Agricultural Productivity and CO_2 Emission in Pakistan: An Econometric Analysis

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Abstract-This paper inspects association between carbon dioxide emission and agricultural productivity in Pakistan. The time series data from (1966-2014) has been taken for analysis. Kendrick's model is used to determine total agricultural productivity (AGP) and optimization is found with the help tool of the Langrage Multiplier. The order of integration is decided by Ng-Perron test. This test points out that both variables are integrated of order one 1(1). The short run impact of CO_2 emission on AGP is found by using the technique of the vector autoregressive regressive (VAR). Jhonson Cointegration technique (JCT) was used to detect long- term connection between variables. The results show there is no short- term and long- term co-relationship between the CO_2 emission and AGP. The results of the impulse response functions show behavior of influence of the both variables. The results of variance decomposition show the variation in AGP and carbon dioxide emission (CDE). The findings of Granger causality test indicate that there is not a unidirectional causality from CDE to AGP.

Key Words- CO_2 emissions; agricultural productivity; Johansen cointegration; Pakistan

1. Introduction

The atmospheric situation which exist for some days is known as weather, whereas, climate overcome for a term, decapod or a centum. Fossil fuel is used to meet the energy requirements. Nevertheless, some The gases are added in the ambiance due to burning of fossil fuels which bring changes in the climate with the passage of time. More precisely, burning of fossil fuel produces Carbon dioxide emission (CO_2), Nitrous Oxide (N_2O), Methane (CH_4), and water vapors and thus, these gases are called Greenhouse gases [1]. The burning of squanders, wood, carbon, and fossil fuels formulate CO_2. The deforestation massive use of fossil fuels, wood and carbon dioxide emission has increased concentration of CO_2 from 280 kt to 380 kt. [2, 3, 4, 5] emphasize that the burdens of climate variation put negative impact on crops yields. The various researchers emphasize that climate change heavily effect on agriculture production in developing countries' economy [6, 7].

As IMF reported in Pakistan agriculture sector supports the several people and seventy percent provides employment opportunities [8]. In refs. [9, 10, 11] it is shown that agricultural sector creates revenue from export, supplies raw materials for domestic agro-industries, foreign agro-industries and play major role in contribution of Gross domestic Product (GDP). As a result, the whole economy is influenced by any negative shock to the agricultural sector which provides pollution in atmosphere. An increase in crops biomass and yields take place due to increases in carbon dioxide concentration in the atmosphere, or carbon fertilization (CF) [12, 13]. In refs. [14, 15, 16] it is shown about 70–90% of anthropogenic CO_2 emissions is attained by burning of fossil fuels.

Since CO_2 emission heavily affect the scenario of weather variation, therefore, association with agricultural productivity in Pakistan.

Thus, the ratio of agricultural outputs to agricultural inputs is called agricultural productivity. The several strategic factors which explain the concept of emission of CO_2 in many shapes like consumption of nuclear energy, agricultural productivity, and economic growth. Many researchers' studies examined the causal associations of CO_2 emissions with agricultural productivity and economic growth. They concluded carbon dioxide emission produced contamination in high level income and low level income nations [17, 18, 19, 20, 21, 22]. Some variables from these studies affect CO_2 emissions positively; some other variables influenced CO_2 emissions negatively, consisting on the integration of the variables, selection of time period and method of empirical analysis. Similarly, in refs. [23, 24, 25, 26,] it has been investigated mixed results. The researcher finds positive association between CO_2 emission and GDP for 36 developed countries over the span 1980-2005 under the applications of Environment Kuznets Curve (EKC) hypothesis [27]. Some studies are suggested that this test is fit for analysis to find association between these variables. The unit root test is employed to find order of integration between these two variables and Johnson co-integration test is employed to detect the long-term association between carbon dioxide (CO_2) emissions and GDP [2]. The deforestation massive use of fossil fuels, wood and carbon dioxide emission has increased concentration of CO_2 from 280 kt to 380 kt. [2, 3, 4, 5] emphasize that the burdens of climate variation put negative impact on crops yields. The various researchers emphasize that climate change heavily effect on agriculture production in developing countries' economy [6, 7]. As IMF reported in Pakistan agriculture sector supports the several people and seventy percent provides employment opportunities [8].

In refs. [9, 10, 11] it is shown that agricultural sector creates revenue from export, supplies raw materials for domestic agro-industries, foreign agro-industries and play major role in contribution of Gross domestic Product (GDP). As a result, the whole economy is influenced by any negative shock to the agricultural sector which provides pollution in atmosphere. An increase in crops biomass and yields take place due to increases in carbon dioxide concentration in the atmosphere, or carbon fertilization (CF) [12, 13]. In refs. [14, 15, 16] it is shown about 70–90% of anthropogenic CO_2 emissions is attained by burning of fossil fuels. The both series GDP and carbon dioxide (CO_2) emissions are integrated of order one; consequently, they are co-integrated in long-term. Additionally, the generalized method of moments (GMM) finds panel causality between these two variables under the setting of a vector error-correction mechanism (VECM). He founds unidirectional causality from real GDP to per capita CO_2 emission in the both short-term and long-term. The EKK test is empirically approved for Malta, Portugal, Oman, Portugal, the United Kingdom and Greece. Nevertheless, it can be observed that for the whole panel, if a one percent boosts in GDP, which creates a boost of 0.22 percent in the long -term and 0.68 percent in the short-term. However, the lower income elasticity does not give proof of an Environment Kuznets Curve (EKC) in the long-term. It also indicates that, CO_2 emissions stabilized in the rich countries over time.

The ARDL approach was used to find the dynamic causal associations among CO_2 emissions, foreign trade, output, and energy utilization in case of Turkey by the researcher [22]. It is investigated the causal associations among per capita agricultural energy utilization (oil, electricity, gas), real agricultural production, and power prices for Pakistan. They found a unidirectional causality from electricity utilization to agricultural production and from agricultural production to oil utilization by employing the Granger causality test. These authors recommend that agricultural output may be enhanced if governments develop the infrastructure and support financially rural people and reduce tariff on agricultural electricity and crops. To our knowledge, they employed the first econometrics techniques to find association between renewable energy and agricultural productivity [17]. The short-term and long-term associations between GDP, per capita CO_2 emanations, renewable and non-renewable energy utilization, agricultural value added and trade openness in Tunisia was investigated by them. They found long-term associations between these variables. Similarly, the studies of refs. [26, 30] found the dynamic causal association between agricultural production, carbon dioxide emanations, and energy utilization in France during the period 1960-2000.

The findings indicated that economic growth caused long- term power utilization and environment pollution, and they also investigated short run casual relation from power utilization to production growth. They also found that use of utilization of energy and emissions of carbon dioxide move in same direction. They investigated in their study, there is the long-term association between carbon dioxide emanations and power utilization in America for spanning 1850- 2002 [31]. They concluded intensity of CO_2 emissions increases by increasing population growth, fossil fuels, growth of power utilization and these factors manipulate the variables and it was significant. Seeing as carbon dioxide emanation have implication for agriculture productivity, variability among living organism, food supply, fresh water resources, air, water, sunlight, insects, microorganisms and health of human being in refs [34]. Nevertheless, many carbon dioxide emission. In refs. [32, 33] it is observed dynamic involvement between carbon dioxide emission and power utilization in America. They added variables, labor and capital in model and they concluded a significant nonnegative relationship between CO_2 emissions and power utilization. For the period of 1971-2009 it was investigated cointegration and casual association among CO_2 emanation, economic growth and power utilization in selected Southeast Asian countries [23]. For analysis, they used ARDL approach and Granger causality test. They investigated cointegration among
studies of refs [35, 36, 37, 38] have examined the impact of weather modify variables such as temperature, CO_2 emanation, sea level rise, rainfall, on agricultural productivity (AGP) and food supply. The supplementary assessments regarding these variables are available in the

studies of refs [39]. The researcher found the negative effect of GHG emanations on agricultural productivity [31]. He used methane and nitrous oxide emanations and GHG emissions, as a proxy for climate change and for analysis he used ARDL approach and found non-positive effect on AGP. In the same way, the studies of refs[33] found that climate change has negative effect on agricultural productivity and hundred percent boost in greenhouse emanation will lead to 22.26 percent turn down in agricultural productivity.

However, some studies also focus renewable energy sources depend on the mechanism of prices in certain countries. The renewable energy resources (RES) are worldwide distinguished as a appropriate choice for economic development in many off-grid applications [32]. The studies of refs [39] stated that the generator system and the wind turbine have solid influenced on the stabilization of wind generations. The energy system proposed minimum cost and the Hybrid components produced maximum power is picture of the techno-economic analysis [40]. [41] stated that fossil fuel sources are very limited and supply of fossil fuel resources are lagging behind for fossil fuel based electricity generation plants. [42] suggested that several researchers make debate over wide range of ML related areas and emerging of big Data for machines. [43] emphasize and his findings shows that the best model for predicting the global solar radiation of Ibadan is based on a quadratic temperature model. The studies of refs [44] predict improvement of the NAR model and he finds the value of coefficient 0.91, RMSE values about 15.5% and mean absolute error 23.89%. The research of [45] demonstrates in the study of time series meteorological records that the results of DRNNs are better over simple MLPs. The studies of [46] predict that without extensive long term weather data the artificial intelligence provide good optimization of system in the field of hybrid renewable energy system. Furthermore, in refs.[37], it is investigated the effect of artificial manufacturing carbon dioxide emission on agricultural productivity efficiency and wellbeing for the household for the period 2010-2030 by using a computable general equilibrium model.

The findings show that household welfare and agricultural total productivity negatively influenced by carbon dioxide emission. They projected real agricultural GDP was reduced 4.5 percent in the 2020s. He studied a variety of assumptions and suggested quantifiable statistical analysis is needed.

Exclusively, in this research the following questions are replied: (a) what is the effect of CO_2 emissions on the agriculture productivity in short run and long run? (b) What is casual relationship between these three variables? To answer these questions, for the Pakistan' economy Jhonson cointegration, VAR, Ng-Perron test at level and first difference, the impulse response function and the variance decomposition of CDE and AGP are used. The main objective of this research is to fill the gap about the impacts of CO_2 emission on the AGP, find the short-term and long-term correlations between CDE and AGP and is to determine the casual relationship between CDE and AGP.

2. Methodology

For a given function subject to equal constraints, the Lagrange multipliers method is used to determine the optimization. For finding the optimization, we selected two variables and one constraint:

maximize $f(\alpha, \beta)$

subject to $g(\alpha, \beta) = 0$.

Here it is assumed that both f and g are continuous function. For finding critical values, we take first partial derivatives of a function. A new variable (λ) induct in this system, which is called a Lagrange multiplier.

Langrangian expression may be defined as

$$F(\alpha, \beta, \lambda) = f(\alpha, \beta + \lambda\, [k-g(\alpha, \beta)] \quad \text{Ref [47]} \tag{1}$$

An arbitrary number of M constraints and an arbitrary n of choice variables constraints may be written as in the Lagrangian form;

$$F(\alpha_1, \dots\dots\dots \alpha_n, \lambda_1 \dots\dots\dots \lambda_m) = f(\alpha_1, \dots\dots\dots \alpha_n) + \sum_{k=1}^{m} \lambda k\, gk(\alpha 1, \dots \dots \dots \alpha n) \tag{2}$$

Now both explained and explanatory variables can be written as in shape of a model:

$$F\,(AGP, EC, \lambda) = F\,(AGP, CDE) + \lambda\, [k-g(AGP, CDE)]\ ; \tag{3}$$

AGP = Agricultural productivity, CDE = Carbon dioxide emission

In the above equation F (AGP, CDE, and λ) is called Langrangian function and F (AGP, CDE) is called objective function. The objective function is f(AGP, CDE) and the constraint of the function is g (AGP, CDE). In fact g (AGP, CDE) = 0, therefore, the product λ [k-g(AGP, CDE) = 0 The critical values of AGP, CDE and λ can be calculated by taking first partial derivate. Thus, critical values of AGP and CDE are given as:

$$F_{AGP}\,(AGP, CDE, \lambda) = 0 \tag{4}$$

$$F_{EC}\,(AGP, EC, \lambda) = 0 \tag{5}$$

2.1 Kendrick's model

Moreover, Kendrick's model may also be used to find total AGP, which is defined as follow:

$$\mathrm{TAPt} = \frac{\mathrm{VAt}}{\alpha \mathrm{Kt} + \beta \mathrm{Nt} + \eta \mathrm{Ct}} \quad [48] \tag{6}$$

In which TAPt shows total AGP, Kt for real capital VAt shows real value added of the sector, Nt shows labor force, Ct shows emission of carbon dioxide, α, β and η are the elastic ties of labor, emission of carbon dioxide and capital value added of agricultural product respectively [35]. For analysis, data of AGP and CDE have been taken from the following website: https://ycharts.com/indicators/pakistan_from 1966 to 2014. CDE was measured as in kilotons and collected from above web site. The value of AGP has been taken into dollar at current prices and carbon. Nevertheless, these series will be confirmed by statistical test. CDE was measured as in kilotons and collected from above web site. The value of AGP has been taken into dollar at current prices . Nevertheless, these series will be confirmed by statistical test.

2.2 Agricultural productivity

The ratio of agricultural outputs to agricultural inputs is known as Agricultural productivity. The Jhonson cointegration technique is used to determine long-term association between CDE and AGP and short-term association is found by VAR. The casual association is determined by use of Granger causality test. It is assumed that the vector Y_t has a VAR form as below:

$$Yt = \sum_{i=1}^{p} \Delta Yt - 1 + \beta Vt + \eta t \quad (7)$$

Where, Where Y_t is non-stationary vector and Yt is based on CDE and AGP ηt is used for an error term. The VAR needs to be changed into an ECM for use of the Johansen cointegration and this may be written as: V_t is a nx1 vector of deterministic variables.

$$Yt - 1 = \Pi \Delta Yt - 1 + \sum_{i=1}^{p-1} \lambda Yt - 1 + \beta Vt + \eta t \quad (8)$$

Where Π = Ai –I, $\lambda = -\sum_{j=i+1}^{p-1} Aj$

where ΔXt shows that all variables are stationary of order1(0), Δ represents the first difference operator, π i is a n and n demonstrates parameters of matrix whose rank finds out the number of co integrating associations. The Granger [49] causality test is used to determine casual association between carbon xide emission and AGP in this study. This test estimate bivariate regression of variables. The empirical bivariate regressions for the causal association between CDE and AGP are given as:

$$CDEt = \phi o + \sum_{i=1}^{p} \phi i\, AGPt - i + \sum_{i=1}^{p} \omega CDE\, t - i + € \quad (9)$$

$$AGPt = \eta o + \sum_{i=1}^{p} \eta i\ CDE\, t - i + \sum_{i=1}^{p} \psi\ AGPt - i + € \quad (10)$$

Where AGP is Agricultural productivity and CDE is carbon dioxide emission. Ψ and € are error terms. Φ, ω, η and ψ are parameters to be guesstimated. In equation (9) present values of CDE are attached to precedent values of itself. Similarly, AGP series behaves like CDE.

3. Results and Discussion

Table 1. Result of AGP and CDE with trend at level by Ng-Perron test.

Var	MZa	MZt	MSB	MPT
AP	3.94	2.65	0.67	53.84
CD	1.46	1.15	0.79	50.16

The order of integration of carbon dioxide emission and agricultural productivity are detected by employing the Ng-Perron unit root test. The findings are reported in the table 1. The small value of MZa suggests that null hypothesis cannot be rejected and these variables cannot be integrated order of 1(0). This is so because both variables are not significant at 5% of significance level. The result of Ng-Perron at Ist difference are demonstrated in Table2. These findings show that both carbon dioxide emission and agricultural productivity are integrated of order one I(1). In this situation, the Jhonson cointegration technique may be employed to detect the long-term association between AGP and CDE. For cointegration, it is most important to select appropriate lag length. The VAR lag order selection is used detect optimum lag length of variables. The minimum value of Akaike information Criteria, Schwarz information criteria are employed to detect optimum lag length of variables. The findings for optimum lag are reported in Table 3.

Table 2. Result of AP and CD by Ng-Perron test at 1st Difference.

Var	MZa	MZt	MSB	MPT
AP	-23.09	-3.38	0.14	1.11
CD	-17.98	-2.89	0.16	1.72

Note: * shows significance at 1% significance level

outcomes for diagnostics analysis are presented in Table.4. The results divulge that there is absence of white heterosedasticity, conditional heteroskedasticity, autoregressive, and serial correlation, thus model is fit for analysis.

Table 3. Table 3.Results of VAR Lag order

Lag	LogL	LR	FPE	AIC	SC	HQ
0	- 851.36	NA	4.45	37.10	37.18	37.13
1	- 689.74	302.15	4.71	30.24	30.48*	30.33
2	-	9.91*	4.40*	30.18*	30.57	30.33*

	684.18					
3	- 681.88	3.910	4.75	30.25	30.81	30.46
4	- 679.14	4.40	5.05	30.31	30.02	30.57

* indicates lag order selection

Table 4. Diagnostic Tests

Sr.No.	Test	Results
1	Hetroskadastcity	0.21(0.14)
2	W.Hetroskadastcity	0.28(0.30)
3	LM Test	0.14(0.59)
4	JB	0.31(0.59)
5	Con.Hetroskadastcity	0.58(0.64)

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3.2 Stability of the model

The structural stability tests employ on the cumulative sum of recursive residuals (CUSUM) and cumulative sum of recursive residuals of squares (CUSUMSQ) tests as suggested by Pesaran and Pesaran (1997) to check robustness of the long- term results. The CUSUM and CUSUMS square statistics are graphically are depicted in Figs. 1 and 2. The plots of both CUSUM and CUSUMS square remain within the red boundary lines. The plot of the CUSUM has slightly hovered above the zero line. The plot of CUSUMSQ show volatile moment and remain between red lines boundary. As a result, these statistics verify stability of the model and thus model is fit for analysis.

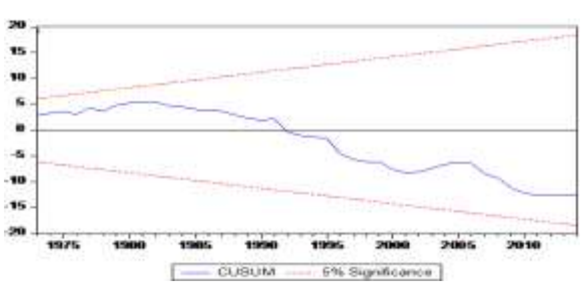

Fig.1. Plot of CUSUM test.

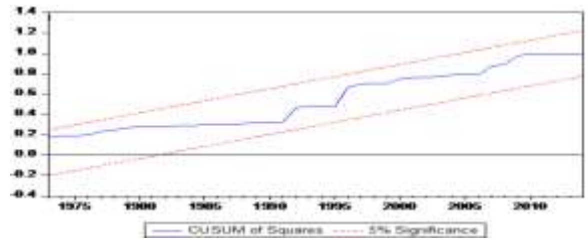

Fig.2. Plot of CUSUM square test.

3.3 Long run association between AGP and CDE

The findings of Trace and Eigenvalue rank tests are reported in Table 5 and Table 6 respectively. In the trace test, the values Trace statistics are less than the critical values of Trace statistics, thus the null hypothesis is accepted, and this shows that there is no long- run association between AGP and CDE. For that reason, the null hypothesis accepted that there is no long- term association between CDE and AGP that is, cannot be rejected. This implies that the CDE and AGP have not long- run association between each other. This means that variables do not move together over time, it may be said that these variables are non-stationary, because their' mean, autocorrelation and variance are not constant all over time. Thus, their linear combination is also non-stationary and, therefore these variables do not reach to equilibrium level because there is no error correction for the association.

Table 5.The Findings of Johansen cointegration test.

HypoNo.ofCE(s)	Trac.Stat	0.05 cri value	Pro
H0:r=0	12.62	15.49	0.12
H0:r ≤ 1	0.14	3.84	o.70

In second equation the value of Trace test is less than critical value of Trace statistics. So null hypothesis is

Table 6. Eigenvalue Rank test

HyopoNo.ofCE(s)	Trac.Stat	0.05Cri value	Pro
Ho::r=0	12.47	14.26	0.09
H0:r≤ 1	0.14	3.84	0.70

accepted, and it is found that there is no sustain a long-term association between AGP and CDE. In the maximum Eigenvalue test, the consequences show that there is no long-term association between AGP and CDE. Thus, both Trace and Eigenvalue test demonstrate that there is no long-term association between AGP and CDE in Pakistan. The researchers find a long-term association between CDE and economic variables in IPCC studies. Nevertheless, in references [36], it is detected that there is no long-run association between CDE, openness and economic growth for Kora, China and Japan. They also detected a large heterogeneity among the countries and influence of variables. The present study shows the absence of short-run and long-run association between both variables because of Pakistan's CDE at this moment as result no long- term association take place between these variables. Nonetheless, if the speed of increasing CDE gathering is not controlled by necessary policy actions, this may ultimately guide to long-term spoil of economic status.

Table 7. VAR Estimates of Short Run**.**

Var	AGP	CDE
AGP(-1)	0.67(0.14)[4.67]	-1.14(7.7)[-0.14]
AGP(-2)	0.26(0.15)[1.72]	8.10(8.0)[1.01]
EC(-1)	864.10(2750.87)[0.31]	1.33(0.14)[9.36]
EC(-2)	-548.56(27.77)[-0.2O]	-0.37(0.14)[-2.65]
Constant	10334.98(21189.9)[0.48]	2.58(1.10)[2.34]

3.4 Short run association between CDE and AGP

Since the Johansen cointegration [50] technique fails to perceive a long run association between CDE and, AGP. VAR test is employed to find short run association. The VAR helps to study variance decomposition of variables in the system and observe impulse response mechanisms for causality, forecasting, and policy analysis [43]. The results of VAR are demonstrated in Table 7. It can be seen that CDE has positive and insignificant effect on AGP in the first lag, while in second lag CDE has negative and insignificant effect. This shows there is positive association between CDE and AGP in the first lag, while there is no association between these variables in second lag in a short run. Over a particular time period in the model, an impulse response function demonstrates the reply of variables to one standard deviation innovation in itself and in other variables. In refs. [42], It is reported that impulse response functions find out within a given period how the variation take place in one variable impacts the other endogenous variables of the model in the economy. In this research Cholesky one standard deviation over a time period of ten years is used to see behavior of variables. The upper and lower boundary is also represented by the impulse response function, which is based on non- negative and non- positive of two standard errors.

3.5 Figures of an impulse response function of variables

It is observed in the first panel of Figure 1, that AGP's response to a shock. It was initially highly significantly non-negative. Nevertheless, the response became non-positive after that it remains significant between 1.5 and 2 years. But the shock approaches again positive between 2.5 to 3.5 years, negative in fourth year and it became again positive from 4.5 to 5.5 and afterwards this effect seems to be died out. Similarly, the AGP'S response to shock in CDE has increasing trend from 1 to 2 years; afterwards it has decreasing trend between 2.5 to 3.5 years. More precisely, the effect of CDE on AGP is positive but insignificant between1 to 1.5 and afterwards the effect of CDE on AGP vanishes out. Generally, the VAR parameter estimation and impulse response functions demonstrate the behavior of CDE and AGP.

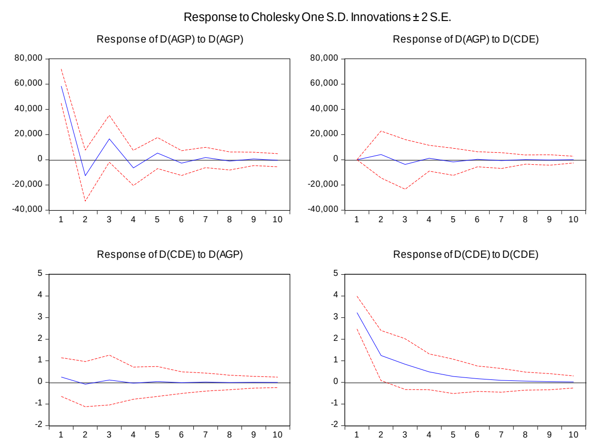

Fig..3 Impulse response function of variables

The results of variance decomposition of CDE and AGP are reported in Table 8. The shock of AGP itself brings 99.4 percent change in first period. Nevertheless, by the seventh, ninth and tenth periods of CDE gives detail about 0.63 percent changes in AGP. This means that CDE has brought minute changes in AGP in all periods. Furthermore, variance decomposition of AGP and CDE shows in the second panel that CDE itself brings 100 percent changes. More, precisely a shock brings small change in seventh, eighth, ninth and tenth period in CDE.

Table 8. Variance Decomposition of CDE and AGP.

Variance decomposition of CDE and AGP		
Stages	CDE	AGP
1	99.41	0.58
2	99.43	0.56
3	99.37	0.62

4	99.37	0.62
5	99.36	0.63
6	99.36	0.63
7	99.36	0.63
8	99.36	0.63
9	99.32	0.63
10	99.36	0.63

Table 9. Variance Decomposition of AGP and CDE.

Stages	CDE	AGP
1	100	0
2	99.52	0.47
3	99.21	0.78
4	99.18	0.81
5	99.11	0.88
6	99.11	0.88
7	99.11	0.89
8	99.10	0.89
9	99.10	0.89
10	99.10	0.89

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Table 10. Granger Causality test between CDE and AGP.

Null. Hypothesis	F.Statistics	Prob
CDE does not Granger cause AGP	0.210	0.18
AGP does not Granger CDE	1.71	0.18

The conclusion of Granger [51] causality analysis between CDE and AGP are reported in Table 4. The findings in the first line proposes that CDE does not Granger cause AGP. This shows that CDE has no influence for AGP. In the same way in the second row AGP does not Granger cause CDE and this also implies that AGP has no effect for CDE. As a consequence, neither CDE Granger causes AGP, nor AGP Granger cause CDE. This is so because in Pakistan, several small- scale farmers work in the agricultural sector whose AGP is less influenced by CDE.

4. Conclusion

This study observes the association between CO_2 emission and, agricultural productivity in Pakistan. Both variables are non-stationary in levels but stationary in their first difference in Ng-Perron Test. The empirical results of this study show that there is a positive short run association between CDE and AGP, , but this is insignificant. Similarly, there are no long-run association between CDE and AGP in Pakistan. Furthermore, the neither CDE Granger cause AGP, nor AGP Granger causes CDE. The results are similar to the results of [33, 37]. Lastly, policy-makers should impose those policies which will boost up agricultural productivity. Future studies on this topic may be conducted to understand the relationship between carbon dioxide emission and agricultural productivity is nonlinear or time-varying.

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