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The Impact of Air Transportation on Carbon Dioxide, Methane, and Nitrous Oxide Emissions in Pakistan: Evidence from ARDL Modelling Approach

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Abstract: No one can deny the progression and innovation in the aviation transportation collected at national and international level. But the accountancy of the impact of air transportation on environmental degradation is naive and emerging trend of the current era. The air transportation versus environment is the key contribution to the literature that is solely conducted for Pakistan first time in this context. The objective of this research is to compute the impact of air transportation on carbon dioxide emissions, nitrous emissions and methane emissions separately in the three models by applying ARDL bound test approach during 1990 to 2017. The result depicts significant and positive relation of air transportation (carriage) to carbon dioxide emissions (0.77), nitrous emissions (0.20) and methane emissions (0.38) in long-run. The short-run results infer that the air transportation (passenger) has significantly positive relation to carbon dioxide emissions (0.278), nitrous emissions (0.207), and methane emissions (0.080). The econometric outcomes show the significant and direct relation to transportation (both passenger and cargo) to carbon dioxide, methane, and nitrous oxide emissions in short and long-run. Moreover, per capita GDP, population density, and energy demand also significantly affect the environment showing significant and positive coefficients to all three categories (carbon dioxide, methane, and nitrous oxide) of emission. In case of Pakistan, FDI and trade for this duration didn't significantly contribute to the CO2, NO2, and methane emissions. Since the last decade the economic issues of Pakistan like terrorism, political instability, energy crises, and poor management along with the worst performance by tertiary sectors have severely hit the economy, and as a result, the FDI and trade sector has tormented in a substantial proportion. Finally, pairwise Granger causation also supports the short and long-run consequences. The outcomes suggested that the fuel-efficient energy use and technological diversification in the transportation sector are essential to mitigate the degrading environmental emissions.

Keywords: Air transportation, Environmental degradation, ARDL-Bound test approach, Per capita GDP, Population density, Energy demand, Granger causality

1. Introduction

Air transportation refers to the movement of passengers and cargo within the nation and foreign nation by aircrafts such as airplanes and helicopter. The transportation system is considered as a backbone of the economy in revenue generation as well as a medical link as central and vital for certain industries and services. The key economic integration and development can easily be measured by the transportation facility and efficiency regarding economic and environmental cost. The growth rate of population is far beyond to meet the demand of transportation which results in the high commercial transports using substandard and fossil fuel as energy that emits high carbon and other dangerous emissions (Maddalon, 2014). Air transport enables incorporation into the international economy and is responsible for connectivity on a national, regional, and global level. It increases trade, FDI, encourages tourism and creates occupation opportunities. The World Bank has funded aviation-related development along with transport plan and guideline, safety, infrastructure rehabilitation, institutional establishment, and capability building.

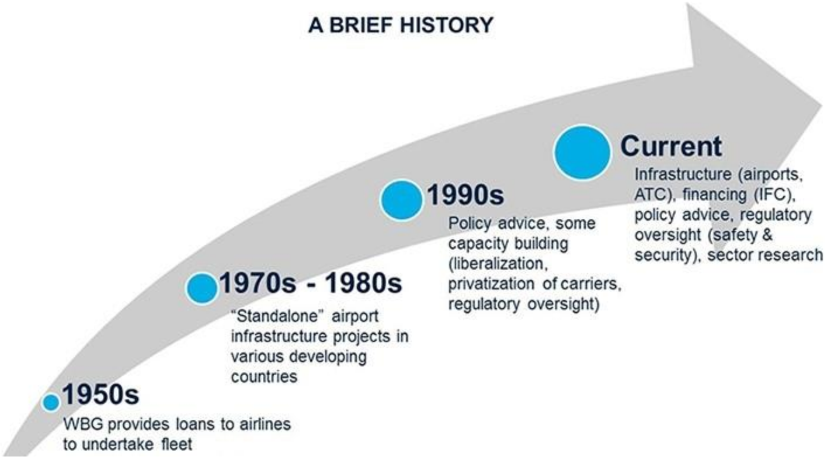

Figure 1: A Brief History by World Bank

In initial stages of aviation projects, the World Bank had provided funds for air crafts for public-owned and groundwork projects. With the trade openness, liberalization and high demand of air transportation by emerging worldwide population led the phenomena of privatization, and as a result, the World Bank shifted its funding to other investments like the capacity edifice, strategy, and governing support. The WBG's Air Transport Portfolio amount was US$1.47 billion in 2015, a rise of 2% from 2014. Major current projects by World Bank include the aim to promote safe and efficient air travel by refining aviation infrastructure, administration, and procedures (World Bank Air Transport Annual Report, 2015).

The aviation industry uses the huge amount of fossils fuels and million barrels of oil every day. The Burning of fossils fuel currently contribute 2.5 percent of carbon emission and is expected to rise 22 percent by 2050 only by a single nation US. Moreover, the increasing demand and population put more pressure on the transportation via air crafts. The divesting dilemma is that like other industries the alternative energy options (like solar not coal and LED not light bulbs) cannot be used in the aviation industry and there is no way out without burning off a lot of dirty kerosene in aircraft. Though, airplanes are becoming more fuel efficient but even cannot meet the required need of the current growth. The aviation commerce accounts for 11 percent of transportation linked emissions in the US. According to NASA landing and taking off emits 25 percent of airplanes emissions that is 0.9 metric tons of carbon per single passenger and for sustainability, it requires an investment of wind farm of $10.75 and forest conservation of $8.95. Business class and first class airplanes emit nine times more fuel than economy class. Furthermore, the former acquire more fuel consumption and less space than the later movement of aircraft. The biofuel can lower the carbon emission by 60 percent along with clean transportation and fuel efficiency (Byrne, 2017).

According to Shahbaz et al., (2015) total energy consumption consumed by transportation is 33%. Gasoline and diesel use by total passenger cars about 13%. The road transport uses heavy fuel oil, bunker fuel which corresponds to 60% of consumption of water transport. Energy consumption in transportation adversely affects the environmental quality. The transport industry is contributing to environmental degradation by releasing many harmful gases into the atmosphere. These include carbon dioxide (CO2), methane (CH4), carbon monoxide (CO), nitrogen oxides (NO), nitrous oxide (N2O), chlorofluorocarbons (CFCs), heavy metals (zinc, chrome, copper, and cadmium) (Zvijakova, 2014). Aircraft during flights cause emissions of GHG extensively that contribute to global warming and conventional air pollution by high-altitude aircraft emissions as Nitrogen oxide, carbon monoxide, and hydrocarbons. Road transport accounts for 25% of energy usage of transport, 16% by heavy vehicles, and 9% by medium Trucks. High growth in transport volume leads to decreasing air pollution due to various vehicle standards in different countries (Hill et al., 2011). In the developed countries effective measures are introduced to combat urban air pollution. Traditional pollutants have been brought under control in many developed countries. New machinery and technologies are adopted by developed countries which do not emit excessive pollution. So air pollution in such countries is either better or at least decreasing the pollution or both. As people get richer, their priorities change, after sustaining basic needs of food, clothing, water, and shelter people can begin to confer importance to other constituents in total welfare comprising the environment. Therefore, communities will be more willing to deal resources in this regard. For example, Unites States make expenditures to combat pollution nearly 2% of US GNP (Beckerman, 1992). Worldwide, international transport results in 33% of trade-related emissions, especially in the manufacturing sector. For example, 80% of trade-related releases in equipment are due to the international transportation (Cristea et al., 2013). International trade is liable for Green House Gas (GHG) emissions because of the production of exported goods and the carriage of these goods between dealing partners. During the trade, the production and the delivery of the product have a massive impact on global warming. Sim et al. (2007) estimate that Kenyan Guatemalan beans shipped to the UK and its impact on global warming are 20-26 times larger than UK production. But the goods and partner composition of trade has an impact on categories of transportation and also on GHG emissions. The emissions release also depend on the volume of the product and mode employed, not on value, e.g., one million dollars of coal is weightier than a million dollars of a microchip with more substantial carriage emissions. Beside this, two-thirds of trade emissions of US is due to transportation. And worldwide, transport apparatus, electric equipment, machinery, and manufacturers are responsible for 75% of trade-related emissions (Cristea et al., 2013). The major cause of worsening of the environment in developing nations is the rising population with low labor productivity, inequality in income distribution and high unemployment. For example, burning forests and converting them into cropland which leads to an ecological imbalance in using the land. Growth in population also leads to deforestation because of over-harvesting of fuelwood from forests; this further leads to soil erosion and flooding in hilly areas. Thus the pressure of population on such economies results in the straining of environmental resource base beyond its carrying capacity (Sengupta, 2010).

Green growth is the growth and development to promote the economic growth while making certain that natural assets endure delivering the resources and environmental services for the wellbeing. Green growth results in increasing the efficiency and productivity of natural resource utilization, natural capital used within ecological limits, reduces adverse environmental impact and improves natural management. Green growth policies are in action in places like Sri Lanka, Bangladesh, Nepal, Azerbaijan, Ghana, and Pakistan (Hynes and Wang 2012).

In case of Pakistan, the air travel contributed to 40% of carbon emissions .The environmental damage by air transportation happens for the reason that aircraft engines release heat, particulates, and emissions which add ecological variations and global warming. Air transportation releases particles and gases like carbon dioxide, water vapor, carbon monoxide, hydrocarbons, sulfur oxides, nitrogen oxides, lead, and black carbon (Higham, at al., 2016). The government should take an effective step regarding the current transportation and environmental loss caused by transportation. The government must pay keen attention towards the significant implementation and controlling climate changes.

1.1 Significance of the Study

The demand for air transport is persistently growing, and nations must consent with the costs (pollution, ecological changes, risk, resource usage). Air transportation is considered as a key component of economic growth but at the same time there is an immense need to consider environmental damages. This study targets to investigate the impact of air transportation on environmental emissions using the annual data from 1990 to 2017 for Pakistan.

1.2 Objectives

The key objectives of the analysis are:

- To find the impact of air transportation carriage on carbon emission, nitrous emission, and methane emission.
- To find the impact of air transportation passenger on carbon emission, nitrous emission, and methane emission.
- To find the impact of per capita GDP on carbon emission, nitrous emission, and methane emission.
- To find the impact of trade on carbon emission, nitrous emission, and methane emission.
- To find the impact of energy demand on carbon emission, nitrous emission, and methane emission.
- To find the impact of population density on carbon emission, nitrous emission, and methane emission.
- To find the impact of FDI on carbon emission, nitrous emission, and methane emission.

2. Review of Literature

Uddin (2014) observed the causal association between economic growth and carbon emissions in seven SAARC countries during the period 1972 to 2012. By using Johansen cointegration and Vector Error Correction Modeling (VECM) approach, the results exhibit a co-integration relationship between economic growth and environmental pollution. Furthermore, results also demonstrate that the GDP has positive and significant impacts on CO2 emissions in the long-run. These results facilitate the environmental establishments to realize the worse effects of economic growth on the environment and deal the environmental problems using macroeconomic approaches. Bozkurt and Akan (2014) studied the association between Economic Growth, Energy Consumption, and CO2 Emissions in Turkey form 1960-2010. By employing Co-integration investigation, the empirical results show that economic growth is directly and energy consumption is adversely affected by carbon emission. The findings suggest that in order to save the environment from more damage, the government should implement policies to use clean and renewable energy resources. Inglesi-lotz and Bohlmann (2014) studied the long-run relationship between economic growth and environmental quality for South African economy using ARDL approach over the period 1960 to 2010. The study found no evidence for the existence of environmental Kuznets curve in South Africa and concluded that because of its initial level of development, the results might indicate that economy is shaping the initial stage of environmental Kuznets curve. Mehrara et al. (2014) studied to find out the relationship between trade, GDP, and the environment in Iran for the time 1970-2011. Granger Causality test shows significant uni-directional and a long-run and positive relationship between GDP and trade openness to CO2 emissions. This study suggested that Iran tends to control CO2 emission by effective measures that level of trade openness is drop off to combat the environmental degradation. Similarly, Cetin and Ecevit (2015) aimed to find out a relationship between urbanization, energy consumption, and carbon dioxide (CO2) emissions in Sub-Saharan countries for the period 1985 to 2010. By using Pedroni Kao co-integration methods and Granger causality test the results show that there is a bi-directional Granger causality between energy consumption and CO2 emissions. The study indicates that more stern environmental and energy policies should be implemented and develops new policies to use alternative sources of energy. Cheema and Javid (2015) explored the relationship between disaggregate energy consumption, economic growth and environment for 8 Asian developing nations over the time frame 1990 to 2012. By using fully modified OLS the results confirm the existence of EKC along with the significant impact of energy consumption on economic growth. This Study recommended that government must make policies regarding renewable energy consumption. Farhani and Ozturk (2015) studied the relationship among energy consumption, trade openness, real GDP, financial development urbanization, and CO2 emissions in Tunisia during 1971 to 2012. ARDL Model of co-integration was employed to check the long-run causal relationship. The study indicates that Environmental Kuznets Curve hypothesis does not hold for the Tunisian economy. The study suggested that there should be effective policy making for energy conservation and usage, in order to reduce the increasing level of CO2 emissions and degradation of the environment. Kasman and Duman (2015) studied the relationship between economic growth, energy consumption, urbanization, trade openness and CO2 emissions for new European Union member during 1992 to 2010. Co-integration and causality tests are used to study the links among the variables. The short-run causality result implies a uni-directional relationship between the independent variables and CO2 emissions. The study also concluded the presence of Environmental Kuznets Curve hypothesis which shows an inverted U-shaped relationship. Pandey and Mishra (2015) studied the impact of CO2 emissions and economic growth of SAARC countries for the time frame 1972 to 2010. By using panel co-integration, panel VECM, Impulse Response Functions (IRFs) and Variance decomposition (VDs), the econometric results explain that CO2 emissions and GDP positive relationship. The result of VECM analysis suggests uni-directional interconnection running from economic growth to CO2 emissions. Moreover, the result contradicts to Environmental Kuznets Curve hypothesis. Shahzad and Jamil (2015) studied the impact of three sectors of the economy on the emission of carbon in Pakistan from 1990 to 2013 using Log Mean Divisia Index (LMDI). This study also focused on different fuel types that are used for energy purposes in the main sectors of the economy including agriculture, industrial and services sectors. CO2 emissions increase with the increase in overall economic activity and decrease with the decline in economic activity. This study recommends that energy efficiency policies should be introduced in industrial and services sector of the economy. Chen et al., (2016) explained the relationship of economic growth energy consumption and CO2 emissions for 188 countries by employing panel co-integration and VECM model over the time frame 1993 to 2010. The results found the long-run relationship between variables and negative relationship exists between energy consumption and economic growth in developing nation. There is a uni-directional relationship of energy consumption to CO2 emissions exists for developing and developed the nation. This study recommends economy use should follow the environmental regulations, energy efficient resources to mitigating Green House Gas Emissions (GHGE). Mohiuddin et al., (2016) find out the relationship between energy consumption, GDP and CO2 emission in Pakistan by using time series data from 1971 to 2013. By using Johansen co-integration and vector error correction model (VECM) the results exhibit there is 1% increase in energy production will results 13.7% increase in CO2 emissions. There is found uni-directional causality from energy production to CO2 emission. This study suggested that government should subsidize renewable energy system to mitigate environmental damage. Kostakis et al., (2016) studied the effect of FDI inflows on environmental quality in case of Brazil and Singapore for the time 1970s to 2010. This empirical study used multivariate models (ARDL, FMOLS, and OLS) and results reveal that FDI inflows in Brazil generate environmental degradation but results are contrary for Singapore. The U-shaped relationship found for Brazil and confirms the environmental Kuznets curve. Singapore used clean technologies for industrial sectors but Brazil not using remedial measure for reduction of CO2 emissions. This study suggested that Brazilian economy should use environmental measure for reducing environmental degradation. Li et al., (2016) examined the energy consumption, economic growth, urbanization and trade openness relationship to the CO2 emission in 28 provinces of China over the time 1996 to 2012. Generalized Method of Moments (GMM) and Auto Regressive Distributed Lag (ARDL) method confirms the positive impact of energy consumption and trade on pollutant emissions in the long-run. This study suggested Chinese government to achieve goal of capping greenhouse emissions up to 2030. Saibu and Mesagan (2016) analyzed the impact of FDI on environmental quality of Nigeria over the time 1970 to 2013. Johansen co-integration test is used to estimate the long-run impact of FDI, human capital, trade openness on environmental degradation. The result suggests to Nigerian economy doesn't exceed the 67.4% threshold level of CO2 emission. This study suggests that Nigerian economy not only concentrate to attract the FDI but also make sure to promote green growth. Ozokcu and Ozdemi (2017) carried out the analysis to ascertain the role of energy usage and GDP in environmental degradation for 56 emerging economies over the time frame 1980 to 2010. By using panel data techniques and Driscoll-Kraay Standard Errors application the results shows inverted N shaped relationship for these countries. The results contradict to the EKC hypothesis that implies the problem of environmental damage does not curtail automatically by economic growth. Asumadu-Sarkodie and Owusu (2017) studied the link of energy consumption population economic growth and CO2 emissions in Ghana for the time period 1971 to 2013. By using OLS regression the results reveal long-run causality equilibrium relationship of economic growth, population and CO2 emissions. 1% increase in population, GDP and energy use leads to 1.30%, 0.73%, and 0.58% increase in CO2 emission respectively. This study suggests Ghanaian economy should invest in small and medium enterprises and focus on technological advancement and innovations. Sinha et al., (2017) find out the impact of various forms of energy consumption (renewable, non-renewable and biomass) trade openness and economic growth on environmental degradation for N-11 countries over the time period 1990-2014. Generalized Moments Method (GMM) is employed and results confirm the existence of N shaped relationship between GDP and CO2 emissions. The results show negative relationship of energy consumption, trade openness, economic growth and environmental degradation. This study recommends that N-11 countries should focus on technological diffusion by trade for economic progress and keep energy resources in economic system. Countries must take emphasis on long-term benefits of renewable energy. Mitic et al., (2017) attempted to find out the relationship between GDP and CO2 emission for 17 transition countries in 1997 to 2017. By using (DOLS) Dynamic, Ordinary Least Squares and (FMOLS) Fully Modified OLS approaches the results conclude that there is long-run co-integration exist between GDP and CO2 emission.1 % increase in GDP leads to their 35% increase in CO2 emission in 17 transition economies. Policy implication suggested to generalize the global policy incentives and adopted new instruments e.g. Implantation of environmental taxes, CO2 capture and storage techniques for the reduction of CO2 emission. Hassan and Haq (2017) examined the impact of economic growth, population, trade openness and energy consumption on CO2 emissions in Pakistan over the time frame 1980 to 2016. This study used Augmented Dickey Fuller Test (ADF) for analysis of stationary of variables. For long-run analysis Johansen co-integration test and short-run ECM (Error Correction Model) is employed. The results reveal that environment deteriorated by these factors in a long-run. This study suggested that Pakistan must import cleaner technology for growth of industrial sector that could help to save the environment. Baek and Choi (2017) attempted to analyze FDI impact on environment in 17 Latin American states for the time frame 1971 to 2011. Pooled Mean Group (PMG) method is used to check the impact of FDI, energy consumption and income on CO2 emission. The results confirm the presence of pollution haven hypothesis. Increasing flows of FDI lead to increase the level of CO2 in Latin American nation. Latin American nations pay attention to attract clean and energy efficiency industries for growth process in order to control the environmental degradation. Jamel and Maktouf (2017) analyze the causal relation among energy consumption, economic growth, trade openness and CO2 emissions for 40 European economies over the time frame 1985 to 2014. By using Ordinary Least Squares regression, the result shows bi-directional causality between economic growth and environmental degradation. This relationship confirms the presence of environmental Kuznets curve in European economies. This study suggested to energy preservation policies for economic growth perspective in order to lessen the distraction of environment. Mkonda and He (2017) explored the impact of Emerging Population on Environmental Challenges in Tanzania by using household surveys, physical observations and informative interviews. The results exhibit that increasing population is 90% responsible factor for increase in environmental degradation. The anthropogenic activities highly increase the level of CO2, NO2 and CH4 that harm the environment. This study advises that economy should use alternate energy resource and proper agronomic practices to improve the eminence of environment. Zheng and Sheng (2017) studied the impact of Foreign Direct Investment (FDI) on the environment for 30 provinces of China over the time period 1997 to 2009. This study used GGM method to check the effect of market-oriented reforms on Carbon emissions. The results reflect that FDI promotes CO2 emission and these emissions gradually become lowers year by year. Therefore China should introduce Market-oriented reforms for the economy as it lowers the environmental degradation.

All the past and current research were done on the carbon emissions are solely in the context of a single nation or on panel data by considering general transportation or energy. However, there is a significant gap in the literature for the transportation sector separately as degrading emissions other than carbon emission both at the national level and panel data context.

3. Data Source and Methodology

The annual data from 1990 to 2017 have been collected from WDI (2017) used for the investigation of air transportation on carbon emissions, methane, and nitrous emissions including the key variable such as GDP per capita, population, energy usage, FDI and trade for Pakistan.

There the three dependent variables which will be estimated one by one in the system of econometric ARDL model.

Dependent Variables (Environmental Indicators):
1. CO2 emissions from transport (% of total fuel combustion)
2. Methane emissions in energy sector (thousand metric tons of CO2 equivalent)
3. Nitrous oxide emissions in energy sector (thousand metric tons of CO2 equivalent)

Independent Variables:
1. Air transportation Goods (registered carrier departures worldwide)
2. Air Transport, passengers carried (total [international and domestic])
3. Per capita Income: GDP per capita (constant 2010 US$)
4. Energy Demand/Consumption: Energy use (kg of oil equivalent per capita)
5. FDI Inflows: Foreign direct investment, net (BoP, current US$)
6. Population density: (people per sq. km of land area)
7. Trade: Trade (% of GDP)

3.1 ADF - Unit Root Test

Time-series data is frequently non-stationary, containing a unit root. Ordinary Least Squares (OLS) estimates are efficient if variables, encompassed in the model are stationary of the same order. Therefore, first, it is desirable to check the stationarity of dissimilar variables in order to get efficient results along with the model selection technique. Therefore, Augmented Dickey-Fuller (ADF) test is employed.

3.2 ARDL - Bound Test Approach

This study uses the autoregressive distributed lag (ARDL) model, or bounds testing approach (Pesaran et al., 2001), that is applied to check the existence of short and long-run relationships among the variables. Econometric theory designates a set of variables is cointegrated if there is a linear combination among them without stochastic trend. In this instance, a long-run association subsists among these variables.

The usage of the bounds technique is built on three validations. First, Pesaran et al. (2001) advocated the use of the ARDL model for the estimation of level relationships because the model suggests that once the order of the ARDL is identified, the connection can be estimated by OLS. Second, the bounds test permits a mixture of I(1) and I(0) variables as regressors, that is, the order of integration of suitable variables may not necessarily be the same. Therefore, the ARDL technique has the advantage of not requiring specific identification of the order of the underlying data. Third, this procedure is suitable for finite sample size (Pesaran et al., 2001).

Subsequent Pesaran et al. (2001), we accumulate the vector autoregression (VAR) of order p, indicated VAR (p), for the following growth function:

$$Z_t = \mu + \sum_{i=1}^{p} \beta_i z_{t-i} + \varepsilon_t$$

Where z^t is the vector of both x^t and y^t, where y^t is the dependent variable defined as carbon, methane and nitrous emissions (X), x_t is the vector matrix which represents a set of explanatory variables. Explanatory variables in its turn include Air transportation carried and passenger, per capita GDP, trade, energy demand, population density, and FDI. According to Pesaran et al. (2001), y_t must be I(1) variable, but the regressor x_t can be either I(0) or I(1). The existence of long-run relationships is determined by F-stats. The null and alternative hypotheses are as follows:

$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ (No long-run relationship)

Against the alternative hypothesis

$H_A : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$ (A long-run relationship exists)

The computed F-statistic value will be evaluated with the critical values tabulated in Table CI (iii) of Pesaran et al. (2001).

If the F-stats exceeds the upper bound there is long-run cointegration, if F-stats is lower than lower bound then there is no long-run cointegration among the variables. However, there is inconclusive range if the F-stats lies between the upper and lower bound. In this case, the error correction term will specify the existence of relationship if it has with negative and significant value. The ECT represents the convergence coefficient means that if there is one percent random shock from independent variables, the shock will be corrected by x percent in each period.

The three econometric ARDL model as a dependent variable carbon dioxide emission, methane emission, and nitrous emission are:

$$\Delta\ln(CO2)_t = \beta_0 + \beta_1\ln(CO2)_{t-1} + \beta_2\ln(ATC)_{t-1} + \beta_3\ln(ATP)_{t-1} + \beta_4(GDP)_{t-1} + \beta_5(TR)_{t-1} + \beta_6(ED)_{t-1}$$
$$+ \beta_7(PD)_{t-1} + \beta_8(FDI)_{t-1} + \sum_{i=1}^{p}\beta_9\Delta\ln(CO2)_{t-i} + \sum_{i=0}^{q}\beta_{10}\Delta\ln(ATC)_{t-i} + \sum_{i=0}^{r}\beta_{11}\Delta\ln(ATP)_{t-i}$$
$$+ \sum_{i=0}^{s}\beta_{12}\Delta\ln(GDP)_{t-i} + \sum_{i=0}^{s}\beta_{13}\Delta\ln(TR)_{t-i} + \sum_{i=0}^{s}\beta_{14}\Delta\ln(ED)_{t-i} + \sum_{i=0}^{s}\beta_{15}\Delta\ln(PD)_{t-i} + \sum_{i=0}^{s}\beta_{16}\Delta(FDI)_{t-i}u_t \text{........(1)}$$

$$\Delta\ln(CH4)_t = \beta_0 + \beta_1\ln(CH4)_{t-1} + \beta_2\ln(ATC)_{t-1} + \beta_3\ln(ATP)_{t-1} + \beta_4(GDP)_{t-1} + \beta_5(TR)_{t-1} + \beta_6(ED)_{t-1}$$
$$+ \beta_7(PD)_{t-1} + \beta_8(FDI)_{t-1} + \sum_{i=1}^{p}\beta_9\Delta\ln(CH4)_{t-i} + \sum_{i=0}^{q}\beta_{10}\Delta\ln(ATC)_{t-i} + \sum_{i=0}^{r}\beta_{11}\Delta\ln(ATP)_{t-i}$$
$$+ \sum_{i=0}^{s}\beta_{12}\Delta\ln(GDP)_{t-i} + \sum_{i=0}^{s}\beta_{13}\Delta\ln(TR)_{t-i} + \sum_{i=0}^{s}\beta_{14}\Delta\ln(ED)_{t-i} + \sum_{i=0}^{s}\beta_{15}\Delta\ln(PD)_{t-i} + \sum_{i=0}^{s}\beta_{16}\Delta(FDI)_{t-i}u_t \text{........(2)}$$

$$\Delta\ln(NO2)_t = \beta_0 + \beta_1\ln(NO2)_{t-1} + \beta_2\ln(ATC)_{t-1} + \beta_3\ln(ATP)_{t-1} + \beta_4(GDP)_{t-1} + \beta_5(TR)_{t-1} + \beta_6(ED)_{t-1}$$
$$+ \beta_7(PD)_{t-1} + \beta_8(FDI)_{t-1} + \sum_{i=1}^{p}\beta_9\Delta\ln(NO2)_{t-i} + \sum_{i=0}^{q}\beta_{10}\Delta\ln(ATC)_{t-i} + \sum_{i=0}^{r}\beta_{11}\Delta\ln(ATP)_{t-i}$$
$$+ \sum_{i=0}^{s}\beta_{12}\Delta\ln(GDP)_{t-i} + \sum_{i=0}^{s}\beta_{13}\Delta\ln(TR)_{t-i} + \sum_{i=0}^{s}\beta_{14}\Delta\ln(ED)_{t-i} + \sum_{i=0}^{s}\beta_{15}\Delta\ln(PD)_{t-i} + \sum_{i=0}^{s}\beta_{16}\Delta(FDI)_{t-i}u_t \text{........(3)}$$

In the above econometric model, the β0 is intercepted, β1 to β8 are the long run coefficients while from β9 to β16 are short-run coefficients.

3.3 Pair-Wise Granger Causality

Granger (1969) developed the technique for analyzing the causality of the variables along with the ability of a variable to predict the other. If a pair of series is co-integrated, then there must be Granger-causality in at least one direction, which reflects the direction of influence between series. Theoretically, if the current or lagged terms of a time series variables X_t determine another time-series variable, Y_t then there exists a Granger-causality relationship between X_t and Y_t, in which Y_t is Granger caused by X_t

4. Result and Discussion

4.1 Descriptive Statistics

Table 1: Descriptive Result

	CO2	CH4	NO2	ATC	ATP	GDP	PD	ED	TR	FDI
Mean	3.302	10.286	8.069	11.006	15.604	6.837	5.254	6.132	3.487	-1.249
Median	3.313	10.348	8.076	11.073	15.548	6.806	5.262	6.133	3.495	-7.618
Maximum	3.446	10.836	8.380	11.217	15.951	7.075	5.541	6.260	3.661	6.228
Minimum	3.147	9.640	7.670	10.643	15.236	6.609	4.938	5.985	3.045	-5.499
Std. Dev.	0.073	0.388	0.215	0.166	0.193	0.144	0.180	0.071	0.138	1.499
Skewness	-0.053	-0.169	-0.435	-0.512	0.507	0.113	-0.110	-0.327	-1.400	-1.827
Kurtosis	2.309	1.611	2.195	2.002	2.321	1.558	1.862	2.514	5.256	5.586
Jarque-Bera	0.568	2.384	1.640	2.385	1.736	2.485	1.566	0.776	15.098	23.394
Probability	0.752	0.303	0.440	0.303	0.419	0.288	0.456	0.678	0.055	0.008

Table 1 shows the statistical depiction of all the variables such that the mean value of CO2 emission is 3.302, methane emission is 10.286 and nitrous emission is 8.069. The mean value of air transportation passenger and carriage is 11 and 15.6 respectively. Whereas, the average values of GDP, population density, energy demand, trade, and FDI is 6.8, 5.2, 6.13, 3.48 and -1.249 respectively. The variables are measured in the form of a natural log. However, the FDI has negative value. The deviation from the mean value is measured as standard deviation such that all the variables have positive statistics deviation. All the variables are negatively skewed except ATP and GDP, whereas the Kurtosis shows that all the variables are platykurtic except trade that is leptokurtic. The normality value based on the Jarque –Bera test shows that residuals of all the variables exhibit normal distribution except FDI.

4.2 ADF-Unit Root

The ADF test shows mix results regarding the significance of the variables recommending the ARDL-Bound test approach. The Methane, nitrous oxide emission and population density are integrated at level while rests of all the variables, i-e integrated at first difference. After unit root ADF, the bound test approach is used to find the long-run co-integration between the variables. Table 3 shows the bound test results that are based on the Pesaran et al. (2001) and Narayan (2005) value. For the model one, where the dependent variable is CO2, F-Stats (2.19) exists between 10 percent level of significance depicting an inconclusive range, therefore, suggesting the long-run relation by error correction term. The second model comprises of methane as dependent variable shows the value of F-stats 10.94 that exceeds the upper bound so rejecting the null hypothesis. Finally, in the third model the dependent variable is nitrous oxide emission with the F- stats 10.16 which is also exceeding the upper bound. Therefore, the bound test approach based on the F-stats value depicts the long-run co-integration among all the variables.

Table 2: Augmented Dickey-Fuller (ADF) Test on the levels and the First Difference of the Variables (1990-2017)

Variables	Level	First Difference	Decision
	Trend and Intercept	Intercept	
CO2	-1.314	(-5.237)*	Stationary at first difference, i.e., I (1).
CH4	(-3.475)***	(-3.070)**	Stationary at level and first difference i.e., I (0) and I(1).
NO2	(-5.459)*	(-4.018)*	Stationary at a level and first difference, i.e., I (0) and I(1).
ATP	-1.882	(-6.010)*	Stationary at first difference, i.e., I (1).
ATC	-1.729	(-3.867)*	Stationary at first difference, i.e., I (1).
ED	0.299	(-3.085)**	Stationary at first difference, i.e., I (1).
FDI	-2.063	(-3.222)*	Stationary at first difference, i.e., I (1).
GDP	-2.573	(-2.938)***	Stationary at first difference, i.e., I (1).
PD	(-.270)***	(3.380)**	Stationary at a level and first difference, i.e., I (0) and I(1).
TRADE	-1.510	(-5.655)*	Stationary at first difference, i.e., I (1).

Note: "*The null hypothesis is that the series is non-stationary, or contains a unit root. The rejection of the null hypothesis is based on MacKinnon (1996) critical values, i.e., level [trend and intercept]: -4.252, -3.548, and -3.207 are significant at 1%, 5%, and 10% level respectively. At first difference-intercept critical values are -3.639, -2.951 and -2.614 are significant at 1%, 5% and 10% level respectively. * shows 1%, ** shows 5% and *** shows 10% level of significance*."

4.3 ARDL Bound Test

Table 3: ARDL-Bound Test Results

ARDL Bounds Test			
Null Hypothesis: No long-run relationships exist			
Dependent Variable	**Log(CO2)**	**Log(CH4)**	**Log(NO2)**
F-Statistics	2.1936	10.9455	10.16
Critical Value Bounds			K = 7
Significance	**I0 Bound**	**I1 Bound**	
10%	2.03	3.13	
5%	2.32	3.5	
2.5%	2.6	3.84	
1%	2.96	4.26	

4.4 Long Run Coefficients

Table 4: ARDL-Long Run Results

ARDL Cointegrating - Long Run Coefficients						
Dependent Variable	**Log(CO2)**		**Log(CH4)**		**Log(NO2)**	
Independent Variables	**Coefficient (Std-Error)**	**P-value**	**Coefficient (Std-Error)**	**P-value**	**Coefficient (Std-Error)**	**P-value**
Constant	17.778* (5.639)	0.0071	11.110 (16.445)	0.5146	1.9081** (0.6837)	0.0235
Log(ATC)	0.771** (0.306)	0.024	0.382* (0.056)	0.008	0.2073*** (0.1028)	0.078
Log(ATP)	0.934*** (0.442)	0.053	0.560* (0.1251)	0.0051	-0.0111 (0.0296)	0.7173
Log(GDP)	0.3609* (0.0561)	0.008	0.507** (0.0921)	0.0501	-0.6816* (0.1217)	0.0005
Log(ED)	2.563** (0.9778)	0.0202	0.9752* (0.099)	0.0029	0.2042*** (0.0997)	0.087
Log(TRADE)	0.027 (0.1519)	0.8585	0.451 (0.921)	0.7970	-0.1276* (0.0325)	0.0007
Log(Pop Density)	2.5853* (0.7803)	0.0051	0.792* (0.091)	0.0041	1.8676* (0.1195)	0.0000
FDI	-0.0016 (0.0562)	0.1187	0.0029** (0.0891)	0.0503	0.0017* (0.00016)	0.00057

The above table depicts the long run coefficients of all the three separate estimated econometric models with three dependent variables such as CO2, methane emissions, and NO2 emissions. For the air transportation carriage/cargo, one percent increase in the number of flights (cargo) increases the CO2, methane and nitrous oxide emissions by 0.771, 0.382 and 0.207 percent that is significant at 5%, 1%, and 10%. It means that there is a significant and positive impact of air transportation carriage on CO2, methane and nitrous oxide emissions, thus degrading the environment. The results are consistent with the study of Gurney et al., (2009), Park and Lee (2011) and Wen et al., (2017).

Similarly, the air transportation passengers have also the positive and significant relation with CO2 and methane emission. The results infer that one percent increase in air transportation passenger leads to increase the CO2 and methane emission by 0.93 and 0.56 percent that is significant at 10% and 1%. NO2 has a negative but insignificant relation. The results are reliable with the analysis of Brouwer et al., (2008) and Talbi, (2017). Higher the landing and taking of airlifts uses extensive fuel combustions that lead to higher polluting emissions which also depends on the fuel standard and type such as oil, petrol, etc. The per capita GDP has positive and significant relation with CO2 and methane emission as shown in the statistical value such that 0.360 and 0.507. It shows that one percent rise in per capita GDP increases the CO2 and methane emission by 0.360 and 0.507 percent respectively that at significant at 1percent and 5percent. Higher the GDP leads to increases the fuel usage in the factories and industries along with many developmental projects that lead to degrading the environment by pollution emissions. In this analysis, the nitrous oxide emission shows negative relation to per capita GDP which means it lowers the NO2 by 0.68 percent that is significant at one percent showing improvement in the agriculture sector. The results are consistent with the study of Lane (2014), Ucak, et al., (2015), and Morales-Lage (2016). Moving towards the trade there is an insignificant relation to CO2 and methane emission while one percent rise in the trade leads to decrease NO2 by 0.172 percent i-e, is significant at a level of one percent. It supports the agriculture and fishing the sector that lifts the trade with costing the environment. The results are stanch with the study of Ubaidillah et al., (2017).

The energy demand has positive and significant relation to CO2, methane and NO2 emission that is one percent escalation in energy demand leads to rising the CO2, methane, and NO2 emission by 2.56, 0.975, and 0.204 percent that is at 5 %, 1% and 10% level of significance. This indicates that high energy demand leads to a higher proportion of goods and services that uses energy itself as fuel in different forms. The outcomes are reliable with the analysis of Soytas et al., (2007), Tanczos and Torok (2007) and Shahbaz et al., (2013).

Population density is significantly and positively related to CO2, methane and NO2 emission as the coefficient values are 2.585, 0.729 and 1.867 percent respectively that are all significant at one percent. This means that one percent increase in population density leads to increase the CO2, methane and NO2 emission by 2.585, 0.729 and 1.867 percent. The increase in population density results in higher usage of resources economic and environmental directly and indirectly which leads to emit pollution emissions. This effect is steady with the study of Strazicich and List (2003), Kasman and Duman (2015) and Rahman, (2017).

The FDI throughout the analysis has a very negligible impact on the carbon dioxide, nitrous oxide, and methane emission. The econometric consequences show that one percent increase in FDI increases the methane emission by 0.0029 and nitrous oxide by 0.0017 percent that is significant at 5 and 1 percent. The fact behind the emission is the decline in the FDI over the selected years which show no significant increase in the environmental emissions. The results oppose the study of Hou et al., (2016) and consistent with the study of Appiah et al., (2017). The impact of constant is significant for CO2 and NO2 emission.

4.5 Short Run Coefficients

Table 5: ARDL-Short Run Results

ARDL Cointegrating - Short Long Run Coefficients						
Dependent Variable	**Log(CO2)**		**Log(CH4)**		**Log(NO2)**	
Independent Variables	**Coefficient (Std-Error)**	**P-value**	**Coefficient (Std-Error)**	**P-value**	**Coefficient (Std-Error)**	**P-value**
Log(ATC)	0.0844* (0.0091)	0.008	0.0554** (0.0123)	0.0453	0.2105*** (0.0925)	0.0566
Log(ATP)	0.2780*** (0.1312)	0.0525	0.0809** (0.0353)	0.0448	0.2073 (0.1028)	0.0786
Log(GDP)	1.666** (0.6059)	0.0156	0.4907* (0.1371)	0.0050	0.6215*** (0.1993)	0.0104
Log(TRADE)	0.0192 (0.1039)	0.8557	0.0651 (0.099)	0.5776	-0.0344 (0.0334)	0.3335
Log(ED)	0.3080* (0.0544)	0.002	0.1407* (0.019)	0.0072	1.0528* (0.1487)	0.0001
Log(Pop Density)	1.8041* (0.5184)	0.0037	0.0362* (8.935)	0.0040	0.0204* (6.2097)	0.0032
FDI	-0.0011*** (0.110)	0.0728	-0.0017 (0.0915)	0.1859	-0.0001 (0.069)	0.0188
ECT_{t-1}	-0.6978* (0.2083)	0.0048	-0.1443* (0.0256)	0.0084	-0.911* (0.1893)	0.0013
R^2	0.893		0.979		0.991	
Adjusted-R^2	0.802		0.955		0.989	

The above table shows the short-run elasticities of all the independent variables on CO2, methane and NO2 one by one as three models. The air transportation cargo has a positive and significant impact on CO2, methane, and NO2. One percent increase in air transportation increases the carbon dioxide emissions by 0.0844, methane 0.0554 and NO2 by 0.210 that are significant at 1, 5, and 10 percent level respectively. In connotation, to long-run, the short-run results also have a positive and significant relation. In the pretext to long-run results, there is a significant and positive impact of air transportation passenger to carbon and methane emission by 0.278 and 0.080 percent with the significance level of 10 and 5 percent respectively short-run.

Similarly, one percent increase in the per capita GDP increases the CO2, methane and NO2 emissions by 1.666, 0.490, and 0.621 percent that is significant at 5, 1 and 10 percent correspondingly. This indicates that increase in the per capita GDP results in the progression of industries (demand side) Devezas et al., (2017). Moving towards the energy demand; one percent increase in the energy demand increases the CO2 emissions 0.308, methane by 0.140, and NO2 by 1.05 percent that is all significant at one percent. The population density also increases the emission significantly and positively by 1.804 to CO2, methane by 0.036 and NO2 by 0.0204 that are all significant at one percent. In short-run FDI has negatively and significant impact on CO2 emissions that is -0.0011 that is significant at 5 percent.

Finally, the Error Correction term has a negative and significant term for the entire models such that for CO2 is -0.69, methane has -0.144, and NO2 have -0.911 that are all significant at one percent. This means that one percent random shock by all the independent variables converge to the equilibrium by -0.69, -0.144 and -0.911 percent for the model where dependent variables are CO2, methane, and NO2 emissions. The R2 shows the goodness of fit of the model that shows that all the independent variables explain CO2 emission by 0.89 percent, methane by 0.97%, and NO2 by 0.99 percent respectively.

4.6 CUSUM Plot

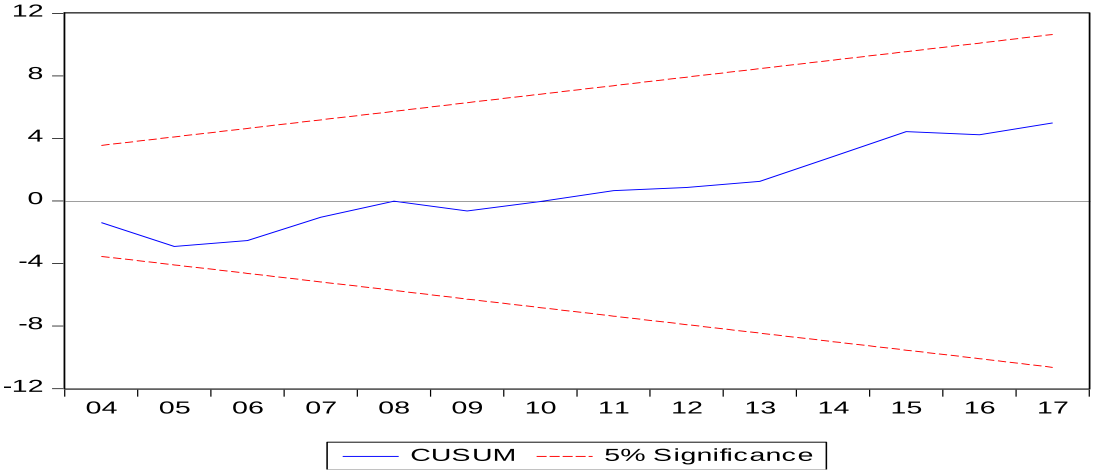

Figure 2: CUSUM Stability for CO2 Emission

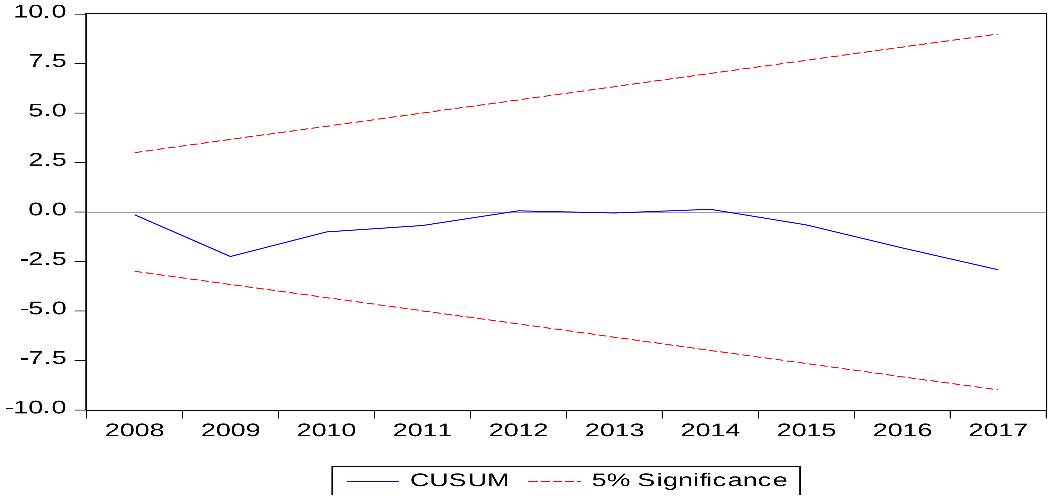

Figure 3: CUSUM Stability for Methane Emission

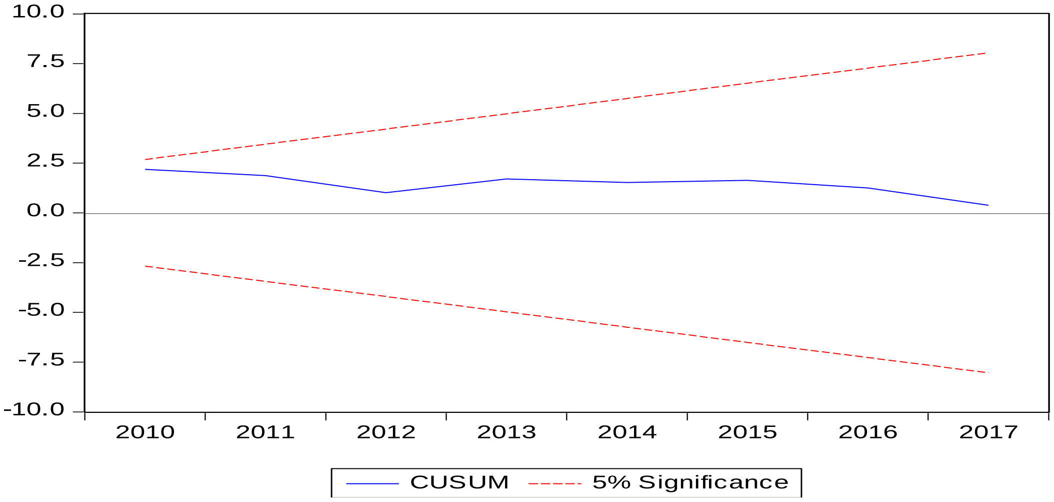

Figure 4: CUSUM Stability for NO2 Emission

The CUSUM shows that cumulative sum of randomness. The above plots show the stability of the model that is the plotted lines exist in the critical region signifying the stability of the all the three models.

4.7 Diagnostic Tests

Table 6: Diagnostic Tests

Diagnostic Tests				
Test Statistics		**Log(CO2)**	**Log(CH4)**	**Log(NO2)**
Breusch-Godfrey Serial Correlation LM Test:	F-statistic	0.2091	0.231	1.2845
	Prob. F(stats)	0.8134	0.8194	0.3123
	Obs.R Square	0.6519	0.9371	4.5846
	Prob.chi-square	0.7218	0.6259	0.1010
Heteroskedasticity-Breusch-Pagan-Godfrey	F-statistic	0.6967	2.0187	1.2822
	Prob. F(stats)	0.7318	0.1274	0.3731
	Obs.R Square	10.095	16.505	16.94
	Prob.chi-square	0.6076	0.8268	0.3219
Normality Test (Jarque Bera)	JB	1.6265	2.5967	1.0197
	Prob.	0.4434	0.2729	0.6005
Ramsey RESET	t-statistics	1.3063	0.1525	1.9308
	Prob.	0.2141	0.8825	0.8495
	F-statistics	1.7064	0.0232	3.7283
	Prob.	0.2141	0.8821	0.1948

The diagnostic test for the serial correlation accept the null hypothesis as the probability statistics for the CO2 model is 0.813, methane has 0.819and NO2 has 0.312. This shows the absence of serial correlation of the considered models. The Heteroskedasticity test such that Breusch-pagan shows the insignificant probability value that accepts the null hypothesis i-e there is no heteroscedasticity. Similarly, the Jarque Bera test of normality and Ramsey RESET (regression equation specific test) also shows that models have no issue of normality and specification. Summing up all the diagnostic test results is acceptable.

4.8 Pair-Wise Granger Causality

Model 1: (CO2) Pairwise Granger Causality Tests

Null Hypothesis:	Obs.	F-Statistic	Prob.
ATC does not Granger Cause CO2	26	1.21311	0.3173
CO2 does not Granger Cause ATC		2.67074	0.0926
ATP does not Granger Cause CO2	26	4.05365	0.0325
CO2 does not Granger Cause ATP		1.13742	0.3396
GDP does not Granger Cause CO2	26	1.81025	0.1882
CO2 does not Granger Cause GDP		2.14334	0.1422
TR does not Granger Cause CO2	26	0.26089	0.7728
CO2 does not Granger Cause TR		2.89897	0.0773
ED does not Granger CauseCO2	26	1.67657	0.2111
CO2 does not Granger Cause ED		3.38234	0.0533
PD does not Granger Cause CO2	26	4.65280	0.0212
CO2 does not Granger Cause PD		6.36445	0.0069
FDI does not Granger Cause CO2	26	0.36543	0.6982
CO2 does not Granger Cause FDI		3.70395	0.0419
ATP does not Granger Cause ATC	26	2.88204	0.0783
ATC does not Granger Cause ATP		6.43122	0.0066
GDP does not Granger Cause ATC	26	0.29388	0.7484
ATC does not Granger Cause GDP		1.22753	0.3132
TR does not Granger Cause ATC	26	5.12249	0.0154
ATC does not Granger Cause TR		1.23508	0.3111
ED does not Granger Cause ATC	26	0.65460	0.5299
ATC does not Granger Cause ED		4.47746	0.0240
PD does not Granger Cause ATC	26	4.82876	0.0188
ATC does not Granger Cause PD		2.54114	0.1027
FDI does not Granger Cause ATC	26	0.73555	0.4912
ATC does not Granger Cause FDI		1.28973	0.2963
GDP does not Granger Cause ATP	26	1.78618	0.1921
ATP does not Granger Cause GDP		0.09503	0.9097
TR does not Granger Cause ATP	26	0.68667	0.5142
ATP does not Granger Cause TR		3.32101	0.0558

ED does not Granger Cause ATP	26	0.31141	0.7357
ATP does not Granger Cause ED		7.53455	0.0034
PD does not Granger Cause ATP	26	11.5321	0.0004
ATP does not Granger Cause PD		1.05556	0.3657
FDI does not Granger Cause ATP	26	1.42317	0.2633
ATP does not Granger Cause FDI		0.77172	0.4749
TR does not Granger Cause GDP	26	0.55245	0.5837
GDP does not Granger Cause TR		2.71382	0.0895
ED does not Granger Cause GDP	26	0.55590	0.5818
GDP does not Granger Cause ED		6.30326	0.0072
PD does not Granger Cause GDP	26	2.54674	0.1023
GDP does not Granger Cause PD		7.14233	0.0043
FDI does not Granger Cause GDP	26	1.41752	0.2646
GDP does not Granger Cause FDI		3.43548	0.0512
ED does not Granger Cause TR	26	1.59541	0.2264
TR does not Granger Cause ED		1.58494	0.2285
PD does not Granger Cause TR	26	3.51505	0.0482
TR does not Granger Cause PD		15.1005	9.4505
FDI does not Granger Cause TR	26	0.12613	0.8822
TR does not Granger Cause FDI		0.11458	0.8923
PD does not Granger Cause ED	26	5.92201	0.0091
ED does not Granger Cause PD		4.88432	0.0181
FDI does not Granger Cause ED	26	0.18990	0.8284
ED does not Granger Cause FDI		7.40024	0.0037
FDI does not Granger Cause PD	26	3.23464	0.0596
PD does not Granger Cause FDI		2.06144	0.1523

The above table shows the pairwise Granger causality for the first model where CO2 is the dependent variable and model is double log such that log-log model in all cases of pairwise Granger causality. The results built on the probability values and F-stats show that there exist uni-directional Granger causation running from CO2 emission to trade, per capita GDP, FDI, air transportation carriage, and energy demand. Meanwhile, there is bi-directional casual relations exist between CO2 to population density and per capita GDP to population density. There is a unidirectional relation from air transportation passenger to energy demand, trade, air transportation carriage and CO2. Finally, there exists uni-directional Granger causality running from per capita GDP to FDI and trade while there is unidirectional relation exists between population density to trade, air transportation passenger, and energy demand.

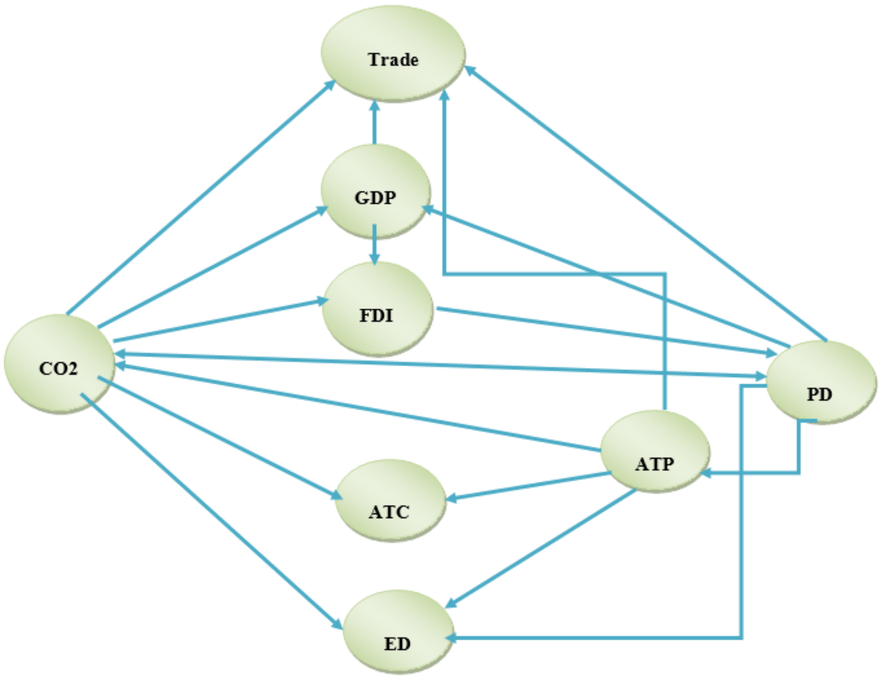

Figure 5: Pairwise Granger causality for CO2

Model 2: (Methane) Pairwise Granger Causality Tests

Null Hypothesis:	Obs.	F-Statistic	Prob.
ATC does not Granger Cause CH4	25	1.78252	0.1865
CH4 does not Granger Cause ATC	4.67391	0.0109	
ATP does not Granger Cause CH4	25	2.69850	0.0765
CH4 does not Granger Cause ATP	4.23858	0.0197	
GDP does not Granger Cause CH4	25	5.27722	0.0087
CH4 does not Granger Cause GDP	5.61428	0.0067	
PD does not Granger Cause CH4	25	6.33305	0.0040
CH4 does not Granger Cause PD	5.13220	0.0097	
TR does not Granger Cause CH4	25	2.31463	0.1103
CH4 does not Granger Cause TR	2.96863	0.0595	
ED does not Granger Cause CH4	25	1.90782	0.1645
CH4 does not Granger Cause ED	1.06234	0.3896	
FDI does not Granger Cause CH4	25	0.06053	0.9799
CH4 does not Granger Cause FDI	0.96696	0.4299	
ATP does not Granger Cause ATC	25	1.69715	0.2033
ATC does not Granger Cause ATP	6.23237	0.0043	
GDP does not Granger Cause ATC	25	0.71154	0.5577
ATC does not Granger Cause GDP	1.13763	0.3605	
PD does not Granger Cause ATC	25	7.74307	0.0016

ATC does not Granger Cause PD	3.17482	0.0493	
TR does not Granger Cause ATC	25	2.60890	0.0832
ATC does not Granger Cause TR	1.47516	0.2548	
ED does not Granger Cause ATC	25	0.47061	0.7065
ATC does not Granger Cause ED	2.48980	0.0932	
FDI does not Granger Cause ATC	25	0.60222	0.6219
ATC does not Granger Cause FDI	2.36652	0.1049	
GDP does not Granger Cause ATP	25	2.25548	0.1168
ATP does not Granger Cause GDP	0.24572	0.8633	
PD does not Granger Cause ATP	25	9.93737	0.0004
ATP does not Granger Cause PD	0.03167	0.9922	
TR does not Granger Cause ATP	25	0.46514	0.7102
ATP does not Granger Cause TR	5.77434	0.0060	
ED does not Granger Cause ATP	25	1.07217	0.3857
ATP does not Granger Cause ED	4.03234	0.0234	
FDI does not Granger Cause ATP	25	1.84367	0.1754
ATP does not Granger Cause FDI	1.21856	0.3317	
PD does not Granger Cause GDP	25	4.36057	0.0108
GDP does not Granger Cause PD	1.85978	0.1726	
TR does not Granger Cause GDP	25	2.08130	0.1385
GDP does not Granger Cause TR	1.94273	0.1589	
ED does not Granger Cause GDP	25	0.12447	0.9444
GDP does not Granger Cause ED	3.59651	0.0340	
FDI does not Granger Cause GDP	25	1.26371	0.3166
GDP does not Granger Cause FDI	2.39264	0.1023	
TR does not Granger Cause PD	25	0.53125	0.6666
PD does not Granger Cause TR	3.33493	0.0427	
ED does not Granger Cause PD	25	1.32010	0.2987
PD does not Granger Cause ED	7.87592	0.0015	
FDI does not Granger Cause PD	25	0.24646	0.8628
PD does not Granger Cause FDI	3.50261	0.0369	
ED does not Granger Cause TR	25	1.57606	0.2299
TR does not Granger Cause ED	2.13743	0.1311	
FDI does not Granger Cause TR	25	0.14526	0.9314
TR does not Granger Cause FDI	1.11174	0.3703	
FDI does not Granger Cause ED	25	0.10750	0.9546
ED does not Granger Cause FDI	6.44188	0.0037	

The above table shows the Pair-wise Granger causation for the second model where methane act as the dependent variable. The results show that there is bi-direction Granger causality of methane emission to population density, per capita GDP, and air transportation passenger and uni-direction relation to air transportation carriage and trade. Population density has unidirectional relation to Per capita GDP, FDI, energy demand, trade, and air transportation passenger, while bi-direction to air transportation carriage. Energy demand and per capita GDP have unidirectional causality to FDI. Finally, there exists unidirection relation between per capita GDP, air transportation carriage, and air transportation passenger to energy demand.

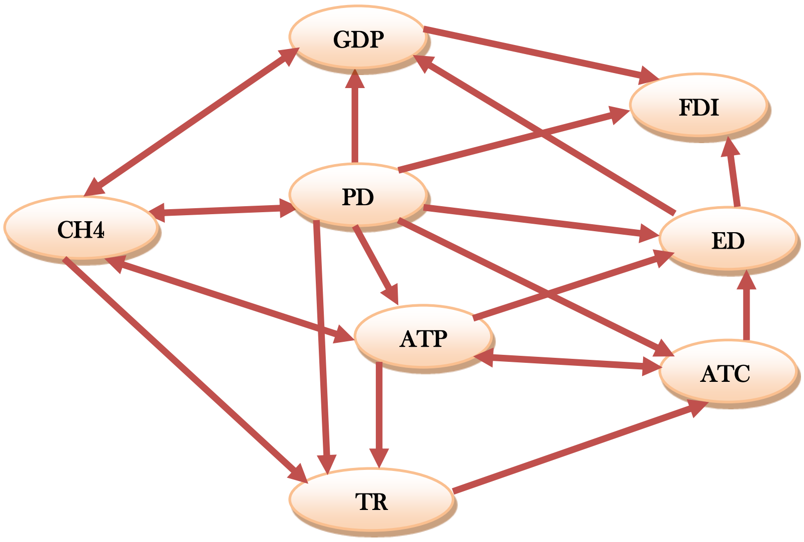

Figure 6: Pairwise Granger causality for Methane

Model 3: (NO2): Pairwise Granger Causality Tests

Null Hypothesis:	Obs.	F-Statistic	Prob.
ATC does not Granger Cause NO2	24	0.15065	0.0598
NO2 does not Granger Cause ATC		0.97505	0.4501
ATP does not Granger Cause NO2	24	0.60321	0.0662
NO2 does not Granger Cause ATP		0.88950	0.4940
GDP does not Granger Cause NO2	24	7.34341	0.0017
NO2 does not Granger Cause GDP		1.88922	0.1647
PD does not Granger Cause NO2	24	8.89363	0.0007
NO2 does not Granger Cause PD		1.70618	0.2009
TR does not Granger Cause NO2	24	0.39402	0.8098
NO2 does not Granger Cause TR		0.93511	0.4702
ED does not Granger Cause NO2	24	1.07365	0.4039
NO2 does not Granger Cause ED		0.99729	0.4393
FDI does not Granger Cause NO2	24	0.10745	0.9781
NO2 does not Granger Cause FDI		0.79009	0.5495
ATP does not Granger Cause ATC	24	1.38689	0.2856
ATC does not Granger Cause ATP		3.94196	0.0221

GDP does not Granger Cause ATC	24	0.79309	0.5477
ATC does not Granger Cause GDP		0.73861	0.5801
PD does not Granger Cause ATC	24	5.48682	0.0063
ATC does not Granger Cause PD		1.23064	0.3396
TR does not Granger Cause ATC	24	1.69604	0.2031
ATC does not Granger Cause TR		1.04117	0.4187
ED does not Granger Cause ATC	24	0.67192	0.6216
ATC does not Granger Cause ED		2.41518	0.0946
FDI does not Granger Cause ATC	24	0.57547	0.6848
ATC does not Granger Cause FDI		4.36029	0.0105
GDP does not Granger Cause ATP	24	1.71741	0.1985
ATP does not Granger Cause GDP		0.13292	0.9678
PD does not Granger Cause ATP	24	8.51069	0.0009
ATP does not Granger Cause PD		0.18589	0.9421
TR does not Granger Cause ATP	24	0.46345	0.7616
ATP does not Granger Cause TR		4.54455	0.0033
ED does not Granger Cause ATP	24	1.82378	0.1768
ATP does not Granger Cause ED		2.43709	0.0925
FDI does not Granger Cause ATP	24	1.74614	0.1923
ATP does not Granger Cause FDI		1.51386	0.2482
PD does not Granger Cause GDP	24	3.36188	0.0374
GDP does not Granger Cause PD		3.99643	0.0211
TR does not Granger Cause GDP	24	2.09859	0.1317
GDP does not Granger Cause TR		1.13105	0.3791
ED does not Granger Cause GDP	24	0.42494	0.7883
GDP does not Granger Cause ED		2.03524	0.1408
FDI does not Granger Cause GDP	24	0.54985	0.7021
GDP does not Granger Cause FDI		4.48154	0.0100
TR does not Granger Cause PD	24	0.31301	0.8648
PD does not Granger Cause TR		4.12947	0.0088
ED does not Granger Cause PD	24	0.51439	0.7263
PD does not Granger Cause ED		5.33464	0.0071
FDI does not Granger Cause PD	24	2.01378	0.1441
PD does not Granger Cause FDI		2.93562	0.0562
ED does not Granger Cause TR	24	0.94975	0.4627
TR does not Granger Cause ED		1.65555	0.2124

FDI does not Granger Cause TR	24	0.10669	0.9784
TR does not Granger Cause FDI		1.44200	0.2687
FDI does not Granger Cause ED	24	0.29517	0.8765
ED does not Granger Cause FDI		7.74107	0.0014

The above table shows the pairwise Granger causality assessment for the third model where NO2 is the dependent variable. The estimated results show that there is unidirectional Granger causality running from population density to trade, air transportation carriage, air transportation passenger, energy demand, NO2 emissions, and FDI. Additionally, there exists a bi-directional relation between population density and per capita GDP. There is Granger causation from per capita GDP to NO2 emissions and FDI. Air transportation carriage Granger cause FDI, energy demand and air transportation passenger. Finally, air transportation passenger, population density, per capita GDP and air transportation carriage has unidirectional relation to NO2 emissions.

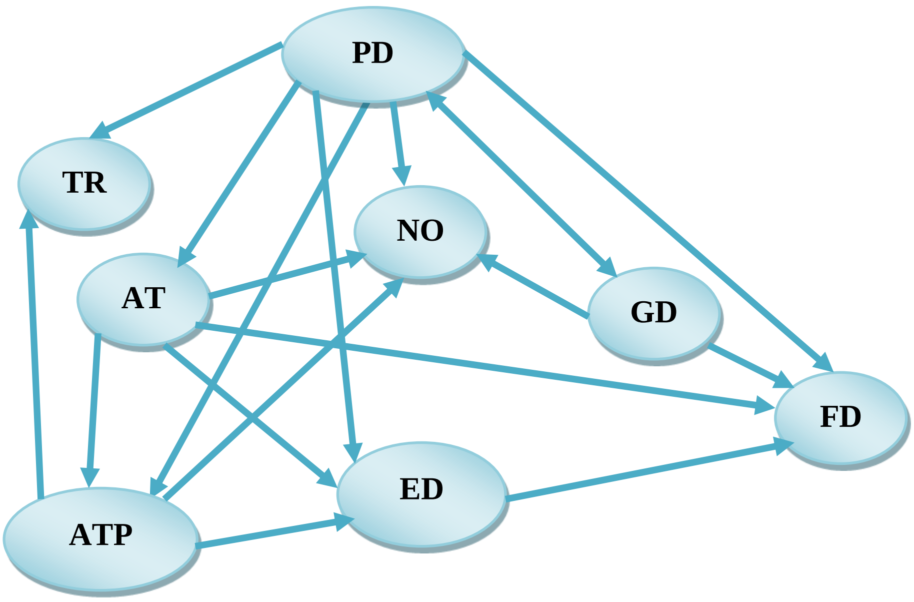

Figure 7: Pairwise Granger causality for NO2

5. Conclusion and Recommendations

As the demand for transport will rise, the energy consumption will unquestionably raise. Energy efficiency procedures are not able to capture all the rise of the demand resulting from this growth. Advancement in refining energy efficiency in the arena of transport is fundamental.

The increase in the transportation sector increases the deteriorating emissions like CO2, NO2 and methane emissions. The consistent increases in the transportation, usage of fuel, and population density shortly would be intense the climate change such as global warming. Fuel usage like gasoline, ethanol, diesel, jet fuel and oil in the aviation sector on each flight emit 75 percent of energy use (Colbeck, 2010). The economic impact of transportation on Pakistan is undeniable, but at the same time, the environmental cost is there which need to be internalized. Using the time series data from 1990 to 2017 this article quantifies the impact of air transportation on carbon dioxide emissions, nitrous emissions and methane emissions separately in the three models by applying ARDL bound test method. The econometric results show that there exists a significant and positive relation between air transportation to these selected emissions. Moreover, per capita GDP, population density, and energy demand also greatly influence the environments directly and indirectly thus degrade in a significant ratio. In case of Pakistan, FDI and trade for this duration don't significantly contribute in the CO2, NO2, and methane emissions. Since the last decade the economic issues of Pakistan like terrorism, political instability, energy crises, and poor management along with a worst performance by tertiary sectors have badly hit the economy, and as a result, the FDI and trade sector have suffered in significant proportion. Finally, pairwise Granger causality has been used to check the causation of the variables that also supports the results.

From the root of the current analysis, the policy recommendation can be drawn as; the fuel-efficient energy use along with energy management and technological diversification in the transportation sector is essential to mitigate the degrading environmental emissions. Moreover, the air tax such that per fight tax on the ticket should also be added to internalize the externality. This tax in long-run can be used in the proficient energy use that lowers the degrading emissions in the nation. The policy decisions must constructively well-thought-out for a long term, ecological growth and fortune of Pakistan by strengthening the aviation sectors by innovation, modification, dynamic and efficient energy use.

5.1 Future Research

The aim of this analysis is to quantify the impact of air transportation on environment degrading emissions like CO2, NO2 and methane only for Pakistan as a time series analysis. The current article is one of the key objectives of my PhD research. The Future research will be conducted on the panel data in order to quantify the impact of these variables on a large scale to recommend effective policymaking that possibly will converge the nations towards environmental quality.

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