Energy consumption and agricultural economic growth in Pakistan: is there a nexus?

Article *in* International Journal of Energy Sector Management · December 2018

DOI: 10.1108/IJESM-08-2018-0009

Abbas Ali Chandio
Sichuan Agricultural University

Abdul Rehman
Anhui University

International Journal of Energy Sector Management

Energy consumption and agricultural economic growth in Pakistan: is there a nexus?

Abbas Ali Chandio, Yuansheng Jiang, Abdul Rehman,

Energy consumption and agricultural economic growth in Pakistan: is there a nexus?

Abbas Ali Chandio and Yuansheng Jiang
College of Economics, Sichuan Agricultural University, Chengdu, China, and
Abdul Rehman
Research Center of Agricultural-Rural-Peasants, Anhui University, Hefei, China

Abstract

Purpose – This study aims to empirically examine the relationship between energy consumption and agricultural economic growth in Pakistan over the period from 1984 to 2016.

Design/methodology/approach – This study used the autoregressive distributed lag (ARDL) bounds testing approach to cointegration to investigate the long-run and short-run determinants of agricultural economic growth in Pakistan.

Findings – The results of the ARDL bounds testing approach to cointegration revealed that long-run linkage exists among the study variables. The findings of this paper showed that agricultural economic growth is positively affected by gas consumption and electricity consumption both in the long-run and short run. The long-run and short-run coefficients of gas consumption and electricity consumption were estimated to be 0.906, 0.421, 0.595 and 0.276, respectively. The estimated equation remains stable during the period from 1984 to 2016 as analyzed by the stability tests.

Originality/value – This study considers the relationship between energy consumption and agricultural economic growth in Pakistan by using an ARDL bounds testing approach to cointegration. The study has three contributions to economic literature:this study used different unit root tests to test stationarity of the variables such as ADF unit root test by Dicky and Fuller and P-P unit root test by Philip and Perron; the ARDL bounds testing approach to cointegration is applied to test the existence of long-run analysis between energy consumption and agricultural economic growth; and to check the robustness, the authors used the Johansen cointegration test to examine the long-run relationship between dependent and independent variables.

Keywords Co-integration, Energy sector, Time series analysis, Regression, Electricity, Agricultural

Paper type Research paper

Abbreviations

ARDL = autoregressive distributed lagged;
ADF = augmented Dickey-Fuller;
P-P = Phillips-Perron;
AEG = agricultural economic growth;
CUSUM = cumulative sum of recursive residuals; and
CUSUMS = cumulative sum of squares of recursive residuals.

The authors are very thankful to anonymous reviewers and Dr Prasanta Dey (Editor of *International Journal of Energy Sector Management*) for valuable comments and suggestions, which greatly improved the quality of this empirically research paper.

International Journal of Energy Sector Management

1750-6220
DOI 10.1108/IJESM-08-2018-0009

1. Introduction

Pakistan's electricity sector was considered as a natural monopoly of the public sector until the 1980s and as of late it has experienced privatization, rebuilding, and private sector investment. The nation's energy division, often referred to as an underdeveloped, underfunded and mismanaged, suffers from significant system losses in 2009-2010 and each year, with estimated transmission and distribution losses in Pakistan at about 20 per cent. All of these have adversely affected the health of the industry (GOP, 2009, 2010; Khan and Ahmad, 2008). Pakistan's agricultural sector including crops and livestock production provides jobs to over 60 per cent rural households in the country (Anwer *et al.*, 2015; Aslam, 2016; Chandio *et al.*, 2017). The livelihoods of the rural households are influenced by key agricultural inputs, especially energy (Mushtaq *et al.*, 2007). The mechanization of Pakistan's agricultural sector has in recent times influence the rise in demand for natural gas and electricity in the country. Electricity is applied in running tube-wells as agricultural machinery, whiles the production of pesticides and chemical fertilizers rely on the use of natural gas (Ahmed and Zeshan, 2014; PCGOP, 2012). Without energy consumption in terms of gas, oil, and electricity agricultural economic growth could not be achieved. Due to the 1973 Middle East oil embargo, the world oil price rose rapidly. The debate on economic growth and its impact on energy consumption have to be extremely important. The shocks in these oil prices have negatively affected the real supply of most oil-importing countries, which in turn have raised the rate of inflation and reduced their economic growth (Riaz and Stern, 1984). The technology was concentrated in the hands of a few at the early stages of agricultural mechanization widening the income inequality between lager and smallholder farmers. Evidence from previous studies indicated that mechanization reduces labor (Binswanger, 1986). This surplus labor force faces a substantial drop in income levels, thus increasing the incidence of poverty. A similar increase in urbanization in the Republic of Korea, Japan, and Taiwan resulted in the sharp fall in the demand for labor in those countries (APO, 1996). The agricultural sector has keen role to boost the economy of Pakistan including energy sector. In the recent decade, many studies have been conducted to highlight the energy consumption and production in the form of oil and gas and its association with economic growth in Pakistan to boost the economic and the energy sector (Akber *et al.*, 2017; Mirjat *et al.*, 2017; Naqvi *et al.*, 2016; Rehman and Deyuan, 2018; Shah *et al.*, 2018). The main objective of this study is to empirically examine the relationship between energy consumption including agricultural gas consumption, agricultural oil consumption, agricultural electricity consumption and agricultural economic growth in Pakistan. Time series data is used in this study from 1984 to 2016. Besides the introduction section, the paper is arranged as follows: Section 2 reports the existing review of the literature on energy consumption; Section 3 is about the data and methodological framework; Section 4 reports the empirical results; and Section 5 presents the conclusion.

2. Existing review of literature

The promotion of industrial sector energy to agriculture has already topped the natural function due to the promotion of industrialization. Researchers have identified a key interest in the analysis of agricultural input and output of energy usage in the agricultural sector. Scott Kennedy (2000) uses a case from the USA to classify the efficiency and energy consumption structure in agriculture. Furthermore, several researchers used economic models to analyze in detail the input and output of agricultural energy consumption (Hatirli *et al.*, 2005; Karkacier and Goktolga, 2005;

Karkacier *et al.*, 2006). Pakistan's electricity generation increased by 53 per cent between 1994 and 1999, but this increment was reduced to just 12 per cent between 1999 and 2007. With the healthy growth in electricity demand, the country is at risk from an energy crisis that could erode excess production without any new generation projects coming online. Even though social and economic development depends largely on the energy sector, an estimated 40 per cent of households in Pakistan have no access to electricity (Ahmed, 2007). The Pakistani government estimated USD 2.60 billion per annum loss in income and a further 400,000 loss of jobs in case of any load reduction (Atif and Siddiqi, 2010). Chen *et al.* (2007) revealed that in terms of job creation and the development of the economy of developing economies, electricity infrastructure plays a key role. The backward in power infrastructure in Bangladesh is a barrier to the expansion of the economic activity. The energy sector is characterized by poor management resulting in the poor quality of service, ineffective supply, inefficiency and huge government subsidies (Mozumder and Marathe, 2007; Temple, 2002). Although gains arrived from re-distribution networks in some countries instead of from rising in net productivity, the improvement of the private rate of return on agricultural farms is due to the systematization process of the energy (Farrington, 1986). Emphasis is laid on increasing energy consumption in Asian countries to increase agricultural productivity (Fluck, 1979). As the development process of every economy is energy-driven, the need for energy with emphasis on electricity for the process of growth is acknowledged generally (Ferguson *et al.*, 2000; Stern and Cleveland, 2004). Electricity is a key factor and a central role player in an economy's production and consumption process. Two neighboring South Asian countries such as India and Pakistan have in the past four years experienced growth in their GDP and also rise in electricity consumption. Even for one country, the results of the comparisons have observed changes in the time period of the data and econometric procedures used for the analysis (Ozkan *et al.*, 2004; Ozturk, 2010). In Pakistan for instance, the data for a period of 1971-2003 proves that economic growth influences electricity consumption (Asghar, 2008) also that of 1955-1996 indicated that electricity consumption leads to economic growth (Aqeel and Butt, 2001). New biotechnologies which include the introduction of new seeds for improving physiological quality, synchronicity and vitality, and the establishment of crops in different settings, provide the incentive for the agricultural mechanization. Initial research paid attention to irrigation systems of farming then later the focus turned to "weak farmers" (Akdemir, 2013; Mrema *et al.*, 2008). Prosperous farmers rapidly adopted improved crops varieties and chemical fertilizers and turned to energy mechanization (McInerney and Donaldson, 1975). Different studies has been conducted by using an autoregressive distributed lag (ARDL) approach to cointegration; Sharif *et al.* (2018, 2017) study demonstrated that by using the ARDL approach on tourism and CO2 emission association and democracy embolden economic growth in Pakistan. Furthermore, the energy security and environmental issues are the main drivers of increasing global biomass utilization, especially in developing countries such as Pakistan, and it is important to understand the current energy systems in various sectors. Technologies and initiatives are being developed to achieve renewable resources from non-renewable transition sources, reducing fossil fuel dependence and greenhouse gas emissions (Naqvi *et al.*, 2018). However, still there is a gap of empirical literature that has highlighted agricultural economic growth and energy consumption in terms of gas, oil and electricity consumption. As such, the main purpose of this empirical paper is to analyze the impact of energy consumption on agricultural economic growth in Pakistan. This empirical study is expected to contribute to the to the emerging empirical literature on energy as it is an effort to explore and assess the effect of energy consumption on agricultural economic growth in Pakistan during the period 1984-2016 by using the ARDL approach. Presently, time-series analysis along with ARDL bounds testing approach for cointegration is very much widespread approach to investigate the linkage amongst the variables. The most popular ARDL approach, which can examine the long-run associations with the different order of integration including $I(0)$ and $I(1)$ or purely $I(0)$ or purely $I(1)$ of stationary of the series. This advanced approach has mostly emphasized by a number of very famous economists, (for instance., Narayan, 2005; Pacheco-López, 2005; Pesaran *et al.*, 2001; Zachariadis, 2006). According to their application, the ARDL model is applied in this study.

3. Data and methodological framework

3.1 Data

This study covers the period from 1984 to 2016 to analyze the linkage between agricultural economic growth and energy consumption in terms of gas, oil, and electricity in Pakistan. We have used the Ministry of Petroleum Natural Resources, Oil Companies Advisory Committee and Economic Survey of Pakistan to collect data on agricultural value added (constant 2010 US$), agricultural gas consumption (mm cft), agricultural oil consumption (tons) and agricultural electricity consumption (Gwh), respectively.

3.2 Specification of the model

The present study examines the long-run and short-run linkage between agricultural economic growth and energy consumption in Pakistan, we used the multivariate regression model as specified in the equation below:

$$\text{AEG} = \beta_0 + \beta_1\text{GAS} + \beta_2\text{OIL} + \beta_3\text{ELE} + \varepsilon_t \tag{1}$$

Equation (1) can be converted into Log form as:

$$\text{LnAEG}_\text{t} = \beta_0 + \beta_1\text{LnGAS} + \beta_2\text{LnOIL} + \beta_3\text{LnELE} + \varepsilon_t \tag{2}$$

Where lnAEG represents the natural logarithm of agricultural economic growth, lnGAS represents the natural logarithm of gas consumption, lnOIL represents the natural logarithm of oil consumption, lnELE represents the natural logarithm of electricity consumption and ε_t represents error term.

3.3 Unit root tests for stationarity

To check the stationarity of variables, ADF and Phillips-Perron unit root tests was used to determine that none of the variable was considered to integrated in the order of $I(2)$. Because the bound testing approach for cointegration is invalidated in $I(2)$ cases. The ADF and P-P unit root tests, therefore, were performed by using (equation (3)):

$$\Delta Y_t = \alpha_0 + \beta_0 T + \beta_1 Y_{t-1} + \sum_{i-1}^{m} \alpha_1 \Delta Y_{t-1} + \varepsilon_t \tag{3}$$

where Y represents the variables being tested for unit root, T represents a linear trend, Δ represents the first difference, t represents the time, ε_t is the error term and m represents to achieve white noise residuals.

3.4 Cointegration with autoregressive distributed lag approach

To investigate the cointegration test among the variables, we prefer to use the ARDL approach to avoid the criticism of using conventional techniques of cointegration that may have serious shortcomings. Also, it captures the long-run and short-run linkage. The ARDL approach is very much flexible regarding the order of integration of the study variables. This approach is developed by (Pesaran and Shin, 1998; Pesaran *et al.*, 2001). We may use the ARDL bounds testing approach for cointegration if the series are integrated at $I(1)$ or $I(0)$. The linkage of the long-run and short-run is examined by applying the ARDL bounds testing approach representation of the dynamic unrestricted error-correction model (UECM) of (Equation 2) as depicted in (Equation (4)):

$$\Delta \mathrm{LnAEG_t} = \beta_0 + \sum_{i-1}^{p} \gamma_{1i} \Delta \mathrm{LnAEG}_{t-i} + \sum_{i-1}^{q^1} \gamma_{2i} \Delta \mathrm{LnGAS}_{t-i} + \sum_{i-1}^{q^2} \gamma_{3i} \Delta \mathrm{LnOIL}_{t-i} + \sum_{i-1}^{q^3} \gamma_{4i} \Delta \mathrm{LnELE}_{t-i} + \lambda_1 \mathrm{LnAEG}_{t-1} + \lambda_2 \mathrm{LnGAS}_{t-1} + \lambda_3 \mathrm{LnOIL}_{t-1} + \lambda_4 \mathrm{LnELE}_{t-1} + \varepsilon_\mathrm{t} \quad (4)$$

Where, Δ represents the difference operator, β_0 represents the constant intercept, γ_i represents coefficients of long-run dynamics, while λ captures coefficients of the short-run dynamics. Now we estimate F statistic for comparison with the (a) upper and (b) lower critical bounds generated by (Pesaran *et al.*, 2001) to draw a conclusion on the presence of cointegration. The ARDL bound test will favor the existence of cointegration between the series if the computed value of F-test is greater than the value of upper critical bound. But, the conclusion would be no cointegration among the series if the computed value of lower critical bound is larger than the computed value of F-test and would be inconclusive if the calculated value of F-test is between the values of upper and lower critical bounds. Eventually, this empirical study assess the long-run elasticities and short-run adjustment parameters in equation (4).

4. Empirical results

4.1 Descriptive statistics and correlation matrix analysis

Table I reports the descriptive statistics and correlation matrices of the important variables used in the empirical analysis. The results of descriptive statistics confirm that all the series are normally distributed as showed by Jarque-Bera test. Further, the results of correlation analysis show that electricity consumption and gas consumption are positively and significantly associated with agricultural economic growth while oil consumption is negatively correlated. This study also found a positive connection between electricity consumption and gas consumption.

4.2 Unit root tests analysis

Primarily, the present study has adopted the ADF and P-P unit root tests to check the integrating order of the series. Using the intercept, intercept and trend, estimates show that lnAEG, lnGAS, lnOIL, and lnELE are found non-stationary at the levels (Table II). After the first difference, this study found stationarity for the series (Table III).

Table I. Summary statistics and correlation matrix

Variables	lnAEG	lnELE	lnGAS	lnOIL
Mean	23.69171	8.700892	11.95614	11.86289
Median	23.48644	8.740497	12.07478	12.32715
Maximum	24.93507	9.178746	12.38268	12.70808
Minimum	22.77154	7.890957	11.49614	9.582731
Std dev.	0.702442	0.347015	0.298332	0.876913
Skewness	0.410594	−0.860706	−0.353781	−1.094224
Kurtosis	1.848810	3.008297	1.658115	2.952689
Jarque-Bera	2.749435	4.074578	3.164289	6.588372
Probability	0.252911	0.130382	0.205534	0.037098
Observation (1984-2016)	33	33	33	33
lnAEG	1.0000			
lnELE	0.841175	1.0000		
lnGAS	0.917023	0.828549	1.0000	
lnOIL	−0.904103	−0.629299	−0.728262	1.0000

Source: Author's calculations

Table II. Results of ADF and PP unit root tests at levels

	ADF statistic		PP statistic		
Variables	I	I and T	I	I and T	Status
lnAEG	0.814925	−1.896267	0.849987	−1.867917	Non-stationary
lnGAS	−1.267091	−0.922534	−0.579635	−2.310112	Non-stationary
lnOIL	2.424578	−0.230702	2.156986	−0.329379	Non-stationary
lnELEC	−2.425052	−2.990564	−2.322039	−2.155415	Non-stationary

Notes: I represents intercept, I and T represents intercept and trend; [a] and [b] shows the rejection of null hypothesis at 1 per cent and 5 per cent levels of significance, respectively

Table III. Results of ADF and PP unit root tests at first difference

	ADF statistic		PP statistic		
Variables	I	I and T	I	I and T	Status
lnAEG	−5.410450[a]	−5.564219[a]	−5.410789[a]	−5.564062[a]	$I(1)$
lnGAS	−5.354245[a]	−5.310504[a]	−6.600703[a]	−8.328446[a]	$I(1)$
lnOIL	−4.494472[a]	−5.630222[a]	−3.511214[a]	−4.799506[a]	$I(1)$
lnELEC	−3.684861[a]	−3.827176[b]	−3.552552[a]	−3.620297[b]	$I(1)$

Notes: I represents intercept, I and T represents intercept and trend; [a] and [b] shows the rejection of null hypothesis at 1 per cent and 5 per cent levels of significance, respectively

This study confirmed the integrating order of the series, now the next step of the study is to select the applicable lag order of the important variables to use the ARDL model. It is necessary to check the lag order because the *F*-test is more sensitive with lag order. This empirical study used several lag order tests such as LR, FPE, AIC, SIC, and HQ to select suitable lag order, however, this study chooses to take a decision about applicable lag following Schwarz information criterion (SIC). The comparison with another criterion, the SIC gives more reliable and consistent information. It can be viewed from Table IV showed that one is an optimal lag to be selected.

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	−2.039878	NA	1.69e-05	0.366053	0.547448	0.427087
1	133.1035	229.3343	1.25e-08	−6.854760	−5.947786*	−6.549591
2	154.2046	30.69249*	9.63e-09*	−7.163917*	−5.531363	−6.614612*
3	165.8627	14.13094	1.42e-08	−6.900767	−4.542634	−6.107327
4	178.0174	11.78638	2.31e-08	−6.667719	−3.584006	−5.630143

Notes: *Shows lag order selected by the criterion; LR represents sequential modified LR test statistic (each test at 5 per cent level); FPE denotes Final Prediction Error; AIC stand for Akaike Information Criterion; SIC represents Schwarz Information Criterion and HQ represents Hannan-Quinn information criterion, respectively
Source: Author's calculations

Table IV.
Lag length selection

4.3 Analysis of cointegration

This study has adopted the ARDL bounds testing approach to assessing the existence of a cointegration association between the study variables. The estimated results are reported in Table V, which shows that the calculated *F*-test is found to be 4.7760 which is higher than the upper critical values of 4.0889. It displays that the null hypothesis of no cointegration is rejected at 5 per cent (see Table V).

The Johansen and Juselius cointegration approach is conducted to determine the existence of long-run relationship among the study variables and results are displayed in Table VI which shows that there exists a long-run linkage amongst the variables. It means that the results of

	95% lower bound	95% upper bound	90% lower bound	90% upper bound	Decision
F-statistic					
4.7760	3.6301	4.9000	2.9815	4.0889	Cointegration
W-statistic					
19.1041	14.5203	19.5999	11.9259	16.3557	Cointegration

Note: Calculated and generated from Microfit 5.01 software

Table V.
The results of ARDL bounds testing to cointegration test

Null hypothesis	Alternative hypothesis	Test statistic	5% critical value	Prob
Trace statistic				
$H0: r \leq 0$	$H1: r > 0$	65.40097[a]	47.85613	0.0005
$H0: r \leq 1$	$H2: r > 1$	37.28615[a]	29.79707	0.0057
$H0: r \leq 2$	$H3: r > 2$	12.22173	15.49471	0.1466
$H0: r \leq 3$	$H4: r > 3$	0.346125	3.841466	0.5563
Maximum eigenvalue statistic				
$H0: r \leq 0$	$H1: r > 0$	28.11482[b]	27.58434	0.0428
$H0: r \leq 1$	$H2: r > 1$	25.06442[a]	21.13162	0.0132
$H0: r \leq 2$	$H3: r > 2$	11.87560	14.26460	0.1154
$H0: r \leq 3$	$H4: r > 3$	0.346125	3.841466	0.5563

Note: [a] and [b] show the rejection of the null hypothesis at 1% and 5% level of significance, respectively

Table VI.
Results of the Johansen cointegration test

the long-run analysis are effective and robust. Additionally, this study further assesses the linkage amongst dependent variable and three independent variables by using ARDL approach to cointegration test, an appropriate selection of the lag order of the equation is prerequisite. Consequently, this paper has adopted ARDL long and the short-run association between the constructed variables, the primary approach is to analyze the ARDL short-run and long-run causality relationship by using the unrestricted error correlation model. The specification assumes that the disturbances are casually uncorrelated; so, it is important to choose the appropriate lagging order (for example, AIC, SIC, and HQC). The results of the AIC, SBC, and HQC are displayed in Figure 1 and the appropriate lag orders of the selected variables for the ARDL approach to cointegration test (1, 0, 1, 0) has been selected based on Akaike Information Criteria (AIC) for further estimation.

4.4 Long-run and short-run estimation for the period 1984-2016

The empirical results of long-run dynamics are presented in (Table VII, panel A). Estimates show that gas consumption has a positive and significant linkage with agricultural economic growth ($\beta_1 = 0.906$, $p < 0.0000$). The coefficient of gas consumption is 0.906, which imply that in the long run 1 per cent increase in the gas consumption will promote agriculture economic growth at the 0.906 per cent. Gas plays a vital role in chemical fertilizers production in Pakistan. Also, chemical fertilizers are the main input in the agricultural production (Emmanuel *et al.*, 2016; Nordin and Höjgård, 2017). Application of chemical fertilizers have been a key of green revolution around the world (Abdoulaye and Sanders, 2005; Kelly *et al.*, 2003). Furthermore, results indicate that the oil consumption has a negative effect on agricultural economic growth in the long-run ($\beta_2 = -0.420$, $p < 0.0000$). An estimated coefficient of oil consumption is −0.420899, which imply that in the long run 1 per cent increase in oil consumption will decrease the agricultural economic growth at the 0.420 per cent. The agriculture sector of Pakistan is facing several challenges including the shortage of water, underdeveloped infrastructure, land degradation and raising the price of oil/petroleum (Anwer *et al.*, 2015; Aslam, 2016; Chandio *et al.*, 2016; Hussain, 2013; Rehman *et al.*, 2015). Additionally, the estimated parameter on electricity consumption is positively related with agricultural economic growth ($\beta_3 = 0.595$, $p < 0.0003$). The coefficient of electricity consumption is 0.595147, which imply that in the long run 1 per cent increase in the electricity consumption leads to increase 0.595 per cent in agricultural economic growth. The findings of the study are consistent with the work of (Lili *et al.*, 2011). The short-run model elasticities are presented in Table VII (panel B). It was observed from Table VII (panel B) that agricultural economic growth is positively and statistically significantly affected by

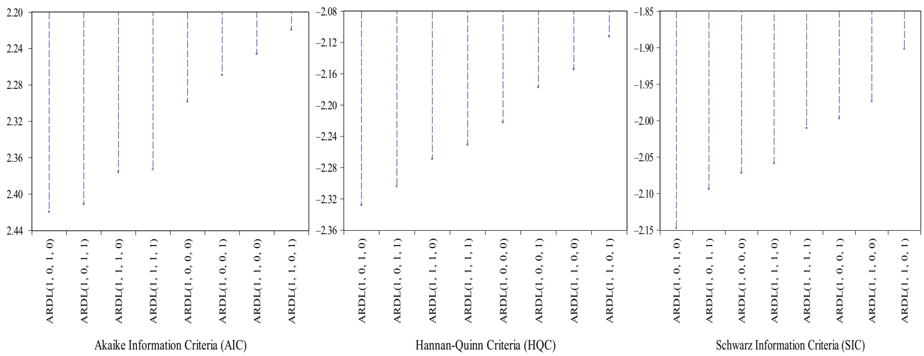


Figure 1.
Represents the lag selection criteria of AIC, HQC and SIC

Regressors	Coefficient	Standard error	T-ratio	Probability
	Dependent variable: *lnAEG*			
Panel A: Long-run estimation				
lnGAS	0.906455[a]	0.172407	5.257640	0.000
lnOIL	−0.420899[a]	0.044182	−9.526522	0.000
lnELE	0.595147[a]	0.143182	4.156562	0.000
C	12.767335[a]	1.947585	6.555469	0.000
Panel B: Short-run estimation				
ΔlnGAS	0.42150[a]	0.13675	3.0822	0.005
ΔlnOIL	−0.046299	0.050210	−0.92211	0.364
ΔlnELE	0.27674[a]	0.075069	3.6865	0.001
ECM(−1)	−0.46500[a]	0.11937	−3.8955	0.001
Panel C: Residual diagnostic tests				
R-squared	0.44956			
F-stat	5.5129			
DW-statistic	2.6558			
Serial correlation	1.5491 [0.205]			
Heteroskedasticity	1.2565 [0.262]			
Jarque-Bera	2.5631 [0.277]			
Functional form	0.3056 [0.580]			
Ramsey RESET test	0.4929 [0.626]			
CUSUM	Stable			
CUSUM Square	Stable			

Note: [a]Indicates significance level at 1 per cent
Source: Author's calculations

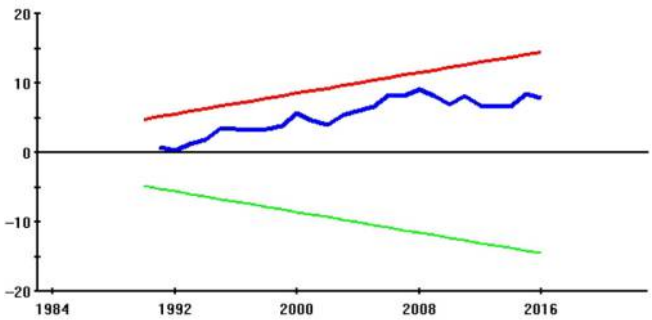
Table VII. Long-run and short-run coefficients using the ARDL model

gas consumption in both long-run and short-run. The coefficient of gas consumption is ($\beta_1 = 0.421$, $p < 0.0047$); this means 1 per cent increase in gas consumption agricultural economic growth boost by 0.421498 per cent. The use of gas consumption has been rapidly increasing over the time for chemical fertilizers production and chemical fertilizers play an important role in the agricultural production. Fertilizers are an essential input for high output. Nutrient-wise one kg of chemical fertilizer produces around eight kgs in cereals crops such as rice, wheat and maize respectively (GOP, 2017). In the short-run, the electricity consumption also exerts a statistically significant and positive influence on agricultural economic growth. The study further displays that the coefficient of short-run of electricity consumption is ($\beta_3 = 0.276$, $p < 0.0010$), which imply that 1 per cent increase in electricity consumption agricultural economic growth will rise by 0.276 per cent. Our result is also consistent with the findings of (Abbas and Choudhury, 2013; Lili *et al.*, 2011). The computed ECM is negative −0.464995 and significant at 1 per cent. The coefficient of ECM was found to be −0.464995, which indicates that adjustment takes place 46.4 per cent per year toward the long-run equilibrium. The computed F-statistic is 5.5129 ($p = 0.002$) and the value of R-squared is estimated to be above 0.44 per cent, which indicates that the empirical model was strongly good fitted. The ARDL regression model has good fit and passed all diagnostic tests such as the ARCH test for heteroskedasticity, Breusch-Godfrey serial correlation LM test and Jarque-Bera (Table VII, panel C). All diagnostic tests confirm that there are found no heteroscedasticity problem, no abnormality problem and also no serial correlation in the model. Likewise, the stability tests using cumulative sum (CUSUM) and CUSUM square point were performed to stabilize the long and short-run parameters. The graph of both the

CUSUM and CUSUM square tests are mentioned in the (Figures 2 and 3) and indicate that all values lay within the critical boundaries at a significance level of 5 per cent; this means the stability of the long-run and short-run parameters during the period 1984 to 2016.

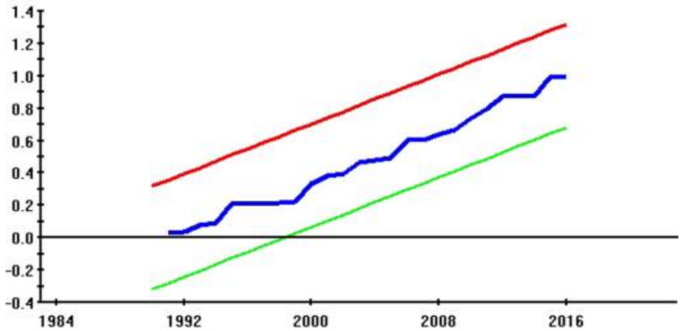
5. Conclusion

This study examined for the first time the causal association amongst the energy consumption and agricultural economic growth in Pakistan over the period from 1984 to 2016. An ARDL bounds testing approach was adopted in this paper to test for the existence of long-run linkage amongst the study variables. The results reveal evidence of cointegration or long-run association amongst the study variables. The findings of this paper displayed that gas consumption and agricultural electricity consumption variables significantly effect on agricultural economic growth both in the long-run and the short-run in Pakistan while oil consumption variable demonstrated a negative effect on agricultural economic growth. The error correction term has a negative singed and it was highly statistically significant in providing further evidence of long-run association. The empirical results of this study suggest that agricultural economic growth can be boosted through increased gas consumption,



Note: The straight lines represent critical bounds at 5 per cent significance level

Figure 2.
Plot of cumulative sum of recursive residuals



Note: The straight lines represent critical bounds at 5 per cent significance level

Figure 3.
Plot of cumulative sum of squares of recursive residuals

electricity consumption and and oil consumption. Also, the government of Pakistan should control rising prices of oil/petroleum because the economy of Pakistan is primarily based on the agriculture sector. The government also should pay further attention regarding energy supplies in the agricultural sector to boost it. In addition the subsidy on gas, oil and electricity also subsidized and produce more cost-effective reduction in these fuels.

References

Abbas, F. and Choudhury, N. (2013), "Electricity consumption-economic growth nexus: an aggregated and disaggregated causality analysis in India and Pakistan", *Journal of Policy Modeling*, Vol. 35 No. 4, pp. 538-553.

Abdoulaye, T. and Sanders, J.H. (2005), "Stages and determinants of fertilizer use in semiarid African agriculture: the Niger experience", *Agricultural Economics*, Vol. 32 No. 2, pp. 167-179.

Ahmed, M. (2007), "Meeting pakistan's energy needs", in Hathway, R.M., Muchhala, B. and Kugelman, M. (Eds), *Fuelling the Future: Meeting Pakistan's Energy Needs in the 21st Century*, Woodrow Wilson International Center for Scholars, Asia Program, Washington, DC.

Ahmed, V. and Zeshan, M. (2014), "Decomposing change in energy consumption of the agricultural sector in Pakistan", *Agrarian South: Journal of Political Economy*, Vol. 3, pp. 369-402.

Akber, M.Z., Thaheem, M.J. and Arshad, H. (2017), "Life cycle sustainability assessment of electricity generation in Pakistan: policy regime for a sustainable energy mix", *Energy Policy*, Vol. 111, pp. 111-126.

Akdemir, B. (2013), "Agricultural mechanization in Turkey", *IERI Procedia*, Vol. 5, pp. 41-44.

Anwer, M., Farooqi, S. and Qureshi, Y. (2015), "Agriculture sector performance: an analysis through the role of agriculture sector share in GDP", *Journal of Agricultural Economics, Extension and Rural Development*, Vol. 3, pp. 270-275.

APO (1996), "Agricultural mechanization in Asia, Report of an APO seminar", Tokyo, 7-17 March 1995.

Aqeel, A. and Butt, M.S. (2001), "The relationship between energy consumption and economic growth in Pakistan", *Asia-Pacific Development Journal*, Vol. 8, pp. 101-110.

Asghar, Z. (2008), "Energy-GDP relationship: a causal analysis for the five countries of South Asia",

Aslam, M. (2016), "Agricultural productivity current scenario, constraints and future prospects in Pakistan", *Sarhad Journal of Agriculture*, Vol. 32 No. 4, pp. 289-303.

Atif, S.M. and Siddiqi, M.W. (2010), "The electricity consumption and economic growth nexus in Pakistan: a new evidence".

Binswanger, B. (1986), "Agricultural mechanization: a comparative historical perspective", *World Bank Research Observer*, Vol. 1 No. 1, pp. 27-56.

Chandio, A.A., Yuansheng, J. and Magsi, H. (2016), "Agricultural sub-sectors performance: an analysis of sector-wise share in agriculture GDP of Pakistan", *International Journal of Economics and Finance*, Vol. 8 No. 2, p. 156.

Chandio, A.A., Yuansheng, J., Gessesse, A.T. and Dunya, A. (2017), "The nexus of agricultural credit, farm size and technical efficiency in Sindh, Pakistan: a stochastic production frontier approach", *Journal of the Saudi Society of Agricultural Sciences*, available at: www.sciencedirect.com/science/article/pii/S1658077X17302291

Chen, S.-T., Kuo, H.-I. and Chen, C.-C. (2007), "The relationship between GDP and electricity consumption in 10 Asian countries", *Energy Policy*, Vol. 35 No. 4, pp. 2611-2621.

Emmanuel, D., Owusu-Sekyere, E., Owusu, V. and Jordaan, H. (2016), "Impact of agricultural extension service on adoption of chemical fertilizer: implications for rice productivity and development in Ghana", *NJAS-Wageningen Journal of Life Sciences*, Vol. 79, pp. 41-49.

Farrington, J. (1986), "Mechanization policy and the Impact of tractors in South Asia – areview, Small farm equipment for developing countries", *Proceedings of the International Conference on Small Farm Equipment for Developing Countries: Past Experiences and Future Priorities, 2-6 September 1985. Int. Rice Res. Inst*., p. 85.

Ferguson, R., Wilkinson, W. and Hill, R. (2000), "Electricity use and economic development", *Energy Policy*, Vol. 28 No. 13, pp. 923-934.

Fluck, RCaCDB. (1979), *Agricultural Energetics*, AVI Publishing Co, New York, NY.

GOP (2009), *Economic Survey of Pakistan 2008-09*, Economic advisor's wing, Ministry of Finance, Islamabad, Government of Pakistan.

GOP (2010), *Pakistan Economic Survey (2010-11)*, Ministry of Finance.

GOP (2017), *Economic Survey of Pakistan 2016-17*, Agricultural Statistics of Pakistan. Ministry of Food Agriculture and Livestock Division, Islamabad.

Hatirli, S.A., Ozkan, B. and Fert, C. (2005), "An econometric analysis of energy input–output in Turkish agriculture", *Renewable and Sustainable Energy Reviews*, Vol. 9 No. 6, pp. 608-623.

Hussain, A. (2013), "Economic analysis of rice crop cultivation in district swat", *Journal of Agricultural Research*, Vol. 51.

Karkacier, O. and Goktolga, Z.G. (2005), "Input–output analysis of energy use in agriculture", *Energy Conversion and Management*, Vol. 46 Nos 9/10, pp. 1513-1521.

Karkacier, O., Goktolga, Z.G. and Cicek, A. (2006), "A regression analysis of the effect of energy use in agriculture", *Energy Policy*, Vol. 34 No. 18, pp. 3796-3800.

Kelly, V., Adesina, A.A. and Gordon, A. (2003), "Expanding access to agricultural inputs in Africa: a review of recent market development experience", *Food Policy*, Vol. 28 No. 4, pp. 379-404.

Kennedy, S. (2000), "Energy use in American agriculture. Sustainable energy term paper 5", pp. 1-26.

Khan, M.A. and Ahmad, U. (2008), "Energy demand in Pakistan: a disaggregate analysis", *The Pakistan Development Review*, pp. 437-455.

Lili, H., Shuwen, N., Li, M. and Jing, Q. (2011), "The empirical analysis of the relationship between agricultural economic growth and energy consumption in regions of China, Computer distributed control and intelligent environmental monitoring (CDCIEM)", *2011 International Conference on. IEEE*, pp. 1418-1426.

McInerney, J.P. and Donaldson, G.F. (1975), *The Consequences of Farm Tractors in Pakistan: An Evaluation of IDA Credits for Financing the Mechanization of Farms in Pakistan 1966-1970*, World Bank.

Mirjat, N.H., Uqaili, M.A., Harijan, K., Valasai, G.D., Shaikh, F. and Waris, M. (2017), "A review of energy and power planning and policies of Pakistan", *Renewable and Sustainable Energy Reviews*, Vol. 79, pp. 110-127.

Mozumder, P. and Marathe, A. (2007), "Causality relationship between electricity consumption and GDP in Bangladesh", *Energy Policy*, Vol. 35 No. 1, pp. 395-402.

Mrema, G.C., Baker, D. and Kahan, D. (2008), *Agricultural Mechanization in Sub-Saharan Africa: Time for a New Look*, FAO.

Mushtaq, K., Abbas, F. and Ghafoor, A. (2007), "Energy use for economic growth: cointegration and causality analysis from the agriculture sector of Pakistan", *The Pakistan Development Review*, Vol. 46 No. 4II, pp. 1065-1073.

Naqvi, M., Yan, J., Dahlquist, E. and Naqvi, S.R. (2016), "Waste biomass gasification based off-grid electricity generation: a case study in Pakistan", *Energy Procedia*, Vol. 103, pp. 406-412.

Naqvi, S.R., Jamshaid, S., Naqvi, M., Farooq, W., Niazi, M.B.K., Aman, Z., Zubair, M., Ali, M., Shahbaz, M. and Inayat, A. (2018), "Potential of biomass for bioenergy in Pakistan based on present case and future perspectives", *Renewable and Sustainable Energy Reviews*, Vol. 81, pp. 1247-1258.

Narayan, P.K. (2005), "The saving and investment nexus for China: evidence from cointegration tests", *Applied Economics*, Vol. 37 No. 17, pp. 1979-1990.

Nordin, M. and Höjgård, S. (2017), "An evaluation of extension services in Sweden", *Agricultural Economics*, Vol. 48 No. 1, pp. 51-60.

Ozkan, B., Akcaoz, H. and Fert, C. (2004), "Energy input–output analysis in Turkish agriculture", *Renewable Energy*, Vol. 29 No. 1, pp. 39-51.

Ozturk, I. (2010), "A literature survey on energy–growth nexus", *Energy Policy*, Vol. 38 No. 1, pp. 340-349.

Pacheco-López, P. (2005), *Foreign Direct Investment, Exports and Imports in Mexico*, World Economy 28, pp. 1157-1172.

PCGOP (2012), . "Planning commission (2012). Current energy situation prevailing in the country and its possible solution", Government of Pakistan, Islamabad, available at: www.pc.gov.pk (accessed 30 August 2014).

Pesaran, M.H. and Shin, Y. (1998), "An autoregressive distributed-lag modelling approach to cointegration analysis", *Econometric Society Monographs*, Vol. 31, pp. 371-413.

Pesaran, M.H., Shin, Y. and Smith, R.J. (2001), "Bounds testing approaches to the analysis of level relationships", *Journal of Applied Econometrics*, Vol. 16 No. 3, pp. 289-326.

Rehman, A. and Deyuan, Z. (2018), "Pakistan's energy scenario: a forecast of commercial energy consumption and supply from different sources through 2030", *Energy, Sustainability and Society*, Vol. 8 No. 1, pp. 26.

Rehman, A., Jingdong, L., Shahzad, B., Chandio, A.A., Hussain, I., Nabi, G. and Iqbal, M.S. (2015), "Economic perspectives of major field crops of Pakistan: an empirical study", *Pacific Science Review B: Humanities and Social Sciences*, Vol. 1, pp. 145-158.

Riaz, T. and Stern, N.H. (1984), "Pakistan: Energy consumption and economic growth [with comments]", *The Pakistan Development Review*, Vol. 23 Nos 2/3, pp. 431-456.

Shah, S.H., Raja, I.A., Rizwan, M., Rashid, N., Mahmood, Q., Shah, F.A. and Pervez, A. (2018), "Potential of microalgal biodiesel production and its sustainability perspectives in Pakistan", *Renewable and Sustainable Energy Reviews*, Vol. 81, pp. 76-92.

Sharif, A., Afshan, S. and Nisha, N. (2017), "Impact of tourism on CO_2 emission: evidence from Pakistan", *Asia Pacific Journal of Tourism Research*, Vol. 22 No. 4, pp. 408-421.

Sharif, A., Afshan, S. and Khan, B.S. (2018), "Does democracy embolden economic growth in Pakistan? Evidence from ARDL bound testing and rolling window analysis", *International Journal of Economics and Business Research*, Vol. 15 No. 2, pp. 180-203.

Stern, D.I. and Cleveland, J.C. (2004), "Energy and economic growth, Rensselaer working papers in economics no. 0410", available at: http://economics.rpi.edu/workingpapers/rpi0410.pdf

Temple, F. (2002), "Energy subsidies in Bangladesh: magnitude and beneficiaries", speech given at Dhaka Chamber of Commerce and Industries (DCCI), June 9.

Zachariadis, T. (2006), "On the exploration of causal relationships between energy and the economy", Discussion paper no. 2006-05, Department of Economics, University of Cyprus.

About the authors

Dr Abbas Ali Chandio is a Postdoctoral Scientific Research Fellow in the College of Economics, Sichuan Agricultural University, Chengdu 611130, China. Abbas Ali Chandio is the corresponding author and can be contacted at: 3081336062@qq.com

Prof Dr Yuansheng Jiang is a Dean, College of Economics, Sichuan Agricultural University, Executive Director, Sichuan Center for Germany Research, Deputy Director, Southwestern Center for Poverty Alleviation and Development Huimin Rd. 211, Wenjiang district, Chengdu, China.

Dr Abdul Rehman is a Postdoctoral Scientific Research Fellow in the Research Center of Agricultural-Rural-Peasants, Anhui University Hefei, China.