Agricultural Productivity, Carbon Dioxide Emission And Nuclear Energy Consumption In Pakistan: An Econometric Analysis

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Abstract — The main principle of this study is to observe the association among carbon dioxide emission (CDE), nuclear energy consumption (NEC) and agricultural productivity (AGP) in the case of Pakistan. The carbon dioxide (CO2) emission, nuclear energy consumption (NEC), and the agricultural productivity (AGP) are used as the environmental indicator, energy consumption indicator, and economic indicator respectively. The Augmented dickey Fuller Unit Root test, Johansen Co-integration, VAR and Granger causality tests are used to make analysis of data from 1971 to 2016. The findings of Augmented Dicky Fuller and Phillip and Perron test indicated that series are integrated at order I (1). The long-run relationship was determined by applying Johansen cointegration test. The results show that there is no long run association among these three variables. VAR estimation and the impulse response function show that there is significant short run relationship among CO2 emission, and agricultural productivity. The CO2 emission has negative effect on agricultural productivity in short run in second lag and it is significant, while nuclear energy has no effect on agricultural productivity. The Granger causality test shows bidirectional causality between CO2 emissions, nuclear energy consumption and agricultural productivity. Further, the variance decomposition shows that CO2 emission contributed about 83.28 percent and nuclear energy consumption 83.78 percent to the variation in AGP. The empirical findings will help the policy makers in understanding the impact of the CO2 emissions therefore; they suggest adopting carbon tax policy and cleaning power plan for reduction of carbon dioxide emission.

Keywords: carbon dioxide emission (CO2), nuclear energy consumption, agricultural productivity, Pakistan

1. Introduction

Agriculture sector play vital role in area of Pakistan’s economy, such as it help in poverty alleviation, improve living standard of people and provides raw material to industrial sector. The contribution of this sector to GDP is 19.8 percent and it provides 42.3 percent jobs to the country’s labour force. The favorable weather conditions play important role to boost up crops in agriculture sector. So, there is a solid associations among agriculture and climate—temperature, precipitation, floods, carbon dioxide emission, nuclear energy, carbon mono oxide, nitrous oxide (N2O), methane (CH4) and other aspects that affect economic efficiency including economic growth, agriculture production, and commodity prices. In past few years the emerging challenges of climate change, nuclear energy consumption and national food security have forced to policy makers to resolve agriculture sector’s alarming issues. This sector has valuable potential in foreign exchange market. There are small farmers in Pakistan’s agriculture community and they have faced a lot of problems in their day to day farming. Therefore, per yield level in Pakistan has been reduced to some extent. To cater food requirements of its
growing population and with present pace of development the government of Pakistan envisages reducing the food requirement of rapidly growing population in Pakistan.

Generally economics and environment are extremely interlinked with each other. Firms and industries use scarce natural and artificial resources such as material, water, nuclear energy, and electricity to produce goods and services. During process of produce some used inputs return to the environment as wastes like waste water, carbon dioxide, carbon mono oxide, methane, nitrous oxide, sulfur dioxide, and solid waste. These wastes cause pollution and impose external cost on society.

Environmental damages and hazards are more enlightening over the past three decades. The population growth and industrial activities are main cause of hazards and environmental damages. Thus hazards and environmental damages can be controlled if economic and environmental activities do collectively at one platform. Strong, 1992; Olivier et al., (2013) emphasize CO2 emissions (CEs) and other gases are produced by burning of fossil fuels. Clayton, (1996); Houghton, (1998) stated that the short-wave radiation from the sun to penetrate the atmosphere, and the lower wavelength energy which is re-radiated from the earth’s surface, because heat radiation is absorbed by these GHGs very well. Since carbon emission influences fresh water resources, agriculture productivity, human health, biodiversity, natural ecosystem and food supply (IPCC, 1996, 2007; Ayres et al., 1991), it is essential to finds its impacts. So far some studies Chang, 2002 and Aye et al., 2012 have analyzed the impact of climate change variables such as rainfall, sea level rise, temperature, burning fuel, energy consumption among others on agricultural productivity (AGP). Seo et al. (2011), Abubakar et al., (2011) emphasize the anthropogenic gathering changes in the earth’s radiation balance and thus GHGs carbon emission may affect food security, stability, access, availability.

Similarly, Schmidhuber et al., (2007) advocated CO2 directly put impacts on crop pests crop yields, soil fertility and crops’ diseases. They suggested that climate change indirectly through income distribution, and agricultural demands impacts economic growth. In addition, crop yields and food supply are negatively affected by climate change, thus food prices raise, agricultural production declines, and purchasing power decreases. Further carbon dioxide emission negatively affects human health (IPCC, 2011).

Since CO2 emission and nuclear energy consumption are main pillars of climate change, it is important to study their specific relationship with AGP. Exclusively, in this study replies to the following research questions: (a) What is the impact of CO2 emissions on the agriculture productivity in short run and long run? (b) What is the impact of nuclear energy consumption on agricultural productivity in short run and long run? (c) What is casual relationship between these three variables? To answer these questions, for the Pakistan economy Jhonson cointegration, VAR, ADF, approaches are used.

Several strategic factors which explain the development of carbon dioxide emissions such as nuclear energy consumption, agricultural productivity, and economic growth. Many researchers’ studies examined the causal associations of CO2 emissions with agricultural productivity and economic growth. They concluded carbon dioxide emission related to the progression of pollution in all countries (Aye et al., 2012). Some variables from these studies affect CO2 emissions positively and some other variables influenced CO2 emissions negatively, depending on the integration of the variables and selection of time period and method of empirical analysis. Similarly, Shahbaz et al., 2014; Apergis and Ozturk, 2015; Fodha and Zaghdoud, 2010; Ang, 2007 investigated mixed results.

The ARDL approach was used to find the dynamic causal associations among CO2 emissions, foreign trade, output, and energy consumption in case of Turkey by (Aye et al., 2012). Seo, et al., (2005) investigated unidirectional causality from electricity consumption to agricultural output and from agricultural output to oil consumption by using 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, Ben Jebli and Ben Youssef (2015, 2017) used the first econometrics techniques to find association between renewable energy and agricultural productivity. The short and long-run associations between GDP, per capita CO₂ emissions, renewable and non-renewable energy consumption, agricultural value added and trade openness in Tunisia was investigated by them.

Cape, (2003) found in his study the dynamic causal association between carbon dioxide emissions, production, and energy consumption in France during the period 1960-2000. Findings indicated that economic growth caused long term energy consumption and environment pollution, and investigated short run casual relation from energy consumption to production growth. They also found that use of energy and emissions of carbon dioxide move in same direction.

Alege (2010), investigated in their study, there is the long term association between carbon dioxide emissions and energy consumption in America for spanning 1850-2002. They concluded carbon dioxide intensity emissions increases by increasing population growth, fossil fuels, electricity consumption growth and economic growth also manipulate the carbon dioxide emissions. Suveytas et al. (2006) studied the relationship between carbon dioxide emission and energy consumption in America. They added variables, labor and capital in model of Tul et al. (2006) and they concluded a significant positive relationship between carbon dioxide emissions and energy consumption.

Seeing as carbon dioxide emission may have implications for agriculture productivity, biodiversity, food supply, fresh water resources, natural ecosystems, and human health (Ayres & Walter, it is imperative to enumerate its impacts. So far some studies (Chang, 2002; Hassan, 2008; Kurukulasuriya & Ajwad, 2003; Fonta et al. 2011; Molua, 2002; Gbetibouo & Hassan, 2005; Sakurai et al., 2014) have analyzed the impact of temperature, sea level rise, rainfall, on agricultural productivity (AGP) and/or FS and they investigated negative effect on agricultural productivity. The supplementary appraisals are available in the studies of (Kang, and Ma (2009).

Valin et al. (2013) found the negative outcome of GHG emissions on AGP. He used GHG emissions (CO2), CH₄ and nitrous oxide emissions as a proxy for climate change and for analysis he used ARDL approach and found no positive effect on AGP. In the same way, the study of Ekpenyong and Ogbuagu (2015) found a negative effect of climate change on AGP and these leads 100% increase in greenhouse emission and 22.26% decline in AGP. Furthermore, Dawit, et.al (2016) investigated the impact of simulated carbon dioxide emission on agricultural efficiency and welfare for the household for the period 2010-2030 by using a computable general equilibrium model. The findings shows that household welfare and agricultural total productivity negatively influenced by carbon dioxide emission and they projected real agricultural GDP was 4.5% lower in the 2020s. They studied a variety of assume and suggested quantifiable statistical analysis is needed.

2. Methodology

Let the following optimization problem

\[
\text{Maximize } f(X)
\]

subject to

\[
g_j(X) \leq 0 \quad \text{for } j=1,2,\ldots,p
\]

where the decision variable vector

\[
X=[x_1, x_2, \ldots, x_n]
\]

Kuhn-Tucker conditions for \( X^* = [x_1^*, x_2^* \ldots x_n^*] \) to be a local maximum are

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if the problem is one of maximization with the constraints in the form \( g_j(X) \geq 0 \), then \( \lambda_j \) have to be nonnegative.

Thus above model to see the effect of NEC and CDE on AGP may be used as under:

The data on AGP, NEC, and CDE were gathered from secondary sources. AGP was measured as the gross production of agricultural crops (2004–2006 = 100). NEC was measured as Terawatt-hours; CDE was measured in matric tones and was collected Euro stat Federal Reserve and S&P World Bank. Data on agriculture productivity was collected through various issues of Economic survey of Pakistan. The Johansen (1991, 1995) cointegration approach is employed to find the long-run association among NCE, CDE and AGP. For the short-run association between NCE, CDE and AGP, the vector autoregressive (VAR) approach is employed. To evaluate the relationship between NCE, CDE and AGP, the standard Granger causality test is used.

\[
Y_t = \sum_{i=1}^{P} B_i Yt - 1 + CT + \psi t
\]  

(1)

Where \( Yt \) is a vector of non stationary variables, which are I(1). Thus \( Yt \) consist of AGP, CDE and NEC. \( X_t \) is a vector of deterministic variables, and \( \psi t \) is a white noise error term or innovation.

\[
\Delta Y_t = \epsilon \Delta Yt - 1 + \sum_{i=1}^{p-1} \lambda Yt - 1 + \beta Vt + \eta t
\]  

(2)

Where \( \epsilon = A_i - I \), \( \lambda = \sum_{j=i+1}^{p-1} A_j \)

where \( \Delta Yt \) shows that all variables are stationary of order 1(0), \( \Delta \) represents the first difference operator, \( \epsilon \) is an \( n \) and \( n \) shows coefficient of matrix whose rank finds out the number of cointegrating associations.

\[
AGPt = \phi_0 + \sum_{i=1}^{p} \phi_i AGPt - 1 + \sum_{i=1}^{p} \phi_i CDEt - i + \sum_{i=1}^{p} \eta_i NECT - i + \lambda
\]  

(3)

\[
NECt = \alpha_0 + \phi_i \sum_{i=1}^{p} NECT - i + \alpha \sum_{i=1}^{p} AGPt - i + \eta_i \sum_{i=1}^{p} CDEt - i + \epsilon
\]  

(4)

\[
CDEt = \eta_0 + \sum_{i=1}^{p} \eta_i CDEt - 1 + \sum_{i=1}^{p} \gamma_i AGPt - 1 + \sum_{i=1}^{p} \psi_i NECT - 1 + \beta
\]  

(5)

Where AGP is Agricultural productivity, NEC nuclear energy consumption and CDE are carbon dioxide oxide emission. \( \phi_0, \alpha_0 \) and \( \eta_0 \) are intercept. \( \lambda, \beta \) and \( \epsilon \) are error terms. \( \Phi, \omega, \eta \) and \( \psi \) are parameters to be estimated. In equations (3), (4) and (5) current values of AGP, CDE and NEC are related to past values of series of AGP, CDE and NEC series.
For casual relationship between carbon dioxide emission, nuclear energy consumption and agricultural productivity, the empirical mechanism is given as:

\[ AGPt = \phi_0 + \sum_{i=1}^{P} \phi_i AGPt - i + \sum_{i=1}^{P} \omega_i CDEt - i + \sum_{i=1}^{P} \eta_i NECt - i + \lambda \]  
\[ (6) \]

\[ NECt = \alpha_0 + \sum_{i=1}^{P} \eta_i NECt - i + \Pi_i \sum_{i=1}^{P} AGPt - i + \eta_i \sum_{i=1}^{P} CDEt - i + \epsilon \]  
\[ (7) \]

\[ CDEt = \eta_0 + \sum_{i=1}^{P} \eta_i CDEt - 1 + \sum_{i=1}^{P} \psi_i AGPt - 1 + \sum_{i=1}^{P} \psi_i NECt - 1 + \beta \]  
\[ (8) \]

Table 1  The findings of Units Root tests

<table>
<thead>
<tr>
<th>Var</th>
<th>Level</th>
<th>First diff</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ADF</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Augmented Dickey Fuller test</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>t-statistics</td>
<td>Probability</td>
</tr>
<tr>
<td>AGP</td>
<td>-0.863</td>
<td>0.392</td>
<td>-6.838</td>
</tr>
<tr>
<td>CDE</td>
<td>-1.090</td>
<td>0.281</td>
<td>-7.423</td>
</tr>
<tr>
<td>NEC</td>
<td>0.133</td>
<td>0.894</td>
<td>-5.341</td>
</tr>
<tr>
<td>PP</td>
<td></td>
<td>Phillips-Perron test</td>
<td></td>
</tr>
<tr>
<td>AGP</td>
<td>-0.261</td>
<td>0.922</td>
<td>-8.357</td>
</tr>
<tr>
<td>CDE</td>
<td>-1.025</td>
<td>0.736</td>
<td>-7.036</td>
</tr>
<tr>
<td>NEC</td>
<td>0.107</td>
<td>0.962</td>
<td>-6.698</td>
</tr>
</tbody>
</table>

Where CDT, AGP and NEC are carbon dioxide emission, agricultural productivity and nuclear energy consumption respectively. \( \phi_0, \alpha_0, \eta_0 \) are intercept. \( \phi_i, \eta_i, \omega_i, \psi_i \) are coefficient are to be estimated. \( \lambda \) and \( \epsilon \) are error terms.

3. Results and Discussions

Results of Unit root tests

The ADF (Augmented Dickey Fuller) and PP (Phillips-Peron) tests were used to determine the unit root property of data. The findings of ADF and PP are reported in Table 1. The empirical results of three variables AGP, CDE and NEC in level suggested unit root problems exist in these series, thus null hypothesis was accepted with empirical evidence of t-statistics and probability. This implies AGP, CDE, and NEC are non stationary in level and have unit roots problems. Both tests ADF and PP are implied again on these series at first difference. The results of these series rejected null hypothesis at 1% level, therefore, the series are stationary with empirical evidence of t-statistics and probability. It may be concluded the series AGP, CDE and NEC are integrated of order one, I(1).

Long Run Relationship among AGP, CDE and NEC

The Johanson (1991,1995, and 2002) cointegration test is applied to determine long run association between AGP, CDE, and NEC. Findings of Trace test and maximum Eigen value are reported in Table 2. Optimum lag length is determined by using the Akaike Information Criteria for lag length. The results VAR LAG order selection criteria are reported in Table 3. The optimum lag order 2 is estimated on the bases of Akaike Information Criteria for lag length. The statistics values of Trace test and maximum Eigen value indicated, there was no cointegration between AGP, CDE, and NEC at 5 percent.
level. Therefore, null hypothesis is accepted that there is no cointegration between AGP, CDE and NEC is accepted. This shows that variables do not move in same direction and they do not convergence at equilibrium position. The non-stationarity of variables in level shows linear combination of variables is also non stationary.

Table 2. The findings of Johansen Cointegration Test

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>No. of co integrating equations</th>
<th>Statistics</th>
<th>0.05 critical value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace test</td>
<td>None</td>
<td>30.543</td>
<td>28.797</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>At most 1</td>
<td>9.886</td>
<td>15.49</td>
<td>0.289</td>
</tr>
<tr>
<td></td>
<td>At most 2</td>
<td>1.258</td>
<td>3.841</td>
<td>0.261</td>
</tr>
<tr>
<td>Maximum Eigen value</td>
<td>None</td>
<td>20.657</td>
<td>21.131</td>
<td>0.058</td>
</tr>
<tr>
<td></td>
<td>At most 1</td>
<td>8.627</td>
<td>14.26</td>
<td>0.318</td>
</tr>
<tr>
<td></td>
<td>At most 2</td>
<td>1.258</td>
<td>3.841</td>
<td>0.261</td>
</tr>
</tbody>
</table>

Since there is no error correction for relationship, thus if these variables deviate from mean or equilibrium position, it will be too much difficult to bring these variables to equilibrium position. IPCC (1997, 2006) and other studies are reported there was a long run relationship between carbon dioxide emission and economic variables. But findings of this study show that there is no long run relationship between AGP, CDE and NEC. The results of this study consist with the study of Heshmati, and Cho (2010). They investigated a large heterogeneity among countries and impacts of variables. In present study, it can be given reason the absence long run relationship in the point of view that intensity of carbon dioxide emission and use of nuclear energy consumption is not large to some extent at this stage.

Nevertheless, it may be said if policy makers will not take steps to reduce level of carbon dioxide emission and increase in use of nuclear energy consumption, the economy of Pakistan will be influenced negatively. However, now the unrestricted VAR model is used to detect the impulse function and variance decomposition of AGP, CDE and NEC, because variables are not co integrated in the long run. The impulse function and variance decomposition of series shows behavior of variables in short run.

Short run relationship between CDE, NEC and AGP

The Johansen cointegration test is used to detect a long run association between AGP, CDE and, NEC, while VAR test is used to find behavior of impulse response function and variance decomposition of variables in system. However, it also helps to find influence of independent variables on dependent variables. The results of estimation of VAR are reported in Table. 4. The results of VAR Lag order selection criteria are presented in Table.3. The findings suggest optimum lag 2 is appropriate for analysis.

It is observed that Agricultural productivity influences AGP in first lag, while CDE influences AGP negatively in first lag and it is highly significant. Further, NEC does not influence AGP in first and second lag. CDE in first lag influence NEC positively, while in second lag influence negatively. As per report of Alege (2010), variance decomposition of variables and impulse response mechanisms help to find association between variables and for policy analysis (Alege & Osabuohien, 2010).
Table 3: Findings of VAR Order Selection Criteria

<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-1739.75</td>
<td>NA</td>
<td>1.67</td>
<td>85.01</td>
<td>85.13</td>
<td>85.05</td>
</tr>
<tr>
<td>1</td>
<td>-1547.84</td>
<td>346.33*</td>
<td>2.29*</td>
<td>76.08*</td>
<td>76.56*</td>
<td>76.28*</td>
</tr>
<tr>
<td>2</td>
<td>-1540.06</td>
<td>12.84</td>
<td>2.39</td>
<td>76.15</td>
<td>77.02</td>
<td>76.47</td>
</tr>
<tr>
<td>3</td>
<td>-1533.22</td>
<td>10.38</td>
<td>2.71</td>
<td>76.25</td>
<td>77.50</td>
<td>76.71</td>
</tr>
<tr>
<td>4</td>
<td>-1527.12</td>
<td>8.33</td>
<td>3.24</td>
<td>76.39</td>
<td>78.02</td>
<td>76.98</td>
</tr>
</tbody>
</table>

* indicates lag order selected by the criterion

The VAR system is given below:

\[ AGP_t = \eta + \eta_1 CDE_{t-1} + \eta_2 NEC_{t-1} + \eta_3 AGP_{t-1} + \lambda_1 \]  \hspace{1cm} (9)
\[ CDE_t = \eta_4 + \eta_5 AGP_{t-1} + \eta_6 NEC_{t-1} + \eta_7 CDE_{t-1} + \lambda_2 \]  \hspace{1cm} (10)
\[ NEC_t = \eta_8 + \eta_9 CDE_{t-1} + \eta_{10} AGP_{t-1} + \eta_{11} NEC_{t-1} + \lambda_3 \]  \hspace{1cm} (11)

The impulse response function is a unit shock applied to each variable and sees its effect on VAR system. In equation (9) AGP is dependent variable, while CDT lag t minus 1, NEC lag t minus 1 and AGP t minus i are independent variables, while in equation (10) CDE is dependent variable, while CDT lag t minus i, NEC lag t minus 1 and AGP t minus 1 are independent variables, similarly in equation (11) NEC is dependent variable, while CDT lag t minus 1, NEC lag t minus i and AGP t minus 1 are independent variables. The impulse response function is a shock to a VAR system. More precisely, when shock is put to the error terms \( \lambda_1 \), \( \lambda_2 \), and \( \lambda_3 \), these impulses response identify the responsiveness to dependent variables in the VAR system. Thus shock is applied to each variable AGP, CDE and NEC and theirs responsiveness are observed in the VAR system. The change in error term \( \lambda_1 \) brings change in AGP and this change in CDE, NEC and AGP during next period. Thus the shock is given to the innovation or residuals on \( \lambda_1 \) or \( \lambda_2 \) or \( \lambda_3 \) to see effects of shocks on whole VAR system. The Cholesky adjustment is used to determine impulse responses in VAR system. In this analysis all variables are endogenous. The impulse response function can be applied in both unrestricted VAR and restricted VAR, which is VEC. Here unrestricted VAR is chose for analysis.

The findings of VAR are presented in Table 7. It can be seen that AGP, NEC and CDE are dependent variables and AGP (-1), AGP (-2) NEC (-1), NEC (-2) and CDE (-1) and (CDE (-2) are independent variables. VAR estimation is based on two appropriate lags.

Table 4: Vector Autoregressive Estimates

<table>
<thead>
<tr>
<th></th>
<th>AGP</th>
<th>CDE</th>
<th>NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGP(-1)</td>
<td>0.802</td>
<td>-0.027</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>(0.168)</td>
<td>(0.013)</td>
<td>(0.051)</td>
</tr>
<tr>
<td></td>
<td>[ 4.762]</td>
<td>[-2.075]</td>
<td>[ 0.444]</td>
</tr>
<tr>
<td>AGP(-2)</td>
<td>-0.058</td>
<td>0.024</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.15709)</td>
<td>(0.013)</td>
<td>(0.048)</td>
</tr>
</tbody>
</table>

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How and in what manner standard deviation shocks CDE and NEC affect AGP with lag one and lag two and how and in what manner AGP react on standard deviation shocks. AGP has positive and significant effect on AGP in the first lag, while in second lag AGP has positive but it is insignificant. CDE has negative effect on AGP in first lag and it is significant, but it has negative effect in second lag but it is insignificant. Similarly, NEC has negative effect in first and second lag respectively, but these are insignificant. This can be said that there is association between CDE and AGP in a short run. In impulse response function it is seen that how CDE and NEC affect AGP in Pakistan and how the AGP in what manner, in what channel and how long affect CDE and NEC during standard deviation shocks to the residuals that means when one standard deviation shocks to the residuals then it can be seen that how three variables AGP, CDE and NEC react each other. Over a particular time period in the model impulse response function demonstrates the response of variables to one standard deviation shock in itself and in other variables. Alege (2010), 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 innovation 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 positive and negative two standard errors.
Table 5 Variance Decomposition of AGP, CDE and NEC

<table>
<thead>
<tr>
<th>Period</th>
<th>AGP</th>
<th>CDE</th>
<th>NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100.0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>97.26</td>
<td>0.41</td>
<td>2.32</td>
</tr>
<tr>
<td>5</td>
<td>92.42</td>
<td>1.06</td>
<td>6.50</td>
</tr>
<tr>
<td>10</td>
<td>54.95</td>
<td>5.31</td>
<td>39.74</td>
</tr>
</tbody>
</table>

The variance decomposition develops between CDE, NEC and AGP under VAR environment and three variables are stationary because this is basic need of VAR model to run it. The optimum lag selection criterion has advised to take two lags in the VAR model. The selection of variance decomposition is based on VAR model and takes 10 lags of time series data. The results of Cholesky variance decomposition of CDE, NEC and AGP are reported in Table 4. It is observed in the variance decomposition of AGP in period 3, in short run impulse or innovation, or shock to AGP account for 97.26 percent variation of the fluctuation in AGP. This can be said its own shock. This shock can cause 0.41 percent to CDE and this shock creates fluctuation in AGP 0.41 percent and shock to NEC causes 2.32 percent fluctuation in AGP. In period 5 impulse or innovation, or shock to AGP account for 92.42 percent variation of the fluctuation in AGP and it is its own shock. This shock can cause 1.06 percent to CDE and this shock creates fluctuation in AGP 1.06 percent and shock to NEC causes 6.50 percent fluctuation in the variance of AGP. In long run, period 10, 54.95 percent shock or innovation or impulse to AGP can contribute 54.95 percent to AGP and this is its own shock. The shock can cause 5.31 percent shock or impulse to CDE and this can create fluctuation in AGP 5.31 percent. Similarly in case of variance decomposition of carbon dioxide emission shock in AGP can cause 9.46 percent fluctuation in AGP and impulse on CDE can cause 90.18 percent to CDE and this is its own shock and 2.32 percent shock in the NEC can cause 2.32 percent fluctuation in CDE in short run. Finally, in long run 6.46 percent shock to AGP and this is its own shock and it can create 83.28 percent create fluctuation in CDE. However, in case of variance decomposition of NEC in short run a shock or innovation to NEC cannot contribute much in fluctuation of AGP neither in the short run nor in the long run. In the fluctuation of AGP shocks to CDE play vital role. In the variance decomposition of NEC, a shock to AGP can contribute in variance fluctuation of NEC is 89.51 percent and in the long run (period 10) a shock in AGP can cause 83.78 percent variance fluctuation in NEC.

It is observed in the first panel of Figure 1, that AGPs response to a shock in itself AGP and it was initially highly significantly positive. Nevertheless, the response becomes steadiness between 8 to 10 years. In second figure the standard deviation shock is given in the residuals or one standard deviation is given to AGP or in other way how one slandered deviation shock change in CDE and change in NEC. Thus figure shows a shock AGP to CDE remains positive from one year to 10 years. Furthermore, in third
figure a shock or impulse to NEC remains below the boundary line. The second panel of figure shows that a shock to CDE creates fluctuation in AGP negatively from one year to 10 years and in second figure a shock to CDE create positive fluctuation in itself and same way in third figure a impulse of CDE create negative fluctuation in NEC. Finally, in last panel of figures shows effect of shock of NEC on CDE and AGP respectively. In first figure it remain negative up to 5 years, after this it become steadiness and in second and third it remains positive from one years to ten years.

**Granger Causality Tests**

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>F-Statistics</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGP does not granger cause CDE</td>
<td>1.63</td>
<td>0.20</td>
</tr>
<tr>
<td>CDE does not granger cause AGP</td>
<td>5.15</td>
<td>0.01</td>
</tr>
<tr>
<td>NEC does not Granger Cause AGP</td>
<td>0.31</td>
<td>0.73</td>
</tr>
<tr>
<td>AGP does not Granger Cause NEC</td>
<td>0.52</td>
<td>0.59</td>
</tr>
</tbody>
</table>

The direction of causality and causation from one variable to another is determined by Granger causality test (Okodua & Olayiwola, 2009). VAR based Granger causality is used to find direction of causality and causation from one variable to another. Furthermore, Granger causality is used on first difference series. The results of Granger causality between CDE to AGP and NEC to AGP are reported in Table. The results in first show that AGP does not Granger cause CDE, it tells that unidirectional causality does not run from AGP to CDE, thus null hypothesis is accepted and there is no influence of AGP on CDE. In the same way, results indicate a unidirectional causality run from CDE to AGP, meaning that CDE Granger causes AGP. However the null hypothesis is rejected in economy of Pakistan and it is found there is significant relationship between CDE and AGP. The findings is with the results of Joo, Kim, and Yoo (2015) who found carbon dioxide emission reduce agricultural productivity and economic growth.

The results in third row of Granger causality test suggest that NEC does not Granger cause AGP. This implies that NEC does not influence AGP. So here null hypothesis is accepted. Finally, results in fourth row indicates that AGP does not Granger cause NEC. The null hypothesis is accepted because there is no relationship between AGP, and NEC. It means neither NEC causes AGP nor AGP causes NEC in third and fourth rows.

4. Conclusion

This observed the association among carbon dioxide emission (CDE), nuclear energy consumption (NEC) and agricultural productivity (AGP) in Pakistan. The Augmented dickey Fuller Unit Root test, Johansen Co-integration, VAR and Granger causality tests were used to make analysis of data from 1971 to 2016. The findings of Augmented Dicky Fuller and Phillip and Perron test indicated that series are integrated at order I (1). The long-run relationship was determined by applying Johansen cointegration test. The results show that there is no long run association among these three variables. VAR estimation, the impulse responses function and variance decomposition show that there is significant short run relationship between CO$_2$ emission, nuclear energy consumption and agricultural productivity. The Granger causality test shows unidirectional causality between CO$_2$ emissions, and agricultural productivity, while there is no Granger causality between NEC and AGP in Pakistan. Further, the variance decomposition shows that CO$_2$ emission contributed about 83.28 percent and nuclear energy consumption 83.78 percent to the variation in AGP. The relationship between agricultural productivity and CO$_2$ emission has been found negative for the sample period in short run. The empirical findings will
help the policy makers of Pakistan in understanding the harshness of the CO₂ emissions issue in Pakistan and therefore, carbon tax policy, adoption of clean power plan, and other regulatory measures are recommended for raise of economic growth.

References

Environment and Forestry Study, Yale University.


