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Revisiting Triangle of Trade-Growth and Pollution for Middle-Income Transitions

Syeda Anam Hassan[1*], Inayatul Haq[2]

[1] GGPGC.NO.1 Abbottabad, Pakistan

[2] SS Economics, Richbhen Abbottabad, Pakistan

**Corresponding Author*

Abstract

The focus of this analysis is to explore the empirical association of environmental degradation as a consequence of energy, economic growth, and trade along with the population in perspective for carbon dioxide pollution emissions. Firstly, the panel unit root and Cross-sectional Augmented Dickey-Fuller (CADF) tests show mixed integration for the 27 middle-income nations during 1990-2020. The Pedroni and Kao panel cointegration tests confirm the long-run association. The estimated econometric results by panel GMM, Panel ARDL, and Dynamic Fixed Effect (DFE) shows a positive association of population density, GDP, energy demand (use/consumption) and openness of trade to environment degrading indicator (i-e CO2 emissions). The econometric results infer that middle-income nations are in the developing stages that require increasing economic activities and export earnings, which in turn uses carbon-intensive fuel industries that compromise environmental quality. Moreover, the Pairwise Dumitrescu Hurlin Panel Causality test exhibits that CO2 pollution emissions are granger caused by energy demand, population density, and GDP, while uni-directional relation is running from energy demand to GDP and CO2 emissions to trade openness. This study suggests the global policy framework cleaner technologies, renewable energy resources, and implementation of environmental taxes e.g. Green taxes and subsidies to environmental goods that are required at top priority to limit environmental degradation.

Keywords: Carbon dioxide Pollution Emissions; Dynamic Fixed Effect (DFE); Energy Demand; GDP Growth Rate; Panel GMM; Trade Openness

Email addresses: *syedaanam6695@gmail.com* **(Syeda Anam Hassan), inayateconomist33@gmail.com (Inayatul Haq)**

1. Introduction

During the last few decades social scientists, economists, and policymakers pay huge attention to environmental change, global warming, and greenhouse effects. It is an overwhelming and critical issue that human activities are injurious and badly extinct wildlife, ecological system, and natural resources that directed ecological degradation. Environmental depletion is a devastating element for forests, the ozone layer, and marine life. A clean and healthy environment is crucial and needs for survival of human beings.

Affluence-population and Technology (IPAT) equation highlights the nature of the anthropogenic activities and identifying major elements that worsen the environment. This conceptual framework is used to illustrate the several key components behind environmental degradation. The influence of human activities on the environment is the combination of these three factors affluence**,** population, and technology (Ehrlich and Holdren, 1971).

It is visible that anthropogenic activities by individuals fluctuating the environment worldwide on an exceptional scale. Human activities change the chemical structure of the air by the emissions of Greenhouse Gases (GHGs) and depletion of the ozone layer. It disturbs major biochemical cycles and hazardous for species existence (Harrison and Pearce, 2000).

The population is a key factor and has a proportional effect on energy demand and CO_2 emissions. Population density boosts urbanization and industrialization that would encourage human activities to disturb the environment. The term, affluence is the burden of population and energy use that raises the energy consumption in all sectors of the economy and thus CO_2 pollution emissions. As affluence rises, it will increase the inelastic to elastic in the association between environment and energy footprint (York et al., 2003).

The world population growth rate is about 1.5% that implies 80 to 85 million individuals are supplementary per year. United Nations declares that population density is highly intense in African and Asian developing nations. Moreover, these nations have a large share in Green House Gases (GHGs) relatively in developed nations. The population density increases the level of human economic activities, which increases the demand for more energy resources. There is a positive link found among population density, energy demand, and degraded environment. Recently developing nations demonstrate a motivational behavior for lessening the CO_2 pollution emissions but still lagging behind a certain level of environmental quality. If energy this demand increases as the same prospects it would become a worse challenge for the emerging economies to reduce the level of CO_2 (Audi and Ali, 2016). Population density has intensely cause greenhouse gases (GHGs) emissions. Human influence, highly climate change, and environment that becomes serious and critical issue globally.

The anthropogenic activities raise methane (CH_4), carbon dioxide (CO_2), and nitrogen oxides (NOx) that would increase the greenhouse gases and have a harmful influence on climate change. Increasing trends in population density and their demand for livelihood are the main reason behind the degradation of the environment. The link between environment and man is asymmetric and parasitic that means the worse effect on the environment is greater than its protection (Mkonda& He, 2017).

The term technology in the IPAT equation is the instrument of foreign direct investment and trade openness. Foreign direct investment (FDI) is a stimulating factor for the GDP growth rate. The inflows of FDI has an essential role in triggering growth by technology transformation, innovative activities, and spillover effects (Kostakis et al., 2017). In linkage to technology and FDI, the key hypothesis is valid in the literature of environmental degradation that is the "Pollution Havens hypothesis". "*The pollution haven hypothesis posits that, when large industrialized nations seek to set up factories abroad, they look for the cheapest option in terms of resources and labor that offers the land and* *material access they require”.* So, in developing nations the labor is cheap along with lower or no environmental cost in the form of heavy taxes that reduces the overall cost of production. This attracts the developed nations to invest in foreign developing nations and turn developing nations allows as an option to trade openness and FDI which ultimately pollutes the nations destructively (Zhang, 2011).

The Pollution haven hypothesis (PHH) for South Korea is confirmed and there is a positive relation between CO_2 pollution emissions and FDI (Chung, 2014). Ren et al., (2014) made analyses regarding aggregate FDI inflows relation to the environment, that FDI increases the intensity of CO_2 pollution emissions in China. FDI ensures a pivotal role in accelerating GDP growth rate and increasing the level of pollution emissions from the 1980s to onwards. FDI stimulates negative environmental externalities. There occurs bi-directional causality between CO_2 production level and FDI (Wang & Chen, 2014; Pao & Tsai, 2011).

Moving towards GDP growth rate, it improves standards of living and enhancing quality of life, as well as it creates environmental problems through depletion of natural resource and degradation of the ecosystem. Sustainability of GDP growth rate without depletion of environmental assets has challenges for emerging economies (Everett et al., 2010).

The linkages between GDP and pollutant emissions in developing nations are determined by the Environmental Kuznets Curve (EKC). According to the EKC hypothesis, deprivation of environment quality rises throughout the initial stage of GDP growth rate until reaching a turning point or threshold level. There is the beginning of the deterioration of environmental quality. There is an inverted U-shaped association that exhibits a link between affluence and GDP (Boluk & Mert, 2015; Mitic et al., 2017). Hence, together with the theories of IPAT, PHH, and EKC, the current study combines the key factors responsible for the pollution emissions along with the empirical outcomes.

Greenhouse gases (GHGs) is thus an absolute cause for global climate changes because CO_2 concentration is much in abundance. However, it is directly linked with anthropogenic activities such as, transportations, deforestation, combustion of fossil fuels, and clearing lands for industrial purposes. Reduction of CO_2 pollution emissions worldwide carried out on an international platform with the significant role of the United Nations (Ozokcu and Ozdemir, 2017).

Contribution of the Research

The current era is most profound to trade outcomes and completion in increasing economic growth without considering environmental degradation. The energy use, population density, and trade play a significant role in GDP growth rate but at the same time exert heavy pollution cost. Therefore, it is important to quantify the benefits as well as the level of environmental degradation faced by the nations. The current study fills the research gap of past literature by providing empirical pieces of evidence regarding combined effect by population-consumption and trade on environmental indicator i-e CO_2 pollution emissions. This analysis aims to quantify the influence of energy demand, trade, and GDP growth rate in 27 middle-income nations in context to CO_2 pollution emissions that have not been done in the previous analysis.

The first chapter comprises a brief introduction regarding how human activities, energy demand, technological affluence, and population density worsen the environmental quality badly in middle-income nations. The second chapter explains the extensive literature and past studies where analysis showed that anthropogenic activities degraded the environment. The third chapter presented data sources and descriptions of variables. The fourth chapter discusses the methodology and results. It explains the conceptual framework and statistical approaches. The fifth chapter concludes the whole analysis and suggests recommendations to save a healthy environment from degrading indicators.

Literature Review

Every economic activity includes transport, trade, and energy consumption for accelerating the GDP growth rate but without including the environmental compensations. Consequently, it is a cry prerequisite at the nationwide and worldwide stage to consider environmental sustainability along with the improvement in key factors like trade, population, and GDP growth rate. This analysis is requisite to unveil the important findings for middle-income nations in the context of environmental degrading indicators. (CO_2 pollution emissions from the transport sector) which will add a comprehensive empirical contribution to the current literature. The past studies are either done on Green House Gases (GHGs) emissions and for only selected nations and traditional sectors.

Yue et al., (2013) aimed to check the link between population, GDP growth rate, energy demand, and renewable energy and Carbon pollution emission for Jiangsu province of China. This study employed the IPAT model and decomposition method. This analysis shows that from 2005 to 2020, there is a 40-45% reduction in the optimal level of CO_2 pollution emissions. The results exhibit that the GDP growth rate is the main cause behind environmental deterioration and the influence of energy intensity and renewable energy has valuable influences in falling the carbon emissions level. The population density rate appreciating increasingly, and energy intensity reaches as it's maximum and renewable energy share increase up to 15 % in 2020. This study recommends that business investment should be promoted at the public and private level, improvement in energy efficiency, and GDP growth rate should be kept at a moderate rate so that pollution could control.

Bozkurt and Akan, (2014) observed the link among GDP, energy demand, and CO_2 pollution emissions for Turkey during the period 1960 to 2010. By using the co-integration technique, the empirical analysis exhibit that energy demand has negatively, and the GDP growth rate has positively influence carbon pollution emission. The findings advocate that to protect the environment from more hazardous influence, the government should put into practice those policies that utilize renewable and clean energy resources for production level.

Inglesi-lotz and Bohlmann, (2014) aimed to observe the link between GDP growth rate and the environmental value of South African nations for the period 1960 to 2010. By employing the ARDL approach the result reveals the absence of EKC in South Africa economies. This study concludes that nations are an early stage of development so that incurring the shape of EKC.

Mehrara et al., (2014) studied the link among GDP, trade, and carbon pollution emission in Iran over the time frame 1970 to 2011. In the long run, the Granger Causality test reveals a positive association between GDP and openness of trade to CO_2 pollution emissions. This study recommends that the country tends to manage CO_2 emission by importing clean technology and excess level of trade is drop off to control the degradation of the environment.

Uddin, (2014) aimed to inspect the link between GDP growth rate and carbon emissions in seven SAARC countries through the period 1972 to 2012. By using Johansen co-integration and VECM approaches the findings demonstrate a co-integration among GDP growth rate and environmental degradation. Furthermore, in the long period, the findings express that GDP has a positive influence on CO_2 pollution emissions. These results assist environmental authorities to recognize the unhealthy influence of GDP growth rate on ecological quality and deal with environmental issues using macroeconomic processes.

Ali et al., (2015) considered the relationship between carbon pollution emission, GDP growth rate, and energy demand in Pakistan during the period 1980 to 2012 for the short and long run. By employing the Johansen Co-integration approach the results validate the presence of EKC only in a long period but not validate in a short period. There is found a one-way link from energy demand to CO_2 emission.

Apergis and Ozturk, (2015) confirmed the presence of EKC for fourteen Asian nations analyzing the panel data for the time frame 1990 to 2011. This paper seeks to verify the influence of population density and GDP growth rate on CO_2 emission. The GMM (Generalized method of moments**)** method was used with a multivariate framework to test the EKC. The empirical result validates the presence of the Environmental Kuznets Curve for Asian economies.

Ahmed et al., (2015) examined the presence of EKC in Pakistan from 1980 to 2013. This study observed the influence of deforestation, population, GDP growth rate, and energy demand and trade openness on environmental pollution. By employing the ARDL approach and VECM, the finding validates the presence of EKC for Pakistan and confirmed association among the indicators in the short and long periods.

Cheema and Javid, (2015) aimed to examine the association involving disaggregate GDP growth rate, environment, and energy demand for 8 Asian nations through time frame 1990 to 2012. Fully Modified OLS was employed and the result confirms the presence of EKC along with positive influence found between GDP growth rate and energy demand. This study recommends that the government should implement policies regarding the usage of renewable energy resources.

Pandey and Mishra, (2015) explored the influence of CO_2 pollution emissions and GDP growth rate for SAARC nations through the period 1972 to 2010. By employing Panel Co-integration, Panel VECM, Variance Decompositions, and Impulse Response Function the econometric findings reveal that CO_2 pollution emissions and GDP growth rate has a significant association. The finding of VECM analysis recommends unidirectional affiliation from GDP to CO_2 pollution emissions. Environmental Kuznets Curve (EKC) hypothesis does not valid for SAARC nations. Mallick and Tandi, (2015) studied the presence of an environmental Kuznets curve for SAARC nations over the time frame 1972 to 2010. This paper inspects the link between GDP growth rate, CO_2 pollution emissions, energy demand, and trade. The FMOLS and panel co-integration techniques were employed. The result confirms that there is a link between all the variables. FMOLS exhibit that (EKC) is not validated for SAARC countries but there exists a significant association between GDP and carbon emissions.

Ohlan, (2015) aimed to explore the association between energy demand, population, GDP growth rate, the openness of trade, and CO_2 pollution emissions for India over the time 1970 to 2013. This study used the ARDL bound testing approach and results explain the link among GDP growth rate, energy demand, CO_2 pollution emissions, and population. This study suggests adopting a population stabilization policy and using alternative energy resources with cleans and green technologies to lessen the CO_2 emission without reduction of energy demand.

Alam et al., (2016) aimed to study the influence of population, energy demand, and CO_2 emissions for Brazil, Indonesia, India, and China for the period 1970 to 2012. ARDL bounds test was employed. The findings confirm the emissions of carbon by rising in energy demand. Carbon emissions by the population are significant for Brazil and India. EKC Hypothesis suggests that the level of carbon pollution emission gradually decreases as the income level increase in Brazil, Indonesia, and China but not in the case of India. So, the Indian economy should take effective environmental measures that could protect and save the environment.

Chen et al., (2016) studied the relation of energy demand, GDP, and CO_2 emissions for 188 nations by using VECM and panel co-integration through the time 1993 to 2010. The results illustrate the long-run association among all variables and reveal a negative association between GDP rate and energy demand in developing nations. There is a one-way association of CO_2 pollution emissions and energy demand exists for emerging and developed countries. This study concluded that countries should pursue environmental regulations and uses energy-efficient resources to mitigate Green House Gas (GHG) emissions. Ali et al., (2016) aimed to analyze the association among urbanization, GDP growth rate, energy demand, and trade openness, and carbon pollution emission for Nigeria over the years 1971 to 2011. This study employed the STIRPAT model which is an extended form of the IPAT model and ARDL (autoregressive distributed lags) model. The results indicate that urbanization does not have a significant association with Carbon pollution emission while trade has a significant and negative association and GDP growth rate. However, energy use has a positive influence on CO_2 emissions. This study suggests that the Nigerian economy emphasizes more open economic policies that might help to overcome the major excessive pollutants from the environment.

Ameer and Munir, (2016) examined the influence of population, trade openness, GDP growth rate, and technology on environment indicators CO_2 and SO_2 emission for eleven Asian nations over the years 1980 to 2014. This study based on IPAT and STIRPAT framework. By using panel co-integration, and DOLS estimators, the result for the carbon model shows that technology and GDP growth rate have a significant influence on Carbon pollution emissions while the Sulphur model exhibit a U-shaped EKC framework. The study recommends that governments should administrate research and development programs to abetment of pollution through advanced technologies.

Jebli et al., (2016) explored the association of energy demand, trade, and CO_2 emission for 25 nations over the time frame 1980 to 2010. DOLS and FMOLS confirm the U-shaped relationship. The granger causality test shows the one-way association from trade to CO_2 pollution emissions. The Co-integration test shows more trade lowering the levels of CO_2 in a long period. The results indicate more trade and efficient utilization of renewable energy resource helps to diminish the environmental damage.

Mohiuddin et al., (2016) evaluated the link between GDP growth rate, energy demand, and CO_2 emission for Pakistan for the period from 1971 to 2013. By using Johnson co-integration and VECM the results demonstrate that there is a 1% rise in energy production that will consequently raise 13.7% CO_2 emissions. There present uni-directional causation from energy use to CO_2 emission. This study recommends that the government subsidize renewable energy resources to combat environmental damage.

Saibu and Mesagan, (2016) carried out the influence of FDI, the openness of trade, and human capital on the quality of the environment in Nigeria during the time 1970 to 2013. By employing Johnsen co-integration test, the result explains that the Nigerian economy shouldn't exceed the 67.4% threshold level of CO_2 pollution emissions. This study recommends that the Nigerian government not only deliberate to draw attention to attracting FDI but also certify along to encourage green growth.

Asumadu-Sarkodie and Owusu, (2017) found the relation of population, GDP growth rate, energy demand, and CO_2 emissions in Ghana through the time frame 1971 to 2013. By employing the OLS regression and results from the exhibit that causality equilibrium between GDP, population, and CO_2 emissions. The finding shows a 1% increase in GDP, population, and energy use leads to 0.73%, 1.30%, and 0.58% increase in the level of CO_2 emission respectively. This finding recommends the Ghanaian government should invest in small and medium enterprises and always focusing on receiving new technological advancement and innovations.

Baek and Choi, (2017) aimed to explain the impact of FDI on the environment for 17 Latin American states through time frame 1971 to 2011. By employing the pooled mean group method, the study explores the link between FDI, energy demand, and income on CO_2 emission. The results support the existence of the pollution haven hypothesis (PHH). This study advises that Latin American countries should use clean and energy-efficient industries for the process of growth and to protect the environment.

Mitic et al., (2017) explored the influence of GDP and CO_2emission for 17 economies over the time from 1997 to 2017. FMOLS and DOLS methods are employed. The results exhibit that there exists an association between CO_2 emissions and GDP in the long run. One percent rise in GDP directs to an increase in 35% CO_2 emission. This study recommends that simplify the global policy incentives and should use new technology e.g. implantation of environmental duties.

Mkonda and He, (2017) studied the effect of population density on environmental challenges for Tanzania by employing physical observations, household surveys, and informative interviews. The results reflect that rise in population density would result in a 90% increase in degradation of the environment. The anthropogenic activities highly raise the concentration of carbon pollution emission that would damage the environment. This study recommends that the Tanzanian government should utilize alternate energy resources to save the environment.

Ozokcu and Ozdemi, (2017) analyzed the role of energy demand and GDP in the degradation of the environment for 56 emerging nations during the time 1980 to 2010. By using and Driscoll-Kraay Standard Errors application the results reveal an inverted N shaped relation for these 56 countries. The results were contradictory for the EKC hypothesis that involves the issue of environmental damage and it does not restrict involuntarily through GDP growth rate.

Sinha et al., (2017) attempted to check the impact of different renewable, biomass, non-renewable, GDP, and trade openness on the degradation of environment for N-11 countries during the time 1990 to 2014. Generalized Moments Method (GMM) is used and finding verifies the presence of N shaped association among GDP and CO_2 emissions. The results explain the negative link of trade openness, energy demand, GDP growth rate, and environmental degradation. This study suggested that N-11 nations should pay attention to technological diffusion by trade for GDP growth rate and to keep energy resources within the economic system.

Zheng and Sheng, (2017) explained the affiliation between FDI and environmental value for 30 provinces of China over the period 1997 to 2009. This analysis employed the GGM method to analyze the influence of market-oriented reforms with prospective related to carbon pollution emissions. The result shows FDI enhances the level of CO_2 emission and the concentration level gradually lessens. The policy implication for the Chinese government should initiate Market-oriented reforms for the country that reduces the degradation of the environment.

Ahmad et al., (2017) examined the EKC in Croatia during the time frame of 1992 to 2011. By using the VECM and ARDL method the findings confirm the EKC. The results reveal that one-way association from GDP to CO_2 and two-way causation in the short and long run respectively. The findings reflect that renewable energy resources should consume in the production process.

Kostakis et al., (2017) explained the influence of FDI inflows on the environment for Brazil and Singapore through the time 1970 to 2010. This empirical analysis used multivariate models (ARDL, OLS, and FMOLS,) and results put forward that FDI inflows in Brazil create a degradation of the environment, but findings are contradictory for Singapore. The inverted U-shaped link confirmed for Brazil. On the other hand, Singapore used environment-friendly technologies for industrial sectors, but Brazil has not employed remedial measures for the lessening of CO_2 pollution emissions. These findings concluded that the Brazilian government should employ environmentally friendly technologies for combating hazardous influence.

Wang et al., (2017) aimed to inspect the link among population mass, GDP growth rate, and environmental deprivation for 290 cities of China. EKC hypothesis analyzed for the time frame 2003 to 2012. The findings exhibit that population clusters have a slight influence, but population density has a positive effect on environmental deprivation. The conclusion of this study helps policymakers in terms of achieving sustainable GDP growth rates and environmental quality.

Lv and Xu, (2018) aimed to analyze the heterogeneous influences of urbanization and trade openness on environmental pollutants for 55 middle-income nations. This paper used the IPAT equation for the years 1992 to 2012. By utilizing the Pooled Mean Group (PMG) method the results confirmed that trade has harmless influence in a short period but there is the worst effect in the long period. In contrast, there is significant and negative influence found for urbanization and environmental pollutants. This paper suggests that middle-income nations are encouraging to implement those policies that boost environmental quality along with enhancing the urbanization and step forward to open trade policies. Hassan et al., (2019) confirmed the existence of the aviation Kuznets curve and environmental Kuznets curve for the SAARC nation by taking the period 1980 to 2018. By employing the DOLS and FMOLS, the results demonstrate the presence of an inverted U-shaped curve for the EKC and U shaped curve for AKC. The study recommends that SAARC nations use renewable energy sources along with eco-friendly technologies. The previous studies are carried solely on the selected countries and particular variables. This research fills the gap by providing key contributions for the 27 middle-income nations in the context of significant pollution indicator CO_2. Some recent studies are mentioned in the tabulated form (See Table: 01) that reveals the outcomes of economic growth, trade, and energy use. The crux of all the previous studies can be summarized as a relationship between economic growth, energy use, and trade rather than specifying empirical outcomes and emissions. The results of the earlier studies are limited to conventional associations and findings. Hence, the current study provides a deep analysis of the pollution emissions CO_2 in context selected 27 middle-income countries.

Table 01: A literature review

Study	**Country**	**Time frame**	**Methodology**	**Results**
Ahmad et al. (2017)	Croatia	1992 to 2011	VECM and ARDL	EKC exists, unidirectional relation from economic growth to CO_2 in short-run and bidirectional causality in the long run.
Mitic et al. (2017)	17 different countries	1997–2017	DOLS and FMOLS	1 % rise in GDP leads to rising CO_2 by 35%.
Jamel and Makatouf (2017)	40 European Nations	1985–2014	OLS	Bi-directional link found from economic growth to CO_2 & EKC valid.
Acar et al. (2018)	The Middle East and OPEC	1970–2016	GMM	“N” Shaped EKC exists.
Abdouli et al. (2018)	BRICKS countries	1990–2014	Panel GMM	Positive relation of economic growth to CO_2 emissions.
Baloch and Suad (2018)	Pakistan	1990–2015	ARDL and VECM	Transport energy consumption is positively associated with CO_2 emissions.
Hassan and Nosheen (2018)	Pakistan	1990–2017	ARDL bound test	The result depicts a positive link of air transportation to CO_2 emissions (0.77)%, N_2O emissions (0.20)%, and CH_4 emissions (0.38)% in the long-run.
Khan and Khan (2018)	America continent, low, lower-middle, upper–middle income	1990–2014	2SLS	PHH and EKC do not validate. Energy use and CO_2 emissions have a negative association.
Saleem et al. (2018)	Next–11 countries	1975–2015	Panel FMOLS	The energy use of carbon emissions has a negative association.

Jiang et al. (2018)	30 provinces of China	2002-2015	Panel Co-integration	EKC hypothesis is confirmed for Chinese provinces Trade openness has a negative link to CO_2 emissions.
Khan et al. (2018)	America continent, low, lower-middle, upper-middle-income	1990-2014	Two Stages Least Square (2SLS)	PHH and EKC do not validate. Energy use and CO2 emissions have a negative association.
Hassan and Nosheen (2019)	High-income nations	1990–2017	Panel GMM	The “U shaped” railways Kuznets curve for CO_2 and CH_4 emissions Whereas, N_2O emissions confirm EKC.
Hassan et al. (2019)	SARRC nations	1980–2018	FMOLS and DOLS	The results validate the EKC.
Wu et al. (2019)	China	2001–2015	Log mean divisa index (LMDI)	Energy use and economic growth have a positive relation to environmental pollution.
Shuai et al. (2019)	133 countries and income-level groups	2000–2014	Tapio decoupling index (TDI)	1% increase in economic growth increases carbon intensity, carbon per capita, and total carbon by 74%, 35%, and 21% respectively.
Bekun (2020)	16 European Union countries	1996–2014	PMG and ARDL	The positive link between energy use and economic growth to CO_2 emissions.

Data Source

The middle-income nations comprising of 27 countries are analyzed for the years 1990 to 2020. The middle-income nations have been taken from the World Bank income classification. The list of 27 middle-income nations is given in appendix A. The data of variables have been taken from IEA Statistics (2020), World Bank population estimates (2020), International Monetary Fund (2020) World Development Indicator (2020).

The environmental indicator is CO_2 emissions. The proxy used is emissions from transport “(% of total fuel combustion)” The independent variables are: energy consumption measured as energy use, per capita income is taken as GDP per capita (constant 2010 US$), population density “(people per sq. km of land area)” and trade openness is trade (% of GDP).

Note: *The CO_2 is abbreviated for Carbon dioxide emissions from the transport sector, GDP is a gross domestic product, PD is population density, ED is energy demand, and TOP is trade openness.*

Methodology and Results

The panel data analysis is first handed through descriptive statistics and correlation analysis. After then, it is analyzed by panel techniques along with incorporating cross-sectional dependence to obtain efficient estimates.

Descriptive Statistics

Table 02 describes the outlay of all the variables. The mean value of CO_2 is 224.984 that shows the on average value from the last 27 years for lower-middle-income nations. The median value is the midpoint for CO_2 that is 24.515. The maximum value of CO_2 is 67.307 that reveals extreme outlier up to maximum end while the least value is 4.654 that shows data spread to the lowest minimum end.

Skewness and Kurtosis show the extent to which data is volatile or not symmetrical. The skewness value for all independent and dependent variables exhibits that data is positively skewed. The results exhibit variables have positive kurtosis.

Table 02: Descriptive statistics

	CO_2	PD	ED	TOP	GDP
Mean	24.984	50.956	1841.220	74.7408	6067.832
Median	24.515	43.791	1536.477	70.503	5518.659
Maximum	67.307	147.587	5928.661	220.407	14652.18
Minimum	4.654	1.7183	363.415	0.020	698.564
Skewness	0.643	0.537	1.192	0.855	0.633
Kurtosis	3.020	2.172	4.078	3.824	2.814
Jarque-Bera	52.135	57.975	215.693	113.715	51.587
Probability	0.000	0.000	0.000	0.000	0.000

Correlation Analysis

Table 03 shows the correlation matrix for the 27 middle-income nations. The CO_2 pollution emissions have a negative and weak association to population density and trade openness while energy demand exhibits a negatively strong association with CO_2 pollution emissions. The GDP shows a positive association with environmental degrading indicator CO_2 pollution emissions. Similarly, population density has a negative and weak association to energy demand and GDP while positive relation to trade openness. Moreover, energy demand shows a positive association to trade openness and GDP. Finally, trade openness has a weak and negative relation to GDP growth rate such as GDP.

Table 03: Correlation Matrix

Covariance Analysis: Ordinary					
Sample: 1990 2020					
Correlation (Probability)					
	CO_2	**PD**	**ED**	**TOP**	**GDP**
CO_2	1.000				
Prob.	-----				
PD	-0.239	1.000			
Prob.	0.000	-----			
ED	-0.544	-0.231	1.000		
Prob.	0.000	0.000	-----		
TOP	-0.133	0.123	0.206	1.000	
Prob.	0.000	0.000	0.000	-----	
GDP	0.116	-0.279	0.286	-0.190	1.000
Prob.	0.0014	0.000	0.000	0.000	-----

Residual Cross-Section Dependence

Table 04 shows the cross-sectional dependence test. This study analyzes a pool of 27 nations that may have the chance of cross-sectional dependence; therefore, data is estimated for the cross section-dependence test. The findings specify the rejection of the null hypothesis that represents no-cross sectional dependence as the values of probability is less the 5 percent. This shows the country's dependence on one another. All the test statistics Pesaran scaled LM, Breusch-Pagan LM, and Pesaran CD is 1 percent significance at rejecting the null hypothesis.

Table 04: Residual Cross-section Dependence

Null hypothesis: No cross-section dependence (correlation) in residuals			
Test	**Statistic**	**Prob.**	**d.f.**
Breusch-Pagan LM	1907.657	0.0000	
Pesaran CD	18.28459	0.0000	351
Pesaran scaled LM	57.73318	0.0000	

Panel Unit Root

The panel unit root is evaluated for panel data by applying ADF - Fisher, and PP - Fisher Chi-square test, Im, Pesaran and Shin W-stat, Levin et al. (1992).

$yit = \rho yi\ t{-}1 + \alpha 0 + \sigma t + \sigma i + \theta t + \varepsilon it$

where, ρ, 0, σ are coefficients, αi is an individual effect, θt is the time-specific effect. The ADF model is presented as:

The alternative and null hypotheses are shows as:

$$H_0 : \rho_i = 0$$

$$H_A : \rho_i < 0$$

Cross-sectional Augmented Dickey-Fuller (CADF) test is employed to check the stationarity in the panel series. CADF test runs the t-test for unit roots with cross-sectional dependence, presented by Pesaran (2003). Similarly, I'm, Pesaran and Shin (IPS, 2003) test, it is based upon the mean values of individual ADF t-statistics of each unit of the panel. CADF test considers finite first and order moments. Table 05 shows the CADF results indicating that panel series are stationary. There is another aspect of panel data as the panel data exceeds over the 20 years it also exhibits the properties of time series data. So, we have also applied panel unit root tests Levin, Lin & Chu, (2002); Im, Pesaran & Shin W-stat (2003). The Levin, Lin & Chu (LLC) statistics restrict the assumptions of being homogeneity across all the series, whereas In, Pesaran & Shin (IPS) allow the heterogeneity on the coefficients. So, both tests are applied for more validation of stationarity.

The Null hypothesis is,

$H_0 = \delta_i = 0$ for all i=0 (All the series are non-stationary) against the alternative

$H_a = \delta_i < 0$ for at least one i.

The null hypothesis of the panel series is rejected at a level for trade openness and the first difference for the rest variable with the significance level of 1 percent. The unit root test shows mixed results of integration I (0) and I (1) that indicate the usage of Panel ARDL as a sensitivity model.

Table 05: Pesaran CADF and Panel Unit Root

Pesaran CADF	Level (constant and Trend)			First Difference (constant and Trend)			
Variables	**t- bar**	**Z [t- bar]**	**P-value**	**t- bar**	**Z [t- bar]**	**P-value**	**Results**
CO_2	2.048	1.466	0.929	3.737	-7.973	0.000	**I (1)**
PD	3.066	-4.224	0.000	3.357	-5.850	0.000	**I (0)**
ED	2.613	-1.696	0.045	3.700	-7.768	0.000	**I (0)**
TOP	2.925	-3.436	0.000	4.146	-10.258	0.000	**I (0)**
GDP	2.177	0.746	0.772	3.124	-4.549	0.000	**I (1)**
***Note**: The critical value for the Pesaran CADF test is -2.580 for 10%, -2.660 for 5 % and -2.810 for 1%.*							

Variables	Panel Unit Root Methods	Level		First Difference		Results
		Stats.	**Prob.**	**Stats.**	**Prob.**	
CO_2	Levin, Lin & Chu t*	1.909	0.971	-21.157	0.000	**I(1)**
	Im, Pesaran and Shin W-stat	0.876	0.809	-21.313	0.000	
GDP	Levin, Lin & Chu t*	3.041	0.998	-11.322	0.000	**I(1)**
	Im, Pesaran and Shin W-stat	7.030	1.000	-13.382	0.000	
ED	Levin, Lin & Chu t*	1.592	0.944	-20.240	0.0 00	**I(1)**
	Im, Pesaran and Shin W-stat	3.505	0.999	-20.938	0.000	
PD	Levin, Lin & Chu t*	6.432	1.000	-0.284	0.088	**I(1)**
	Im, Pesaran and Shin W-stat	7.822	1.000	-1.560	0.050	
TOP	Levin, Lin & Chu t*	-3.991	0.000	-26.862	0.000	**I(0)**
	Im, Pesaran and Shin W-stat	-5.237	0.000	-24.748	0.000	

3.1 Panel Co-Integration Test

Before moving the modeling, it is crucial to consider the test of co-integration to avoid spurious regression. The most appropriate technique of co-integration is the Kao test (1999) and Pedroni (2001) Co-integration. The Kao test executes homogenous AR coefficients and co-integrating vectors but doesn't incorporate the several explanatory variables in the panel co-integrating. Therefore, Pedroni (2000) is also applied that captures the within and between effects in the panels. It is based on the "within" dimension that shows the pooling of the AR coefficients and residuals across the cross-sections of the panel). Both results (Table 06) of cointegration tests exhibit the rejection of the null hypothesis (H_0) as the probability values are smaller than 5 percent. So here we accept H_1 as the long-run co-integration exists in the panel series.

Table 06: Kao and Pedroni Cointegration test

Kao Residual Cointegration Test		
Series: CO_2PD ED TOP GDP		
Null Hypothesis: No cointegration		
Newey-West automatic bandwidth selection and Bartlett kernel		
	t-Statistic	Prob.
ADF	-2.660429	0.0039
Residual variance	6.722660	
HAC variance	6.136519	

Pedroni Residual Cointegration Test				
Alternative hypothesis: common AR coefs. (within-dimension Weighted)				
	Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	1.432423	0.0760	-1.782315	0.9627
Panel rho-Statistic	-1.262919	0.1033	0.164898	0.5655
Panel PP-Statistic	-5.644144	0.0000	-5.282265	0.0000
Panel ADF-Statistic	-7.474400	0.0000	-6.774599	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	1.570592	0.9419		
Group PP-Statistic	-5.239555	0.0000		
Group ADF-Statistic	-6.306347	0.0000		

Panel Generalized Method of Moments (GMM)

After the presence of long-run co-integration, the Panel GMM is applied (see Table 07) as the independent variable GDP and dependent variable CO_2 exhibit the properties of endogeneity. Therefore, it is reasonable to quantify the long-run linkages between variables in context to middle-income nations.

$$\mathbf{CO2 = a_0 + a_1(Pop)_{it} + a_2(Energy)_{it} + a_3(Trade)_{it} + a_4(GDP)_{it} + \varepsilon_{it} \ldots\ldots (Eq. 1)}$$

The Eq.1 shows “i” as the number of 27 nations, “t” time period, a_0 is a constant term, a_1 *to* a_4 are the coefficients of population, energy, trade, and GDP growth rate respectively.

The Influence of population effluence technology is determined as an environmental influence (CO_2 pollution emissions) by population density, affluence (GDP and Energy demand), and technology indicated by trade openness. Hence, Therefore, the method of GMM overcomes the problem of endogeneity by more than one variable by using the moment restriction E [Ze] = 0, and thus also called MM (Ketokivi and McIntosh, 2017). GMM is a superior technique in a class of estimators mainly used in dynamic panel models. The estimators of GMM exhibit to be naturally well suited to deal with potential endogeneity issues when the dependent variables suffer from an endogeneity require a certain instrument with a lagged dependent variable. In this study, the dynamics of the model are explained by GMM along with encountering the problems of heteroskedasticity and endogeneity. Hence, this model is introducing to add some important and dynamic effects to the standard panel model.

Table: 07 Panel GMM

Dependent Variable: CO_2 emissions
Method: Panel Generalized Method of Moments
2SLS instrument weighting matrix
Instrument specification: PD (-1) ED(-1) TOP(-1) GDP(-1) C

Variables	Coefficients	Std. Error	t-Statistic	Prob.
PD	0.1134	0.0092	12.307	0.0000
ED	0.008	0.0003	24.315	0.0000
TOP	0.039	0.0102	3.8652	0.0001
GDP	0.001	0.0001	8.4807	0.0000
C	37.206	1.3560	27.438	0.0000

The GMM results depicted in Table 07 shows that constant term is significant at 1 percent and population density exhibits that 1 unit rise in population increases the carbon emissions by 0.1134 % of total fuel combustion that is significant at 1%.

Likewise, energy use shows that one-unit increase in energy use increases the carbon pollution emissions by 0.008 units (% of total fuel combustion) that are significant at one percent. The outcomes are reliable with Cole & Neumayer (2004), and Isik et al., (2018). These indicators infer that middle-income nations have to adopt the alternative energy use mode that lowers the environmental pollution. Moreover, CO_2 pollution emissions are related to transport which indicates the alternative energy use in vehicles such as electric vehicles must be used by these developing nations. The increase in population density can only be positively contributing in a manner that if a population uses efficient energy mode and alternative eco-friendly techniques in high dense areas.

On the other side, the openness of trade and GDP depicts a positive association with CO_2 emissions. The econometric results show that a one-dollar increase in openness of trade increases the carbon pollution emissions by 0.039 % of total fuel combustion that is significant at one percent. The findings are steady with the study of Yang et al., (2018).

Finally, one unit rise in per capita GDP leads to an increase in the carbon pollution emissions by 0.001 units (% of total fuel combustion). This implies that the increase in economic growth rate is closely related to production processes that require accessing the larger and diverse base of connection related to industries, production of goods as well as services. Hence, improvement in transport is positively connected to a higher and efficient GDP growth rate that in turn results in environmental damages. The findings are similar to the study of Al-Mulali et al., (2018). Moreover, trade is part of the GDP that requires an extensive production process to export goods and commodities for achieving a higher GDP growth rate. Therefore, increasing GDP growth rate together with export require large scale production, manufacture, and transportation for transferring raw material to the final market. Consequently, production is carried on the cost of a degrading environment. It infers that trade openness requires to access the market location, manufacturing plant, transportation of raw material from diverse areas, and delivery of final output at large scale. Similarly, the purchase and acquisition of physical infrastructure, developmental efficiencies and to increase in competitiveness of the market require an efficient network of transportation. Moreover, trade requires exporting maximum productions which likely require transport from the initial stage of production to the final stage and distribution at mega-scale across the nations. This study is consistent with Zhang and Zhang (2018). This confirms that energy use is a key variable used in transport, trade, and GDP growth rate but simultaneously degraded the environment significantly.

The GMM results illustrate the long-run negative impact of GDP, energy consumption, population, and trade openness on environmental quality. It means that in lower-middle-income nations, the increase in economic activities, and trade is significantly contributing to the environmental degradation in case of these selected nations.

Sensitivity Analysis

The econometric results are further obtained from the Panel ARDL or PMG analysis and Fixed Effect (DFE) models as the unit root has mix co-integration i-e I(1) and I(0). The Panel ARDL model shows run estimates (β_1 to β_4) and short-run coefficients (β_6 to β_9) in Eq. 2.

$$\Delta \ln(CO2)_{it} = \beta_0 + \beta_1 ln(Pop)_{it=1} + \beta_2 ln(Energy)_{it-1} + \beta_3 ln(Trade)_{it-1} + \beta_4 ln(GDP)_{it-1} + \sum_{i=1}^{p} \beta_5 \Delta \ln(CO2)_{it-1} + \sum_{i=0}^{q} \beta_6 \Delta \ln(Pop)_{it-1} + \sum_{i=0}^{r} \beta_7 \Delta \ln(Energy)_{it-1} + \sum_{i=0}^{s} \beta_8 \Delta \ln(Trade)_{it-1} + \sum_{i=0}^{t} \beta_9 \Delta \ln(GDP)_{it-1} + \varepsilon_{it} \ldots Eq.2$$

The Panel ARDL model shows significant long-run estimates while the population density is significant in the short run.

In the long run, the econometric outcome indicates that population density and energy demand have positive relationships that are significant at 1 percent. Moreover, trade openness and GDP have also positive associations which is significant at 1 percent. In the short-run, Error correction term (ECT) shows significant and negative association that indicates the speed of convergence from disequilibrium to equilibrium by 0.16 percent.

Similarly, Dynamic Fixed Effect, Random Effect has also been obtained, and then the Hausman test is employed to select the suitable model. The detailed analysis is given in appendix B showing estimates of DFE and RE along with the Hausman test. For the consistency of sensitivity analysis by Panel ARDL results, the dynamic fixed effect (DFE) is also mentioned in table 08. The econometric results show a positive and significant association of GDP to CO_2 emissions while, trade openness has a positive but insignificant association. The results are similar to Wang et al., (2015) & Wang and Li, (2016) analysis. On the other hand, energy demand and population density show a direct link to carbon dioxide emissions. The results of panel ARDL, DFE, and GMM are all consistent with the nature and significance of associations.

Table 08: ARDL and DFE Estimates

Dependent Variable: D(CO_2)					
Long Run Estimates	**Variable**	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
	PD	0.3915	0.0574	6.8152	0.0000
	ED	0.0025	0.0004	5.5711	0.0000
	TOP	0.1348	0.0086	15.5973	0.0000
	GDP	0.0052	0.0003	18.6631	0.0000
Short Run Estimates	**ECT**	-0.161	0.013	-12.308	0.0004
	D(CO_2)	-0.580	0.192	-3.020	0.0029
	D(PD)	276.876	165.379	1.674	0.0958
	D(ED)	0.005	0.005	1.037	0.3010
	D(TOP)	-0.018	0.037	-0.499	0.6182
	D(GDP)	0.001	0.001	0.914	0.3619
	C	10.670	6.069	1.758	0.0804
Dependent Variable: CO_2	**Method: Dynamic Fixed Effect (DFE)**				
	Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
	C	4.945	1.118	4.160	0.000
	PD	0.022	0.020	1.110	0.266
	ED	0.001	0.0004	2.730	0.006
	TOP	0.003	0.006	0.510	0.607
	GDP	0.001	0.0001	3.850	0.000

Pairwise Dumitrescu Hurling Panel Causality Tests

When the cross-sectional dependence occurs among the panels, the study uses a panel granger causality test for incorporating the dynamics of panel data (Dumitrescu and Hurlin 2012). It is expanded form and exhibits the casual association among variables (Granger 1969). The fundamental basis of the model is as follow:

$$Yi,t = \alpha i + \sum_{k=1}^{K} \beta ikYi,t-k + \sum_{k=1}^{K} \gamma ik\, x_{i,t-k} + \varepsilon_{i,t}$$

Where, $x_{i,t,}$ and $Y_{i,t}$ are the observations in the panel regarding stationary variables in time frame t. Parameters are expected to fluctuate crosswise panels but are supposed to time is fixed. For all panels, the null hypothesis shows no causal relationship among the variables.

$H_0 = \beta i1 = \beta i2 \ldots\ldots\ldots \beta ik = 0$ (i= 1to N)

$H_1 = \beta i1 = \beta i2 \ldots\ldots\ldots \beta ik \neq 0$

The pairwise causation table (see. Appendix C) shows a one-way association between the measured variables in this research. Fig 01 indicates the entire causation framework between the measured variables.

In this setting, the methodology Dumitrescu Hurlin (DH) suggested to run the N individual regressions and F-test of the linear hypotheses to recapture W_i, and calculate $\overline{W}$ as the average of the individual Wald t statistics:

$$\overline{W} = 1/N \sum_{i=1}^{K} W_i$$

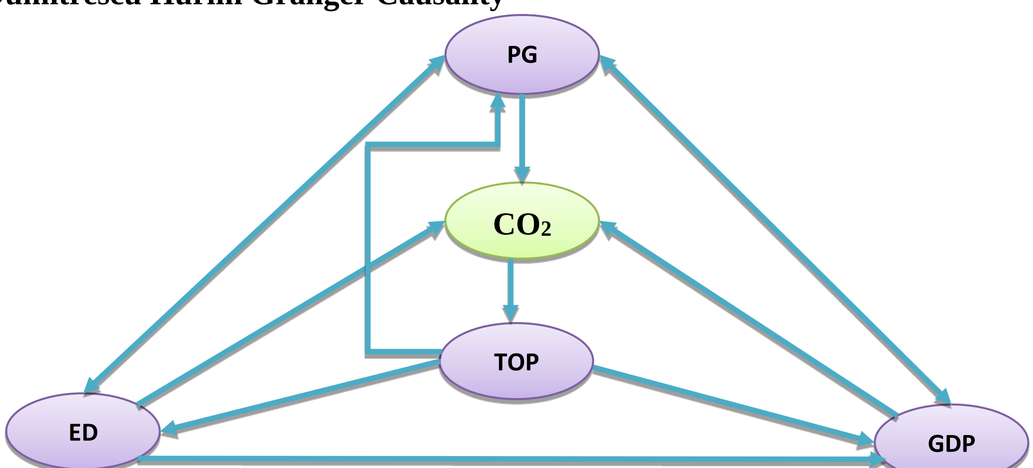
Where W_i is the standard adjusted Wald statistics for a panel *i* cross-sectional units during the T periods. W_i is independently distributed across the panel and can be revealed as the standardized statistics

$\bar{Z}$ when T and N are sufficiently large approaching ∞ follows a standard normal distribution.

$$\bar{Z} = \sqrt{\frac{N}{2K}.(\overline{W} - K)} \xrightarrow[T, N' \to \infty]{d} N(0,1)$$

Hence, the testing procedure is based on $\bar{Z}$ and Wald statistics. Fig 01 presents the causal association among the variables.

Figure 01: Panel Dumitrescu Hurlin Granger Causality

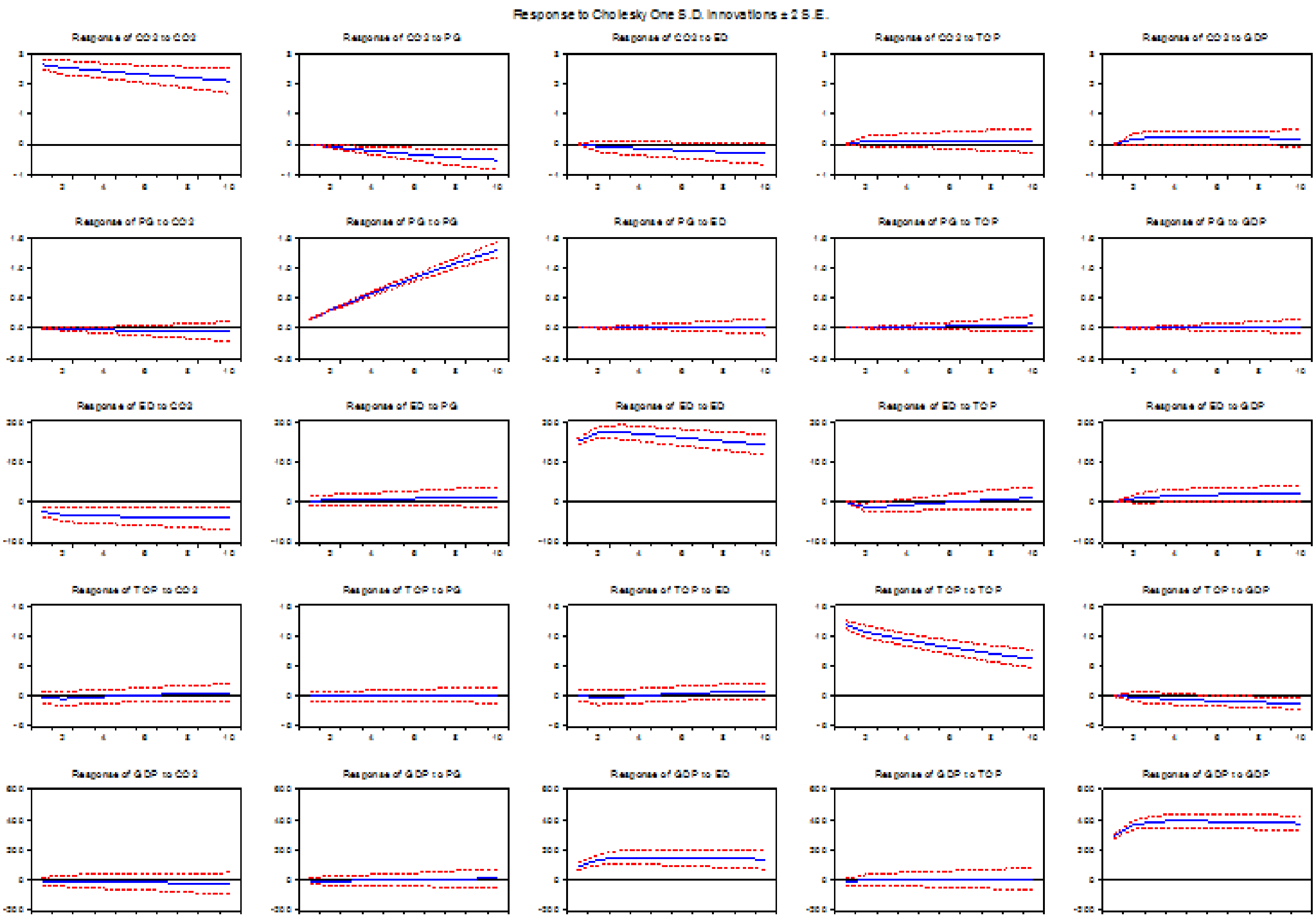


The results of Dumitrescu Hurlin (DH) indicates that CO_2 pollution emissions are granger caused by population density, energy demand, and GDP that are all rejecting the null hypothesis at 1 percent. Energy demand and GDP have bidirectional Granger causation to population density while trade openness has unidirectional causation to population density that is all significant at 1 percent. Moreover, trade openness granger cause energy demand and GDP rejecting the null hypotheses of no causation at 1 and 5 percent correspondingly. Finally, energy demand granger cause GDP and CO_2 pollution emissions granger cause trade openness that are significant are 1 and 10 percent respectively.

Impulse Response Function

The estimations show the direction of the association disseminating over the next ten years. For the middle- income nations, the data set indicates the positive penetration by CO_2 pollution emissions to trade openness and GDP while negative and declined impulse of population density and energy demand by CO_2 pollution emissions. The population density and GDP show a positive association with the entire variable. Similarly, trade openness shows a comparatively negative association to energy demand and the rest of the considered variables. Finally, energy demand shows a declining negative association with CO_2 pollution emissions and population density while positive association to trade openness and GDP. The impulse responses (see figure 02) of all the variables are presented in the multiple graphs based on Cholesky One S.D innovations.

Figure 02: Impulse Responses Graphical Outlay



2. Conclusion and Recommendations

Environmental degradation is a common phenomenon that is prevailing all over the globe from last many centuries. This dilemma is more severe than the rate for recovering and regenerating the environment is far beyond the rate of degradation. Excessive increases in population density, trade openness, and energy use have put a huge drain and strain on limited and inadequate natural resources on the earth (Clark et al., 2018).

The essence of this research is to analyze the influence of energy consumption, GDP growth rate, and trade over a sample of 27 middle-income nations by utilizing the GMM, Panel-ARDL, and Dynamic fixed effect (DFE) over the time frame 1990 to 2020. The results of all the techniques in this study exhibit that there exist a statistically positive association of energy use and population density to carbon pollution emissions whereas; GDP and openness of trade also have a positive association with CO_2 emissions. Besides, panel Dumitrescu Hurlin causality tests indicate bi-directional causation to population density to energy use and GDP while CO_2 pollution emissions are granger caused by population, GDP, and energy consumption. Finally, CO_2 granger causes the trade openness that is significant at 10 percent.

This research unveils the environmental pollution indicators in middle-income nations such as trade and GDP and also reveals the pollution contributing factors such as population and energy demand in context to CO_2 emissions. This indicates the compromise on GDP growth rate, trade, and environmental deprivation. Hence, the essence of this analysis is that the trade openness can only be positively utilized for the GDP growth rate, if and only if this could bring advanced technology, research, and innovation that may result in lowering the degradation of the environment. Moreover, trade and alternative energy use for the GDP growth rate can be gained without damaging environmental quality due to the import of cleaner technology and strict environmental policies. This study suggests that selected countries should ensure emissions control policies and global policy frameworks for cleaner incentives about trade.

Measures must be taken for the utilization of biofuel and organic energy in the local as well as exporting industries along with new technology in production processes. Finally, constructive trade rules, strategic energy-saving policies, and removal of trade barriers for the environmental goods and technologies must be put into practice to lessen the excessive amount of environmental pollution.

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Appendix (A) List of Middle - Income Nations:

1. Albania
2. Algeria
3. Argentina
4. Azerbaijan
5. Belarus
6. Bosnia and Herzegovina
7. Botswana
8. Brazil
9. Bulgaria
10. China
11. Colombia
12. Gabon
13. Iran, Islamic Rep.
14. Iraq
15. Kazakhstan
16. Macedonia, FYR
17. Malaysia
18. Mexico
19. Namibia
20. Peru
21. Romania
22. Russian Federation
23. South Africa
24. Thailand
25. Turkey
26. Turkmenistan
27. Venezuela, RB

Appendix B.

Dependent Variable: CO_2 Correlated Random Effects - Hausman Test			
Cross-section random	**Chi-Sq. Stats**	**d.f**	**Prob.**
	38.405	4	0.000

Appendix C. Pairwise Dumitrescu Hurlin Panel Causality Tests

Pairwise Dumitrescu Hurlin Panel Causality Tests
Sample: 1990 2020
Lags: 2

Null Hypothesis:	W-Stat.	Z bar-Stat.	Prob.
PD does not homogeneously cause CO_2	6.24992	8.54313	0.0000
CO_2 does not homogeneously cause PD	5.01480	5.93091	3.9009
ED does not homogeneously cause CO_2	4.85692	5.59700	0.0008
CO_2 does not homogeneously cause ED	5.20069	6.32405	3.1110
TOP does not homogeneously cause CO_2	2.83960	1.33047	0.1834
CO_2 does not homogeneously cause TOP	3.01251	1.69615	0.0899
GDP does not homogeneously cause CO_2	6.53244	9.14064	0.0000
CO_2 does not homogeneously cause GDP	4.48190	4.80385	2.6606
ED does not homogeneously cause PD	13.0887	23.0069	0.0000
PD does not homogeneously cause ED	8.43432	13.1630	0.0000
TOP does not homogeneously cause PD	7.95073	12.1403	0.0000
PD does not homogeneously cause TOP	4.55548	4.95948	7.0707
GDP does not homogeneously cause PD	10.3423	17.1983	0.0000
PD does not homogeneously cause GDP	9.34992	15.0995	0.0000
TOP does not homogeneously cause ED	5.29114	6.51536	0.0011
ED does not homogeneously cause TOP	5.85058	7.69854	1.4114
GDP does not homogeneously cause ED	5.67397	7.32502	2.1313
ED does not homogeneously cause GDP	3.75505	3.26661	0.0011
GDP does not homogeneously cause TOP	5.96432	7.93910	2.2115
TOP does not homogeneously cause GDP	3.30941	2.32410	0.0201