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Research on Factors Influencing Grain Crops Production in Pakistan: An ARDL Approach

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Abstract

Ensuring food security is an important for economic development and social stability. Pakistan's economy is primarily dominated by agriculture sector. This paper employed the ARDL approach to cointegration in order to investigate the short and long-run determinants of grain crops productivity in Pakistan over the period 1978 to 2016. The results of ARDL bound test showed that the value of computed F-statistic exceeded the upper bound value, which means the equations were statistically significant at 5%. Further, empirical results of long-run and short-run revealed that area under grain crops, improved seed, fertilizer, and availability of water have a positive and significant effect on grain crops production in Pakistan. The estimated equation remains stable over the period of 1978 to 2016 as shown by stability tests. Currently, in Pakistan, small-scale farmers are unable to purchase farm machineries such as a tractor, tube -well and other inputs due to high prices. Therefore our study recommended that government should give subsidy to farmers on main agricultural inputs for improvement of grain crops production.

Keywords: Grain Production, Major Inputs, ARDL Model, Pakistan

Introduction

Agricultural sector accounts 19.5 percent of the GDP in Pakistan as it engages 68 percent of the rural population, which produce 42.3 percent of labor force. This sector plays a key role in national development, food security and poverty reduction (GOP, 2017). Agricultural sector is the main source of foreign exchange earnings, and this sector exports raw materials and processed agricultural products. It is very important because of its relations with other countries. In order to increase high growth rates in national income, creating jobs opportunities for fast-growing population, achieving food security and reducing poverty, rapid growth of agriculture sector is essential. Wheat, rice, and maize are major food crops of Pakistan contributing 9.6, 3.0 and 2.7 percent in the value added in agriculture while 1.9, 0.6 and 0.5 percent of GDP, respectively (Chandio, 2017; GOP, 2017). In Pakistan, food grain crops including rice, maize, bajra, and jowar are mostly grown in Kharif (June-October) season, while wheat and barley are mostly grown in Rabi (December-April) season (Aslam, 2016; Chandio et al., 2016a). For 2016-17, the area sown for wheat was estimated at 9052 (000 hectares), 1.9% lower than last year's area sown in 9224 (000 hectares). The estimated wheat production was remained 25.750 (million tonnes), indicating an increase 0.5 % over the corresponding period of last year's record production of 25.633 (million tonnes). Similarly, the area sown for rice was an estimated 2724 (000 hectare), 0.6 percent decrease than last year's area sown of 2793 (000 hectares). The production of the rice crop was stood at 6849 (000 tonnes), showing 0.7 percent increase than the corresponding period of last year's production of 6801 (000 tonnes). Furthermore, the area sown for maize crop has increased to 1334 (000 hectares), representing a substantial increase of 12.0 percent higher than last year's area sown in 1191 (000 hectares). An estimated production of maize crop was recorded high of 6.130 (million tonnes) during 2016 showing a major increase of 16.3 percent over the corresponding period of last year's production of 5.271 (million tonnes) (GOP, 2017). Wheat is the leading grain crop for many countries where it is being consumed as a staple food. It is fact that nothing is more important than the human being's needs. Sustainability and reliability in food grain production are important for sustainable crops production. Regarding wheat production in the world, Pakistan has a 10th position. Thus, wheat production in Pakistan is lower than China, India, and USA (Chandio et al., 2016a). Wheat crop is grown in overall regions of Pakistan and more than 70% of the farmers grown this crop (Hussain et al., 2012).

Rice is widely consumed as a staple food in the world. Most of the Asian countries produce high quality of rice. Furthermore, rice crop is cultivated many countries including China, India, Bangladesh, Indonesia, Vietnam, Nepal, Thailand, Japan, Brazil Philippines and Pakistan respectively (Ali et al., 2014; Chandio, 2017). In China, more than 90 percent of the area is irrigated under rice crop. China is the 1st largest rice producer country in the world, about 144,560 (1000 metric tons) rice production was recorded in 2016. China has 33% share in the world's overall rice production (Li et al., 2014; Rehman and Jingdong, 2017). On the other hand, Thailand is the largest better quality of rice exporting country in the world. Due to highest consumption of rice in the world, it has exported largest output over the other countries. In Pakistan, rice is second staple food grain crop after wheat, it is also cash crop after cotton (Mirani et al., 2002). Rice is a major source of foreign export earnings items of Pakistan, during 2013-14, rice export earned foreign exchange of USS 1.667 billion (GOP, 2014). However, an average yield of food grain crops in Pakistan is still quite low as compared to other producing countries. Pakistani farmers are facing many problems including, poor infrastructure, low adoption of latest technology, high prices of inputs, lack of government subsidy and less availability of formal credit. (Aslam, 2016; Chandio et al., 2017). Thus, the agricultural sector of Pakistan supports directly to the country's population. The main crops include sugarcane, rice, wheat, cotton, vegetables, and fruits (Chandio et al., 2016b). The critical pressing need is to improve agricultural production in order to make more efficient use of resources such as water, adoption of modern technology, sufficient usage of inputs and land. Therefore, the main objective of this study is to examine the short and long-run determinants of grain crops production in Pakistan over the period 1978 to 2016.

Factors affecting on grain production in Pakistan

Improved seed

Various researchers in different regions of the world including India (Kumar et al., 2016), Pakistan (Ali et al., 2014), Malaysia (Adedoyin et al., 2016), Bangladesh (Hossain et al., 2006), Nepal (Ghimire et al., 2015), Nigeria (Abubakar et al., 2016; Odoemenem and Obinne, 2010; Ologbon et al., 2012), Ghana (Al-Hassan and Jatoe, 2002), Ethiopia (Abebaw and Belay, 2001; Asfaw et al., 2012; Kebede et al., 2017), Kenya (Okello et al., 2016) Sudan (Maruod et al., 2013), Uganda (Kassie et al., 2011) and Zimbabwe (Mango et al., 2014) who found positive and significant effect of socio-economic factors of the farmers such as education, farming experience, farm size, farm machinery, availability of water, soil quality, market distance, extension service, access to credit facilities, market information, household savings and off-farm income on adoption of improved food grain crops (rice, wheat and maize) varieties respectively. Improved/ certified seed is the most desirable agricultural input for improving food grain crops yield. Improved seed is an essential component in agricultural productivity system (Khonje et al., 2015). Access to improved seed ensures food security and prosperity of the farmers. The adoption of improved seed can result in higher food grain crops production and improve the income of farming families which has a positive influence on rural development (Fatima and Khan, 2015). Improved seed is a high technology and is an innovation most widely adopted by the farmers in developing countries to improve their crops productivity and produce more foods for poor people (Farooq et al., 2007). The federal seed certification and registration department are attached department of the ministry of national food security and research, with the mandate to regulate improved/ certified varieties of food grain crops. Improved seed being the main input in crop production plays an important role for sustainable agricultural production and national food security. According to economic survey of Pakistan (2014), about 372.0 thousand tons of improved seeds of various crops was procured. Further, 39.784 thousand m.tones of seed was imported for various crops including (paddy, maize, potato, sunflower, canola, fodders, vegetables etc.) in 2017 (GOP, 2017).

Usage of fertilizer

Fertilizers are very important agricultural input for high per acre yield and quick return (Nordin and Höjgård, 2017). Nutrient-wise one Kg of fertilizer produces almost eight Kgs cereals (rice, wheat, and maize) respectively. In Pakistan, more than 90% of the soil is deficient in nitrogen; about 80% to 90% are deficient in phosphorus and 30% in potassium. However, balanced fertilization is defined as the optimum yield of the fertilizer necessary for optimal use of fertilizers and other inputs for all the necessary nutrients. During 2016-17 (July-March), in Pakistan, domestic production of fertilizers was slightly decreased by 0.3% over the period of last year’s while imported fertilizers also decreased by 5.8%. Therefore, timely availability of fertilizers is more important for the farmers at the sowing time of food grain crops (GOP, 2017). According to Hamid and Ahmad (2009) used the time series data over the period of 1972 to 2007 and used the Cobb-Douglas production function to identify the change in agriculture value added. Results revealed that the agriculture value added depends on the level of agriculture and trade in the labor force involved in farming activities, intermediate inputs of agricultural technology including (fertilizers, high-yield varieties, seeds, and pesticides), capital stock and human resource development. The state also established the role of fertilizers to improve agricultural productivity as a developing country. Some people think that fertilizers are more important as the seeds of the green revolution in Asia that contribute as much as 50% of the growth in agricultural productivity (Tomich et al., 1995). Analysis of the urgent need; is one of the fundamental ways to increase crops production, especially in sub-Saharan Africa and to enhance the agricultural productivity through the usage of participation, such as adoption of improved varieties of food grain crops, fertilizers, pesticides and the usage of modern agricultural technology (Wanyama et al., 2009). The effects of production, education level, landholding size, and fertilizer price levels on having a deep influence on food grain crops production. Farmers use the fertilizers for crops production, while gender, age and family size are not (Amanze et al., 2010). The impact of agricultural extension on adoption of fertilizers and their effect on the productivity of rice crop in Ghana was investigated (Emmanuel et al., 2016) by employing PSM method. Results showed that access to agricultural extension service positively and significantly promotes adoption of fertilizers. A study by Amanze et al. (2010) research showed that balanced use of fertilizers leads to increase the yields of food grain crops, and also improve the livelihood of the farmers. Additionally, deficiencies of soil nutrient serve as a remedy and help to maintain the fertility of the soil. It was observed that without the use of fertilizers, crop yields can no longer be increased. According to Quddus et al. (2008) in Pakistan, the use of commercial fertilizer was initiated during 1952, and only 1000 nutrient tons was consumption of N, while in 1959-60 with the initial acquisition of nutrients 100 tons of phosphorus was introduced. Whereas, potash fertilizers were started in 1966 with a capacity of about 120 nutrient tones.

Availability of water

Availability of water is essential to meet the need of food of the country's growing population. The efficient use of water is an important requirement for sustainable food grain crops production. The agricultural sector of Pakistan is closely associated with the availability of water. According to Economic Survey of Pakistan (GOP, 2017), availability of water for Kharif season of 2016 stood at 71.4 (in million acre-feet) indicating an increase of 9.0% over Kharif season of 2015 and 6.4% more than the normal supplies of 67.1 (in million acre-feet). Whereas, for Rabi season 2016-17, the availability of water remained at 29.7 (in million acre-feet), which is 9.7% less than Rabi season of 2015-16 and 18.4% less than the normal availability of 36.4 (in million acre-feet). However, proper harvesting of food grain crops and efficient use of water is of great significance. Shortage of water will cause a drop in food grain crops yields and food security. Globally, agriculture is the largest source of water and consumes about 70 percent of all freshwater extraction (WINPENNY, 2010). In Pakistan, more than 70 percent of the area is irrigated through the canal system. Recently, almost 93 percent resources of freshwater are used in the agriculture sector (Bhanger and Memon, 2008). Evidence suggests that existing surface water resources are not lacking, but also extremely unbalanced in time and space. This variation in surface water runoff has led to the expansion of the large-scale groundwater irrigation system in the Indus basin in Pakistan. The affected rise in groundwater usage over the past half-century has evolved into the "quiet revolution" supported by the majority of the farmers pursuing the use of groundwater that has evolved over the past half-century into a reliable irrigation water supply. Since 1960, the share of total irrigated groundwater has increased by more than 50 percent (Qureshi et al., 2010). However, the resources of the groundwater having an important for crops production, nonetheless these resources of groundwater are at the serious moment in Pakistan (Shah, 2000).

Agricultural mechanization

The utilization of modern farm machinery plays a vital role in the timely sowing and harvesting of food grain crops. Improving more food crops productivity is a path for meeting the future food requirement of growing population (Kulakarni, 2009). For food grain crops production, human sources, animal, and modern machinery are extensively used. In developing countries, due to lack of low income, low household savings, lack of government subsidy and lack of credit facilities in small farms except for tillage, other operations including sowing, weeding, harvesting and threshing of various crops are normally manually performed by farmers (Iqbal et al., 2015). At present in Pakistan, tractors are being used in small and large farms for tillage. However, still, small farmers are utilizing bullock operated equipment system. The average yield of food grain crops in Pakistan is quite low as compared to those countries that use the modern agricultural technology. The yield of various crops is 50 to 83 percent lower than the average of the other countries of the world (Khan et al., 2011; Tewari et al., 2012). The contributions of agricultural mechanization can be viewed in many stages of crops production as saving in time (20 to 30%), reduction in labor (20 to 30%), saving in fertilizers (15 to 20%), saving in seeds (15 to 20%), increasing in cropping intensity (5 to 20%) and high production (10 to15%) (Chauhan et al., 2006; Singh and Kohli, 2005). The main aspect of mechanization is that it helps in improving the yield of crops and reducing post-harvest losses. In 2017, a total number of 37,634 tractors have been manufactured compared to the production of 21,229 during the corresponding period of last year, showing an increase of 77.3 percent as the GST on locally manufactured while imported tractor has been reduced from 10 percent to 5 percent that has increased the demand for farm machinery (GOP, 2017). There is limited empirical evidence on the relationship between technological factors and food grain crops production. Therefore, this study aims to fulfill this research gap in the existing literature by investigating the short and long-run determinants of grain crops production in Pakistan over the period 1978 to 2016. The rest of the paper is organized as follows: the next section consists of methodology, data sources and empirical estimations method. Empirical results and discussion is presented in section 3; section four draws conclusion and policy implications.

Methodology

Data sources

The main purpose of this research is to examine the short and long-run determinants of grain crops production in Pakistan over the period 1978 to 2016. Annual data from 1978 to 2016 from the Pakistan economy have been used to construct the specified ARDL model. The data has been sourced from various issues of Pakistan Economic Survey, Pakistan Agricultural Statistics, and Pakistan Statistical Year Books respectively. Basically, there are eight variables included in the empirical ARDL model for our estimations. The unit of the grain crops production variable is in (000 tonnes). However, the unit of land area under grain crops is in (000 hectares), improved seed in (000 tonnes), fertilizers in (000 N/T), water availability in (MAF), agricultural machinery including tractors (No) and a number of tube wells respectively. The linear regression model is:

$$lnGCP_t = \alpha_0 + \alpha_1 lnAREA_t + \alpha_2 lnISEED_t + \alpha_3 lnAWA_t + \alpha_4 lnFER_t + \alpha_5 lnINS_t + \alpha_6 lnTRAC_t + \alpha_7 lnTWS_t + \upsilon_t \dots\dots\dots\dots\dots\dots (1)$$

Where, GCP represents grains crops production, AREA represents area under grain crops cultivation, ISEED represents improved seed distribution, AWA represents the availability of water, FER represents fertilizers off-take, INS represents insecticide, TRAC represents tractors, TWS represents tube wells, α_0 represents constant intercept and $\upsilon_t$represents error term.

Estimation methods

For this study, we have applied the popular Augmented Dickey (1981) unit root test to ensure the reliability of analyzing the study by observing the stationary properties of the variables in question so as to avoid spurious and misleading outcomes. After checking the stationary properties of the variables, we have employed ARDL bounds test to analyzing the long-run correlation between agricultural technology factors and grain crops production. The selection of the ARDL approach is based on its efficiency in small sample size as in this study (38) observation and the possibility of the variable having a number of different optimum lags. Also, ARDL model allows for co-integration assessment by the use of the OLS method after identifying the lag of the model (Pesaran et al., 2001). In order to examine the long-run relation between food grain crops production and seven explanatory independent variables, the bounds test procedure has been used for co-integration by estimating the following conditional version of the ARDL approach.

$$\Delta lnGCP_t = \beta_0 + \gamma_1 lnGCP_{t-1} + \gamma_2 lnAREA_{t-1} + \gamma_3 lnISEED_{t-1} + \gamma_4 lnAWA_{t-1} + \gamma_5 lnFER_{t-1} + \gamma_6 lnINS_{t-1} + \gamma_7 lnTRAC_{t-1} + \gamma_8 lnTWS_{t-1} + \sum_{i=1}^{p} \psi_{1i}\, \Delta lnGCP_{t-i} + \sum_{j=1}^{q} \psi_{2j}\, \Delta lnAREA_{t-j} + \sum_{k=1}^{q} \psi_{3k}\, \Delta lnISEED_{t-k} + \sum_{l=1}^{q} \psi_{4l}\, \Delta lnAWA_{t-l} + \sum_{m=1}^{q} \psi_{5m}\, \Delta lnFER_{t-m} + \sum_{n=1}^{q} \psi_{6n}\, \Delta lnINS_{t-n} + \sum_{r=1}^{q} \psi_{7r}\, \Delta lnTRAC_{t-r} + \sum_{s=1}^{q} \psi_{8s}\, \Delta lnTWS_{t-s} + \upsilon_t \dots\dots\dots\dots\dots\dots (2)$$

Where, ψ_i represents the difference of the independent variables are the short-run dynamics of the empirical model to be estimated through the ECM while $\gamma_i$represents the long-run multipliers; $\beta_0$represents the constant intercept and υ_t is the random disturbance term. In the ARDL bound test for co-integration, there are three steps are involved like as first step is to test the presence of long-rua n association between the variables by estimating Eq.(2) by the Ordinary Least Square (OLS) method. Thus, F-statithe stic test is estimated for the joint significance of the numerical values of the lagged levels of the variables.

It is hypothesized that;

H_0: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0$ (not cointegrated)

H_1: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 \neq 0$

Pesaran et al., (2001) and Pesaran and Shin (1998) have been developed an ARDL bound test for examining the long-run and co-integration association between variables, which is appropriate regardless of whether the underlying series are $I(0)$ or $I(1)$. If the values of estimated F-statistics lies above the upper bound, the null hypothesis of no co-integration is rejected which is indicating an association among the variables while the values of estimated F-statistics are higher than values of upper bound, we cannot reject the null hypothesis of no integration exists.

Furthermore, now our second step is to examine the long-run association after establishing the presence of co-integration. The ARDL long-run model for grain crops production is presented below:

$$lnGCP_t = \beta_0 + \sum_{i=1}^{p} \psi_1\, lnGCP_{t-1} + \sum_{i=0}^{q1} \psi_2\, lnAREA_{t-1} + \sum_{i=0}^{q2} \psi_3\, lnISEED_{t-1} + \sum_{i=0}^{q3} \psi_4\, lnAWA_{t-1} + \sum_{i=0}^{q4} \psi_5\, lnFER_{t-1} + \sum_{i=0}^{q5} \psi_6\, lnINS_{t-1} + \sum_{i=0}^{q6} \psi_7\, lnTRAC_{t-1} + \sum_{i=0}^{q7} \psi_8\, lnTWS_{t-1} + \mu_t \dots\dots\dots\dots\dots (3)$$

Based on the Akaike Information Criterion (AIC), we have been selected the order of the lags for ARDL$(p, q1, q2, q3, q4, q5, q6\ and\ q7)$.

Now our last step (3) is to estimate the short-run relationship between food grain crops production and independent variables. The model is presented below:

$$\Delta lnGCP_t = \emptyset_i + \sum_{i=1}^{p} \alpha_{1i}\, \Delta lnGCP_{t-i} + \sum_{j=1}^{q} \alpha_{2j}\, \Delta lnAREA_{t-j} + \sum_{k=1}^{q} \alpha_{3k}\, \Delta lnISEED_{t-k} + \sum_{l=1}^{q} \alpha_{4l}\, \Delta lnAWA_{t-l} + \sum_{m=1}^{q} \alpha_{5m}\, \Delta lnFER_{t-m} + \sum_{n=1}^{q} \alpha_{6n}\, \Delta lnINS_{t-n} + \sum_{r=1}^{q} \alpha_{7r}\, \Delta lnTRAC_{t-r} + \sum_{s=1}^{q} \alpha_{8s}\, \Delta lnTWS_{t-s} + \rho ECM_{t-1} + \upsilon_t \ldots (4)$$

The short-run coefficients of the model equilibrium have been presented by α_i in Eq. (4). The Error-Correction Model is ECM_{t-1} and ρ denotes the coefficient which measures the speed of short run adjustment convergence to long-run equilibrium in the event of a shock in the system. The ECM is calculated as:

$$\mathrm{ECM}_t = lnGCP_t - \beta_0 - \sum_{i=1}^{p} \psi_{1i}\, lnGCP_{t-i} - \sum_{j=1}^{q1} \alpha_{2j}\, lnAREA_{t-j} - \sum_{k=1}^{q2} \alpha_{3k}\, \Delta lnISEED_{t-k} - \sum_{l=1}^{q3} \alpha_{4l}\, \Delta lnAWA_{t-l} + \sum_{m=1}^{q4} \alpha_{5m}\, \Delta lnFER_{t-m} - \sum_{n=1}^{q5} \alpha_{6n}\, \Delta lnINS_{t-n} - \sum_{r=1}^{q6} \alpha_{7r}\, \Delta lnTRAC_{t-r} - \sum_{s=1}^{q7} \alpha_{8s}\, \Delta lnTWS_{t-s} \ldots \ldots \ldots \ldots \ldots \ldots (5)$$

Results and discussions

Results of unit root test

The status of stationarity of all variables is identified for the present study was determined prior to the long-run association between grain crops production and its dynamic regressors. The estimated results of ADF unit root test including trend and intercept are presented in Table 1.

Table 1. ADF unit root test (trend and intercept)

Variables	At level	First Difference
lnGCP	-4.696633***	-3.959290***
lnAREA	-3.612790**	-9.493981***
lnISEED	-3.415029*	-6.751716***
lnFER	-2.742474	-5.215926***
lnAWA	-0.327663	-11.93912***
lnINS	-4.254235***	-10.99152***
lnTRAC	-2.672744	-4.782833***
lnTWS	-1.892573	-6.567927***

Note: *****, **,*** indicates the rejection of null hypothesis of non-stationary at 1%, 5% and 10% of significance levels.

From Table 1, grain crops production, area under grain crops cultivation, improved seed, and insecticide were found to be stationary at their levels which imply they are integrated of order zero I(0). However, fertilizer, tractors, and tube-wells were all stationary after their first difference, hence integrated of order one, I(1). It is, hence, prudent to estimate the model using the ARDL bounds test specification.

ARDL bound test for a long-run relationship

After checking the stationarity of all the variables, now we tested for the presence of long-run relationship among the variables by means of ARDL bounds test. The results of ARDL bound test are illustrated in Table 2.

Table 2. ARDL Bounds Test for Co-integration Results

F-Statistic	Significance level	Lower Bound	Upper Bound	Decision
5.022981	10%	2.03	3.13	Co-integrated
	5%	2.32	3.5	
	1%	2.96	4.26	

Note: Calculated and generated from E views 9.5 software

The estimated results of ARDL bounds test confirm the existence of long-run correlation between grain crops production and the explanatory variables since the calculated F-Statistic exceeds the upper critical value at 5% level of significance.

Results of long-run relationship

The results in Table 3 indicate the long-run relationship between grain crops production (the dependent variable) and the various exogenous variables.

Table 3. Estimated long-run coefficients using the ARDL approach

Dependent Variable: LnGCP				
Regressors	**Coefficient**	**Std. Error**	**T- Ratio**	**P-value**
lnAREA	1.010417***	0.285321	3.541337	0.0025
lnISEED	0.124528***	0.025272	4.927444	0.0001
lnFER	0.439817***	0.115269	3.815562	0.0014
lnAWA	-0.761352*	0.350291	-2.173480	0.0442
lnINS	-0.024917	0.020792	-1.198403	0.2472
lnTRAC	0.012814	0.022550	0.568233	0.5773
lnTWS	-0.017476***	0.005154	-3.390719	0.0035
Constant	0.473148	3.001430	0.157641	0.8766

* Significance level of 10%; *** Significance level of 1%.
Note: Calculated and generated from E views 9.5 software

Table 3 reports that the coefficients of area under grain crops, improved seed and fertilizer were found to be positive and statistically significant at 1%. These results imply that area under grain crops cultivation, improved seed, and fertilizer were positively correlated with the grain crops production in the long run. Specifically, a percentage increase in area under cultivation, improved seed and fertilizer leads to about 1.010417%, 0.124528% and 0.439817% increase the production of grain crops in Pakistan, respectively. Further, area under cultivation, adoption of improved/certified seed and balanced use of fertilizer are an important technology factors which plays a vital role to increase grain crops production and also improve welfare of the farmers (Badar et al., 2007; Emmanuel et al., 2016; Khonje et al., 2015; Nordin and Höjgård, 2017). Whereas, the coefficients of water availability and insecticide were negative and statistically significant at 5%. This means water availability and insecticide were negatively linked with grain crops production in the long run. However, in Pakistan most control of the irrigation system is under the landowners, who have about 40 percent of the arable land, and that makes difficulties to mean a wide range of reforms (Buriro et al., 2015; Koondhar et al., 2016). Lack of skills and knowledge Pakistani small farmers do not know appropriate usage of insecticide during spray-on grain crops. Therefore, small farmers need training and workshop which may guide them how to utilize insecticide on their crops. Additionally, the adoption of latest agricultural technology plays a very important role in the timely sowing and harvesting of crops. The farm machinery (tractors) is showing a right positive relation with grain crops productivity. This means tractors was positively related to grain crops productivity in long-run. The tractor is statistically insignificant with a coefficient of 0.012814. These results show that 1% increase in usage of farm machinery (tractor) will increase the grain crops production almost by 0.012%. Finally, the coefficient of tube-well was negative and significant; this means that tube-well were negatively linked with grain crops production in long-run. Due to shortage of electricity and high price of diesel, in rural Pakistan farmers are rarely using tube-well and small-scale farmers cannot afford the high price of diesel to operate their tube-well. The empirical findings of this study are contradicted by the results carried out in most of the past studies such as (Buriro et al., 2015; Chandio et al., 2016a; Chandio et al., 2015; Hussain, 2012; Koondhar et al., 2016; Rehman and Jingdong, 2017). Most of these studies in the past applied Ordinary Least Square (OLS) approach but this study followed ARDL approach to co-integration in order to estimate the long-run and short-run connection in the model with desired variables.

Table 4. Estimated ARDL Short Run Error Correction

Dependent Variable: LnGCP				
Regressors	**Coefficient**	**Std. Error**	**T- Ratio**	**P-value**
Δ lnAREA	1.447796***	0.344200	4.206261	0.0006
Δ lnAREA-1	0.260674	0.314051	0.830037	0.4180
Δ lnISEED	0.053064	0.045895	1.156219	0.2636
Δ lnISEED-1	-0.024242	0.039072	-0.620459	0.5432
Δ lnFER	0.343591***	0.115350	2.978695	0.0084
Δ lnFER-1	-0.281221**	0.131252	-2.142601	0.0469
Δ lnAWA	0.018000	0.383175	0.046977	0.9631
Δ lnAWA-1	0.548978*	0.294418	1.864620	0.0796
Δ lnINS	-0.062429*	0.030977	-2.015323	0.0600
Δ lnINS-1	-0.013319	0.025636	-0.519533	0.6101
Δ lnTRAC	-0.016475	0.037161	-0.443352	0.6631
Δ lnTRAC-1	-0.054390	0.038918	-1.397573	0.1802
Δ lnTWS	-0.005875	0.006765	-0.868457	0.3972
Δ lnTWS-1	0.002407	0.006931	0.347345	0.7326
ECM (-1)	-1.385586***	0.232913	-5.948940	0.0000
R-squared 0.843628			Durbin-Watson stat 2.258327	
Adjusted R-squared 0.641265			F-statistic4.168883(0.002034)	

* Significance level of 10%; ** Significance level of 5%; *** Significance level of 1%.
Note: Calculated and generated from E views 9.5 software

Results of short-run error correction

In this article, the short-run error correction model (ECM) was used to examine the short-run dynamics of the variables. It thus illustrates the short-run correlation between the endogenous variable (grain crops production) and its respective exogenous variables. The empirical results of ECM are presented in Table 4.

It was observed from Table 4 that area under grain crops cultivation was positively and significantly related to the grain crops production in the short run just as in the long run. The land as a basic input shows its coefficient 1.447796; this means 1% increase in area under cultivation will enhance the grain crops production about by 1.44%. This finding is similar to the findings of (Ahmad, 2011). Whereas, improved seed also was positively linked to the grain crops production in the short-run just as long-run. Nevertheless, it was statistically insignificant in the short run. This means that in Pakistan, the improved seed does not impact on grain crops production in the short-run. In Pakistan, the majority of small farmers are still utilizing the traditional method in farming activities. Further, due to high prices of improved/ certified wheat, rice, and maize varieties, farmers are less adopting this technology and resulted low per acre yields of grain crops in Pakistan (Farooq et al., 2007). Similarly, fertilizer is an essential agricultural input for higher per acre yields of food grain crops productivity and quick return. Appropriate and nutrient wise one Kg of fertilizer produces almost eight Kgs of cereals (rice, wheat, and maize), respectively. Just like in the long-run, fertilizers was positively correlated with grain crops production in the short run. It has a positive coefficient of 0.343591at 1%. This result implies that 1 percent increase in balanced use of fertilizer grain crops production will increase almost 0.243% in the short run. The sufficient supply of irrigation is a very important requirement for sustainable per acre yields of grain crops (GOP, 2017). Availability of water showed a positive relationship with food grain crops production in the short run contrary to the long run result. Availability of water has a positive coefficient of 0.548978 which is statistically significant at 10%. This result implies that 1 percent increase in availability of water grain crops production will enhance about 0.548% in short-run. In other words, farmers need water at the sowing time of food grain crops (Anwer et al., 2015). On the contrary, insecticide, tractors, and tube wells were found to be negatively related with grain crops production in short-run as we also found in long-run results The findings of this study is consistent with the findings of (Badar et al., 2007). Finally, the estimated ECM is negative (-1.385586) and statistically significant at 1% confidence level. The coefficient of ECM was found to be -1.385586 which indicates that adjustment takes place 1.38 percent per year towards the long run equilibrium. The value of R-squared was estimated to be above 84 percent, which shows that the model is strongly good fitted.

Results of diagnostic tests

In this study, diagnostic tests were checked and there is no problem in the presented model. All functions were rightly specified and our empirical model was stable. Various tests we have checked including serial correlation, normality, and heteroscedasticity and we found there was no any problem (see Table 5). The relevant figures for testing stability are depicted in (Figs.1, 2 and 3).

Table 5. Diagnostic and Stability tests

Test Statistics (LM version)	**Prob.**
Serial Correlation	0.1028
Normality Test	0.1151
Heteroscedasticity	0.3337
CUSUM	Stable
CUSUMSQ	Stable

Note: Calculated and generated from E views 9.5 software

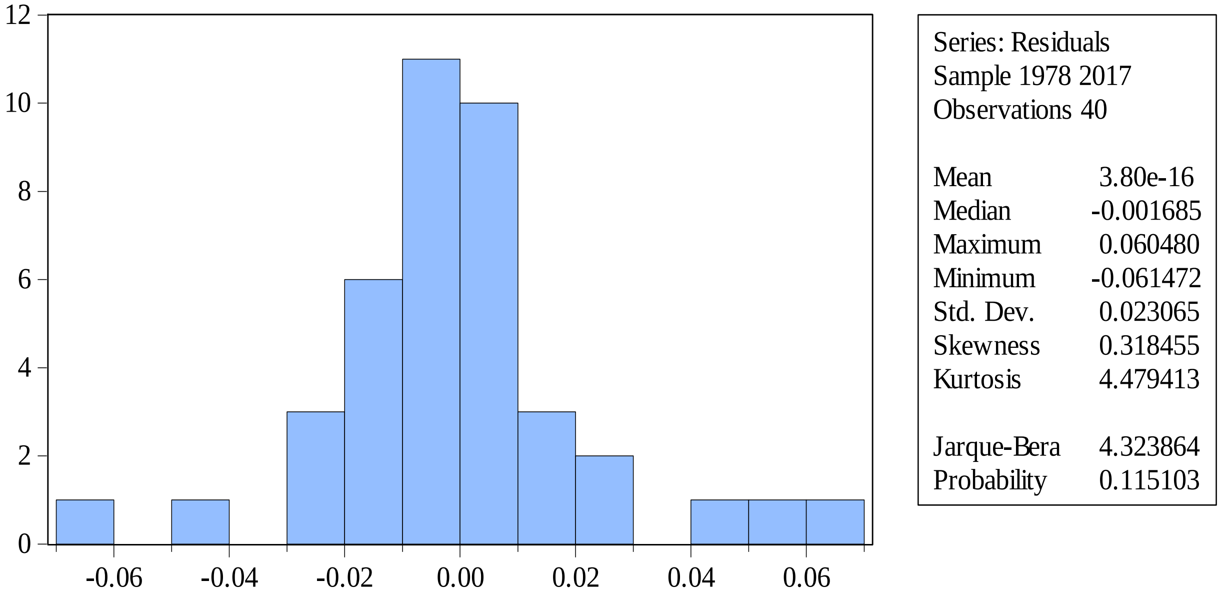

Figure 1. Normality test

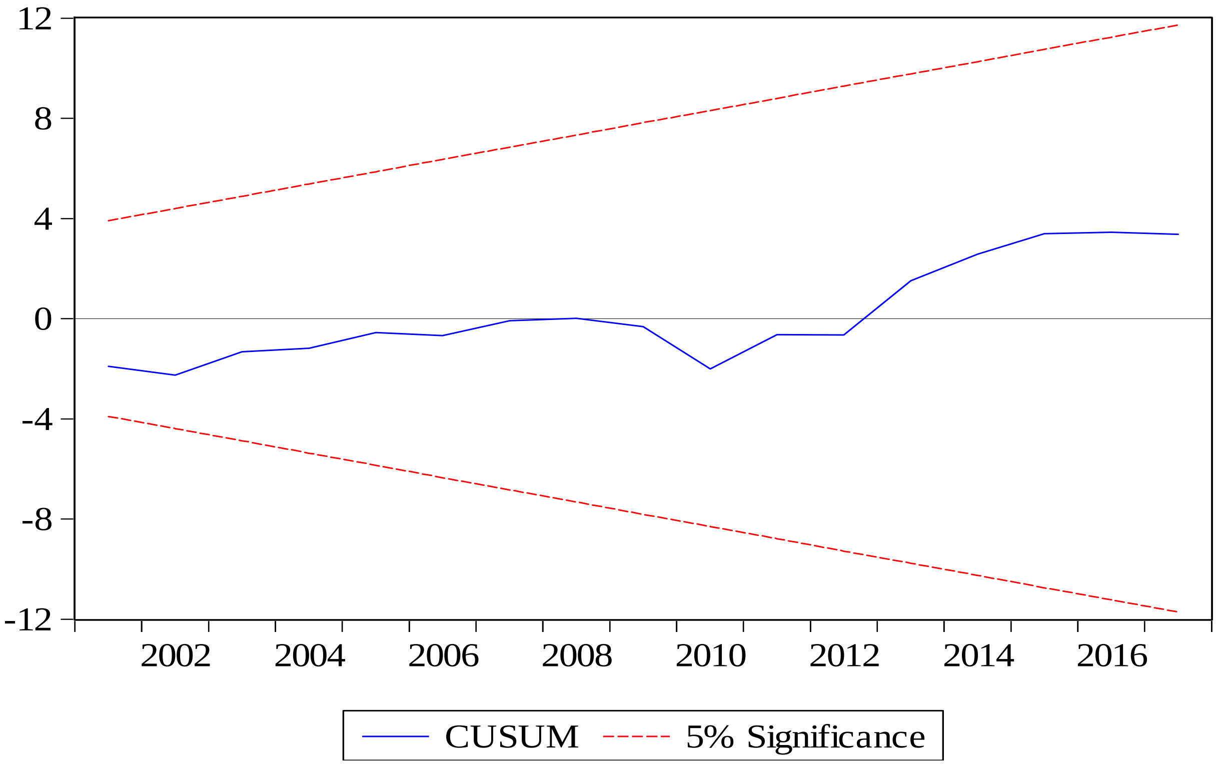

Figure 2. CUSUM test

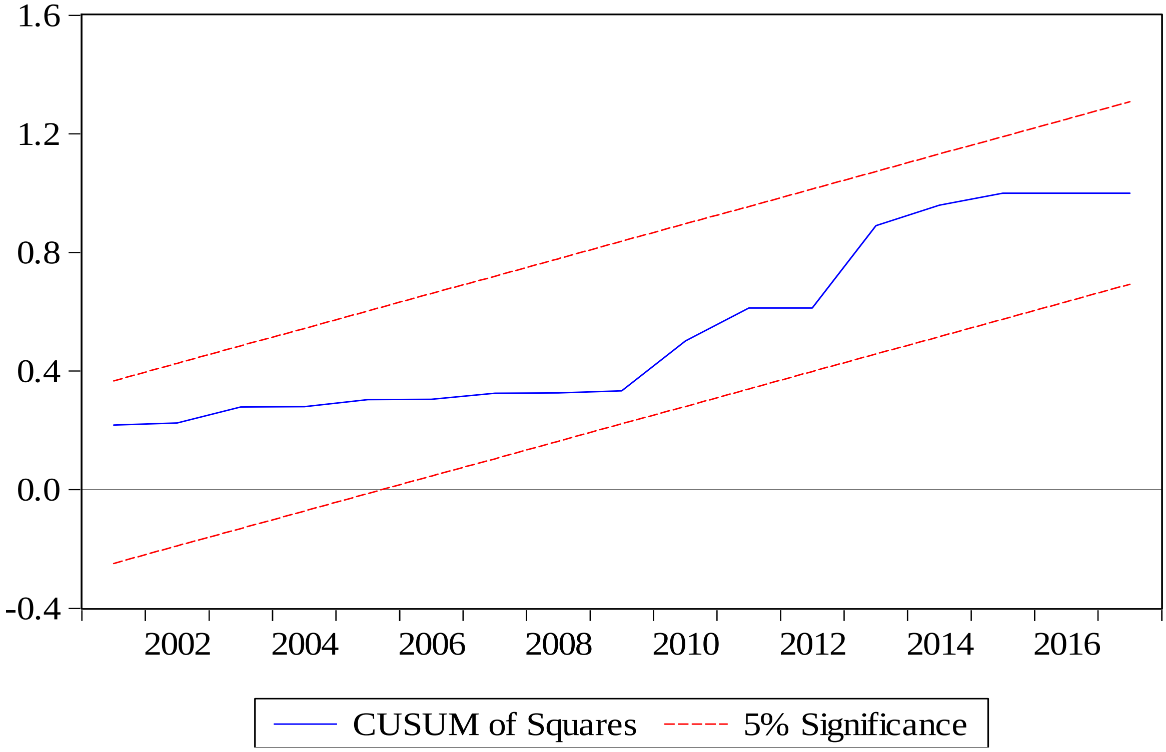

Figure 3. CUSUM of Squares test

Conclusion and policy implications

Increasing grain crops production is one of the most important determinants of economic growth and poverty reduction. This study focused on determining empirically the impact of major factors on grain crops production in Pakistan for the period of 1978 to 2016 by using an Autoregressive Distributed Lag (ARDL) to co-integration model. Employing the bounds testing to cointegration, the results showed that there is cointegration between grain crops production, area under grain crops cultivation, improved seed, fertilizer, insecticide, availability of water, tractors and tube-wells when grain crops production was taken to be the dependent variable. The empirical results revealed that long-run and short-run coefficients of area under grain crops cultivation, improved seed, fertilizer and availability of water are estimated to be 1.010, 1.447, 0.124, 0.053, 0.439, 0.343 and 0.548, respectively which makes highly positive and significant impact on grain crops production in Pakistan. On the other hand, insecticide, tractors, and tube-wells have a negative effect on grain crops production. Currently, in Pakistan, farmers are unable to purchase farm machineries such as tractor, tube -wells and other inputs due to the high price of these inputs. Therefore our study recommended that government should give subsidy to them on main agricultural inputs. Furthermore, poor knowledge and little awareness about the exact quantity of fertilizer and chemical spray on food grain crops. Therefore agricultural extension officers should pay more attention to small group meetings and workshops at the village level to enhance practical knowledge for obtaining per acre maximum yield of grain crops.

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