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Crude Oil Price and Agriculture Productivity Growth in Pakistan

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Abstract: The objective of study is to empirically examine the impacts of crude oil price fluctuations on agriculture productivity growth in Pakistan. Time series data from various sources for the period of 1980-2013 has been utilized. To check the stationarity of variables, the study utilizes Augmented Dickey Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin test (KPSS) unit root tests. Johnson Cointegration approach is employed to estimate the relationship in long run and in short run. The results demonstrate the long run dynamics among variables. Oil Price and excess intake of fertilizer have negative impact on agriculture productivity growth. Water Availability and Real Effective Exchange Rate have positive impacts on agriculture productivity growth.

Key words: Agriculture Productivity · Oil Price · Exchange Rate · Pakistan

INTRODUCTION

Oil prices play major role to find out whole economic movement of any nation [1-2]. The historical oil price shows considerable fluctuations over the time (Figure 1). The global oil prices have rocked during end-November 2013 by 4.8 percent [3]. The upward trend in Global oil price directly influences the oil prices in the domestic markets [4]. Therefore, these sharply rising prices of oil have affected all sectors of Pakistan economy.

Pakistan is considered to be an oil importing nation [1-5]. It has to depend on oil imports to a great degree [6-7]. It imports huge amount of crude oil each year. Pakistan's share of oil imports is 30 percent out of total imports [8]. Its imports of crude oil in 2012 are 47104 thousand barrels. Growing population of Pakistan has appeared with high demand and consumption for oil, its products and energy [9]. There exists a huge gap between consumption and production of crude oil in Pakistan. The production of oil is almost stagnant since 1990 (Figure 2).

The high oil prices have direct and indirect influence on economy [10]. High oil prices have induced high costs of production ultimately lowering output and employment rate [11]. It reduces purchasing power and put inflationary stress on economy; consequently, prices of food commodities and other commodities hike [12]. It has negative effects on balance of trade, exchange rate, balance of payment and GDP. In fact, it creates hurdle in economic development. Like all other sectors, Agriculture is also a victim of it. Not only are the input prices of agriculture but also output prices have growing tendency with growing oil prices. The oil prices have direct and indirect influence on agriculture input prices [13]. Oil price, exchange rate and world price are key determinants of domestic prices to estimate input prices [14]. The high input prices have restricted the farmer to use optimal input level. Expanding input prices are supposed to be among main challenges of Pakistan agriculture sector [15].

Pakistan is an agro-based economy. Agriculture participation in GDP is 21.4 percent (Figure 3). It emerges 45 percent of the country's labor force. It is biggest sector from employment point of view. More than half population of Pakistan depends on agriculture [16]. It provides raw material to other sectors. Now a day, it is facing various challenges contributing low agriculture productivity growth. In Pakistan oil and gas are two key components of energy mix contributing almost 65 percent (oil 15% and gas 50%) share to the 64.7 million. The very high petroleum prices in 1970s results in lack of agriculture inputs, which further results in poor total factor productivity growth of agriculture in Pakistan [17].

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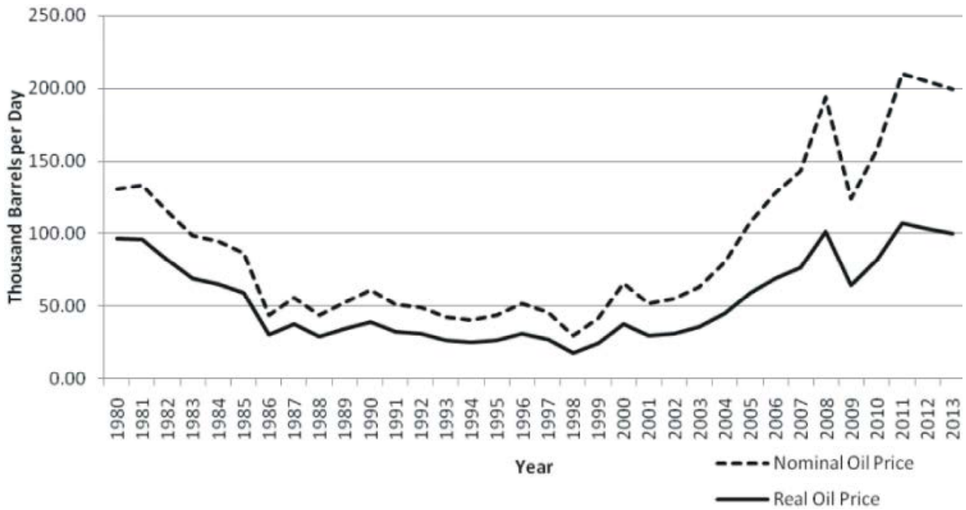

Fig. 1: Real and Nominal Crude Oil Import Price in Pakistan (Energy Information Administration)

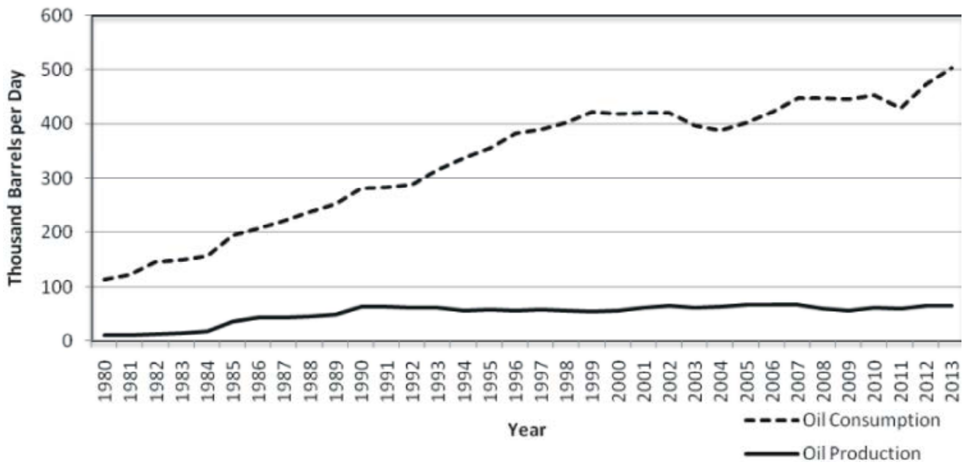

Fig. 2: Pakistan Crude Oil Consumption & Production by Year (Energy Information Administration)

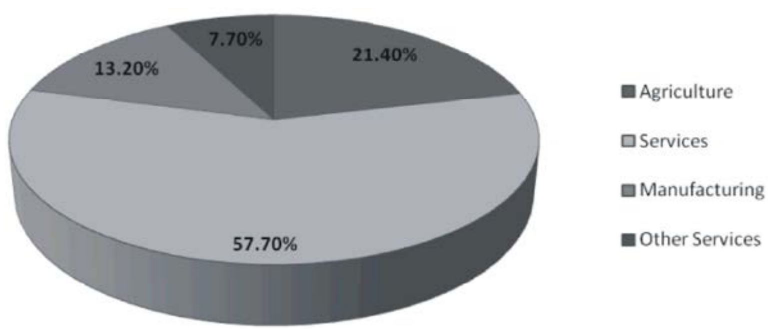

Fig. 3: Sectoral Share of GDP [9]

Crude oil prices, exchange rates and agricultural commodity prices are interrelated. However, their relationship may change over time due to macroeconomic variables [18]. Oil prices have both direct and indirect pressure on agricultural input by raising price of fuel and fertilizer and other inputs. It further leads to high commodity prices. Doubling oil prices may lead to decline in global agriculture output by almost 3% in 2020. [19].

The present study is being conducted to examine the oil price effect on agriculture productivity growth in Pakistan for the period of 1980-2013.

Review of Literature: Binuomote and Odeniyi (2013) empirically study the agricultural productivity growth and crude oil price relationship in Nigeria. According to them, oil industry has major share in the economy of Nigeria as it is an oil exporting country. The oil industry dominates the agriculture sector in Nigeria. They collect time series data from 1981 to 2010. They formulates model by using agricultural GDP, exchange rate, crude oil price, capital, labor, land and fertilizer. They utilize Johnson co-integration Technique and error-correction model. They find that crude oil price and agriculture productivity growth have negative association. The crude oil prices mainly affect the agriculture productivity in short run. While exchange rate, capital and labor mainly affect the agriculture productivity in long run. They suggest that the negative consequences of oil prices can be compensated by rising agricultural production and its exports. The agriculture sector should be provided social services and subsidized inputs. Both private and government sector should contribute in new production methods and technologies. All these raise the agricultural productivity growth [20].

Awan and Mustafa (2013) inspect the key factors to determine the agriculture productivity growth. According to them, Agriculture can help to eliminate absolute poverty and hunger, to raise GDP growth and to attain Millennium Development Goals. The time series date from 1970 to 2009 for cropped area, agricultural credit, availability of water, improved seeds distribution and import of pesticides is collected from Economic Survey of Pakistan and Federal Bureau of Statistics. They adopt Johansen Methodology of Co-integration and Error Correction Model to avoid non-stationarity. They conclude that total cropped area and irrigation water are major indicators of agriculture growth using response model of agriculture productivity growth. Agriculture growth is positively influence by total cropped area, water availability, improved seeds distribution and import of pesticide and negatively influence by agriculture credit [16].

Hanson *et al*., (2013) investigate consequences of oil prices shock on agriculture sector. The United States agriculture sector is suffering from oil prices fluctuations. Agriculture is energy exhaustive sector and high energy prices consequently reducing agriculture productivity. They have used input-output model to see oil price affect on agriculture and other sectors. They evaluate that oil prices has inverse relationship with agriculture output [21].

Timilsina *et al*., (2011) estimates relationship between oil price and biofuel expansion, which further influence food price. However, biofuel producing nations can compensate it. They also illustrate agricultural productivity decline followed by rising oil prices. They formulate a general equilibrium model for including various countries and various sectors. Data of 57 sectors and 113 countries is used in this study. It is also predicted graphically that agricultural productivity would decline by 0.8 percent by 25 percent rise in oil price in 2020. But biofuels can cope with this situation. The empirical evidences from Malaysia and Sub-Sarah Africa prove that biofuels positively affect the agricultural productivity [19].

Twimukye and Matovu (2009) observe consequences of energy prices and electricity short-falls on the Uganda's economy. As Uganda is not an oil producing country, it is totally dependent upon imports of oil products. Increasing oil prices and ultimately low electricity generation has negatively affected all sectors of Uganda's economy and population. They use dynamic general equilibrium model to check their hypothesis. High oil price and low electricity adjust the agriculture, manufacturing and infrastructure to low productivity. Manufacturing sector growth has declined by 2 percent [10].

Lu, *et al*., (2012) observe the effectiveness of agriculture inputs in development process in China. They adopt the Efficiency Decomposition Model. They use monthly data from Nov 1998 to Jan 2009 of prices of crude oil, corn and wheat futures prices. They consider the factors: scalping, speculation and petroleum inventories within the model and analyze their impact on oil price fluctuations using Bayesian Markov chain Monte Carlo. As oil prices increases, agricultural food prices also increases. Wheat and corn are major victims of oil price shocks [22].

Harri, *et al*., (2009) explore crude oil price, exchange rate and agriculture commodity price nexus. The Johansen cointegration and vector error correction model are used to test their relationship. The data is collected from Federal Reserve Economic Data database and Commodity Research Bureau. The results depict that commodity prices are linked to oil for corn, cotton and soybeans, but not for wheat and exchange rates do play a role in the linkage of prices over time [23].

Ansar and Asghar (2013) inquire the oil price effect on stock exchange and consumer price index (CPI) in Pakistan. They collect monthly time series data from 2007-2012. To check stationarity of data, they use

Augmented Dicky Filler Test. All data series of variables are stationary at first difference. Therefore, they have employed the Johansen Cointegration test to estimate the results. They find that oil prices have positive relationship with stock market and CPI [5].

Khan and Ahmad (2011) find out the impacts of international oil prizes and food prices on macroeconomic environment of Pakistan. The macroeconomic variables included in study are interest rate, exchange rate, inflation rate, money balance and real income. The sample period for monthly time series data collection is 1990M1/2011M. To estimate the results, they employ structural vector autoregressive method for short run impacts. Exchange rate responds negatively to exchange rate. Inflation and interest rate respond positively to oil price. The study concludes that exchange rate is major contributor of inflation in Pakistan [24].

Jawad (2013) determine the relationship of oil price and economic growth of Pakistan. He utilizes time series data over the period of 1973-2011. To check the stationarity, he uses Augumented Dicky Filler (ADF). All variables are integrated at level one. He adopts linear regression model for estimation. The results shows that trade balance and private sector investment are key determinants of gross domestic product in Pakistan. Oil price and public sector investment are insignificant determinants of gross domestic product [25].

Sial, *et al*., (2011) explore the linkage between agriculture productivity growth and agriculture credit. The sample period of 1973-2009 is selected. They collect data on Agriculture labor force, Agriculture Gross Domestic Product, Cropped Area, Agriculture Credit and water availability. The study utilizes ADF and PP unit root tests to test stationarity. They hire Johnson Cointegration and Error Correction Methodology. There are both short run and long run dynamics among variables. They evaluate that agriculture labor force, water availability has negative association and cropped area and agriculture credit have positive association with agriculture productivity growth. They apply Granger causality test to find causality direction. There is uni-directional causality between agricultural institutional credit and agricultural productivity growth [26].

Obayelu and Salau (2010) observe the impacts of prices of food, export crops and exchange rate on agriculture output in Nigeria by using Johnson Cointegration and Error Correction Model. The time series data is obtained for the period of (1970-2007). All variables are found to be integrated at level one. The variables display long run as well as short run dynamics. The results show that agriculture output has negative inspiration with food price and positive with exchange rate. They recommend Nigerian Government to focus on price policy in order to boost total agriculture output [27].

Shaari *et al*., (2013) explore oil price effects on different economic sectors in Malaysia. They include agriculture, construction, manufacturing and transportation sectors for analysis. They have gathered time series quarterly data from 2000 to 2011. They apply Johnson Cointegration Maximum Likelihood Method to observe the long run relationship after measuring the stationarity of variables with ADF unit root test. They detect long-run dynamics among variables. To discover the causality direction, they utilize Granger Causality Test. The agriculture sector induces by oil prices and construction sector relies on oil prices. They suggest Government of Malaysia to control oil prices in order to avoid negative effects on different economic sectors [28].

MATERIALS AND METHODS

Data Sources: The present study uses time-series, annual data from 1980-2013. The oil price data series have obtained from Energy Information Administration United States. Water Availability and Cropped Area and Fertilizer intake acquired from various issues of Economic Survey of Pakistan. Data series of exchange rate have been collected from World Bank. While, Agriculture GDP data sources are: Handbook Book of Statistics and annual Reports of State Bank of Pakistan.

The Model: Binuomote and Odeniyi (2013) used a dynamic regression approach using explanatory variables of oil charges, Exchange rate, fertilizer quantity, capital, land size, labor size [20]. While Awan and Mustafa (2013) included crop area, agriculture credit, seeds distribution water, import of pesticide [16]. Extracting from those, the following model is formulated for present study.

$$LAGDP = \beta_0 + \beta_1 LP_o + \beta_2 LEX_R + \beta_3 LF + \beta_4 CA + \beta_5 LWA + \mu$$

where,

AGDP = Agriculture Gross Domestic Product

P_o = Price of Oil

E_XR = Exchange Rate

F = Fertilizer intake

CA = Cropped Area

WA = Water Availability

Empirical Methodology: It is necessary to test the long-run and short-run relationship time series variables. Econometricians have developed many uni-variate and multi-variate cointegration techniques to test these relationships. Prior to apply cointegration technique, we have to make unit root analysis. The order of integration helps us in choosing the cointegration technique. We have to adopt various unit root test in order to avoid spurious regression.

Augmented Dickey Fuller (ADF) Unit Root Test: Dickey and Fuller, (1979, 1981) have formulated a Dicky and Fuller unit root test to check the non-stationarity. Later on, they have presented its augmented version, known as Augmented Dickey Fuller (ADF). The ADF have an additional advantage to abolish the autocorrelation. Because, it comprise additional lagged terms of the dependent variable as an independent variable. The ADF test encompasses the following three models.

$$\Delta W_t = \varphi W_{t-1} + \sum_{i=1}^{p} \pi_i \Delta W_{t-1} + u_t \quad \text{(Intercept)} \tag{1}$$

$$\Delta W_t = \alpha_o + \varphi W_{t-1} + \sum_{i=1}^{p} \pi_i \Delta W_{t-1} + u_t \quad \text{(With trend)} \tag{2}$$

$$\Delta W_t = \alpha_o + \varphi W_{t-1} + a_2 t + \sum_{i=1}^{p} \pi_i \Delta W_{t-i} + u_t$$

(With trend & Intercept) (3)

The equation (i) indicates the model with no trend and no intercept in the data; equation (ii) exhibits the model with intercept only and (iii) states the model with both intercept and trend. Deterministic elements α_0 and a_2t distinguish the above three equation from each other. The two key points should be followed by researcher in ADF. First specify the lag difference term. In ADF, sufficient lags are added to eliminate the problem of autocorrelation. Secondly, when we select the different models of ADF, their critical values are also changed. McKinnon (1991) table of critical values is used to check the acceptance or rejection of null hypothesis.

The Phillips-Perron Unit Root Test: The Dickey-Fuller test considers the assumption that the error terms are identically independently distributed and have a constant variance. Phillips and Perron (1988) have formulated an alternative unit root test with fewer constraints as compared to Dickey and Fuller.

Consider AR (1) process;

$$\Delta w_t = \alpha_o + \pi W_{t-1} + e_t \tag{4}$$

PP test is the modified version of ADF test it just make a correction of the t-statistic of W's coefficient by using comparatively less restrictions than ADF, in order to remove serial correlation. McKinnon (1991) critical values are also used for this test. Moreover, this test also has the same three models which ADF has; intercept, intercept and trend and no intercept and no trend.

The Kwiatkowski, Phillips, Schmidt and Shin Test (KPSS): This test is different from other unit root tests because it is based on the residuals obtain from ordinary least square method. Suppose we have endogenous variable w_t and an exogenous variable L_t

$$\Delta w_t = L'_t \psi + e_t \tag{5}$$

The LM stat is;

$$LM = \sum_t Z(t)^2 / T^2 f_o \tag{6}$$

where at zero frequency f_0 is an estimator of the residual spectrum and Z(t) depicts the cumulative residual function;

$$Z(t) = \sum_{r=1}^{t} \hat{u}r$$

where;

$$\hat{u}_t = Yt - V_t^{'} \hat{\gamma}(0)$$

The estimator γ is calculated with OLS method.

Johansen Co-Integration Approach: Granger (1981) first time introduced the concept of cointegration. But it was applicable for two variables case. Johansen (1988) presented a new approach of cointegration among more than two series. It eliminates all the drawbacks, which Engle-Granger approach has. In case of Johansen approach the ECM also extended into Vector Error Correction Model (VECM). Now suppose that we have three endogenous variables, R, S and T. In matrix form this can be written as;

$$V_t = [R_t, S_t, T_t] \tag{7}$$

$$V_t = \beta_1 Y_{t-1} + \beta_2 V_{t-2} + ... + \beta_k V_{t-k} + \mu_t \tag{8}$$

In the context of VECM we can written as

$$\Delta V_t = \eta_1 \Delta V_{t-1} + \eta_2 \Delta V_{t-2} + ... + \eta_{k-1} \Delta V_{t-k-1} + \omega V_{t-1} + \mu_t \tag{9}$$

whereas,

$$\eta_i = (1 - \beta_1 - \beta_2 - ...... - \beta_k)(i = 1, 2, ..., k-1) \tag{10}$$

$$\omega = -(1 - \beta_1 - \beta_2 - ...... - \beta_k) \tag{11}$$

ω shows the 3×3 matrix, which depicts the true long run relationship between $Vt = [Rt, St, Tt]$. The $\omega = \sigma\,\chi'$, in which σ shows the speed of adjustment towards equilibrium and long run coefficients matrix is θ'. In single equation case θ' $Vt-1$ is error correction term. To find out for multivariate case now assumes $k = 2$. So the model is

$$\begin{bmatrix} \Delta R_t \\ \Delta S_t \\ \Delta T_t \end{bmatrix} = \eta_1 \begin{bmatrix} \Delta R_{t-1} \\ \Delta S_{t-1} \\ \Delta T_{t-1} \end{bmatrix} + \omega \begin{bmatrix} \Delta R_{t-1} \\ \Delta S_{t-1} \\ \Delta T_{t-1} \end{bmatrix} + e_t \tag{12}$$

Or we can say that,

$$\begin{bmatrix} \Delta R_t \\ \Delta S_t \\ \Delta T_t \end{bmatrix} = \eta_1 \begin{bmatrix} \Delta R_{t-1} \\ \Delta S_{t-1} \\ \Delta T_{t-1} \end{bmatrix} + \begin{bmatrix} \sigma_{11}\sigma_{12} \\ \sigma_{21}\sigma_{22} \\ \sigma_{31}\sigma_{32} \end{bmatrix} \begin{bmatrix} \theta_{11}\theta_{21}\theta_{31} \\ \theta_{12}\theta_{22}\theta_{32} \end{bmatrix} \begin{bmatrix} R_{t-1} \\ S_{t-1} \\ T_{t-1} \end{bmatrix} + e_t \tag{13}$$

For simplicity just analyze the first equation's error correction part. The first row of P matrix is;

$$\omega_1 V_{t-1} = ([\sigma_{11}\theta_{11} + \sigma_{12}\theta_{12}][\sigma_{11}\theta_{21} + \sigma_{12}\theta_{22}][\sigma_{11}\theta_{31} + \sigma_{12}\theta_{32}]) \begin{bmatrix} R_{t-1} \\ S_{t-1} \\ T_{t-1} \end{bmatrix} + e_t \tag{14}$$

This can also be written as;

$$\omega_1 V_{t-1} = \sigma_{11}(\theta_{11} R_{t-1} + \theta_{21} S_{t-1} + \theta_{31} N_{t-1}) + \sigma_{12}(\theta_{12} R_{t-1} + \theta_{22} S_{t-1} + \theta_{32} N_{t-1}) \tag{15}$$

Equation clearly expresses the two cointegrating vectors and the terms of their speed of adjustment σ_{11} and σ_{12}.

Regarding the rank of matrix, there are three cases which are as follow;

- The variables in Vt are I(0), if ω has a full rank.
- There are no cointegrating relationships, when the ω is zero.
- There are $r \leq (n - 1)$ cointegrating relationships, when ω has a reduced rank.[1]

RESULTS AND DISCUSSIONS

All variables are integrated at level one in ADF unit root test and PP unit root test considering the trend and intercept model. The order of integration of each variable is same in both tests. The variables are further tested by another unit root test (KPSS) to avoid the possibility of spurious regression. Results of KPSS show that all levels are integrated at level. Level of integration of all variables in KPSS is again same (Table 1). That's why Johanson Cointegration Model is applied.

Table 1: Results of Unit Root Test

	ADF				PP				KPSS	
	With Trend									
Variables	Level	P*	1st difference	P*	Level	Q*	1st difference	Q*	Level	K*
LWA	-2.73*	8	-	-	-5.36***	11	-	-	0.62**	5
LCA	-2.13	8	-8.56***	8	-2.11	2	-8.56***	0	0.68**	4
LEXR	-1.89	8	5.12***	8	-1.86	2	5.12***	2	0.57**	5
LAGDP	-1.80	8	-5.41***	8	-1.80	2	-5.41***	3	0.59**	5
LPo	-1.32	8	-4.36***	8	-0.12	3	-6.19***	2	0.44*	4
LF	-1.97	8	-4.15***	8	-2.08	5	-4.09***	3	0.64**	5
With Trend and Intercept										
Variables	Level	P*	1st difference	P*	Level	Q*	1st difference	Q*	Level	K*
LWA	-2.09	8	-9.03***[	8	-1.93	2	-24.49***	31	0.21**	4
LCA	-2.57	8	-8.99***	8	-2.33	1	-9.01***	1	0.18**	3
LEXR	-0.69	8	-6.44***	8	-0.75	1	-9.04***	11	0.19**	4
LAGDP	-1.06	8	-5.67***	8	-1.16	1	-5.78***	5	0.16**	3
LPo	-1.72	8	-5.68***	8	-1.50	5	-8.98***	10	0.20**	4
LF	-0.07	8	-4.70***	8	1.09	6	4.70***	7	0.19**	3

Notes:. P* shows the maximum lag length, as determined by using SBC. Under PP test Q* and K* in KPSS test shows Newey-West Bandwith, as determined by Bartlett-Kernel.***, ** and * indicates significant at 1%, 5% and 10%

[1]The large part of this methodology is taken from Waqas and Awan (2011) [29]

Table 2: Johansen Maximum Likelihood Test for Cointegration

Hypothesis	Trace Test	5% critical values	Hypothesis	Max-Eigen Values	5% critical values
R=0	148.56	95.75	R=0	60.51	40.08
R=1	88.04	69.82	R=1	47.38	33.88
R=2	40.66	47.86	R=2	17.60	27.58
R=3	23.06	29.79	R=3	10.93	21.13
R=4	12.14	15.49	R=4	7.44	14.27
R=5	4.69	3.84	R=5	4.69	3.84

Table 3: ECM Regression Results

Variables	Coefficient		t-values
Constant	-28212		1.56
DCA	-0.081		1.94
DER	5056.7		2.01
DF	-787.9		6.14
DOP	-5628.3		2.22
DWA	29884.3		6.81
DECM(-1)	-1.05		1.55
R-Squared	0.77	Log-likelihood	-426.45
Adjusted R-Squared	0.57	F-stat	3.91

After detecting long run relationships, it is vital to find short run relationships among variables through error correction. The Error Correction indicates the velocity of convergence towards equilibrium [29].

The results show the oil price effects the agriculture productivity growth negatively. This negative linkage of oil price and agriculture productivity growth can also be verified from findings of Binuomote and Odeniyi (2013) [20]. The exchange rate influences aggregate productivity growth positively, which is in line with Binuomote and Odeniyi (2013), Obayelu and Salau (2010), Adubi and Okunmadewa (1999) [20, 27, 30]. The agriculture productivity growth increases with increase in cropped area, which is in line with Awan & Mustafa (2013) [16]. As water availability increases, the agriculture productivity increases. This finding is in line with Awan & Mustafa (2013) [16]. The fertilizer intake shows negative sign, which means the excess of fertilizer has negative impact on agriculture productivity growth.

CONCLUSION

The purpose of study is to check the oil price impacts on agriculture sector of Pakistan during 1980-2013. Agriculture Gross Domestic product, Real Effective Exchange Rate, Real Crude Oil Price, Water Availability, Cropped Area and Fertilizer intake are used to construct the model. ADF, PP and KPSS unit root tests are used to test stationarity of time series variables. The order of integration of all variables is same in each unit root test. Therefore, Johnson Cointegration Technique & Error Correction Model is used to estimate short run and long run dynamics among variables. The results explore that there exist long run relationship among variables. Oil Price and excess intake of fertilizer have negative impact on agriculture productivity growth. Water Availability and Real Effective Exchange Rate have positive impacts on agriculture productivity growth.

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