

Impact of Economic Growth on Carbon Emissions In Pakistan

¹Muhammad Nameer Wajahat, ²Tabassum Iqbal, ³Sabir Ali

¹Bahria University, Islamabad, Pakistan, nameerwajahat@gmail.com,

²Management Studies, Bahria University, Islamabad, Pakistan, Tabassum_2604@yahoo.com

³Management Studies, Bahria University, Islamabad, Pakistan, Sabirali.buic@bahria.edu.pk,

ABSTRACT

Pakistan is a developing country that seeks economic growth. However, Pakistan must analyse the environmental cost associated with economic growth and work to attain sustainable growth. This study emphasizes on impact of economic growth and CO₂ emissions in Pakistan. This empirical research applies the Engle and Granger cointegration approach to investigate the long-term empirical association between economic growth and CO₂ emissions. Moreover, the Error Correction Model is employed to assess the effect of economic growth on CO₂ emissions in the short-term. Findings of this study indicate a positive and strong correlation between CO₂ emissions and energy consumption per capita in both the short and long term. In comparison, GDP has a positive but weak relationship with CO₂ emissions in both the short-term and long-term. The study concluded that adjustment in the long-run is possible since the ECM model predicts that 37.76% of the long and short-run discrepancies will be corrected within a year. The study recommends that increasing the share of hydel and renewable energy in Pakistan's energy mix and revamping the existing power distribution system to minimize power losses will mitigate the carbon emissions caused by energy consumption. Moreover, the adoption of sustainable practices by manufacturers, installing catalytic converters in manufacturing plants, and incentivizing the use of renewable energy for manufacturers and households will mitigate the carbon emissions caused by GDP growth.

Keywords: *Sustainable Growth; Carbon Emissions; Economic Growth; Sustainable Practices; Energy Consumption Per Capita; and GDP*

INTRODUCTION

Greenhouse gases trap heat in the environment, causing global temperatures to rise (Trenberth, 2018). This phenomenon is called global warming. CO₂ is one of the greenhouse gases that cause global warming. Global warming and climate change are considered the biggest threats to the world. Climate change is the term used to describe alterations in weather patterns that are brought about by global warming. Over the past century, there has been a recorded increase of almost 1°C which has caused a disturbance in the weather patterns due to which the frequency of natural calamities such as floods, hurricanes, and droughts has increased over the years (Yasin & Priyanto, 2019). Climate change has an adverse impact on countries worldwide. Sudden rainfall and droughts can negatively impact agricultural production. This can result in economic and food crises in agro-based economies.

Natural disasters caused by climate change are a source of economic loss for developed and developing countries. From 1980 till 2015, on average, developed countries had to bear an economic loss of 0.13% of their GDP, whereas developing countries had to bear a 0.22% loss of their GDP (Panwar & Sen, 2019). Besides causing economic losses, natural disasters cause loss of human lives. Each year, approximately 60,000 people die across the globe because of natural disasters (Ritchie & Roser, 2014). Like other countries, Pakistan is also affected by global warming and climate change. The duration of

heat waves in Pakistan is increasing, resulting in the loss of precious lives (Khan et al., 2019). In the heat wave of 2015, more than 700 people lost their lives (Masood et al., 2015).

It has been predicted that Pakistan's temperature will increase about 5°C by the end of this century (Rasul et al., 2012). Besides that, the frequency of floods has increased in Pakistan over the years due to global warming. From 1973 to 1993, flooding took place sixteen times, and in the next two decades, Pakistan was hit by floods 54 times (Sardar et al., 2016). Overall, more than 12 thousand people have lost their lives, and around 197,273 villages have been damaged due to floods. Furthermore, Pakistan has incurred a loss of US\$ 38 billion due to floods (Annual Flood Report, 2017). As climate change poses a global threat, the UN has included a 13th goal in the 2030 agenda for sustainable development to address it. (Guiot & Cramer, 2016).

Action against climate change and global warming is only possible by mitigating carbon emissions after identifying their source. According to the data, developed countries significantly contribute to carbon emissions. Since the 1990s, the European Union, China and US have been the top three emitters of greenhouse gases globally (Emissions Gap Report, 2019). All top three emitters of greenhouse gases have high GDP and economic growth in common. This raises questions about how CO₂ emissions impact economic growth. Various studies have explored the association between economic growth and CO₂ emissions. However, limited literature is available that investigates how economic growth affects CO₂ emissions in the case of Pakistan.

This study aims to find the effect of gross domestic product (gdp) growth on CO₂ emissions in Pakistan. The purpose of conducting this study is to find the association between key sectors of Pakistan's economy and CO₂ emissions. This paper also aims to analyze the long-run along with immediate relationship between economic growth and CO₂ emissions. Finding the relationship between the two is essential since Pakistan is a developing country that focuses on achieving economic growth. However, it does not consider the carbon emissions that will take place due to economic growth. The results of this study will identify the correlation between CO₂ emissions and economic growth, which policymakers can use to plan Pakistan's sustainable economic growth.

The results obtained from this study will also guide policymakers to take steps to promote sustainable development in the sectors where the association between growth and CO₂ emissions is positively correlated. This study will highlight the impact of growth in essential sectors of the economy on CO₂ emissions in Pakistan in the short-term and long-term. This research will contribute and fill the gap in the existing literature since the combination of variables used in this study to represent economic growth has not been used in previous studies. Moreover, it will enrich the existing literature by highlighting the relationship between the growth of each sector of Pakistan's economy used in this research and CO₂ emissions.

LITERATURE REVIEW

Over the years, economic activity has seen noticeable growth worldwide. Economists and environmentalists are concerned about how economic growth will impact carbon emissions. Several economists have conducted studies to determine the correlation between economic growth and carbon emissions. Previously, a study analyzed the impact of economic growth on CO₂ emissions in Azerbaijan using data from 1992 to 2013 (Mikayilov et al., 2018). Different tests were applied to the data to find the cointegration between the two. The results showed that economic growth has a statistically

significant and positive long-term relationship with carbon emissions. The study also revealed that short-run imbalances will be adjusted within a year.

Recently, (Khan et al., 2020) studied the empirical linkages between emissions, economic growth, energy consumption in Pakistan. The study found that economic growth leads to an increase in CO₂ emissions in both the long-term and short-term. Based on these previous studies, a hypothesis can be developed that economic growth create a statistically significant impacts on CO₂ emissions in Pakistan. Over the years, various studies have used different economic variables along with the data of carbon emissions to examine the correlation between economic growth and carbon emissions. This literature review highlights how the results of previous studies conflict with each other. Hence, further investigation of the connection between CO₂ emissions and economic growth is essential, especially in the context of Pakistan.

A research studies the impact of gdp growth on CO₂ emissions in G20 countries. The findings of the study reveal that economic growth and CO₂ emissions are positively related in G20 countries (Li et al., 2021). Moreover, an empirical study that investigates the correlation among CO₂ emissions and economic growth in Pakistan also reveals that a positive relationship exists between of economic growth with carbon emissions in both the short-term and long-term (Khan et al. 2020). Moreover, a study investigated the effect of GDP per capita on carbon emissions. According to the results of the study, GDP per capita and carbon emissions are positively correlated (Salman, 2018). Similarly, a research highlights positive correlation between GDP per capita and CO₂ emissions per capita in for a few decades. However, in other decades negative relationship was observed between the two variables (Begum et al., 2015).

Economic growth is represented by various economic variables apart from GDP. One of such economic variables is trade. Many studies have been conducted to find the relationship between trade and CO₂ emissions. A study examined the relationship between trade and CO₂ emissions in ASEAN countries and concluded that trade has a negative relationship with CO₂ emissions In ASEAN countries (Zhu et al., 2016). Similarly, another study highlights the impact of trade on CO₂ emissions. According to this study, trade and carbon emissions are negatively related (Dogan & Seker, 2016). Besides that, the findings of another study reveal the inverse relationship between trade and carbon emissions (Kohler, 2013). Results obtained with the help of Johansen cointegration, ARDL bounds testing, and the VECM Granger causality test used in the research showed higher levels of trade mitigate carbon emissions.

Another study that analyzes the relationship between CO₂ emissions and financial development in Malaysia proves the negative correlation between CO₂ emissions and trade (Shahbaz et al., 2013). On the contrary, according to research, trade openness increases CO₂ emissions (Shahbaz et al., 2014). Moreover, a study analyzes the relationship between CO₂ emissions and trade for the top ten carbon-emitting countries from the developing world (Ertugrul et al., 2016). After analyzing the data through different analytic approaches and tests, mixed results are deduced. In Turkey, China, India, and Indonesia, carbon emissions increase along with trade, whereas Thailand, Korea, and Brazil do not affect the environment.

Other than trade, studies have been carried out to see how the agricultural output affects CO₂ emissions. A study examines the relationship between agriculture and CO₂ emissions in China by analyzing the data from 1971 to 2010 (Dogan, 2019). The findings show a high contribution of the agricultural output in CO₂ emissions in the case of China. Moreover, the study reveals that agriculture output increases CO₂ emissions in the long-run. Furthermore, there are different ways by which the agricultural sector

contributes to carbon emissions. An empirical research reveals that energy activities in irrigation, such as water pumping, contribute around 50% to 70% of emissions from energy-related activities in China's agriculture sector (Zou et al., 2015).

Moreover, machinery used in the agricultural process also causes carbon emissions. A study proves that smoke emitted by the engine of a tractor mainly consists of carbon monoxide, which causes an increase in carbon emissions in the environment (Arapatsakos & Gemtos, 2008). On the contrary, studies like (Alam, 2015) and (Dar & Asif, 2020) have found that agriculture is negatively linked to CO₂ emissions.

Energy consumption is also a significant variable in an economy. Many researches have been conducted to find the relationship between energy usage and emissions. According to a study conducted in 2007 (Soytaş et al., 2007), energy consumption causes CO₂ emissions to increase in the USA in the long-run. Another study examines the impact of different variables on CO₂ emissions in Turkey. The study results show that energy consumption boosts CO₂ emissions (Katircioğlu & Taşpınar, 2017). Similarly, a study on environmental quality reveals that energy use influences environmental degradation in South Asian economies (Nasreen et al., 2017). The impact of energy usage was also analyzed in the BRICS economies, and the results proved that energy consumption positively impacted CO₂ emissions (Haseeb et al., 2018).

Studies mentioned in the literature review provide insights into the relationship between economic growth and CO₂ emissions. However, the findings of several studies are conflicting with other studies. The inconsistencies among the results suggest further research to test how economic growth impacts carbon emissions. Moreover, vast literature reveals the correlation between economic growth and CO₂ emissions in countries across the globe. However, plenty of research gaps are present in Pakistan due to limited research.

Since the findings of other economies cannot be generalized to Pakistan, this paper aims to conduct quantitative research by analyzing the impact of various economic factors on CO₂ emissions in the long-term and short-term in the case of Pakistan through the Engle and Granger approach (Engle & Granger, 1987). The usage of the Engle and Granger approach seems appropriate for this analysis since previous studies such as (Ali et al., 2015) and (Khobai & Roux, 2017) used the Engle and Granger approach to find the long-run and short-run between environmental and macroeconomics proxies.

METHODOLOGY

Numerous economists have investigated the correlation between economic growth and CO₂ emissions. Daly studied the relationship between economic growth and environmental damage and argued that economic growth causes environmental damage (Daly & Farley, 2004). According to Daly, economic growth increases pollution, and this state has no turning point. The environmental Daly curve hypothesis suggests that growth in GDP per capita will cause environmental degradation. Based on the theoretical framework provided by (Daly & Farley, 2004), this paper analyzes the relationship between economic growth and CO₂ emissions in the case of Pakistan by conducting quantitative research. The data used in this research is collected through secondary sources.

This research uses four variables, Agriculture, Energy Consumption Per Capita, GDP, and Goods Exported, to represent economic growth. The data on carbon emissions and energy consumption per capita is obtained from Our World In Data, while the data on all the other variables is collected from the World Bank. Data from 1980 to 2021, spanning 41 years, is collected to obtain accurate results. Table a below shows the variables used in this study, along with their symbols and units of measurement.

Table a

<i>Variables</i>	<i>Symbols</i>	<i>Unit of Measurement</i>
Carbon Emissions	CO2	Tonnes (t)
Agriculture	Agr	Current USD (\$)
Energy Consumption Per Capita	EnergyCon	(KWh/Person)
Goods Exported	GoodsExp	Current USD (\$)
GDP	GDP	Current USD (\$)

The study has used descriptive and inferential statistics to draw conclusions. The mean growth of the variables is obtained through descriptive statistics while the Engle and Granger cointegration approach and Error Correction model is used to draw inferences.

ANALYSIS AND RESULTS

Descriptive analysis of the selected variables is conducted to analyze the mean growth of the variables over the years. The data for descriptive analysis is divided in two. The descriptive analysis conducted in Table b.1 represents the last two decades of the 20th century, which are from 1980 to 1999. Table b.2 represents the first two decades of the 21st century, from 2000 to 2021. The purpose of conducting the descriptive analysis of two different eras is to compare the selected variables for economic growth and carbon emission in both eras. By looking at both figures, a comparison can be drawn about how the growth of these variables varied in the case of Pakistan in the 20th and 21st centuries.

Table b.1

Years 1980-1999	CO2 Growth	Agriculture Growth	Energy Consumption Per Capita Growth	GDP Growth	Goods Exported Growth
Mean	17.91926	23.03995	7.918111	24.44516	22.28302

Table b.2

Years 2000-2021	CO2 Growth	Agriculture Growth	Energy Consumption Per Capita Growth	GDP Growth	Goods Exported Growth
Mean	18.87224	24.43121	8.302805	25.90313	23.62692

Source: Authors' Computation, 2024

Results of the descriptive analysis show that the mean growth in carbon emissions, goods exported, GDP, energy consumption per capita, and agriculture is higher in the current century. Higher mean growth in CO2 emissions from 2000 to 2021 can be justified since energy consumption per capita, goods exported, GDP, and Agriculture also observed growth at a higher mean rate in the same era compared to the 20th century. There are various reasons for the significant growth of these economic indicators in the 21st century. Overall economic activity increased in the 21st century in Pakistan since there was an inflow of dollars in the form of aid from the US as Pakistan was a strategic ally of the US in the war on terror. Moreover, the living standard of Pakistanis increased in the 21st century, causing energy consumption per capita to increase.

Furthermore, the agricultural sector expanded due to the inclusion of the latest techniques in the agricultural sector. Other than that, the government provided incentives to promote Pakistan's exports over the years. Studies such as (Appiah et al., 2018), (Dogan & Turkekul, 2016), and (Ertugrul et al., 2016) show the positive correlation between agriculture, energy consumption per capita, economic growth, and trade with CO2 emissions. Hence, it can be assumed that these variables' higher average growth rate between 2000 and 2021 caused CO2 emissions to grow at a higher mean rate in Pakistan. After analyzing the results of descriptive analysis, the variables are estimated through the multiple regression model.

Equation 1

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \mu$$

After that, an appropriate model is selected. Tables 1, 2, 3, and 4 show all four models that are considered for the data analysis. After analyzing all the models, the model that is chosen to analyze the relationship between economic growth on CO2 emissions is the LOG-LOG model. The results of this model are displayed in Table 1.

Table 1. Model LOG-LOG

<i>Variables</i>	<i>Coefficient</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	-0.5528	-1.4890	0.1452
LAgr	-0.1345	-0.6156	0.5420
LEnergyCon	1.6410	9.3256	0.0000***
LGDP	0.4465	1.9537	0.0585*
LGoodsExp	-0.1049	-1.6138	0.1153
R²	0.9903		
Adjusted R²	0.9893		
Prob (F-statistic)	0.0000***		
Durbin-Watson Statistic	1.0190		

Note: ***, ** and * represent significance at 1%, 5% and 10%

Source: Authors' Computation, 2024

This model is selected since it has the highest value of R^2 , which is 0.9903. Moreover, in this model, the value of R^2 is smaller than the Durbin-Watson Statistic, which means that this regression is not spurious (Newbold & Granger, 1974). Besides that, the Breusch-Pagan-Godfrey test for Heteroskedasticity shows that the model does not have Heteroskedasticity. The result shows that the value of Probability Chi-Square is more than 0.05. Hence, the LOG-LOG model does not contain the problem of Heteroskedasticity, and it is perfect to use this model to analyze the relationship between economic growth on CO2 emissions.

Heteroskedasticity Test: Breusch-Pagan-Godfrey

Obs R²	1.756
Prob. Chi-Square	0.7804

Source: Authors' Computation, 2024

Since the LOG-LOG model is declared fit for the analysis, the general equation generated by the LOG-LOG model is stated below.

Equation 2

$$LCO2 = \beta_0 + LAgr + LEnergyCon + LGoodsExp + LGDP + \mu$$

After selecting the appropriate model, the Engle and Granger cointegration approach will examine the long-run cointegration between the independent and dependent variables. To apply the Engle and Granger approach, first, it is important to check whether all the variables used in the model have the same order of integration. The integration order of variables is checked through the unit root test. The results of the unit root tests in Table c.0 show that all variables are significant at conventional standard at first difference. Since all variables have the same integration order, the Engle and Granger approach can be used to analyze the long-term relation between the independent variables and the dependent variable. Similarly, Table c.1 shows the residual term is stationary at level; this means the residual does not have a unit root, and cointegration or long-run relationship exists. Moreover, this also shows that the regression run is not spurious.

To examine the long-run impact of Agriculture, GDP, Goods exported, and energy consumption per capita on carbon emissions, the model is estimated by the Ordinary Least Square method (OLS).

Equation 3

$$Y = \beta_0 + \beta y + \varepsilon$$

Yt - Xt are cointegrated of order d. b

Where; $d \geq b > 0$ written as $Yt, Xt \sim CI(d, b)$

As $Yt \sim I(1)$ and; $Xt \sim I(1)$; if

$Yt - \beta_1 - \beta_2 Xt = Ut \sim I(0)$ then $Yt Xt \sim CI(1,1)$

If $Yt - \beta_1 - \beta_2 Xt = Ut \sim I(0)$ then $Yt Xt$ will not drift apart overtime

If Yt and Xt are not cointegrated then $Yt - \beta_1 - \beta_2 Xt = (Ut \sim I(1))$ they will drift apart as time goes on. No long-run equilibrium relationship

The results of the regression model displayed in [Table 1](#) show that energy consumption per capita and GDP are two variables that significantly impact CO2 emissions in the long-term. Energy consumption per capita strongly correlates with CO2 emissions since it is statistically significant at conventional standards. On the other hand, GDP has a weak but positive impact on CO2 emissions in the long-run since it is significant at a 10% significance level. Results reveal that an increase of 1% in energy consumption per capita, measured in KWh per person, leads to a rise of 1.6410% in carbon emissions. A study conducted previously also highlights the positive correlation of energy consumption with CO2 emissions after a thorough investigation (Bhattacharya et al., 2017). Similarly, another research was conducted on Middle Eastern and North African countries that proves a long-term correlation between energy consumption and carbon emissions (Arouri et al., 2012). The results of this study also align with the results obtained in [Table 1](#).

A positive relationship among CO2 emissions and energy consumption per capita seems logical since Pakistan's energy mix has a large share of non-renewable fossil fuels. Hence, increasing energy consumption per capita will increase CO2 emissions. Similarly, the results suggest that a 1% increase in the GDP will cause the CO2 emissions to increase by 0.4465% in the long-run. As GDP expands, more machinery becomes operational. An increase in GDP causes the production in industries to increase. As a result, carbon emissions increase. A study carried out in Tunisian (Cherni & Jouini, 2017)

also confirmed a positive correlation between CO2 emissions and GDP. Besides these two variables, the remaining variables have an insignificant impact on CO2 emissions in the long-run.

ECM Specification

$$\Delta Y_t = \alpha_1 + \alpha_2 \Delta X_t + \pi \hat{U}_{t-1} + U_t$$

The long-run model shows the long-term impact of the selected economic variables on CO2 emissions. However, the short-run impact of the same economic variables will be tested through the Error Correction Model (ECM). The results of the short-run model are displayed in [Table 5](#).

Table 5. Short-Run Model

<i>Variables</i>	<i>Coefficient</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	0.0298	3.8990	0.0004***
DAgr	-0.2468	-1.6404	0.1101
DEnergyCon	0.7351	4.3669	0.0001***
DGDP	0.3448	1.8760	0.0692*
DGoodsExp	-0.0567	-1.0021	0.3234
Residual (-1)	-0.3776	-3.6003	0.0010***
R²	0.5282		
Adjusted R²	0.4588		
Prob (F-statistic)	0.0000***		
Durbin-Watson Statistic	1.8698		

Note: ***, ** and * represent significance at 1%, 5% and 10%

Source: Authors' Computation, 2024

The results reveal that the error correction term is statistically significant at conventional standards and has a negative sign. This means that the long-run adjustment is possible. Moreover, the error correction term's coefficient represents the adjustment speed towards the equilibrium. In this short-run model, the coefficient of error correction term shows that 37.76% of the discrepancy between the long and short-run will be corrected within a year. Moreover, only energy consumption per capita and GDP affect CO2 emissions significantly in the short-run. Other variables have insignificant impacts on CO2 emissions. Similar to the long-run, GDP and energy consumption per capita have a positive relationship with carbon emissions in the short-run. An increase of 1% in energy consumption per capita causes the carbon emissions to increase by 0.7351%.

On the other hand, a 1% increase in the GDP causes the CO2 emissions to increase by 0.3448%. GDP and energy consumption per capita cause carbon emissions to increase faster in the long-run. These findings align with (Khan et al. 2020) it also concludes that energy consumption and GDP are positively related to CO2 emissions in both the long-run and short-run in the case of Pakistan.

CONCLUSION

Pakistan is a developing country striving for economic growth. Although economic growth is essential at this point, Pakistan still needs to weigh the environmental cost associated with economic growth. The study reveals that cointegration exists between independent and dependent variables. The results in the

energy consumption per capita and GDP have a positive long-run relationship with carbon emissions. GDP has a weak but positive relationship with carbon emissions since its P-value is significant at 10%. The results show that unit increase in the GDP will increase CO₂ emissions by 0.4465% in the long-run. Moreover, energy consumption per capita has a strong and positive correlation with carbon emissions as it is significant at 1%. The results obtained highlight that a 1% rise in energy consumption per capita will cause CO₂ emissions to increase by 1.6410%.

Moreover, Table 5 presents the short-term correlations between CO₂ emissions and the factors that indicate economic growth. Given that its P-value is significant at 10%, the GDP and carbon emissions have a weak but positive association. According to the findings, CO₂ emissions will rise by 0.3448% for every 1% increase in GDP. In contrast, as its P-value is significant, energy consumption per capita has a strong and positive link with CO₂ emissions. The findings show that unit increase in per capita energy consumption will result in a 0.7351% rise in CO₂ emissions. In addition, the ECM model's results indicate that long-run adjustments are feasible and that 37.76% of the difference between the long- and short-run will be resolved in a year.

In addition, the ECM model's results indicate that long-run correction is feasible and that, in less than a year, 37.76% of the difference between the long- and short-run will be resolved. The entire analysis also shows that GDP and per capita energy use lead to a longer-term increase in CO₂ emissions. According to the study, there is a short- and long-term increase in carbon emissions due to per capita energy consumption and GDP. Therefore, it is imperative to implement environmentally friendly and sustainable methods in order to reduce the carbon emissions that result from GDP growth and energy consumption. Upgrading Pakistan's energy mix to include more hydel and renewable energy will reduce the country's CO₂ emissions from energy use. Apart from that, to reduce power losses, Pakistan's current power distribution system needs to be updated. Systems for distributing power efficiently will reduce the amount of fossil fuels that must be ignited in order to generate energy. Consequently, the amount of carbon released when fossil fuels are ignited will be decreased.

Likewise, the industrial sector's adoption of sustainable practices and the installation of catalytic converters in production facilities will lessen the carbon emissions brought on by GDP growth. Manufacturers should use sustainable practices and install catalytic converters in their manufacturing facilities, according to government regulations. Incentives for the usage of renewable energy by homes and manufacturers should also be announced. As a result, the carbon emissions brought on by GDP growth will be reduced.

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Appendix

Table 1. Model LOG-LOG

<i>Variables</i>	<i>Coefficient</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	-0.5528	-1.4890	0.1452
LAgr	-0.1345	-0.6156	0.5420
LEnergyCon	1.6410	9.3256	0.0000***
LGDP	0.4465	1.9537	0.0585*
LGoodsExp	-0.1049	-1.6138	0.1153
R²	0.9903		
Adjusted R²	0.9893		
Prob (F-statistic)	0.0000***		
Durbin-Watson Statistic	1.0190		

Note: ***, ** and * represent significance at 1%, 5% and 10%
 Source: Authors' Computation, 2024

Table 2. Model LOG-LIN

<i>Variables</i>	<i>Coefficient</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	15.9447	137.3956	0.0000***
Agr	0.0000	1.9090	0.0643*
EnergyCon	0.0007	15.1775	0.0000***
GDP	0.0000	-1.4896	0.1450
GoodsExp	0.0000	-1.3252	0.1934
R²	0.9820		
Adjusted R²	0.9800		
Prob (F-statistic)	0.0000***		
Durbin-Watson Statistic	1.048318		

Note: ***, ** and * represent significance at 1%, 5% and 10%
 Source: Authors' Computation, 2024

Table 3. Model LIN-LOG

<i>Variables</i>	<i>Coefficient</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	1760000000	-29.9836	0.0000***
LAgr	-97895990	-2.8397	0.0074***
LEnergyCon	83138003	2.9953	0.0049***
LGDP	195000000	5.4099	0.0000***
LGoodsExp	-60630274	-5.9098	0.0000***
R^2	0.9781		
Adjusted R^2	0.9756		
Prob (F-statistic)	0.0000***		
Durbin-Watson Statistic	0.9624		

Note: ***, ** and * represent significance at 1%, 5% and 10%

Source: Authors' Computation, 2024

Table 4. Model LIN-LIN

<i>Variables</i>	<i>Coefficient</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	-60433343	-6.5296	0.0000***
Agr	-0.0017	-2.1888	0.0352**
EnergyCon	42001.11	11.3848	0.0000***
GDP	0.0007	4.7688	0.0000***
GoodsExp	-0.0011	-2.0172	0.0512*
R^2	0.9895		
Adjusted R^2	0.9883		
Prob (F-statistic)	0.0000***		
Durbin-Watson Statistic	0.8243		

Note: ***, ** and * represent significance at 1%, 5% and 10%.

Source: Authors' Computation, 2024

Descriptive Analysis 1.0

Years 1980-1999	CO2 Growth	Agriculture Growth	Energy Consumption Per Capita Growth	GDP Growth	Goods Export Growth
Mean	17.91926	23.03995	7.918111	24.44516	22.28302
Median	17.97121	22.96590	7.943435	24.41464	22.35378
Std. Dev.	0.367751	0.284623	0.178364	0.320020	0.478392
Skewness	-0.247024	0.291365	-0.339102	-0.002885	-0.215635
Kurtosis	1.786012	1.840962	1.809746	1.648192	1.429826
Jarque-Bera	1.431541	1.402452	1.563888	1.522848	2.209533
Probability	0.488815	0.495977	0.457516	0.467001	0.331288

Source: Authors' Computation, 2024

Descriptive Analysis 1.1

Years 2000-2021	CO2 Growth	Agriculture Growth	Energy Consumption Per Capita Growth	GDP Growth	Goods Exported Growth
Mean	18.87224	24.43121	8.302805	25.90313	23.62692
Median	18.85674	24.44170	8.316549	25.89942	23.79132
Std. Dev.	0.255441	0.486018	0.093044	0.505132	0.360010
Skewness	0.291376	-0.298102	-0.586024	-0.278301	-0.965014
Kurtosis	2.225898	1.667880	2.366495	1.794117	2.565684
Jarque-Bera	0.821479	1.863752	1.553145	1.543465	3.424435
Probability	0.663160	0.393814	0.459980	0.462212	0.180465

Source: Authors' Computation, 2024

Table a

<i>Variables</i>	<i>Symbols</i>	<i>Unit of Measurement</i>
Carbon Emissions	CO2	Tonnes (t)
Agriculture	Agr	Current USD (\$)
Energy Consumption Per Capita	EnergyCon	(KWh/Person)
Goods Exported	GoodsExp	Current USD (\$)
GDP	GDP	Current USD (\$)

Table b.1

Years 1980-1999	CO2 Growth	Agriculture Growth	Energy Consumption Per Capita Growth	GDP Growth	Goods Exported Growth
Mean	17.91926	23.03995	7.918111	24.44516	22.28302

Source: Authors' Computation, 2024

Table b.2

Years 2000-2021	CO2 Growth	Agriculture Growth	Energy Consumption Per Capita Growth	GDP Growth	Goods Exported Growth
Mean	18.87224	24.43121	8.302805	25.90313	23.62692

Source: Authors' Computation, 2024

Table c.0 Unit root test on variables results

Variables	Augmented Dickey-Fuller (ADF)	
	Intercept	
	P value at Level	P value at First Difference
LCO2	0.0006***	0.0007***
LAgr	0.9416	0.0000***
LEnergyCon	0.2558	0.0000***
LGoodsExp	0.7607	0.0000***
LGDP	0.9230	0.0000***

Note: ***, **, * represent significance at the 1%, 5% and 10% level
 Source: Authors' Computation, 2024

Table c.1 Unit root test on the residual

Variables	Augmented Dickey-Fuller (ADF)
	Intercept
	P value at Level
Residual	0.0161**

Note: ***, **, * represent significance at the 1%, 5% and 10% level
 Source: Authors' Computation, 2024