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IMPACT OF TRADE, ECONOMIC GROWTH, AND SECTORAL VALUE ADDED ON CO2 EMISSIONS: A TIME SERIES STUDY OF PAKISTAN

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ABSTRACT

In this modern age, nations need help to boost their economies; one approach is more trade. However, where trade has a positive influence on the economy, simultaneously, it has an adverse impact on the environment. Therefore, this study has been conducted to check the result of trade by explicitly examining the effects of exports and imports on CO2 emissions in Pakistan while controlling for other factors. Data were obtained from the World Development Indicators (WDI) from 1995 to 2022 on CO2 emissions, exports, imports, gross domestic product, agricultural, industrial, and manufacturing value-added. The study used ADF and PP unit root tests for econometric analysis to check data stationarity. For empirical analysis, study used the Autoregressive Distributed Lag (ARDL) model for regression. The findings of the ARDL model exposed that trade has a favorable impact on the environment of Pakistan. More explicitly, a 1 % increase in exports causes carbon dioxide emissions to reduce by 0.023 % at the 5% significance level. However, the impact of imports was found statistically insignificant. Similarly, economic growth increases CO2 emissions in Pakistan, upholding the common belief that economic growth stimulates CO2 emissions. On the other hand, agriculture value added reduces the CO2 emissions statistically significant. Thus, the paper's findings imply that the country should prioritize its trade by focusing on exports. In addition, to achieve sustainability through trade, Pakistan must identify environmentally friendly trade sectors for more extended prosperity.

Keywords: Exports, Imports, Economic Growth, CO2 Emissions, Sectoral Value Added, ARDL, Pakistan.

INTRODUCTION

Environmental sustainability means the potential to fulfill the current demands without jeopardizing the capacity of subsequent generations to utilize the same resources to meet their needs. It includes alleviating climate change, protecting natural resources, and preserving the ecosystem. Hence, it is crucial to attain environmental sustainability to safeguard the well-being of both present and coming generations. Simultaneously, the world's economies have transformed due to the rapid expansion in global trade; though, its impact on environmental quality is a pressing issue that countries are currently struggling with. The connection between international trade and environmental sustainability has garnered significant attention. Balancing economic growth with the preservation of our planet's ecosystem is often challenging. Trade involves the global exchange of goods and services, playing a vital role in economic progress and prosperity. International trade is essential for fostering technological advancements, opening up markets, increasing productivity, and improving living conditions. However, the pursuit of economic growth has resulted in increasingly apparent negative impacts. The environmental effects of trade, including transportation, resource exploitation, manufacturing, and waste generation, are persistent and concerning.

The potential impact of trade on environmental sustainability can be viewed in both positive and negative terms. One positive aspect is that international trade has the ability to drive environmentally-friendly practices and innovations. This can be achieved through the exchange of eco-friendly technologies, prompting countries to adopt cleaner production methods. Furthermore, trade can lead to specialization that minimizes resource depletion and waste, while also encouraging countries to focus on areas where they have a comparative advantage in terms of resources or expertise. Additionally, trade can have a positive effect on the environment by creating economic opportunities, such as investments in renewable or green energy sources.

Numerous studies have been conducted on the connection between trade and environmental sustainability. For example, Bernard and Mandal (2016) studied how trade openness impacts environmental quality and found a positive influence in 60 countries using a dynamic panel data model. In Pakistan, research by Alam et al. (2011) and Zafar et al. (2022) also supports a positive correlation between trade liberalization and environmental preservation. Qamruzzaman (2022) explored the impact of environmental sustainability, trade, environmental innovation, and renewable energy in Russia and India, showing a beneficial effect on environmental sustainability. Can et al. (2021) investigated the impact of trading environmentally friendly products on ecological degradation, revealing a significant decrease in environmental deterioration. Furthermore, Assamoi et al. (2020) analyzed the relationship between trade openness and carbon emissions in Asian countries using the cointegration technique, indicating a negative association. Free trade provides opportunities for transferring technologies across countries that promote environmentally friendly approaches to producing and manufacturing goods. However, the assumption that adopting such technologies lessens environmental degradation is only sometimes valid. Prior studies have revealed that technological advancement, particularly in the production sector, requires high levels of usage of energy and other resources, such as raw materials that are eventually destructive to the environment (Alhassan et al., 2020; Jun et al., 2020; Mahrinasari et al., 2019; Van Tran, 2020; Zaidi et al., 2018,(Ullah, Xiaoming et al. 2023). Moreover, the trade of goods requires various means of air and road transportation that can be a source of substantial amounts of greenhouse gas emission, hence, the dirtier environment. In addition, trade can cause resource depletion due to the overutilization of resources like minerals, which can further lead to an unsustainable environment.

The economic growth of a nation is closely intertwined with its overall prosperity. This phenomenon yields many favorable outcomes for the economy and society while simultaneously inducing a transformative effect on the economy, leading to modifications in various sectors, populations, geography, and institutional systems (Acemoglu, 2012). The initiative's construction projects have a large impact on the economies of the participating nations, notably on fiscal expansion, infrastructure spending, and financial stability,(Ullah, Khan et al. 2023).

Due to their pursuit of higher growth, communities are overcome by environmental degradation. For example, Kongkuah et al. (2022) have demonstrated that the interplay between economic growth, energy utilization, and trade manifests a significant and immediate impact on the emission of CO_2. This suggests that the escalation of the economy correlates with a surge in CO_2 in the atmosphere, thereby inflicting environmental harm. In scholarly work, different authors produced conflicting results regarding the impact of economic growth on the environment. For example, several scholars found that initially, economic growth contributes to pollution through different emissions; however, in the long term, it contributes to a greener environment. Thus, proving the environmental Kuznets curve in the studied region ((Raza et al., 2022; Salazar-Núñez et al., 2022; Zafar et al., 2022). This paper empirically analyzes trade's impact and other socio-economic factors (such as economic growth, industrialization, manufacturing, and agricultural value-added) on environmental sustainability in Pakistan. Since Pakistan actively trades with several other countries like China, European Union, United States, it profoundly impacts ecological quality in the country. The principal exports of Pakistan include agricultural goods, textiles, manufactured goods, leather products, and so on, while the imports include technological developments, petroleum, and others. Undoubtedly, international trade expands Pakistan's reach to the global market and provides opportunities to enlarge its industries, which can lead to high-value-added sectors. However, to keep up with the increased trade activities, the country must overexploit its natural resources, which adds to resource depletion and environmental degradation. Therefore, it is crucial to examine whether international trade is advantageous for Pakistan's environmental sustainability or vice versa.

The rest of the paper is structured as follows: section 2 provides data and methodology, section 3 displays the results of the empirical analysis, and the conclusion is presented in Section 4.

2. Methodology

2.1. Data and variables

The present study aims to evaluate the impact of trade on environmental sustainability along with other controlled factors in Pakistan. For empirical analysis, this study collected annual time series data from WDI (World Development Indicator) for the time period of 1995 to 2022. Time series data is collected on dependent variable CO2 emission per capita and other controlled variables like GDP per capita, imports, exports, industry value added, manufacturing value added, and agricultural value added. To minimize heteroskedasticity, natural logarithm is taken of the dependent variable (CO2 emissions per capita), while the controlled variables were already in the form of percentages. Before providing methodological approaches' overview and detail, here is a snapshot of the sources and procedures that were taken in this paper, in flowchart form, in Figure 1.

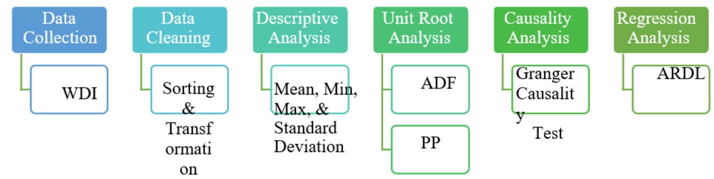

Figure 1: Data Collection and Analysis Flowchart

Once the data collection was finalized, the data were undergone the initial cleaning and transformation. In the second step descriptive analysis of the variables was carried out because information on basic features of variables is an important factor before proceeding to formal estimations. The one of the advantages of the descriptive analysis is that it provides the information on mean, median, standard deviation, minimum, and maximum values feature of factors. After the descriptive analysis, the stationarity of data was checked by using different methods such as ADF and PP. By definition, stationarity refers to constant mean, variance, and covariance of series for every lag taken. In case a series is non-stationary at level, first difference can be taken in order to make it stationary (Vuranok, 2009). The unit root results verified that the variables are stationary at first difference or putting in other words integrated order of 1. As the unit root tests confirmed the stationary level, thus, cointegration analysis was carried out. Undoubtedly, co-integration is a powerful tool to check the association between variables; however, it lacks in providing the direction of cause i.e., which variable cause which and in what way. Therefore, the causality analysis was carried out to provide more practical suggestions based on the findings of this essay. Finally, once all the diagnostic and initial empirical estimations were conducted, the author proceeded toward the regression analysis to find the short run and long run impact of independent variables on the dependent variables (see Figure 1). The description of the selected variables used for econometric analysis is described in Table 1.

Table 1: Description of Variables

2.2. Model Development and Econometric Methodology

Variable Name	Code	Measurement Scale	Data Source
Carbon Dioxide Emissions	CO_2	Per Capita Metric Tons	WDI
Imports of goods and services	IMP	Percentage of GDP	WDI
Exports of goods and services	EXP	Percentage of GDP	WDI
Economic Growth	GDP	Per capita annual Growth Rate	WDI
Industry value added	IND	Percentage of GDP	WDI
Manufacturing value added	MANU	Percentage of GDP	WDI
Agriculture, forestry, and fishing value Added	AGRI	Percentage of GDP	WDI

For the empirical estimation, the carbon dioxide emissions (per capita metric tons) was used as a dependent variable, and exports, imports, economic growth, industry value added, manufacturing value added, and agriculture, forestry and fishing value added were used as independent variables. The general form of the model is given below (see equation 1):

(2) =(*h*, , , , ,
, , *h* (1)

The model given in equation 1 shows the basic framework of the model that is employed in this essay and serves as the foundation for further econometric estimations. Nonetheless, this model has been transformed into econometric form as stated below (see equation 2).

$$2 = {}_0 + {}_1 + {}_2 \quad + {}_3 + {}_4 \quad + {}_5 + {}_6 + \qquad (2)$$

In the above model, the subscript t shows the time of each variable and is the error term of the model. The parameters from $_1$ $_6$ are coefficient estimates of the independent variables that capture their impact on the dependent variable in the long run. However, in order to capture their impact both in the short run and long run, equation (2) changed into the error correction form, as described below in the equation (3):

$$\Delta \; 2 = {}_0 + \sum_{=1} {}_1 \; \Delta \; 2_{-} + \sum_{=0} {}_2 \; \Delta \; _{-} + \sum_{=0} {}_3 \; \Delta \; _{-} + \sum_{=0} {}_4 \; \Delta \; _{-} + \sum_{=0} {}_5 \; \Delta \; _{-} + \sum_{=0} {}_6 \; \Delta + \sum_{=0} {}_7 \; \Delta + {}_1 + {}_2 + {}_3 + {}_4 + {}_5 + {}_6 + \qquad (3)$$

It is important to know that, now equation (3) not only captures the long run impacts of independent variables on dependent variable but also able to analyze the short run impacts.

2.2.1. Cointegration Analysis: ARDL (Autoregressive Distributed Lag)

The present study utilized the ARDL bounds testing method of cointegration to check the long term relationships between the selected variables. Pesaran & Shin (1999) and Pesaran et al. (2000), established this approach. This paper used this econometric technique for various reasons: first and foremost, it does not require variables to have equal integration order; thus, it can be applicable on variables having different optimal lags. In addition, for a small sample size like this study, it provides efficient estimates. Despite of ARDL having superiority over other estimation techniques, it is not valid if the any of the variables is not stationary at level I(0) or first order of integration I(1). Therefore, to clear any doubts regarding order of integration, it is compulsory to check stationarity by using unit root tests before continuing with empirical analysis.

2.2.2. Unit Root Tests:

To assess the stationarity of the selected variables, the study employed ADF (Augmented Dickey fuller) test of unit root that examines if the mean of time series is constant over the years. The ADF test provides accurate estimates in the case of small samples just like this present study; thus, it is used to check integrated order of the variables. The null hypothesis (α=1) of ADF test indicates the occurrence of unit root problem in variables; to reject the null hypothesis, the acquired p-value ought to be less than significance level (e.g. 0.05).

To further confirm the stationarity of variables, the study also utilized Phillips-Perron test of unit root. This test is similar to the ADF test; however, it is more upgraded as it observes if the variance of time series is constant over a specific period of time. Hence, the present study used both tests of unit root to assure that the time series data has constant mean and variance, which implies stationarity.

2.3. Theoretical justification of variables
:

2.3.1.Environmental sustainability:

The study treats environmental sustainability as a dependent variable which is represented by carbon dioxide emissions measured in metric tons per capita. It defines the level of CO_2 emissions per person produced in a country. A higher value of CO_2 emission per capita suggests a significantly adverse impact on environmental sustainability. This variable is considered crucial as it indicates environmental quality and carbon footprint of a specified population.

2.3.2.GDP per capita:

GDP (Gross Domestic Product) per capita growth, measured in annual percentage, is served as a proxy of economic growth of a country. More precisely, it describes rate at which GDP per person changes in a country over a given period of time. A greater value of GDP per capita
growth rate exhibits high levels of economic activity as well as escalated resource exploitation that can have potential environmental consequences.

2.3.3.Trade:

Trade is another main independent variable in this study that is measured by imports and exports both as a percentage of GDP. Imports suggest the level to which a country depends on imported products and services to fulfill its domestic requirements for consumption and production. Thus, higher rates of imports depict higher level of consumption and production in a country which may involve various forms of transportation or long-distance shipping that eventually impact environmental quality. On the flip side, exports portray a country's potential to sell its products and services in markets abroad. An intensive level of exports implies high level of industrial activity and economic output in a given country that may have environmental consequences.

2.3.4.Industry value added:

To study the impact of trade on environmental sustainability, another important explanatory variable is industrial value added that is measured in percentage to GDP. A higher rate of trade indicates heavy reliance on industrial sector that utilizes energy for construction and manufacturing activities; thus, can potentially impact environmental quality.

2.3.5.Manufacturing value added:

Manufacturing sector is closely related to environmental sustainability as manufacturing processes rely on energy consumption. Manufacturing value added is calculated as a percentage to GDP and it defines productivity and output of manufacturing sector.

2.3.6.Agricultural value added:

Agricultural value added is also computed as a percentage to GDP and may have environmental implications due to the fact that agricultural sector make use of various resources like water and land.

Results and Discussion

The basic characteristics of the variables used in this paper are displayed in Table 2. The average values of CO2 emissions per capita and GDP are -0.332399 and 1.675786. The range of CO2 emissions is -0.47809 to -0.085043 while for GDP, it's from -2.970295 to 5.16969. Similarly, the mean values of imports and exports are 18.12272 and 12.95568, with standard deviations 2.665149 and 2.552419, respectively. For industry value added, the mean, standard deviation, minimum and maximum values are 19.77509, 1.457708, 17.54846, and 22.10317, respectively. Likewise, the average value of manufacturing value added is 12.78194 with a minimum value 10.21979, a maximum value 14.78586, and a standard deviation 1.455681. Lastly, agriculture value added has average value 23.22987 with a standard deviation 1.267449, and ranges from 20.67787 to 25.61726.

Table 2: Descriptive Analysis

Variables	Mean	St. dev.	Max	Min
LCO2	-0.332399	0.11526	-0.085043	-0.47809
GDPPCG	1.675786	2.078392	5.169693	-2.970295
IMP	18.12272	2.665149	23.21189	13.24388
EXP	12.95568	2.552419	16.9031	8.221612
IND	19.77509	1.457708	22.10317	17.54846
MANU	12.78194	1.455681	14.78586	10.21979
AGRI	23.22987	1.267449	25.61726	20.67787

After the descriptive analysis, the order of integration of variables is assessed by applying Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Tables 2 and 3 display the results of the ADF and PP test, respectively; the left side shows the results of stationarity at the level I (0), while on the right side, the results of 1st integrated order I (1) are shown. It is apparent from the results that all the selected variables have unit root problems at the level, which indicates non-stationarity. Therefore, the first difference was taken to make them stationary; results showed that all the chosen variables are stationary at the first difference I (1). This procedure was done on the statistical software EViews.

Table 3: ADF Unit Root Test

At Level			At First Difference	
Variables	**Intercept**	**p-value**	**Intercept**	**p-value**
LCO2	-1.118438	0.6920	-4.017003	0.0068
GDPPCG	-3.113243	0.0375	-5.827138	0.0001
IMP	-2.074097	0.2559	-5.042951	0.0004
EXP	-1.496975	0.5198	-4.609681	0.0012
IND	-2.650681	0.0957	-5.704764	0.0001
MANU	-2.452802	0.1377	-5.085282	0.0004
AGRI	-1.776920	0.3833	-4.745061	0.0008

Table 4: PP Unit Root Test

At Level			At First Difference	
Variables	**Intercept**	**p-value**	**Intercept**	**p-value**
LCO2	-1.180177	0.6665	-4.165423	0.0037
GDPPCG	-3.112911	0.0375	-6.906245	0.0000
IMP	-2.125602	0.2368	-5.044383	0.0004
EXP	-1.513826	0.5115	-4.586132	0.0012
IND	-2.651345	0.0956	-5.791948	0.0001
MANU	-2.452802	0.1377	-5.084858	0.0004
AGRI	-1.878333	0.3369	-4.748067	0.0008

ARDL Analysis Results:

The long run result of ARDL model exhibited in Table 5. The ARDL model evaluated the long run impact of trade on environmental sustainability, along with other controlled variables.

Table 5: ARDL Analysis

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG_CO2(-1)	0.370902	0.200408	1.850733	0.0817
GDP	0.007080	0.003581	1.977125	0.0645
IMP	-0.011815	0.007395	-1.597570	0.1286
EXP01	-0.022984	0.008657	-2.654958	0.0167
IND	-0.037707	0.023129	-1.630260	0.1214
MANU	0.073193	0.029334	2.495203	0.0232
AGRI	-0.026060	0.009271	-2.810732	0.0120
C	0.712760	0.295144	2.414959	0.0273

R-squared	0.937953	Mean dependent var	-0.326673
Adjusted R-squared	0.912405	S.D. dependent var	0.113799
S.E. of regression	0.033681	Akaike info criterion	-3.689455
Sum squared resid	0.019284	Schwarz criterion	-3.299415
Log likelihood	54.11819	Hannan-Quinn criter.	-3.581275
F-statistic	36.71244	Durbin-Watson stat	2.053985
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

The findings of the ARDL model exposed that economic growth and manufacturing value added both increased CO2 emissions in Pakistan. The statistical significance and direction of both economic growth and manufacturing value added explain that a 1 percent increase in economic growth and manufacturing value added lead to corresponding increase of 0.008% and 0.073%, respectively. The observed phenomenon of escalated emissions can be linked to the upholding of economic growth, which serves as a catalyst for increased economic activities. This effect is particularly pronounced in developing nations, where the availability and affordability of green energy technologies are severely curtailed, thereby stressing the public's reliance on emission-producing sources, such as fossil fuels and petroleum. These findings confirmed the previous studies by Ghiţă (2019), Hassan (2021), Karimi et al. (2022), and Mamkhezri et al. (2022) but diverge from those of Bjørnskov (2020), de Soysa (2021), Rapsikevicius et al. (2021), Sart et al. (2022), Setyadharma et al. (2021), Sheraz et al. (2021), and Uzar (2021).

As trade not only facilitates the economic growth of a country but also has repercussions on the environment because of its dependence on multifaceted and complex elements. Literature produces different conclusions regarding the impact of trade on the environment and studies mostly use the overall trade share in GDP. However, the uniqueness of this is lies in its incorporation of exports and imports separately to estimate the narrow impact of both factors of trade on CO2 emissions of Pakistan. The findings of this paper revealed that both the imports and exports negatively impact the environment. This negative relation implies that if both imports and exports increased, resultantly, the carbon dioxide emissions will decline. However, it is important to note that the impact of imports is not statistically significant. On the flip side, a 1 % increase in exports cause carbon dioxide emissions to reduce by 0.023 % at the 5% level of significance. These findings not only encourage the country to promote its exports but also paved the way for innovation. As exports increased the balance of payment of a country correspondingly improved.

That ultimately leads to prosperity and innovation in the country. These findings of the study support the evidence produced by several studies (Shuquan (2019); Mahmood (2017); Dou et al. (2021), and diverge from Longe et al. (2020); Rahman et al. (2021); Mania (2019).

Similarly, the coefficient estimates of industrial value added and agricultural value added also confirmed that both variables have favorable impact on environment. For example, a 1 percent increase in industrial value added and agricultural value-added lead to 0.038 % and 0.026% decrease in carbon dioxide emissions, respectively. However, the contribution of industrial value added is statistically insignificant, while agricultural value added is statistically significant at 5% level of significance.

Pairwise Granger Causality Results:

After examining the long term association among variables, pairwise Granger Causality test was applied to check the direction of relationship between variables. The results revealed that GDP granger cause the CO2 emissions but vice versa is not true. Similarly, GDP has a direct causal relationship with agriculture value added while the other way around is not true. Moreover, CO2 emissions have a direct relationship with exports; however, there is no reverse causality is seen in this case. In case of causal relationship between imports and manufacturing value added, the former granger causes the latter one, but vice versa is not true in this case. As far as the causal relationship between imports and agriculture value added is concerned, a two-way causal relationship is seen. Likewise, there is two-way causal relationship between agriculture value added and industry value added. Furthermore, exports are not granger caused by agriculture value added, but the opposite is true. Lastly, a one-way causal relationship can be seen from manufacturing value added to the agriculture value added. In case of the remaining variables, the study was failed to reject the null hypothesis (no granger causality) on the basis of the empirical results. (See table 6).

Table 6: Pairwise Causality Results

Variables	CO2	GDP	IMP	EXP	IND	MANU	AGRI
CO2		3.12053***	0.71368	0.19830	0.25261	0.14655	0.43969
GDP	0.73971		1.75845	0.41955	1.38702	1.31313	0.12524
IMP	1.58941	2.51570		0.70303	1.13927	1.29540	2.91105***
EXP	2.83951***	0.48991	0.19855		1.38024	1.70188	0.06458
IND	0.08248	0.29257	1.98428	1.37666		0.63501	2.62234***
MANU	0.04322	0.32605	2.60352***	0.59725	0.52820		2.24114
AGRI	1.68802	4.34565**	3.58091**	3.58123**	4.30241**	3.76397**	

Conclusion:

This paper examines the impacts of trade along with other controlled variables on environmental quality in Pakistan, for 1995 to 2022 period. Firstly, descriptive analysis has been done to assess the characteristics of the selected variables before analysis. Secondly, stationarity of the data was checked by using unit root tests ADF and PP. Autoregressive Distributed lag (ARDL) model was employed to evaluate long term association between the explained and explanatory variables. After the cointegration analysis, direction of the relationship among variables was checked by utilizing Pairwise

Granger Causality test. Empirical outcomes revealed a negative and significant impact of exports on CO2 emissions, implies that export activities can improve environmental quality in Pakistan. Similarly, the impact of imports on CO2 emissions is negative; however, it is not significant. Furthermore, the sectoral value added has negative effect on Co2 emissions except the manufacturing value added which has a significant positive impact on environmental degradation. At last, Pairwise Granger Causality test was used to find out the direction of the relationship among variables and interestingly outcomes illustrated no variable has a causal relationship with each other.

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