DOES ECONOMIC GROWTH, POPULATION GROWTH AND ENERGY USE IMPACT CARBON-DIOXIDE EMISSIONS IN PAKISTAN? AN ARDL APPROACH

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ABSTRACT

This study shows the impact of four major contributors GDP growth, Population growth, and Energy use on carbon-dioxide emissions in Pakistan. This research reviews a period of 46 years beginning from 1971 to 2017. Time series data is acquired for this purpose from WDI. The technique used here to determine the short run and long run impacts is ARDL. ADF approved the stationarity of data at a 5 % level of significance. ECM validates the co-integration among the variables. while CUSUM, CUSUMSQ, and RAMSEY RESET test displayed the stability and correct specification of the model. Therefore, empirically above-mentioned variables are statistically valid and render positive impact on CO^2 excretion both in the transitory and at length regarding Pakistan.

Keywords: CO_2 Emissions, GDP, ARDL
JEL Codes: E01, P24

I INTRODUCTION

The rising destruction of the environment of our planet earth is rising with each passing day. The situation is becoming worst and human bodies both public and administrative least bother about it since the most weighted source of all this chaos is increasing carbon-dioxide emissions in the world. It is concrete to state that if these levels of carbon emissions would not be controlled then life might become nearly impossible on earth. Abeydeera et al. (2019) suggest that a major contributor to climate change in the world. The carbon emissions have shown significant acceleration from 22.15 Gt in 1990 to 36.14 Gt in 2014. In the case of Pakistan, the government seems a little serious concerning carbon emission. It is highly acknowledged by the SDG authorities about the completion of planting new trees to control the effects.

The intensity of carbon emissions is increasing with every passing day resulting in global warming. Ultimately the earth is going towards chaos due to the reason that global warming encourages calamities like drought, floods, untimely rains, and an increase in temperature, and many more. Global warming is also the prime reason for the increased melting of glaciers resulting in the depletion of water resources as well as increasing levels of seawater. All these indications are enough to prove that socio-economic stability is in danger and it's all due to carbon emissions.
In many developed countries like China, the USA, and England un-diverted attention is being paid to study and analyze the effects of carbon emissions which the human race might have to deal with in the future, and sustainability tends to be under a situation of compromise. A minimum of literature is available in the case of Pakistan, being an underdeveloped country not many resources are available to afford such sort of expensive researches. In addition to that old methods are being used to generate the economic output and to fulfill day to day public's demand.

The primary objective of this study is to gauge the effects of economic activity, population growth, and energy use both in the short-run and long-run in Pakistan using few econometric techniques. This study compromises five sections in which the first one is the introduction, followed by a literature review then methodology and results. At the end of this study conclusion including policy recommendations is presented. This study holds significant because of the

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reason that increasing temperature and other environmental problems are becoming the concern of every single educated person. Adding to that it also elaborates the trade off we make with the usage of fossil fuels.

II. LITERATURE REVIEW

There are tons of literature available debating the junction between CO_2 outflow and economic activity worldwide. Khan et al. (2020) reflected that GDP growth and carbon-dioxide release have a direct relationship, which means that increasing the amount of economic growth is likely to increment the carbon-dioxide emissions in transitory run as well as over the period of time in case of Pakistan. Empirical method used by the author was ARDL, while the data ranged from 1965-2015. In another study of Greece concluded while studying the connection, which turned out to be positive between carbon-dioxide emissions and economic development. The study covered the period from 1970 – 2014 using the Autoregressive distributed lag. The above-mentioned variables reflected co-integration in the long run along with other variables like *financial development*, *international trade*, and *tourism expenditures*. All the economic growth is possible in each scenario only if there are more and more carbon emissions leading to the point that more economic growth is linked with the burning of more and more fossil fuels (Işik et al., 2017).

Khan et al (2019) in his study discussed the use of nonrenewable resources which are the main cause of emission of carbon dioxide and its relationship with economic growth. Increasing numbers of emissions is an unresolved matter for both developing and developed nations since everybody wants to maximize their output that is economic growth. The author used a new technique dynamic ARDL model to project the effects in both short run and long run, instead of the simple ARDL approach which was in practice to determine the impacts in this case. This study covered the time period from 1965 to 2015. The results revealed that economic growth both in the short and long run in Pakistan encourages the excessive use of natural resources resulting in increased carbon dioxide emissions

A similar study was conducted to analyze the impacts in Azerbaijan starting from 1992 to 2013 of development in economy on production of carbon secretion, using different approaches like ARDL, DOLS, FMOLS, and CCR to probe the wholeness of the outcomes. Concretely to state that economic growth had a direct relationship with emissions of carbon dioxide in Azerbaijan. It was proved statistically for the long run specifically (Mikayilov et al., 2018). In another similar study considering Pakistan, variables like GDP, Population Growth, and energy use were tested considering time series data spanning over 40 years starting from 1970 to 2010 to check the impact upon the per capita carbon emissions. ARDL approach was used to estimate the short-run and long-run impact. The outcomes confirmed that all the above-mentioned independent variables had a positive relationship with carbon-dioxide outflow both in transitory and over the period of time (Baig & Baig, 2014).

III. METHODOLOGY

Selection of variables have been done with the help of these studies, i.e., Ali (2011), Ali (2015), Ali (2018), Ali and Bibi (2017), Ali and Ahmad (2014), Ahmad and Ali (2016), Audi and Ali (2016), Ali and Audi (2016), Ali and Audi (2018), Ali and Rehman (2015), Audi and Ali (2017), Ali and Naeem (2017), Audi and Ali (2017), Ali and Zulfiqar (2018), Ali et al., (2016), Arshad and Ali (2016), Ashraf and Ali (2018) Haider and Ali (2015), Sajid and Ali (2018), Ali and Senturk (2019), Kassem et al, (2019), Ali and Bibi (2020), Sulehri and Ali (2020), Audi et al., (2021), Audi et al., (2021), Ali et al., (2021), Ali, et al., (2021), Senturk and Ali (2021), Roussell et al., (2021) and Ali et al., (2021). The model is portrayed by Pesaran et al., (2001) utilized for this investigation is given beneath.

$$\Delta CO2_t = \beta_\circ + \sum_{i=1}^{p} .\pi_i \Delta CO2_{t-i} + \sum_{i=0}^{q} .\beta_i \Delta GGA_{t-1} + \sum_{i=0}^{r} .\alpha_i \Delta EC_{t-1} + \sum_{i=0}^{s} .\lambda_i \Delta PG_{t-1} + \gamma_i CO2_{t-1} + \gamma_i GGA_{t-1} + \gamma_i EC_{t-1} + y_i PG_{t-1} + \varepsilon_t \quad (1)$$

The log representation of the above model (1) is given below.

$$\Delta LCO2_t = \beta_o + \sum_{i=1}^{p} .\pi_i \Delta LCO2_{t-i} + \sum_{i=1}^{q} .\beta_i \Delta GGA_{t-i} + \sum_{i=1}^{r} .\alpha_i \Delta LEC_{t-1} + \sum_{i=1}^{s} .\lambda_i \Delta PG_{t-1} + \gamma_i LCO2_{t-1} + \gamma_i GGA_{t-1} + \gamma_i LEC_{t-1} + \gamma_i PG_{t-1} + \varepsilon_t \quad (2)$$

Carbon-dioxide emissions (kilo tons), Gross Domestic Product Growth annually in percentages, Energy Use i.e. use of oil in Kilograms per capita, and Population Growth in percentages annually are the variables used in the model, represented as CO2, GGA, EC, and PG respectively. In this model, the log of two variables carbon-dioxide emissions and Energy Consumptions are taken into consideration, since these variables contained big values. Log form makes them compact and easy to interpret. Coefficients of the respective variables are presented by "π", "γ", "α", and "λ". while "Δ" shows variables are being differentiated at level. "ε" is for disturbance term, intercept is given by "β_o", and

time represented by "t". Left side of the equation presents Carbon-dioxide (Co_2) Emissions that is dependent variable. while on the right side all are independent variables are listed, which include GDP, Energy Use, and Population Growth.

To estimate short-run and long-run impact, independent variables on CO_2 Emissions, Auto-Regressive Distributed Lag (ARDL). ARDL model is selected for this purpose, as it is very simple and used widely to determine the co-integration among the variables. Different tests have been exercised for ensuring the validity of the results. In first step, we tested the data using *Augmented Dickey-Fuller* (ADF) to check the unit root of all the variables. This is very important as one cannot proceed further using the ARDL approach, provided non-stationarity appears in the data.
In the next step, the bound testing approach is applied confirming the major possibilities of the outcomes to be valid in long run followed by the *Error Correction Model* (ECM) to validate the convergence of the short-run impacts into the long run. In the end, *CUSUM* and *CUSUM* squares are used to reflect the stability of the model as well as the recursive estimation in the model. The data used here is time-series ranging from the year 1971-2014. Source of time is given below:

Table 1: Data Source

Variable	Source
CO2 Emissions	World Development Indicators
GDP Growth Annual	World Development Indicators
Energy Consumption	World Development Indicators
Population Growth Annual	World Development Indicators

IV. RESULTS AND ANALYSIS

Fulfilling the prime condition of the ARDL approach, the stationarity of data is checked via the *Augmented Dickey-Fuller* (ADF) test since we are using time series data. Variables are checked on both at the level and first difference. The results are given below in table 2.

Table 2: Augmented Dickey-Fuller Test

At Level		At First Difference		Decision
Variable	P-value	Variables	P-value	
CO^2 Emissions	0.9780	CO^2 Emissions	0.0000***	I (1)
GDP Growth	0.0003**	GDP Growth	0.0000***	I (0)
Energy Use	0.5359	Energy Use	0.0000***	I (1)
Population Growth	0.9028	Population Growth	0.0359**	I (1)
* Shows significance at 10 %, ** shows significance at 5 %, *** shows significance at 1 %				

It is obvious from the resultants that there is no presence of unit root in data at a 5% level of significance. At level GDP growth turned out to be stationary while the remaining three are stationary at first difference. So, stationarity of data gives the green signal to proceed with the ARDL approach. Moving on with the ARDL approach, Bound testing is necessary which is basically a testimony projecting the probability of long terms relationships among the variables. Developing a *null hypothesis* that no long-run relationship exists. The outcomes of the *Bound test* are presented below in table 3.

Table 3: ARDL Bound Test

Null Hypothesis: No Long-Run Relationships Exist		
Test Statistics	Value	K
F- Statistics	13.54683	3
Critical Value Bounds		
Significance	I (0)	I (1)
10%	2.37	3.2
5%	2.79	3.67
2.5%	3.15	4.08
1%	3.65	4.66

The significance of the bound test is determined by comparing the calculated value of F-statistics and the critical bound value both at the level and first difference. Here, significance level under consideration is 5 %, as this level is generally used to test the statistical significance in all sorts of economic researches. F-stats value is clearly exceeding the critical value at all significance levels at both level and difference of first order. Hence, we do not accept the null hypothesis and report that a long-term connection is possible of independent variables which are *GDP growth*, *population growth*, and *Energy use* upon dependent variable CO^2 emissions given in the model.
Since the bound test has validated the long-run linkages in the model. Now, we shall discuss long run results, outcomes of which are given below in table 4. It is evident from the results that all the variables hold statistically significant confirming them via both t-statistics as well as P-value.

Table 4: Long-Run Coefficients of ARDL (2,3,3,4) Model
Dependent Variable ln (Co2 Emissions)

Variable	Coefficient	Standard Error	T-Statistic	P-Value
Ln Energy Use	4.294262	0.459867	9.338061	0.0000***
GDP Growth Annually	0.024486	0.007161	3.419238	0.0020**
Population Growth Annually	0.119954	0.055723	2.152691	0.0404**
Constant	-6.760855	1.372816	-4.924807	0.0000***
* Shows significance at 10 %, ** shows significance at 5 %, *** shows significance at 1 %				

Results clearly show that independent variables have a direct association with the dependent variable that is carbon-dioxide emissions. While the only constant shows a negative relation. In verbal understanding, carbon-dioxide emissions will increase provided there is an increase in any of the variable's energy use, population growth or GDP growth in the model. Only if we keep independent variables at zero, the carbon emissions shall decrease according to the results. Coming forward to short-run results, Energy use, GDP growth, and Population growth prove positive relation with carbon-dioxide emission in Pakistan. Interpreting the results 61 % of energy use, 0.02% of GDP growth and 6 % of Population growth will be contributed to carbon emissions given there is a 1 % increase in all independent variables in Pakistan. Rahman & Kashem (2017) also reported similar outcomes while analyzing in Bangladesh that is economic development and consuming energy resources tend to increase the carbon emissions. In another study about Saudi-Arabia empirically use of energy resources is likely to be the reason for environmental degradation (Raggad, 2018). Ahmad & Du (2017), also reported a direct impact of economic activity on carbon-dioxide emissions in Iran. All these results hold valid statistically checked via both t-stats and P-value. Results of the independent variable are all significant at level, while some are significant at different difference levels on a different level of significance presented below in table 5.

Table5: Error Correction Representation of the Selected ARDL Model
Dependent Variable ln (Co^2 Emissions)

Variable	Coefficient	Standard Error	T-Statistic	P-Value
$\Delta Co^2{}_{t-1}$	-0.171536	0.109667	-1.564152	0.1294
$\Delta LnEU_t$	0.612514	0.199979	3.062895	0.0049**
$\Delta LnEU_{t-1}$	-0.443652	0.247365	-1.793508	0.0841*
$\Delta LnEU_{t-2}$	-0.787684	0.214971	-3.664144	0.0011**
ΔGGA_t	0.002413	0.000763	3.163903	0.0038**
ΔGGA_{t-1}	-0.001787	0.000912	-1.959588	0.0604*
ΔGGA_{t-2}	0.001477	0.000783	1.886469	0.0700*
ΔPG_t	0.065169	0.028042	2.323959	0.0279*
ΔPG_{t-1}	-0.022065	0.033458	-0.659476	0.5152
ΔPG_{t-2}	-0.002560	0.030067	-0.085132	0.9328
ΔPG_{t-3}	-0.060734	0.023691	-2.563594	0.0162**
$ECM_t(-1)$	-0.242134	0.027457	-8.818664	0.0000***
* Shows significance at 10 %, ** shows significance at 5 %, *** shows significance at 1 %				

Constant of the Error Correction Model (ECM) also turns out to be significant at a 1 % level of significance. It means the transition from the short run to the long run in this research for Pakistan holds valid. Every year in Pakistan the

negative value of ECM recommends that 24.2 % of carbon emissions would be aligned from the short run to the long run. Sulaiman & Abdul-Rahim (2018), revealed that in short period of time *economic growth*, *population growth* and *energy use* displayed significance not only at level but also at different lag levels in Nigeria. To test the stability of the model RAMSEY RESET test is applied. The results of which are given below in table 6.

Table 6: RAMSEY RESET Test Statistics

Statistics	Value	Probability
T-statistics	1.178482	0.2493
F-Statistics	1.388819	0.2493

Probability for both T-stats and F-stats is valid statistically at 5 % significance level. There is no shadow of a doubt that the model is free from any sort of specification errors.

Figure 1: Plot of ARDL CUSUM Test

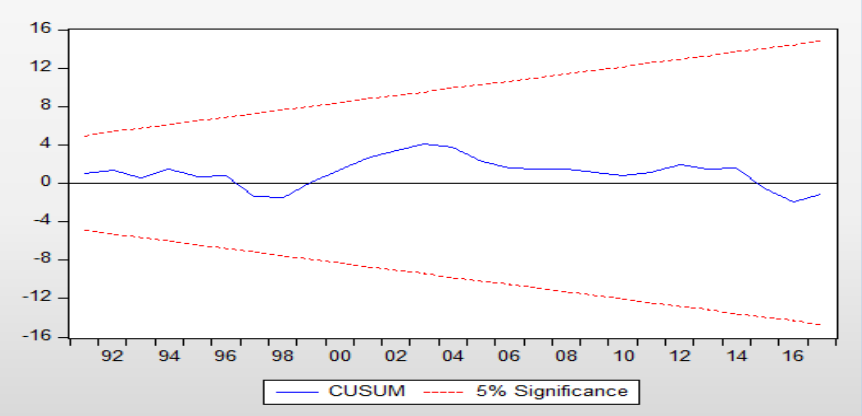
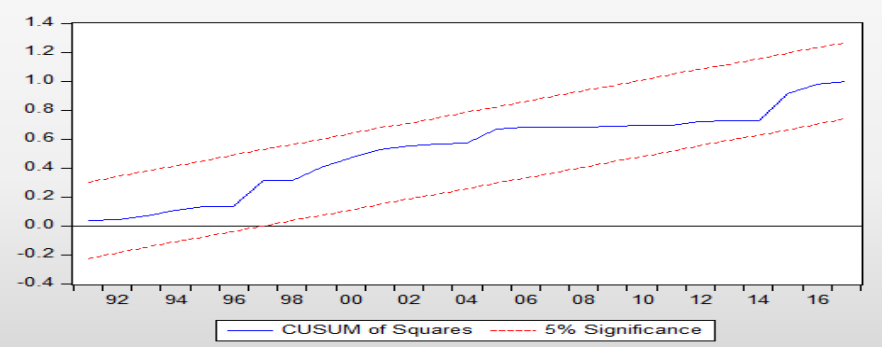


Figure 2: Plot of ARDL CUSUMSQ Test



CUSUM and CUSUMSQ both report stability at 5 % significance level. Overall, these diagnostics reinforce the validity of our short-run and long-run estimates. CUSUM graph given above supports our results about the functional form about its specification at a 5 % level of significance. These graphs also show the stability of long-run and short-run estimates following the literature. Graphs are plotted via the sample size, two straight lines (red) show the critical value. As long the CUSUM lies within them, stability is reported (Brown et al., 1975).

V CONCLUSIONS

After using all the econometric techniques this study concludes that the variable GDP growth, Energy use, and Population growth all are positively linked with carbon emissions in Pakistan. This research confirms the effects of above said variables to have statistically both short-run and long-run impacts. Supporting this study via existing literature Muhammad et al. (2010) reported a significant positive link between energy use and carbon emissions in b the short-run and long-run both in the case of Pakistan. Kebede (2017) also described a positive relation of population, energy use and economic growth upon carbon emissions in Ethiopia. In another study of Pakistan long term impact of population growth and energy were reported while negative impact of economic activity on carbon emissions (Mansoor & Sultana, 2018). Pakistan should shift its energy-producing resources to eco-friendly ones for instance

generating electricity from water, solar and wind energy, diesel, and petrol can be replaced by eco-friendly fuels like ethanol and electrically charged vehicles can be used to avoid unnecessary emissions. In addition to that public transport should be improved and encourage the masses to use them. The concept of carpooling can also prove to be effective for such a cause. To effectively control the emissions putting taxation as well as licensing can prove to be a better cure.

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