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SECTORAL GROWTH AND CARBON EMISSIONS IN PAKISTAN

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ABSTRACT
The basic aim to write this research paper was to assess the impact of relevant determinants like GDP per capita and sectoral growth on carbon emissions in Pakistan. Latest annual time series data set was collected from World Bank Indicators during period 1971-2020 due to unavailability of data of some variables for year 2021. ARDL bound testing and simple VAR techniques of estimation were employed. According to ARDL bound testing foreign direct investment, GDP growth and trade openness have positive and significant effect upon carbon emissions in Pakistan. Value addition in agriculture, Industry, Services, Exports of goods and services and gross fixed capital formation affected carbon emissions negatively and significantly. Impulse response functions and variance decomposition analysis was also made to see the dynamic behaviour of determinants of carbon emissions in Pakistan. Relevant authorities should focus on checking the impact of sectoral growth on carbon emissions. Based on the above mentioned findings, we can say that climate- smart agriculture technology should be adopted, emission free apparatus should be installed in industry and environment friendly services should be provided to prevent from environmental degradation.
Keywords: Agriculture, Industry, Services sector, GDP per capita, Carbon Emission.

INTRODUCTION
High standard life of human beings has been challenged by the degradation of environment and modern so called development (Aguila, 2020). The major cause of global warming is carbon dioxide (CO_2) that is the most common greenhouse gas, and irremediable consequences could be accepted due to its excessive presence in environment. Since 1900 till 2018, the average atmospheric absorption of carbon dioxide was augmented by 38.8% globally. Earth's atmospheric environment has been covered by six hundred billion tons of carbon dioxide gas since last more than twenty years. In 2019, carbon emissions were reached to 45 percent more than the emissions in year 2000 and this number of carbon emissions is increasing day by day. Instead of carbon dioxide gas, many other gases like fluorinated water vapour, nitrous oxide and methane are also creating greenhouse effect. There are many other reasons of carbon emission in environment but the major cause is the madness of improving life style or living standards of human beings in the whole world that is linked to worldwide increasing consumption of energy resources to get all the requirements of a qualitative life. Environmental Kuznets Curve shows that initially in the process of economic developmental activities carbon emissions are increased but after a certain limit, these emissions are decreased automatically (Buneris, 2021).

Pakistan is one of the less developed countries of South Asia. Pakistan is growing fast economically and expectedly the same momentum of economic growth will be continued in coming years. The main sector of Pakistani economy was agriculture in the beginning but with the passage of time, industrial sector and service sector were grown rapidly and agricultural sector was deprived. Increasing population of Pakistan also created the scene of deforestation. Environment has been degraded as a result of increasing industrial sector growth. There is high demand of energy that is being fulfilled by conventional resources of energy (Khan et al., 2020).

This paper, not only evaluates the impact of GDP per capita on Carbon emissions in Pakistan but also the impact of sectors of GDP (agriculture, industry and services) is also considered. Other variables like foreign direct investment, foreign trade, exports and gross fixed capital formation were also included as explanatory variables in the estimation analysis. These variables were collected from existing empirical literature on the specific topic.

Same type research paper was published by Bashir et al., (2020) where authors considered exports growth, energy growth, population growth, agriculture, industry and services sector as explanatory variables. Three explanatory variables including agriculture, industry and services sector are common in both papers but others are different. We additionally applied VAR estimation technique to explain dynamic behaviour of explanatory variables. Our data set is up to 2020 as well.

Organization of the study includes introduction, literature review, material and methods, results and conclusion. References are also attached at the end of paper.

REVIEW OF LITERATURE

Litavcova and Chovance (2021) applied autoregressive distribution lag (ARDL) bound testing methodology to estimate the results for Danube region countries over the period of (1990-2019). The dependent variable was (CO_2) and independent variables were economic growth, energy consumption. Authors explored the long-run and short-run causal relationship between gross domestic product and energy consumption. Economic growth exerted positive and significant impact on carbon dioxide emissions and showed the interconnectedness of energy consumption, economic growth and (CO_2) emissions.

Osadume, R. (2021) wrote a paper to check the effect of economic growth over CO_2. Covering the data period 1980-2019, the authors employed panel econometric methods of statistical analysis for West African Countries. The dependent variable was carbon dioxide emissions and independent variables were population growth and real GDP. The outcome indicated that population growth and real GDP show a significant and positive effect on the carbon dioxide emission (CO2). They examined that 1% rise in the real gross domestic product resulted to 3.11% unit rise in carbon emissions.

Shikwambana et al., (2021) wrote a paper to see the link between economic growth and carbon emissions in South Africa. Covering the period (1994-2019) the data was taken from the World Bank's WDI indicators' (2021) namely gross domestic product and carbon dioxide emissions. Authors explored environmental Kuznets curve as well. The dependent variable was carbon dioxide and independent variables were black carbon, sulfur dioxide and GDP. The results indicated a strong positive linear correlation between GDP and carbon CO_2 emissions. The association between GDP and CO2 emissions showed a concentrated coefficient of correlation (0.05). The results indicated that emission levels were generally correlated with economic growth.

Zhang, J. (2021) wrote a paper "Environmental Kuznets curve hypothesis on carbon dioxide emissions: Evidence for china". During the period (1971-2014), authors used annual time series data and employed ARDL bound testing technique for estimation. The dependent variable was carbon dioxide emissions and the independent variables were energy consumption and GDP. The empirical results showed the N- shape relationship between carbon dioxide emissions and real gross domestic product per capita in long run. Energy consumption affected (CO2) positively while negative impact of urbanization on carbon dioxide emissions was found out in the long run.

Farouq, I. S. (2021) explored the cross country data covering the period 1980-2019) for Sub Saharan African countries. Researcher used linear panel estimation regression model. The dependent variable was carbon dioxide and independent variables were GDP and financial globalization. The empirical results showed that globalization has negative impact on carbon dioxide emissions. GDP showed positive relation with carbon dioxide emissions.

Wen, J. et al., (2021) wrote a paper and scrutinized the consequence of energy consumption, globalization and economic growth over carbon dioxide emissions during period (1985-2018) under the environmental Kuznets curve (EKC). They applied fully modified ordinary least square model (FMOLS). Dependent variable was Carbon dioxide emissions and independent variable was globalization. Results showed that globalization was positively associated with carbon dioxide emissions.

Pilatowsk, M et al., (2020) wrote a paper to assess the impact growth, nuclear and renewable energy consumption over carbon emissions in Spain. Authors used annual data for the period (1997-

2018). The authors estimated threshold autoregressive vector model. Authors found that economic growth and carbon dioxide emissions are positively correlated during expansion but negatively during recession. They found that increasing consumption of nuclear energy clues to reduced carbon dioxide emissions in case of boom otherwise negative and insignificant.

Khan, M. K. et al., (2020) used annual time series data for the period (1965-2015). They employed autoregressive vector model and used (ADF) techniques. The dependent variable was carbon dioxide and independent variables were economic growth, coal consumption, oil consumption and natural gas. They estimated that economic growth has positive impact on the carbon emissions and coal consumption indicates positive effect on (CO_2) emissions in Pakistan. Natural gas shows insignificant and positive impact on carbon dioxide emissions in case of Pakistan.

Liu, M. et al., (2020) employed technological model and conducted the empirical analysis by applying a semi-parametric panel fixed effect model to check the effect of globalization on carbon emissions in G-7 countries. Covering the data period (1970-2015), the dependent variable was (CO_2) emissions and independent variables were elasticity, energy consumption and gross domestic product. The results showed that relationship between globalization and carbon emissions is inverted U-shaped that strongly supports the hypothesis of environmental Kuznets curve. Results further showed that rising economic output is connected positively with carbon emissions. The growth of globalization applies a substantial and positive impact on carbon emissions.

Osobajo, O. A. et al., (2020) checked the relation of economic growth and energy consumption on carbon dioxide emissions' levels by evaluating the data from 70 countries during the period of (1994-2013). The dependent variable was carbon dioxide and the independent variables were population growth, capital stock and economic growth. These variables showed a two-way relationship with carbon dioxide emissions but energy consumption showed a one-way association with carbon emissions. The estimated pool ordinary least square (OLS) and fixed effect method both explained the strong association between carbon emissions and its determinants.

Nam, K.et al., (2020) applied functional coefficient model to estimate the results for the data period 1971-2017. Dependent variable was carbon dioxide and independent variable was income elasticity. Results showed that in rich countries, income elasticity is decreased while it is increased in case of poor countries.

Odugbesan, J. A. & Rjoub, H. (2020) employed ARDL bound testing estimation technique for data analysis in 'MINT' countries. Annual time series data was collected from World Development Indicators (2018). Dependent variable was carbon dioxide emissions and independent variables were energy consumption, urbanization and economic growth. According to findings there was association between energy growth and CO_2 in case of Mexico in long run while in short run two-way causality was found out between economic growth and CO_2.

Adedoyin, (2020) wrote a paper for economies of BRICS countries. Authors used annual time series data from period 1990-2014. They applied the ARDL technique and fixed effect model. The dependent variable was carbon dioxide emissions and independent variables were coal, consumption and coal rent. The empirical results showed that coal rent and coal consumption showed significant and negative association with carbon dioxide emissions.

METHODOLOGY

To prevent the danger of misleading findings from spurious regression, the most necessary task is to check stationarity of collected variables. There are many tests that can be used for unit root checking but here we applied Augmented Dickey Fuller (ADF) unit root test.

There are various techniques that can be used to check the co-integration between the variables. Some techniques are Engle and Granger, (1987), Johansen and Juselius, (1990) and Johansen, (1995) The requirements of the above mentioned techniques is that the data should be stationary at same order either at level or first difference. Pesaran et al., (2001) introduced a technique that is named as Autoregressive Distributive Lag (ARDL) bound testing for cointegration analysis in case of the situation when some variables are stationary at first difference and some are level stationary.

ARDL bound testing approach is employed both for endogenous and exogenous variables. There are many advantages for using ARDL bound testing approach.

1- Small and limited data sets can be accommodated in estimations in case of ARDL model.

2- No need to check stationarity of variables in ARDL but no variable should be stationary at second difference.
3- Short run and long run association of variables can be calculated at the same time.

The initial shape of Kuznets curve in case of sectoral growth and carbon emissions in case of Pakistan is as under:

$$co_2 = f(fdin, lagric, l\exp t, lfc, \lg dpc, lidy, lserc, ltde) \quad (1)$$

Logarithmic transformed shape of equation (1) will be as under:

$$co_2 = \beta_0 + \beta_1 fdin_t + \beta_2 lagric_t + \beta_3 l\exp t_t + \beta_4 lfc_t + \beta_5 \lg dpc_t + \beta_6 lidy_t + \beta_7 lserc_t + \beta_8 ltde_t + \mu_t \quad (2)$$

co_{2t} is showing carbon emissions per capita (log was not taken), $fdin_t$ is used for net inflow of foreign direct investment(already in % of GDP, so log was not taken), $lagric_t$ stands for log of value addition of agriculture, forestry and fishing , $l\exp t_t$ is used for log of exports of goods and services , lfc_t is showing log of gross fixed capital formation , $\lg dpc_t$ is log of GDP per capita, $lidy_t$ stands for log of value addition of industry including construction, $lserc_t$ stands for log of value addition of services, $ltde_t$ is used for log of trade openness and u_t is used for error term where t shows that data is time series. β_s are coefficients of regression.

Several steps are followed in the estimation analysis of ARDL model. Initially F. statistics is calculated and then compared to the lower and upper bounds of critical values given by Pesaran et al., (2001). If the calculated F. statistics value is greater than upper bound value, we come to the conclusion that long run relationship is existed among variables to be estimated. If calculated value is less than the lower bound value, no cointegration is existed. Finally, if the calculated value neither smaller than lower bound nor greater than upper bound, results will be inconclusive about long run relationship existences among variables. Then, we move further if there is existence of long run relationship.

$$co_{2t} = \alpha_0 + \sum_{i=1}^{p} \delta_i co_{2t-i} + \sum_{j=1}^{8} \sum_{j=0}^{qj} \theta_{ij} W_{jt-i} + \varepsilon_t \quad (3)$$

W_t is representing vector of explanatory variables, ε_t stands for error term, ε_t represents the error term, δ_t is used for long run coefficients and p and q_j show lag length that is decided by Schwartz Information Criteria, final prediction error and Akaike Information Criteria for mentioning the specification of ARDL model. Here in this research, due to small sample data covering less than sixty observations, Akaike Information Criteria was preferred due to the reason mentioned by Liew (2004) that it useful in this case.

This study selects the AIC to calculate the optimal lag values since the AIC is a more useful in case of a small sample, which is less than 60 observations (Liew 2004). Short run estimation of relationship among variables through error correction model is the last step of ARDL model that is as under:

$$\Delta co_{2t} = \gamma_0 + \sum_{i=1}^{p} \pi_i \Delta co_{2t-i} + \sum_{j=1}^{8} \sum_{j=0}^{qj} \eta_{ij} \Delta W_{jt-i} + \phi ECT_{t-1} + e_t \quad (4)$$

π_i and η_j represent short run coefficients, ϕ shows the parameter of speed adjustment of error correction term(ECT_{t-1}). Sign of ϕ should be negative (-1 to 0) and it should be significant for converging the system in long run. Negative ϕ corrects lagged errors.

Data

Annual time series data for the period (1971-2020) was collected from World Development Indicators(WDI;2021). All the descripted data details have been attached as Appendix-A at the end of paper.

Vector Auto Regression (VAR)

ARDL bound testing approach gives always point estimators, so it is called fixed parametric approach. We cannot judge the relationship among variables of interest on the basis of only point estimators. In our research study, determinants of carbon emissions only tell about the positive and negative aspect of relationship on average. It was necessary to know about the complete response of carbon emissions as a result of shocks in its relevant determinants. It was also necessary to know about the intensity of the most affecting determinant of carbon emissions in our research study. For that purpose, we employed vector auto regression (VAR) analysis. This estimation technique tells about impulse response function and variance decomposition analysis.

RESULTS

Unit Root Tests

A high standard Augmented Dickey Fuller (*ADF*) test was applied to check the unit root in variables. It is clear from table 1 that two variables like net inflow of foreign direct investment and trade openness are stationary at level. All other variables like value addition of services sector, value addition of industry, value addition of agriculture, GDP per capita, gross fixed capital formation and exports (goods and services) including dependent variable carbon emissions are stationary at first difference

Table 1: ADF Unit Root Test for ARDL

Variables	Level		First Difference		Order of Integration
	Intercept	Trend & Intercept	Intercept	Trend & Intercept	
co_2	0.407	-3.976*	-6.554**	-6.418**	I(1)
$fdin$	-2.966*	-3.417*	-4.816**	-4.769**	I(0)
$lagric$	-2.187	-1.899	-6.816**	-7.060**	I(1)
$lexpt$	-2.984*	-2.859	-7.232**	-7.490**	I(1)
lfc	-2.138	-2.308	-5.533**	-5.636**	I(1)
$lgdpc$	-0.833	-2.378	-6.190**	-6.172**	I(1)
$lidy$	-2.210	-2.785	-7.889**	-7.890**	I(1)
$lsrce$	-1.484	-2.462	-6.142**	-6.119**	I(1)
$ltde$	-3.990**	-3.810*	-7.457**	-7.902**	I(0)
Critical Values(1 %)	-3.574	-4.170	-3.574	-4.170	
Critical Values(10 %)	-2.600	-3.186	-2.600	-3.186	

$co_2, fdin, lagric, lexpt, lfc, lgdpc, lidy, lsrce$ *and* $ltde$ *represent carbon emissions, foreign direct investment net inflow, agricultural sector growth, exports, gross fixed capital formation, gdp per capita, industrial sector growth, services sector growth and foreign trade.*

Note: **, * shows one percent and ten percent significance level respectively.

The Bounds Test

To check the long run association among variables of interest, ARDL bound testing approach was employed. Bound test reports the most sensitive F.statistics' values during testation of long run relationship. Here, to know about the lag length, AIC was chosen as it is very useful in very small samples of time series data. Optimal lag length and bound test suggested by AIC is (1,0,0,1,1,0,0,0) for ($co_2, fdin, lagric, l\exp t, lfc, \lg dpc, lidy, lsrce, ltde$). Table-2 shows that calculated F. statistics is (3.319) that is greater than the upper bound critical values at 5 % significance level. This situation suggests the existence of long run association between carbon emissions and its economic determinants in Pakistan. Our results regarding calculated F. statistics are in line with the results presented by Pal and Mitra, (2017) where a comparison of econometric models were made between India and China. Our findings are in contrast with the findings of Jayanthakumaran et al., (2012) who presented an inconclusive result as the calculated F. statistics was neither greater than upper bound nor smaller than lower bound critical values given by Peasaran, et al., (2001).

Table 2: Bound Test

Dependent Variable: co_2	F.Statistics	5 % critical values bound test I(0)	I(1)	Cointegration Exists
Model: (1,0,0,0,1,1,0,0,0) $co_{2(fdin,lagric,l\exp t,lfc,\lg dpc,lidy,lsrce,ltde}$	3.319	2.11	3.15	Yes

Table-3 is showing results of long run relationship between carbon emissions and its relevant determinants in Pakistan. Foreign direct investment has positive and significant effect upon carbon emissions in Pakistan. Investment from foreign countries to Pakistan creates employment opportunities for local persons to increase aggregate demand as a result of increase in GDP growth. Increasing growth process results in shape of carbon emissions from industry and transportation. FDI is the source of increase in total factor productivity of the recipient country that can cause carbon emissions through industry growth. Huang et al., (2022) resulted that positive association was seen between foreign direct Investment and co_2 emissions in the developed countries having regulatory quality controls. Value addition in agriculture is showing negative impact on carbon emissions. This result is in line with Israel et al., (2020) where authors concluded that households having access to extension services, households having higher education and the rich households involved in agriculture do not become the cause of carbon emissions. Authors recommended that climate-smart agriculture system should be adopted in agriculture to prevent from carbon emissions.

Exports of goods and services have negative but insignificant effect on carbon emissions. Our result is same with Haq et al., (2022) who concluded that variety of exports showed insignificant results with carbon emissions in long run while in short run, export variety reduced the degradation of environment. Bashir et al., (2020) also concluded that exports reduce carbon emissions in Pakistan. Negative and significant relationship was found out between gross fixed capital formation and carbon emissions, GDP per capita showed positive and significant association with carbon emissions and trade openness was found out having positive but insignificant relation with carbon emissions. These results are in line with the results presented by Rauf et al., (2018) who concluded that carbon emissions were affected positively by economic growth and gross fixed capital formation while negatively by trade openness.

Industry value addition affected carbon emissions negatively and significantly. This finding is contrary to conclusion of Mentel et al., (2022) who founded positive relation between share of industry in GDP and carbon emissions. Authors further said that carbon emissions can be reduced by using the renewable electricity. This result is also contradicting the findings of Bashir et al., (2020) who found positive association between industry growth in Pakistan. Reason of negative results in our case may be the only value addition adoption in regression analysis otherwise the industrial sector growth showed positive relation with carbon emissions that has been presented by many authors in case of Pakistan. Value addition of services showed negative but insignificant relation with carbon emissions. This result is in line with Bashir et al., (2020) who concluded that services sector growth affected negatively the carbon emissions in Pakistan.

Table 3: Long run dynamics

Variables	Coefficients	t- statistics	P. Values
Dependent Variable: : co_2		Restricted Constant with no trend	
$fdin$	0.083	1.960	0.058
$lagric$	-4.122	-2.191	0.035
$lexpt$	-0.293	-0.656	0.516
lfc	-1.705	-1.903	0.065
$lgdpc$	0.547	2.304	0.027
$lidy$	-3.563	-1.895	0.066
$lsrce$	-4.755	-1.623	0.113

ltde	0.871	1.215	0.223
c	18.545	1.975	0.056

ARDL model is transformed into Error Correction Model (ECM) for estimation of short run dynamics. Term used to check the speed of adjustment from short run to long run is called error correction term(ECT). This term should be negative in sign and significant for the evidence of convergence from short run to long run. Table-4 shows that there is clear evidence of convergence to long run as the error correction term is significant and negative. All residual diagnostic tests like LM test, ARCH test and white test confirmed that there is absence of auto correlation, heteroscedasticity and multi collinearity. Normality assumption was also confirmed by J-B test.

Table 4: Short run dynamics

Variable	Coefficient	t-statistic	p. value
ect(−1)	-0.201	-6.424	0.000
Residual Diagnostic Tests(F. Statistics)			
B.G. LM Test	1.727		0.842
ARCH Test	0.123		0.727
White Test	1.502		0.172
J-B Test	1.008		0.604
R^2	0.424		

Stability of estimators in model is checked by Cumulative Sum of Squares (CUSUMSQ) and the Cumulative Sum (CUSUM) tests as shown in figure-1 and figure-2. The blue curved line starting from zero point shows the cumulative sum of deviances. The black horizontal line moving towards right starting from zero is the central point. The dashed lines are the controlling limits used to show the standard deviations from central straight horizontal line. It is clear from figures that critical limits are not crossed by blue curved line that shows the stability of our estimators in ARDL model.

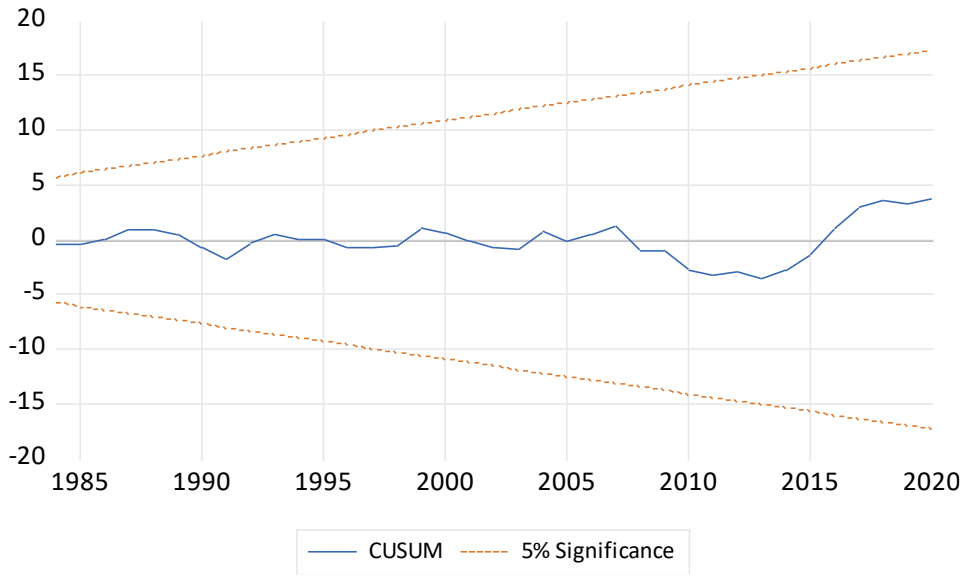

Figure 1: CUSUM Test

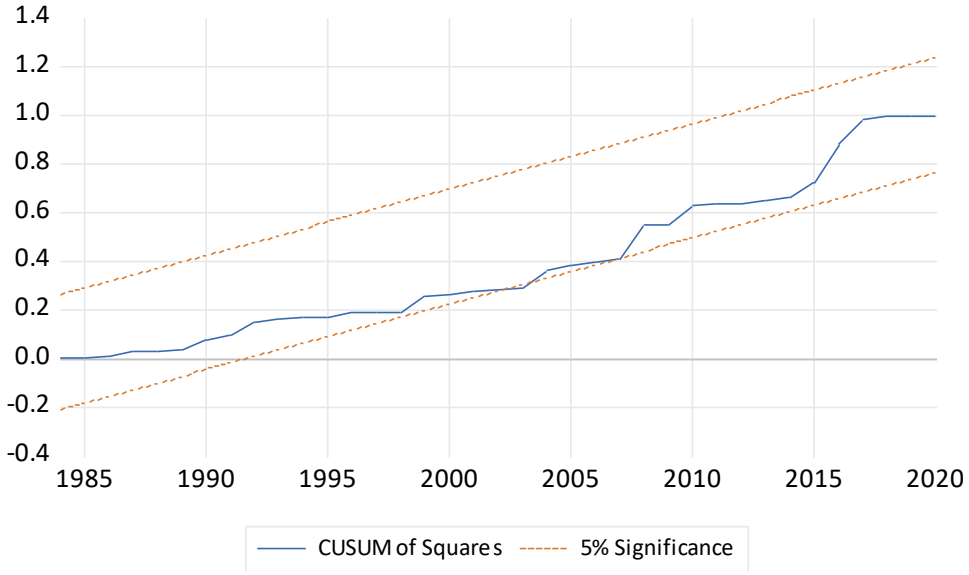

Figure 2: CUSUMQ Test

Results VAR

Before employing VAR technique of estimation, we converted all first differenced stationary variables into differenced shape. Then we applied again ADF unit root test on differenced data series to check the stationarity of all variable. Table-5 indicates that all variables are stationary at level. It is to be noted that three explanatory variables were dropped due to their insignificance in explaining the carbon emissions in Pakistan during ARDL analysis. VAR test was employed on remaining significant explanatory variables foreign direct investment, agriculture, gross fixed capital formation, GDP per capita and industry.

Table 5: ADF Unit Root Test

Variables	Level		First Difference		Order of Integration
	Intercept	Trend & Intercept	Intercept	Trend & Intercept	
co_2	-6.554**	-6.418**	-11.110**	-10.992**	I(0)
$fdin$	-2.966**	-3.417**	-4.816**	-4.769**	I(0)
$dlagric$	-6.816**	-7.060**	-9.738**	-9.635**	I(0)
$dlfc$	-5.533**	-5.636**	-7.469**	-7.370**	I(0)
$dlgdpc$	-6.190**	-6.172**	-7.726**	-7.641**	I(0)
$dlidy$	-7.889**	-7.890**	-8.980**	-8.876**	I(0)
Critical Values(1 %)	-3.574	-4.170	-3.574	-4.170	
Critical Values(10 %)	-2.600	-3.186	-2.600	-3.186	

$co_2, fdin, lagric, lfc, lgdpc$ *and* $lidy$*represent carbon emissions, foreign direct investment net inflow, agricultural sector growth, gross fixed capital formation, gdp per capita ansindustrial sector growth.*

Note: **, * shows one percent and ten percent significance level respectively.

Lag Selection:

First step in estimation of vector auto regression (VAR) analysis is to check lag length of all variables to be estimated. There are different criterions to confirm lag selection in VAR estimation but we preferred Akaike Information Criteria (AIC). Table-6 shows that lag 1 is recommended by most criterions as suitable lag length.

Table 6: Short run dynamics

Lag	LogL	LR	FPE	AIC	SC	HQ
0	482.0108	NA	4.14e-17	-20.69612	-20.45760*	-20.60677
1	541.0912	100.1799*	1.54e-17*	-21.69962*	-20.02999	-21.07416*
2	566.3378	36.22330	2.66e-17	-21.23208	-18.13134	-20.07052
3	592.7534	31.00964	5.03e-17	-20.81536	-16.28351	-19.11771

Stability Test

Stability of VAR model is always tested by eigenvalue test. If all values are found in the unit circle, VAR model is considered as stable model. Figure-3 is showing the inverse root of auto regression. On the basis of evidence, we can say that our VAR model is stable in determining the relevant factors affecting carbon emissions in Pakistan as all the values are located in the unit circle.

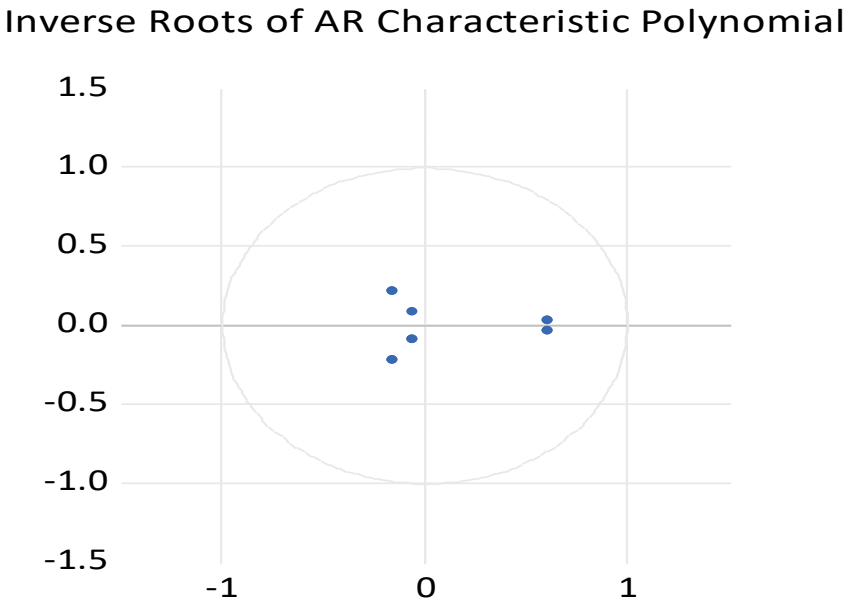

Figure 3: Inverse Roots of AR

Impulse Response Function

Variance decompositions(VDCs) and impulse response functions (IRFs) are used for analysing the dynamic properties of the system. All variables die out to zero after a maximum years' shock. Impulse response functions indicate the impact of all determinants of carbon emissions in Pakistan in figure-4. Response of carbon emissions as a result of shock in carbon emissions itself is positive till year 3 and after that it is negative before dying out to zero. Response of carbon emissions as a result of shock in value addition in agriculture is negative from year one till year 3, positive during years 3 and 4 and dies out to zero after that. Response of carbon emissions as a result of shock of gross fixed capital formation is positive from year one till year 4, zero during years 4 and 5.5, negative during years5.5 till 7.5 and dies out to zero after that. Response of carbon emissions as a result of shock in GDP per capita is mostly positive from year one till year 5, minor negative during year 2 and dies out to zero after that. Response of carbon emissions as a result of shock of value addition in industry is positive from year one till year 4 and negative during years 5 till 8 and dies out to zero after that. Response of carbon emissions as a result of shock in foreign direct investment is negative from year one till year 8 and dies out to zero after that.

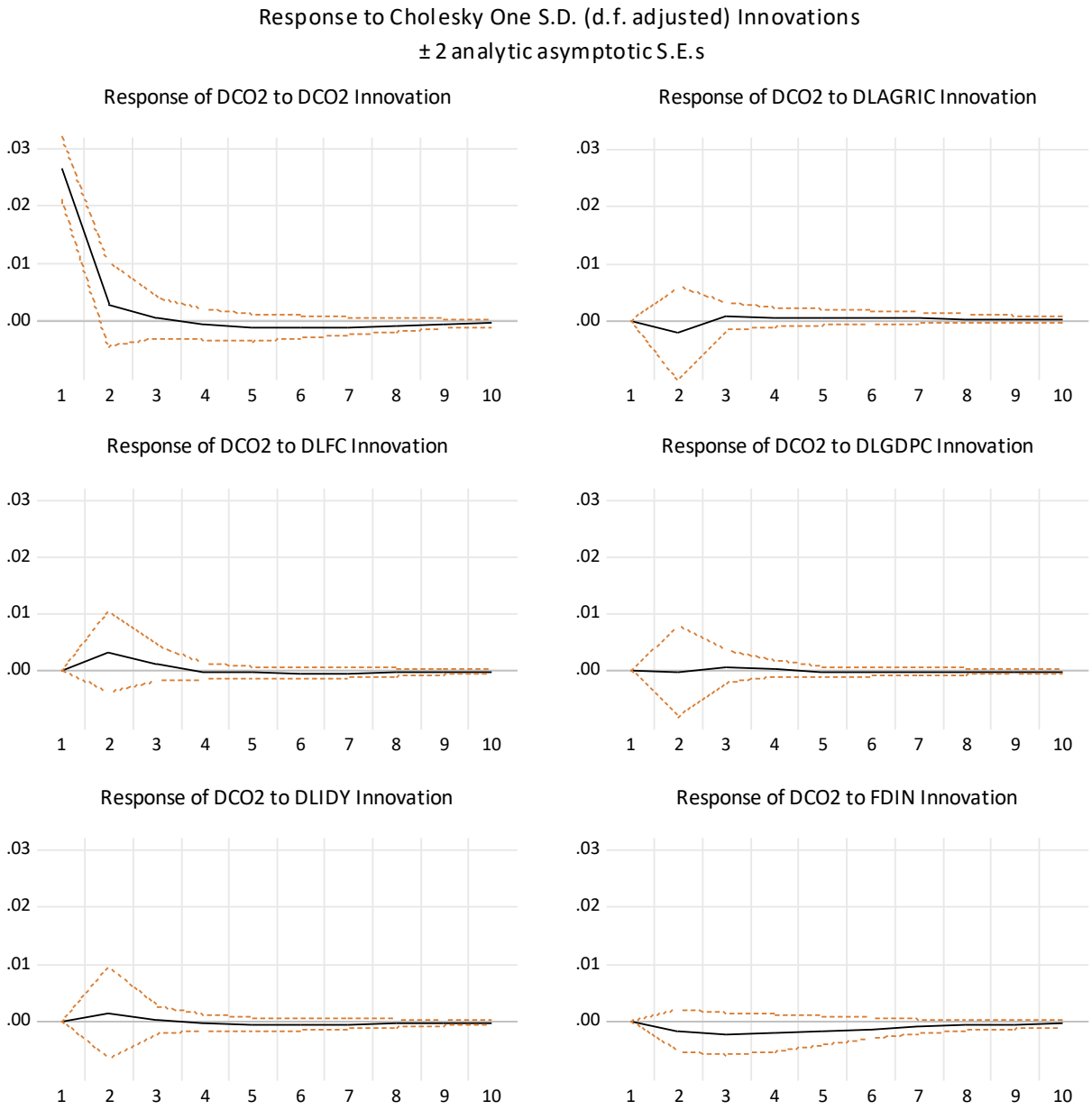

Figure 4: Impulse Response Functions

Variance Decomposition Analysis

Variance decomposition analysis shows how much response of dependent variable comes out by shocks in independent variables (Koengkan et al.,2019, 2020). Table-7 shows the results of variance decomposition analysis of carbon emissions and its determinants like agriculture, gross fixed capital formation, GDP per capita, industry value addition and foreign direct investment. We considered twelve-year window to explain variance decomposition analysis. 45 percent of carbon emissions were affected by carbon emission itself shown in column 3 of table-7. Columns 4, 5, 6, 7 and 8 are showing that carbon emissions are affected 8 percent by agriculture value addition, 13 percent by gross fixed capital formation, 12 percent by GDP per capita, 8 percent by industry value addition and 14 percent is affected by foreign direct investment.

Table 7: Variance Decomposition Analysis

Period	S.E.	dco2	dlagric	dlfc	dlgdpc	dlidy	fdin
1	0.026314	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.028874	83.08696	0.218626	4.422354	3.204876	2.310700	6.756483
3	0.029640	79.04368	1.130221	4.217910	6.224865	2.777993	6.605330
4	0.029885	77.81825	1.427884	5.060495	6.181200	2.740026	6.772142
5	0.033325	69.61484	1.768974	7.283150	7.851066	6.325898	7.156076
6	0.035629	60.93034	7.553870	9.402623	9.646840	5.584649	6.881674
7	0.038417	55.82635	7.273537	8.968239	8.910919	5.660448	13.36050
8	0.041798	51.20933	8.816392	7.590529	12.50384	5.410448	14.46946
9	0.043725	47.59885	8.286046	12.22025	11.44765	7.174506	13.27270
10	0.043963	47.27187	8.490585	12.17560	11.53648	7.329322	13.19615
11	0.045260	46.27411	8.140002	13.09937	11.44650	8.142862	12.89716
12	0.045849	45.10094	7.997580	12.78847	11.99819	8.012161	14.10265

CONCLUSION

The basic aim to write this research paper was to assess the impact of relevant determinants like GDP per capita and sectoral growth on carbon emissions in Pakistan. Latest annual time series data set was collected from World Bank Indicators during period 1971-2020 due to unavailability of data of some variables for year 2021. ARDL bound testing and simple VAR techniques of estimation were employed to create uniqueness in analysis.

According to ARDL bound testing foreign direct investment has positive and significant effect upon carbon emissions in Pakistan. Value addition in agriculture is showing negative impact to carbon emissions. Exports of goods and services have negative insignificant effect on carbon emissions. Negative and significant relationship was found out between gross fixed capital formation and carbon emissions, GDP per capita showed positive and significant association with carbon emissions and trade openness was found out having positive but insignificant relation with carbon emissions. Industry value addition affected carbon emissions negatively and significantly. Value addition of services showed negative but insignificant relation with carbon emissions.

Impulse response function indicates the impact of all determinants of carbon emissions. Response of carbon emissions as a result of shock in carbon emissions itself is positive till year 3 and after that it is negative before dying out to zero. Response of carbon emissions as a result of shock in value addition in agriculture is negative from year one till year 3, positive during years 3 and 4 and dies out to zero after that. Response of carbon emissions as a result of shock of gross fixed capital formation is positive from year one till year 4, zero during years 4 and 5.5, negative during years5.5 till 7.5 and dies out to zero after that. Response of carbon emissions as a result of shock in GDP per capita is mostly positive from year one till year 5, minor negative during year 2 and dies out to zero after that. Response of carbon emissions as a result of shock of value addition in industry is positive from year one till year 4 and negative during years 5 till 8 and dies out to zero after that. Response of carbon emissions as a result of shock in foreign direct investment is negative from year one till year 8 and dies out to zero after that.

According to variance decomposition analysis, 45 percent of carbon emissions were affected by carbon emissions itself. Carbon emissions are affected 8 percent by agriculture value addition, 13 percent by gross fixed capital formation, 12 percent by GDP per capita, 8 percent by industry value addition and 14 percent is affected by foreign direct investment.

Relevant authorities should focus on checking the impact of sectoral growth on carbon emissions. On the basis of findings, we can say that climate- smart agriculture technology should be adopted, emissions free apparatus should be installed in industry and environment friendly services should be provided to prevent from environmental degradation.

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Appendix-A:

Code	Indicator Name	Long definition
EN.ATM.CO2E.PC	CO2 emissions (metric tons per capita)	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.
NY.GDP.PCAP.CD	GDP per capita (current US$)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.
BM.KLT.DINV.WD.GD.ZS	Foreign direct investment, net outflows (% of GDP)	Foreign direct investment refers to direct investment equity flows in an economy. It is the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy. Ownership of 10 percent or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship. This series shows net outflows of investment from the reporting economy to the rest of the world, and is divided by GDP.
NE.TRD.GNFS.ZS	Trade (% of GDP)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
NV.AGR.TOTL.ZS	Agriculture, forestry, and fishing, value added (% of GDP)	Agriculture, forestry, and fishing corresponds to ISIC divisions 1-3 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or

		depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 4. Note: For VAB countries, gross value added at factor cost is used as the denominator.
NE.GDI.FTOT.ZS	Gross fixed capital formation (% of GDP)	Gross fixed capital formation (formerly gross domestic fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.
NV.I ND.TOTL.ZS	Industry (including construction), value added (% of GDP)	Industry (including construction) corresponds to ISIC divisions 05-43 and includes manufacturing (ISIC divisions 10-33). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 4. Note: For VAB countries, gross value added at factor cost is used as the denominator.
NE.EXP.GNFS.ZS	Exports of goods and services (% of GDP)	Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income

		(formerly called factor services) and transfer payments.
NV.SRV.TOTL.ZS	Services, value added (% of GDP)	Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The industrial origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3 or 4.