation LM	0.1685	0.7239
3	Heteroskedasticity: Breusch-Pagan-Godfrey	10.57929	0.646
4	Heteroskedasticity: ARCH	1.385595	0.2392
5	Ramsey RESET	0.127989	0.7267

Table 8: Pairwise granger causality tests

Null hypothesis	F-statistic	Prob.
LNGDP→$LNCO_2$	2.4584	0.129
$LNCO_2$→LNGDP	0.00326	0.9549
LNTO→$LNCO_2$	5.16727	0.0315
$LNCO_2$→LNTO	1.11245	0.3013
LNTR→$LNCO_2$	0.75162	0.3939
$LNCO_2$→LNTR	0.33385	0.5684
LNTO→LNGDP	0.71205	0.4065
LNGDP→LNTO	1.20209	0.283
LNTR→LNGDP	0.2847	0.5982
LNGDP→LNTR	0.41547	0.5249
LNTR→LNTO	1.5091	0.2303
LNTO→LNTR	0.00023	0.9881

For robustness, we perform the pairwise granger causality test (1969). The granger causality results are shown in (Table 8). That describes the direction linkages at a time between two variables. Under the causality tests, all independent variables have no causality and nominal values with dependent variable CO_2 emission except Tourism, which shows a significant value and unidirectional causality with CO_2 emission.

Figure 2 is divided into two further parts Figure A and Figure B which represent the graphical test of CUSUM and sums of square cumulative (CUSUMQ) test, respectively. The CUSUM and CUSUMQ plot does not exceed the critical limit of 5%, indicating the absenteeism of any structural uncertainty resistance that determines CO_2 emission and other variables in the economy. So, the constancy of coefficient estimation is reinforced. For this

Figure 1: (a) CO_2 emission Metric Tons Per Capita, (b) GDP Per Capita (Current $US), (c) Trade Percentage of GDP, (d) International Tourism (No. of Arrivals)

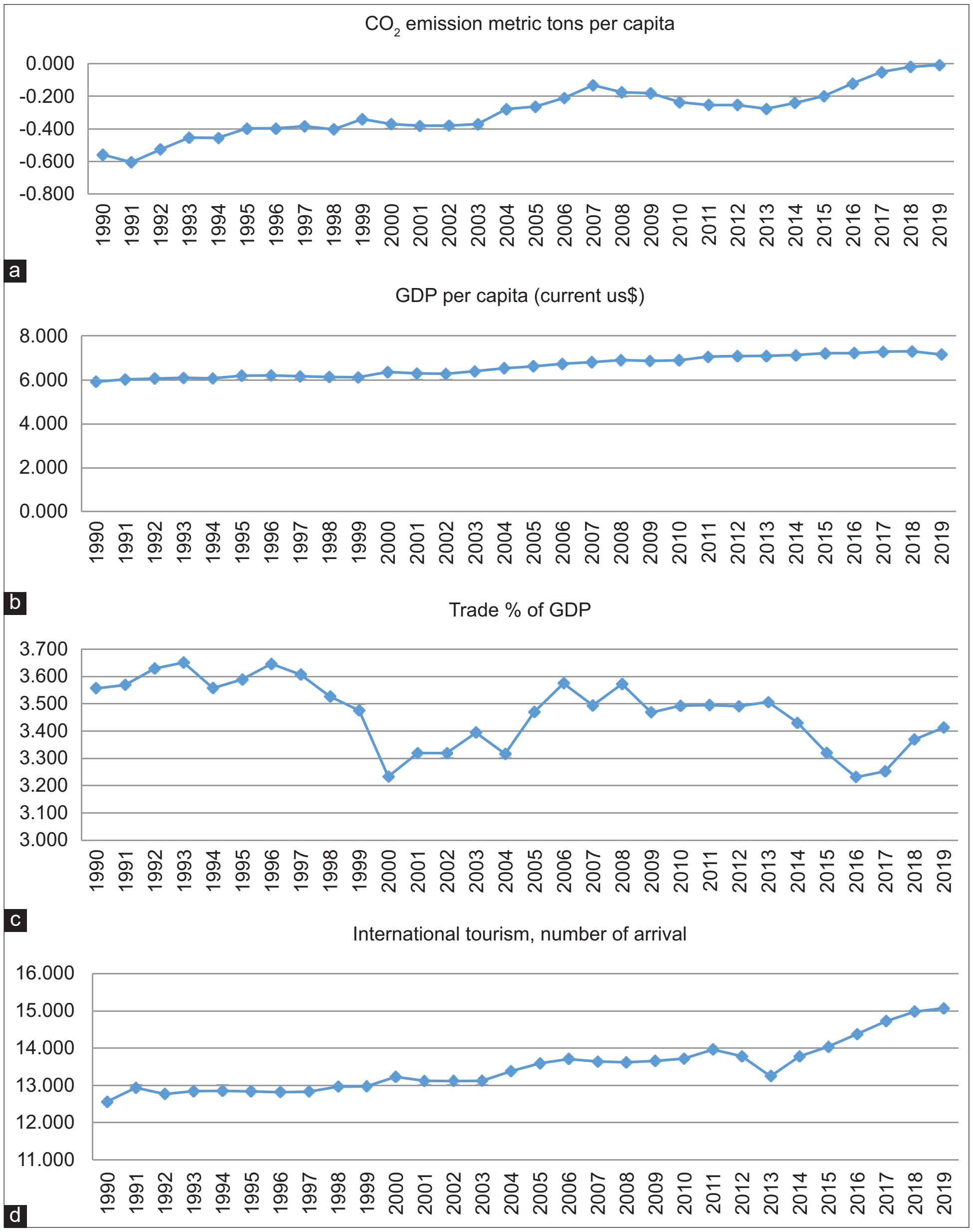


Figure 2: Stability diagnostic test. (a) CUSUM test. (b) CUSUM square test

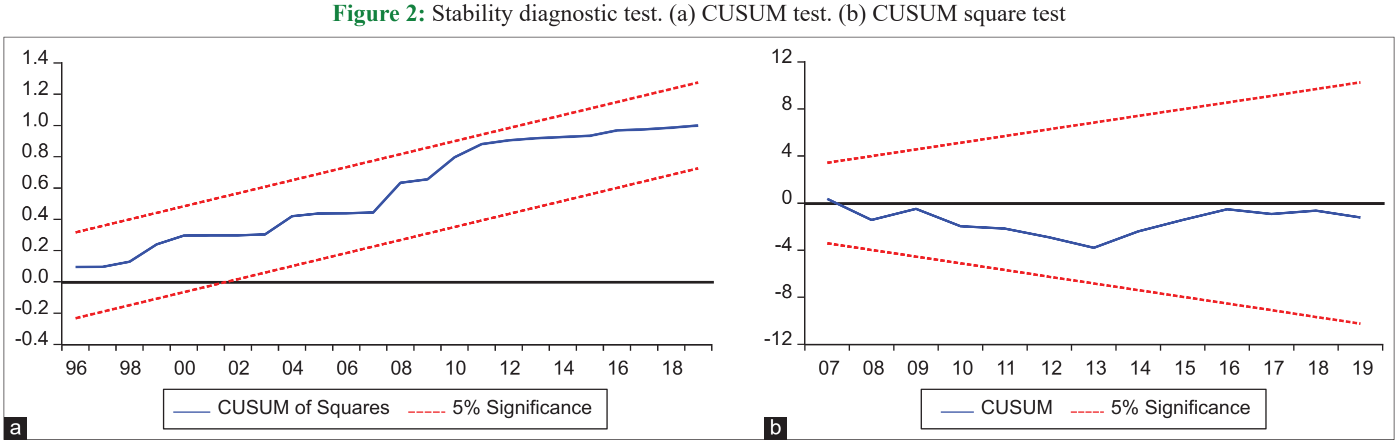
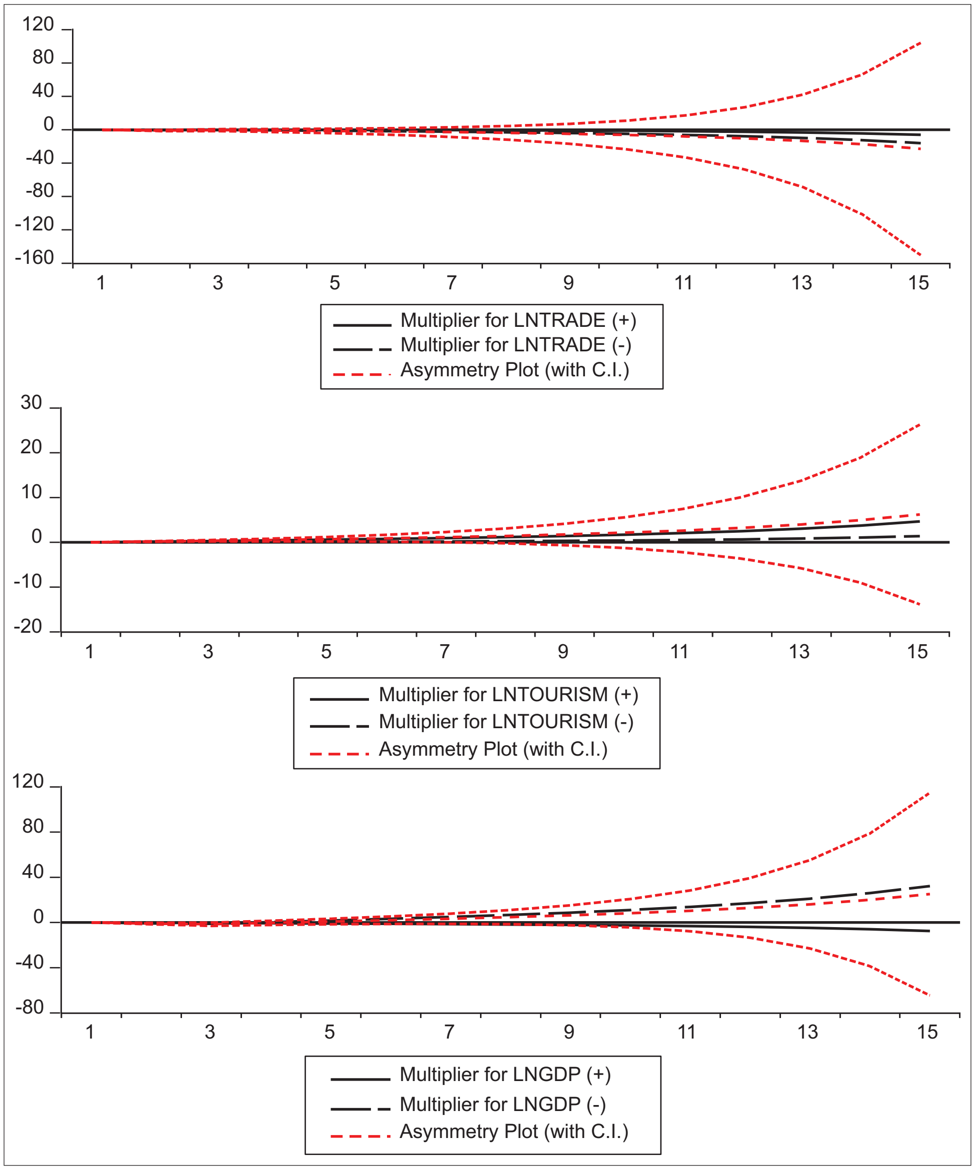


Figure 3: Dynamic multiplier graphs. Source: The solid black lines indicate the positive (+) effect of ln Tourism, Trade, and GDP. While the black dotted lines show the negative (−) impact, and the middle red color dotted lines demonstrate an asymmetric plot



time, CUSUM and CUSUMQ plots are significant at 5% within the significance limit. The facts are postulated that the estimated parameters do not grieve from the structural uncertainty. The dynamic multipliers are presented in Figure 3.

5. CONCLUSION

This pragmatic research study demonstrates the present work of asymmetric relationship amongst GDP, CO_2 emissions, Tourism, and Trade in Pakistan. This study also captures the innovative breaks in the rapidly developing areas of the international tourism industry in the context of Pakistan's economic growth and CO_2 emissions. CO_2 emission was not detected in correlation with trade, GDP, and tourism expression. We prefer the non-linear technique through utilizing NARDL to detect the asymmetric relationship between GDP, CO_2 emissions, Tourism, and trade. The findings support several previous studies, confirming that tourism and trade contribute positively to the CO_2 emissions volume, supporting the asymmetric relations between CO_2 emissions, trade, and tourism. All results also confirm an asymmetric and statistically significant association between GDP and CO_2 emissions. Similar consequences were obtained in the previous literature (Mikayilov et al., 2018). The ARDL model outcomes exposed that tourism and trade promote the GDP and economic evolution.

Furthermore, the conclusion endorses that GDP, tourism, and trade are all variables that contribute positively to CO_2 emissions. This research contributes to the present data and further highlights the significance of global tourism. Results-oriented, we propose policy suggestions that are nearby to a region's development and social development. Initially, we declare that the number of people growing in fertile regions is associated with CO_2 emissions. The government and relevant stakeholders should emphasize the need for persons with disabilities, children, and women in their healthcare development policy (Hwang and Lee, 2015). This pragmatic research indicates the valuable channel of monetary funds to offer people goods and services. Finally, to promote competent health, consider all possible practices to promote sustainable financial growth. The government must make appropriate arrangements to manage the waste from tourism and trade and recycle these wastes properly to reduce the emission of hazardous gases into the country's atmosphere. And the import of certain goods causing pollution should also be banned. Moreover, the government of Pakistan must arrange for some relevant handouts for national and international tourists, which must contain proper information and special instruction for domestic and international tourists on how to contribute to lush green Pakistan. The same instructions should be issued to trade and manufacturing industries on disposing of their hazardous material. The tourism industry and the chamber of commerce and industry should address these issues.

Future research should consist of more variables related to tourism and trade that are linked to development, and emphasis should be placed on closely capturing development policies by management to observe its consequences on CO_2 emissions. In the same way, future researchers could provide similar examples using related cases for two or more regions. In addition, the state's legal and legislative agenda as an arbitrator in integrating these variables also provide a new perspective to scholars. To conclude, spatial evaluation can be a new endeavor in the existing literature.

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