Disaggregate Energy Consumption, Agricultural Output and Economic growth in Pakistan: An ARDL Modelling Approach to Co-integration

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ABSTRACT

The basic goal of the study is to make a vigorous endeavour to analyse the impact of energy consumption (i.e., electricity, oil and gas) on economic growth and agriculture sector output in Pakistan. It is desirable to find out relationship between disaggregate energy consumption, economic growth and agricultural sector outputs of Pakistan because energy crisis has become a central issue now-a-days. Production sector of Pakistan relying on electricity and gas consumption to large extent and these sources of energy are falling short because of many reasons which is upsetting output and consequently exports and real output of the country. To analyse the relationship, we employed time series data ranges from 1972 to 2011 from a reliable source. To find out long run and short run effects of energy consumption on Agricultural output and economic growth, ARDL modelling approach to cointegration is applied which is most appropriate technique over some other techniques of integration after scrutinizing the stationarity of data through ADF Test. Where, bound testing procedure is utilized for cointegration to judge the existence of long run relationship among variables and ECM models are formulated for short run analysis. Our econometric models give the intuition of including agricultural output and economic growth as dependant variables and electricity, coal and gas consumption as independent and core variables. The findings of the study indicate that Gas and Oil consumption turns out very efficient factors for raising economic growth and Agricultural output.

Key Words: Disaggregate Energy Consumption; Economic Growth, Agricultural Output; ARDL; Co-integration; Pakistan

1. INTRODUCTION

Energy is widely regarded as a propelling force behind any economic activity and indeed plays a vital role in enhancing production. Therefore, highly important resources of energy will enhance the technology impact many fold. Eminent quality energy resources can act as facilitator of technology while little worthy resources can humidify the power of new technology. (Ojinnaka, 1998) argued that the consumption of energy tracks with the national product. Hence, the scale of energy consumption per capita is an important indicator of economic modernization. In general countries that have higher per capita energy consumption are more developed than those with low level of consumption.

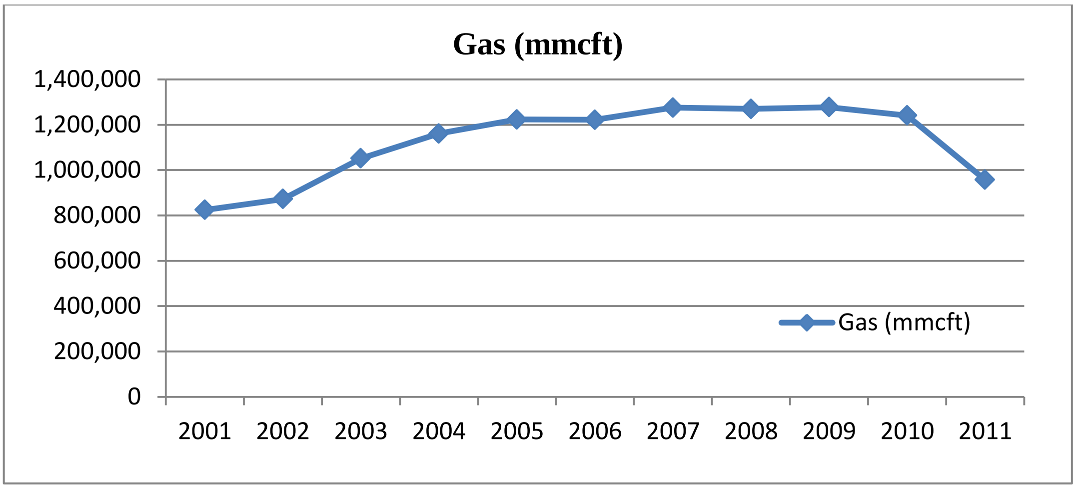
The importance of energy lies in other aspect of development - increase in foreign earnings when energy products are exported, transfer of technology in the process of exploration, production and marketing; increase in employment in energy industries; improvement of workers welfare through increase in worker's salary and wages, improvement in infrastructure and socio-economic activities in the process of energy resource exploitation. Thus in the quest for optimal development and efficient management of available energy resources, equitably allocation and efficient utilization can put the economy on the part of sustainable growth and development. Arising from this argument, adequate supply of energy thus becomes central to the radical transformation of the nation's economy.

One of the interesting features of the study is that it differentiates short run and the long run effect because it has been observed that impact of energy consumption varies from short to long run for the same country. For this purpose, we have employed ARDL modelling to co-integration to find out long run and short run effect. Unit root problem of the data is handled by ADF test. The rest of the article is structured as follows. Trends and structure of energy variables are given in Section 2.while section 3 provides literature review in detail while data and methodology is given in section 4. Empirical results and their discussion are presented in section 5. At the end, some policy implications for energy consumption are suggested on the basis of empirical results.

3. Trends and Size of Pakistan Annual Energy Consumption

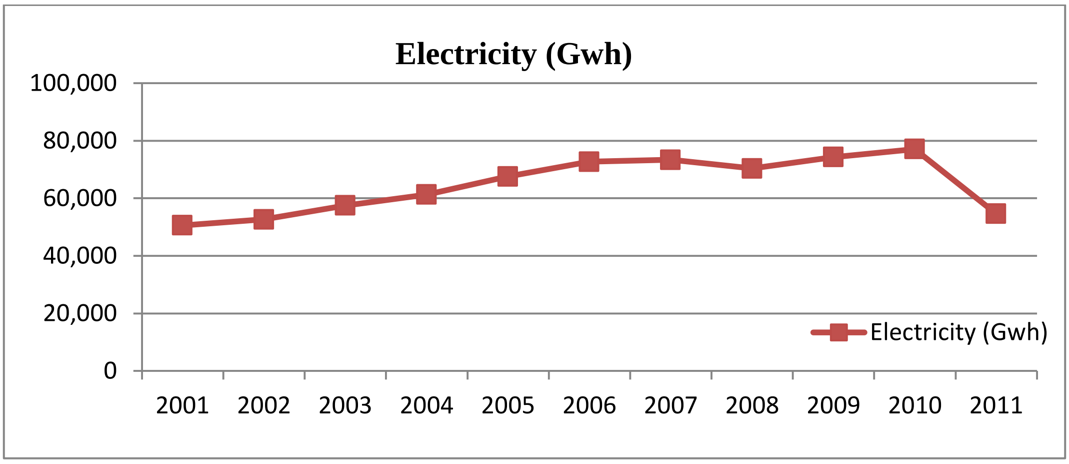
Total energy consumption measured in oil consumption is 38.8 million tonnes in the year of 2010-11. Currently gas consumption is the leading one in all the all energy consumptions that is 43.2 percent of total energy consumption. Since 2005-06, Gas, electricity and coal consumption are equally utilized comparatively. Oil consumption stood at second position regarding usage as its usage value is 29 percent of total energy consumption.

Figure 1: Annual Gas consumption in Pakistan



Gas consumption increases its usage share equal to four percent in the time period from 2005-06 to 20010-11. This is because of the reason of substituting gas form expensive energy source to some cheaper sources of energy. The consumption of oil in Pakistan lose its consumption value by three percent during the period 2001-2011 because of high prices of oil that is purchases from international market at very high prices. Since the yar 2001-02, a decreasing trend is observed in the consumption of petroleum products.

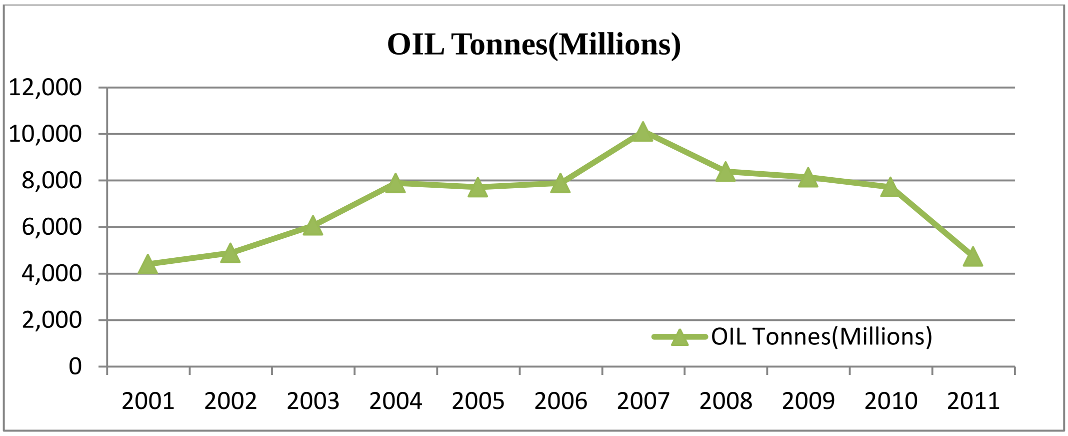
Figure 2: Annual Electricity consumption in Pakistan



Source: Pakistan Economic survey (various issues)

Yet it is observed that due to positive response in oil consumption from year 2004-10, the overall average for last ten years get batter and stood at 11 Percent per annum. Trends indicate that due to high volatility in the oil prices consumption intensity is shifting from oil consumption to some others sources of energy consumption. Thus, Gas, electricity and oil consumption trends indicate an annual increase at an average rate of 5.1 percent, 4.8 percent and 7.7 percent respectively.

Figure 3: Annual Oil consumption in Pakistan



Source: Pakistan Economic Survey (various Issues)

3. LITERATURE REVIEW

Theoretically, neo-classical and endogenous theories both suggest that energy use and efficiency are drivers of economic growth. Though there are many studies that find a direct relationship between productivity and energy consumption in the industrialized world (see Worrell et. al, 2001), evidence from the developing world remains inconclusive. Few disaggregated studies have been conducted on this issue and the studies using data aggregated at the national or economic level indicate mixed findings. Further complicating the relationship is the extent to which economic growth and energy consumption can theoretically be decoupled, a question raised by ecological economists who argue thermodynamic laws limit such division. Below is a brief review of the various theories on the relationship between energy consumption, energy efficiency and economic growth, followed by a summary of a select list of empirical studies.

By incorporating energy end-use efficiency gains into a Cobb-Douglas production function, Wei (2007) theorizes about short-term and long-term effects of increased energy efficiency beginning with the production function specification as output is a function of labour, capital and some measures of energy consumption. In the short term, energy use efficiency is found to lower the cost of non energy and increase the output of non-energy goods. A 100 percent rebound effect is evident such that in the short term, energy efficiency gains have no effect on absolute energy use. In the long term, the impact on non-energy output of energy end use efficiency is positive. The long term impact of energy use efficiency on total energy use is lower than the short-term impact. Wei also finds that energy use efficiency will increase real energy price in the long term. Van Zon and Yetkiner (2003) modify the Romer model to include energy consumption of intermediates and to make them heterogeneous due to endogenous energy-saving technical change. They found out that energy- saving technical transformation can enhance that economic growth positively. On the other hand, it may dampen economic growth with the increase in energy prices that imply that rising real energy prices consistently will cause to harm economic growth.

Embodied technical change includes improvements in energy efficiency, thus positively linking improvements in energy efficiency to economic growth. They conclude that in an environment of rising energy prices, recycling energy tax proceeds in the form of R&D is necessary for both energy efficiency growth and output growth. Sorrell (2009) pointed out that conventional and ecological economists have conflict on the issue of energy effects in economic growth. The growth models presented by Neo-classical and new Endogenous growth theories give small important to energy consumption as a major factor of production by giving argument that it takes a small share in total cost of production. Ecological economist contests their point of view by replying that over the last two centuries, energy inputs are accelerating economic growth at valuable rate as the availability of high quality inputs are available now a days.

For a steady economic growth the role of technological change is of great importance as earlier growth models have integrated technological change an important factor for growth [Solow, 1956)]. Energy and raw material besides labour and capital cause to decrease the statistical residual. Onakoya et. al,(2013) studied the relationship between energy consumption and Nigerian economic growth from the period of 1975 to 2010 to find out the fact of energy consumption as an important variable for production. Co-integration results provide evidence of a long run relationship between energy consumption and economic growth which is positive. Same results are also found by Paul and Bhattacharya (2004) who employed Engle–Granger technique to investigate the direction of relationship between economic growth and energy consumption for India for the period of 1950-1996. Results revealed that energy consumption has causality for energy consumption. Hondroyiannis et. al, (2002) followed the same results in case of Greece by using vector error-correction estimation on the data from 1960-1996.The findings of the study indicate the existence of long run relationship.

Oh and Lee (2004) contradict from the view of significant and positive effect in case of Korea as no relationship is observed between and energy consumption. For Bangladesh, Mozumder and Marathe (2007) examined a positive relationship between per capita income and per capita energy consumption. The relationship between gas consumption and growth was analysed by Apergis and Payne (2010) to reveal the co-integration among labour, capital, gas consumption and economic growth. ECM model was employed to find the bidirectional causality between gas consumption and economic growth but Yang (2000) opposed this relationship as his study show the absence of long run relationship between natural gas consumption and real GDP. Same results of no relationship are also found out by Aqeel and Butt (2001).

Shahbaz and Feridun (2011) investigated the impact of Electricity consumption on economic growth in Pakistan in the period between 1971 and 2008 by using ARDL technique to identify the long run relationship between electricity consumption and economic growth. Study gives the evidence of long run relationship between electricity consumption and economic growth but inverse is not true. Alam and Butt (2001) investigation provided the evidence that structural changes also cause to change the share of various energy consumption variables. And increase in energy is because of increase in activity effect as well as structural changes.

Javid et. al, (2013) argued that shocks to electricity supply will have a negative impact on economic growth. Ifeakachukwu and Temidayo (2012) and Dantama *et. al*,(2011) come to a conclusion that govt should adopt sector specific energy policies rather the one fit-for-all policy by observing positive aggregate energy consumption and sectoral output.

For Pakistan, Kakar and Khilji (2011) explored the nature of relationship between economic growth and total energy consumption for the period 1980-2009 by using Johansen Co-integration and confirmed that energy consumption is essential for economic growth and any energy shock may affect the long-run economic development of Pakistan. Ahmad et. al,(2011) analysed the impact of energy consumption and economic growth in case of Pakistan employing data from 1973 to 2006. The results of ordinary least squares test show positive relation between GDP and energy consumption in Pakistan. A number of reviews of prior work compel us to make a healthy endeavour on the concern issues because a little attention has been given to agricultural output and disaggregate energy consumption for their long run relationship. The study also fulfils a number of imperfections of previous studies such as not using appropriate technique for co-integration, model misspecification and other methodological issues.

4. DATA AND METHODOLOGY

The present segment consists of data and methodology used to estimate effects of disaggregates energy consumption on economic growth and Agricultural output in Pakistan.

To order to analyze relationships, secondary data from year 1972-2011 are employed and Auto Regressive Distributed Lags (ARDL) technique has been used.

A) Data Source

The data generated from Pakistan economic survey (various issues), Handbook of Statistics of Pakistan Economy. While, data on variables of energy consumption, have been obtained from HDIP, Ministry of Petroleum and Natural Resources. The variables about which data are collected, are RGDP (Gross Domestic Product) that is used as dependent variable while RGFCF (Real Gross Fixed Capital Formation), TELF (Total Employed Labour Force), IR (Inflation Rate), TOC (Total Oil Consumption), TGC (Total Gas Consumption), TEC (Total Electricity Consumption) , AGRI (Agricultural Output), TELF (Total Employed Labour force), RAGFCF (Real Agricultural Gross Fixed Capital Formation), TOC (Total Oil Consumption), TGC (Total Gas Consumption), TEC (Total Electricity Consumption), ACRDT (Agricultural Credit).

B) Methodological Issues

The study is consisted on time series data. In order to examine the properties of the time series data, we first examine the stationarity of data and then decide about the appropriate technique.

i) Stationarity of Data

In practice, ADF test is used to check the stationary of variables. If, all the variables are integrated of degree one. In this case, the variables can be estimated by employing error correction model of because co-integrated series. However, if all the variables are not integrated of same degree i.e. some variables are integrated at I (1) or some are at I (0) or both I(1) and I(0). In this case, ARDL modeling approach will be employed to identify the existence of long run and short run relationships among the variables.

ii) Auto Regressive Distributed Lag Approach to Co-integration

ARDL approach will be applied only on single equation. It will estimate the long run and short run parameters of model simultaneously. The estimated model obtained from the ARDL technique will be unbiased and efficient. ARDL approach to co-integration is useful for small sample Narayan (2004). Engel-Granger and Johensan technique are not reliable for small samples. ARDL gives better results in sample rather than Johesan co-integration approach. ARDL approach has a drawback because it is not necessary that all variables to be same order. The variables can be at I(0) or I(1) or combination of both, the ARDL approach can be applied. If the variables are stationary at higher order of I(1) then ARDL is not applicable. ARDL approach is consisted of two stages. First, the long run relationship between variables is tested using F-statistics to determine the significance of the lagged levels variables. Second, the coefficient of the long run and short run relationship will be examined.

iii) Bound Testing Procedure

The bound test is based on three basic assumptions that are; first, use ARDL model after identifying the order of integration of series Pesaran *et al*. (2001). Second, series are not bound to possess the same order of integration i.e., the regressors can be at I(0) or I(1). Third, this technique estimates better results in case of small sample size. The vector auto regression (VAR) of order *p*, for the economic growth function can be narrated as Pesaran *et al*. (2001);

$$Z_t = \mu + \sum_{i=1}^{p} \beta_i z_{t-i} + \varepsilon_t \qquad \text{.....................................} \qquad (1)$$

Where x_t and y_t are included in vector z_t . Economic growth (RGDP) and agricultural output(AGRI) are indicsted by y_t and x_t is the vector matrix which represents a set of explanatory variables such as [Xt = RGFCF, TELF, TOC, TEC, TGC, IR] and [Xt = TELF, RGFCF, TOC, TGC, TEC, ACRDT] for Model-1and Model-2 and *t denoted* time indicator. Vector error correction model (VECM) is given as below:

$$\Delta z_t = \mu + \alpha t + \lambda z_{t-1} + \sum_{i=1}^{p-i} \gamma_t \Delta y_{t-i} + \sum_{i=1}^{p-1} \gamma_t \Delta x_{t-i} + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where Δ is the first-difference operator. The long-run multiplier matrix λ as:

$$\lambda = \begin{bmatrix} \lambda_{YY} \lambda_{YX} \\ \lambda_{XY} \lambda_{XX} \end{bmatrix}$$

The diagonal elements of the matrix are unrestricted, so the selected series can be either I(0) or I(1). If $\lambda_{YY} = 0$, then *Y* is I(1). In contrast, if $\lambda_{YY} < 0$, then *Y* is I(0).

The VECM procedures described above are imperative in the testing of at most one co-integrating vector between dependent variable y_t and a set of regressors x_t . To build up the model, study uses Pesaran *et al*. (2001) postulation of Case V, that is, unrestricted intercepts and trends.

C) Model Specification

The current study is based on general Neo-classical production Function;

$$Y = Af(L, K) \text{........................(iii)}$$

Where, Y = Total Output, L = Total employed labour force, K= Total stock of Capital, A= Total Productivity factor

We have employed extended Neo-classical growth model by incorporating energy as a productivity factor as an endogenous variable.

$$A = f(TOC, TGC, TEC)......................(\text{iv})$$

Substituting A in equation (i), we obtained extended growth model.

$$Y = f(L, K, TOC, TGC, TEC)......................(\text{v})$$

Based on the suggested economic techniques, we have two specified model.these specified models are given below.

Model-1: Impact of Disaggregate Energy Consumption on Economic Growth

$$\Delta(RGDP)_t = \beta_0 + \sum_{i=0}^{a}\beta_{1i}\Delta(RGFCF)_{t\text{-}i} + \sum_{i=0}^{b}\beta_{2i}\Delta(TELF)_{t\text{-}i} + \sum_{i=0}^{c}\beta_{3i}\Delta(TOC)_{t\text{-}i} + \sum_{i=0}^{d}\beta_{4i}\Delta(TGC)_{t\text{-}i} + \sum_{i=0}^{e}\beta_{5i}\Delta(TEC)_{t\text{-}i}$$
$$+ \sum_{i=1}^{f}\beta_{6i}\Delta(RGDP)_{t\text{-}i} + \sum_{i=1}^{g}\beta_{7i}\Delta(IR)_{t\text{-}i} + \beta_8(RGDP)_{t\text{-}1} + \beta_9(RGFCF)_{t\text{-}1} + \beta_{10}(TELF)_{t\text{-}1} + \beta_{11}(TOC)_{t\text{-}1}$$
$$+ \beta_{12}(TGC)_{t\text{-}1} + \beta_{13}(TGC)_{t\text{-}1} + \beta_{14}(IR)_{t\text{-}1} + u_t \quad ....(6)$$

Where, Δ is the first-difference operator while Ut is a white-noise disturbance term. This model would estimate the impact of disaggregate energy consumption on economic growth in which real GDP is used as dependant variable while real gross fixed capital formation (proxy for capital), total employed labour force, total oil consumption, total gas consumption an total electricity consumption are used as independent variables.

Equation (6) also can be viewed as an ARDL of order (*a*, *b*, *c*, *d*, *e*, *f*, *g*). Equation (6) indicates that economic growth tends to be influenced and explained by its past values. The structural lags are established by using minimum Schwarz information criteria (SIC). In our model, we will use the lagged value of first difference dependent variable and independent variables for short run and first lagged values of dependent and independent variables for long run. So, this model is consisted of both long run and short run coefficients of variables as well. Where β_1, β_2, β_3, β_4, β_5 *and* β_6, β_7 are the short run coefficients of variables and β_8, β_9, β_{10}, β_{11}, β_{12} and β_{13}, β_{14} are the long run coefficients of variables and β_0 is the intercept term.

Model-2: Impact of Disaggregate Energy consumption on Agricultural Output

The second model that would capture the effect of energy consumption on agricultural output in Pakistan with the help of some explanatory variables like TELF (Total Employed Labour force), RGFCF (Real Gross Fixed Capital Formation), TOC (Total Oil Consumption), TGC

(Total Gas Consumption), TEC (Total Electricity Consumption), ACRDT (Agricultural Credit); the unrestricted ECM model for Agricultural output is as under;

$$\Delta AGRI_t = \phi_0 + \sum_{i=1}^{p} \phi_{1i}\Delta(\text{TELF})_{t-i} + \sum_{i=0}^{q} \phi_{2i}\Delta(\text{RGFCF})_{t-i} + \sum_{i=0}^{r} \phi_{3i}\Delta(\text{TEC})_{t-i} + \sum_{i=0}^{s} \phi_{4i}\Delta(\text{TGC})_{t-i}$$
$$+ \sum_{i=0}^{t} \phi_{5i}\Delta(\text{TOC})_{t-i} + \sum_{i=0}^{u} \phi_{6i}\Delta(\text{ACRDT})_{t-i} + \sum_{i=1}^{v} \phi_{7i}\Delta(\text{AGRI})_{t-i} + \gamma_1(\text{AGRI})_{t-1} + \gamma_2(\text{TELF})_{t-1}$$
$$+ \gamma_3(\text{RGFCF})_{t-1} + \gamma_4(\text{TEC})_{t-1} + \gamma_5(\text{TGC})_{t-1} + \gamma_6(\text{TOC})_{t-1} + \gamma_7(\text{ACRDT})_{t-1} + \mu_t \quad ....(7)$$

Where Δ shows the first difference operator and U_t is the residual of the model.

Equation (7) also can be viewed as an ARDL of order (*p, q, r, s, t, u, v*). Where ϕ_{1i}, ϕ_{2i}, ϕ_{3i} and ϕ_{4i} , ϕ_{5i} , ϕ_{6i} , ϕ_{7i} are the short run coefficients of variables and γ_1, $\gamma 2$, γ_3, γ_4, γ_5, γ_6 and γ_7 are the long run coefficients of variables and ϕ_0 is the intercept term.

The Wald Test (F-statistics)

After regression of Equation (6) and Equation (7), the Wald test (*F*-statistic) is computed to differentiate the long-run relationship between the concerned variables. The Wald test can be carry out by imposing restrictions on the estimated long-run coefficients of real GDP, total employed labour force, real gross fixed capital formation, total oil consumption, total gas consumption, total electricity consumption and inflation rate for the Model-1 as under: **The null hypothesis is** as follows;

$H_0 : \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = \beta_{13} = \beta_{14} = 0$ (No long-run relationship exists)

Against **the alternative hypothesis,**

$H_1 : \beta_8 \neq \beta_9 \neq \beta_{10} \neq \beta_{11} \neq \beta_{12} \neq \beta_{13} \neq \beta_{14} \neq 0$ (A long-run relationship exists)

If the calculated F-statistics does not exceed lower bound value, we do not reject Null Hypothesis and it is concluded that there is no existence of long run relationship between RGDP and independent variables. On the other hand, if the calculated F-statistics exceeds the value of upper bound, the co integration exists between RGDP and independent variables. We will apply the Wald coefficient test on all lagged explanatory and dependant variables appear in the model equations (7). Our null hypothesis will be that lagged coefficient of explanatory variables are equal to zero or absent from the model. If we do not reject the null hypothesis it means long run relation among variables do not exist.

Null and **alternative hypothesis** for Model-2 to apply Wald test is as follows.

H_0: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0$ (No Cointegration Exists)

H$_1$: $\gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq \gamma_5 \neq \gamma_6 \neq \gamma_7 \neq 0$ (Cointegration Exists)

D) The Time Horizons

To see the effects of explanatory variables on economic growth in case of Pakistan both in the short run and long run, we have to estimate the model which are given equations (6) and (7) with OLS (Bound test approach to co-integration) technique and then normalize the resulting values. The ARDL model for the long run coefficient of Model-1Equation (6) is to determine the long run effect of energy consumption on economic growth in Pakistan.

$$\mathrm{RGDP_t} = \eta_0 + \sum_{i=1}^{k_1} \eta_{1i}(\mathrm{RGDP})_{t-i} + \sum_{i=0}^{k_2} \eta_{2i}(\mathrm{RGFCF})_{t-i} + \sum_{i=0}^{k_3} \eta_{3i}(\mathrm{TELF})_{t-i} + \sum_{i=0}^{k_4} \eta_{4i}(\mathrm{TEC})_{t-i} + \sum_{i=0}^{k_5} \eta_{5i}(\mathrm{TOC})_{t-i} + \sum_{i=0}^{k_6} \eta_{6i}(\mathrm{TGC})_{t-i} + \sum_{i=0}^{k_7} \eta_{7i}(\mathrm{IR})_{t-i} + \varepsilon_t \text{.........(4.5)}$$

The ARDL model for the long run coefficients of Model-2 Equation (7) is to capture the long run energy consumption effects on agricultural output in Pakistan.

$$AGRI_t = \theta_0 + \sum_{i=1}^{z_1} \theta_{1i}(\mathrm{TELF})_{t-i} + \sum_{i=0}^{z_2} \theta_{2i}(\mathrm{RGFCF})_{t-i} + \sum_{i=0}^{z_3} \theta_{3i}(\mathrm{TOC})_{t-i} + \sum_{i=0}^{z_4} \theta_{4i}\ (\mathrm{TEC})_{t-i} + \sum_{i=0}^{z_5} \theta_{5i}\ (\mathrm{TGC})_{t-i} + \sum_{i=0}^{z_6} \theta_{6i}\ (\mathrm{ACRDT})_{t-i} + \mu_t \text{........(4.6)}$$

Now we will find the short coefficient of the model with error correction term. We will use the short run error correction estimates of ARDL model. The difference between actual and estimated values is considered as error correction term. Error correction term is defined as adjustment term showing the time required in the short run to move toward equilibrium value in the long run. The coefficient of error term has to be negative and significant. The short run error correction (ECM) model of Model-1Equation (6) to find out impact of energy consumption on economic growth in time adjusting frame work to attain long run equilibrium is as follows;

$$\Delta RGDP_t = \rho_0 + \sum_{i=1}^{k_1} \rho_{1i}\ \Delta(\mathrm{RGDP})_{t-i} + \sum_{i=0}^{k_2} \rho_{2i}\ \Delta(\mathrm{RGFCF})_{t-i} + \sum_{i=0}^{k_3} \rho_{3i}\Delta(\mathrm{TELF})_{t-i} + \sum_{i=0}^{k_4} \rho_{4i}\ \Delta(\mathrm{TOC})_{t-i} + \sum_{i=0}^{k_5} \rho_{5i}\ \Delta(\mathrm{TGC})_{t-i} + \sum_{i=0}^{k_6} \rho_{6i}\ \Delta(\mathrm{TEC})_{t-i} + \sum_{i=0}^{k_7} \rho_{7i}\ \Delta(\mathrm{IR})_{t-i} + \lambda(\mathrm{ECM})_{t-1} + \varepsilon_t \text{.........(4.7)}$$

ECM_{t-1} is lagged error correction term of the model and λ is the coefficient value of ECM which is the speed of adjustment.

The short run (ECM) model of Model-2 Equation (7) to find out impact of energy consumption on Agricultural output in Pakistan in time adjusting frame work to attain long run equilibrium is as follows.

$$\Delta\, AGRI_t = \sigma_0 + \sum_{i=1}^{k_1} \sigma_{1i}\, \Delta(\text{RGFCF})_{t-i} + \sum_{i=0}^{k_2} \sigma_{2i}\, \Delta(\text{TELF})_{t-i} + \sum_{i=0}^{k_3} \sigma_{3i} \Delta(\text{TOC})_{t-i} + \sum_{i=0}^{k_4} \sigma_{4i} \Delta(\text{TGC})_{t-i} + \sum_{i=0}^{k_4} \sigma_{4i} \Delta(\text{TEC})_{t-i} + \omega(\text{ECM})_{t-1} + \mu_t \quad ....(4.8)$$

ECM_{t-1} is lagged error correction term of the model and ω is the coefficient value of ECM which is the speed of adjustment.

The Error Correction Term ($\mathbf{EC_{t-1}}$)

The error correction term (EC_{t-1}), which instrument the adjustment speed in the dynamic model for restoring equilibrium. Bannerjee et. al, (1998) grasped that a highly significant error correction term is further proof of the existence of stable long run relationship. The negative sign of error correction term also give uni-directional effect of variables.

4. RESULTS AND DISCUSSIONS

After discussing the data sources, we analyze the impact of disaggregate energy consumption on economic growth and Agricultural output on empirical grounds. To analyze these issues, we will give us a deep insight to draw some conclusion on the basis of empirical results of this research. The results are discussed as follows.

a) Descriptive Analysis

The descriptive statistics of the study are presented in the Table 1. Descriptive statistics consists of procedures used to summarize and describe the characteristics of a set of data. The table shows the averages values, standard deviation, skewness, kurtosis and J. Bera values of the selected variables.

Table 1: Descriptive Statistics of variables

	Mean	Median	Maximum	Minimum	Std.Dev.	Skewness	Kurtosis	J.Bera	Prob	Obs
AGRI	587531.9	233130	3016565	17934	737717.6	1.70	5.41	28.33	0.00	39
IR	9.633333	9	30	3	5.732839	1.87	7.08	50.07	0.00	39
RGDP	1507061	446005	5670768	33243	1991864	1.07	2.38	8.16	0.01	39
RGFCF	8910.988	8306.58	21454.19	1748.073	5118.798	0.76	2.87	3.81	0.14	39
TEC	32961.79	31534	74348	5332	22153.06	0.40	1.96	2.77	0.24	39
TELF	31.31373	30.11757	47.09738	17.98223	8.480152	0.26	1.98	2.13	0.34	39
TGC	550732.2	465338	1277821	111514	371132	0.78	2.41	4.53	0.10	39
TOC	10465494	9972457	19131700	2782448	5656927	-0.00	1.44	3.93	0.13	39
ACRDT	43420	15386	248120	129	66478	2.00	5.85	39.39	0.00	39

Source: Authors' calculations

b) ADF test for Stationarity

Table 2 explains the summary statistics of ADF test. The results of the test indicate that some variables are stationary at level and others are stationary at first difference. The findings of the study provide the justification of ARDL Approach.

Table 2: Results of ADF Test

Variables	ADF Statistic (At Level)	ADF(With First Difference)	Order of Integration
IR	-3.64	-7.91	I(0)
ACRDT	-0.12	-2.57	I(1)
RGDP	-1.22	-4.53	I(1)
TELF	-2.70	-8.09	I(1)
TOC	-1.82	-2.77	I(1)
TGC	-1.48	-2.75	I(1)
TEC	-2.22	-4.43	I(1)
AGRI	0.76	-4.09	I(1)
RGFCF	-4.25	-4.16	I(0)

Note: Results are based on author's calculations.

Bounds Test for Co-integration

In the first step the existence of the long run relationship among the variables is needed. We have used Bound Testing Approach in order to examine the long run relationship. Table 3 interprets the findings of Wald-Test (F-Statistics) for long-run relationship.

Table 3: Results of Bound Test for Co-integration

Equations	F-statistic Calculated	Upper Bound Critical Value	Conclusion
Model-1 Equation (6.12) **RGDP / RGFCF, TELF, TOC, TGC, TEC, IR**	**7.42 [0.0002]**	**4.90 (99%)**	**Co integration exists**
Model-2 Equation (6.13) **ARGI / RGFCF, TELF, TOC, TGC, TEC, ACRDT**	**13.51 [0.000]**	**4.90 (99%)**	**Co integration exists**

Note: Computed F-statistic: 7.42 and 13.51 (Significant at 1% marginal values).Critical Values at *k =7-1=6* and *k =7-1=6* are cited from Pesaran et al. (1999), Table CI (V), Case V: Unrestricted intercept and Unrestricted trend. The numbers in parenthesis shows the probabilities of F-statistic.

The value of F-statistics based on Wald test is given in second column. The upper bound values are reported in third column of Table 2. The results of the test indicates that there exits long-run relationship among the variables in both models.

Long Run Estimates of Energy Consumption and Economic Growth

The long-run estimates of the model-1 are reported in Table 4. The dependant variable is economic growth which is proxied as real GDP whereas RGFCF, TELF, TOC, TEC and TGC, IR are independent variables.

Table 4: Long- Run Results of Disaggregate Energy Consumption and Economic Growth

Estimated Long Run Coefficients using the ARDL Approach			
ARDL(1,0,2,0,1,2,1) selected based on Schwarz Bayesian Criterion			
Dependent variable is RGDP			
37 observations used for estimation from 1974 to 2011			
Regressor	Coefficient	Standard Error	T-Ratio [Prob]
RGFCF	604.54	332.51	1.81 [.083]
TELF	588561	523156	1.12 [.273]
TOC	.90	.29	3.00 [.007]
TGC	15.63	6.30	2.47 [.021]
TEC	-346.85	157.78	-2.19[.039]
IR	-69002	60625.9	-1.13 [.267]
C	-1.17	9592168	-1.22 [.235]
T	-779741	351826.6	-2.21 [.037]

Note: Results are based on Author's calculations using Microfit 4.1

we have observed that the value of regression coefficient of Real Gross Fixed Capital Formation (RGFCF) that is 604.54 which means that the one unit increase in Real Gross Fixed Capital Formation increase the economic growth (RGDP) by 604.54 units and this effect is strong and statistically significant.The expansion of infrastructure directly stimulate productive activities. The other channel may be that investment in education and training can produce skilled and more productive labor. Our results stay in line with Khan and Reinhart (1990), (Blomstrom et al, 2009) who find positive relationship between investment and growth.

Table 5: Short Run Estimates of Disaggregate Energy Consumption on Economic Growth

ARDL (1,0,2,0,1,2,1) selected based on Schwarz Bayesian Criterion			
Dependent variable is dRGDP			
37 observations used for estimation from 1972 to 2011			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dRGFCF	229.9852	87.6733	2.6232[.014]
dTELF	153071.4	101752.5	1.5044[.145]
dTELF1	-205340.1	101328.0	-2.0265[.053]
dTOC	.34272	.077428	4.4263[.000]
dTGC	10.8104	2.3522	4.5958[.000]
dTEC	-92.0338	52.6229	-1.7489[.092]
dTEC1	-152.8186	54.7032	-2.7936[.010]
dIR	2370.6	16643.9	.14243[.888]
dC	-4460483	3357701	-1.3284[.196]
dT	-296635.0	113131.6	-2.6220[.014]
ecm(-1)	-.38043	.11781	-3.2290[.003]
ecm = RGDP -604.54*RGFCF -588561.3*TELF -.90*TOC -15.63*TGC + 346.8594*TEC + 69002.1*IR + 1.17E*C + 779741.9*T			
R-Squared	.76189	R-Bar-Squared	.61036
DW-statistic	2.3488	F-stat. F(10, 26)	7.0393[.000]

Note: Results are based on Author's calculations using Microfit 4.1

The coefficient of the employed labour force is although positive but insignificant. Our findings are matched with conventional neo-classical [see (Barrow and Sala-i-Martin, 1995)]. The core variables of the study are energy variables i.e, total energy consumption, total gas consumption, total electricity consumption. We have noted in the present study that total oil consumption directly influence the economic growth. The value of the coefficient of oil consumption is 0.90 which means that an increase of one unit in total oil consumption raises real GDP about 0.90 units. The same results are found in the short run. The findings support the theoretical results. The reason may be that the wheel of the economic life cannot be run without oil now-a-days because of mechanization and technological progress.

We have also noted that the coefficient of total gas consumption is positive and highly significant. The real GDP increases almost 15.6 units due to one unit increase in total gas consumption. It is observed that the third variable of the energy turns out to be negative. The coefficient of the total electricity consumption is (-346.85) and statistically significant. The short run findings also indicate negative impact on growth. The analysis concludes that electricity is considered as limiting factor t economic growth in Pakistan. The reason may be that the continuous short fall of the electricity and electricity supply shock are the main causes of growth deterioration. Our results support the (javaid, et.al,2013), (Kakar and khilji, 2011), Shahbaz et. al,(2013), Onakoya et. al,(2013) and Yuan et. al, (2006) findings.

The inflation rate is used as central variable in the growth model. The analysis concludes that the effect of inflation rate on economic growth is positive and statistically significant. Theoretically, it is sound because rising prices cause more profits for investors. New investments, capital formation and industrialization take place both in the short-run as well as long-run and economy will grow.

Interpretation of Error Correction Term (Ecmt-1)

The coefficient of ecmt-1 for Model-1 is equal to (-0.38) for the short-run model and implies that deviation from the long-term economic growth is corrected by 38 % over each year at 1% level of significance.

Long- Run and Short Run Estimates of Disaggregate energy consumption on Agricultural Output

The value of regression coefficient of real Gross Fixed Capital formation (RGFCF) is 8.92 which means that the one unit increase in real Gross Fixed Capital formation raises the Agricultural output by 8.92 units. The reason may be that investments in agriculture research and extension services also increase Agricultural production. Further, investment in human capital enhance the cost of children reduce. Therefore, per capita saving rate increases and ultimately growth per capita increases (Barro, 1991).

Table 6: Long- Run Effects Of Disaggregate Energy Consumption On Agricultural Output

ARDL(1,2,0,2,1,2,2) selected based on Schwarz Bayesian Criterion			
Dependent variable is AGRI			
38 observations used for estimation from 1973 to 2011			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
RGFCF	8.92	23.65	.377[.710]
TELF	3033	12712	.238[.814]
TOC	.054	.017	3.114[.006]
TGC	1.81	.47	3.817[.001]
TEC	-9.41	8.23	-1.142[.267]

ACRDT	8.83	.95	9.260[.000]
C	-208966	231783	-.901[.379]
T	-33472	11111	-3.012[.007]

Note: Results are based on Authors' calculations using Microfit 4.1

We have observed that the value of regression coefficient of Employed Labour Force (TELF) that is 3033. This means that the one unit increase in Employed Labour Force increases Agricultural output by 3033 units and the result is statistically insignificant.

We have found that the coefficient of total gas consumption is 1.81 is statistically highly significant. The Agricultural product increases by about 1.8 units due to one unit increase in total gas consumption.

Table 7: Short Run Effects of Disaggrigate Energy Consumption on Agricultural Output

Error Correction Representation for the Selected ARDL Model			
ARDL(1,2,0,2,1,2,2) selected based on Schwarz Bayesian Criterion			
Dependent variable is dAGRI			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dRGFCF	-1.03	7.19	-.14[.887]
dRGFCF1	-17.82	7.89	-2.25[.033]
dTELF	1409.2	5927	.23[.814]
dTOC	.007	.006	1.15[.259]
dTOC1	-.016	.007	-2.07[.049]
dTGC	.104	.18	.55[.582]
dTEC	-6.78	5.71	-1.18[.247]
dTEC1	-23.28	5.10	-4.55[.000]
dACRDT	.769	1.19	.64[.527]
dACRDT1	-1.92	1.17	-1.63[.114]
dC	-97067	109958	-.88[.386]
dT	-15548	5548.90	-2.80[.010]
ecm(-1)	-.464	.102	-4.52[.000]
ecm = AGRI -8.9289*RGFCF -3033.7*TELF -.054952*TOC-1.8115*TGC + 9.4111*TEC -8.8307*ACRDT + 208966.6*C + 33472.2*T			
R-Squared	.98	R-Bar-Squared	.97
DW-statistic	1.83	F-stat. F(12, 24)	121.65[.000]

Note: Results are based on Authors' calculations using Microfit 4.

The regression coefficient of Total Oil Consumption is .054. This means that the one unit increase in Total Oil Consumption increases Agricultural output by .054 units. The estimated coefficient of Total electricity consumption (TEC) is -9.41 which implies that Agricultural output is affected negatively by electricity consumption and is statistically significant. The agricultural credit is contributing positively in boosting up economic growth as coefficient of

Agricultural credit is 8.83 that is significant. Results are consistent with (Ayaz et. al., 2011). Formal credit directly influence agoricultural productivity through investment and it is more benefited then financing of fertilizers and seeds [Qureshi and Shah (1992), Jehanzeb et. al, (2008)].

Interpretation of Error Correction Term (Ecmt-1)

The value of Ecmt-1 for Model-2 is (-.46) which implies that the short run variables approach to long run variables by 46% each year. Negative and significant value of error correction term also provides further proof of existence of long run and unidirectional relationship (Bannerjee et al. ,1998).

Diagnostic tests

J-B normality test for residual is conducted to see residual are normally distributed or not because one of the assumptions of CLRM is residual are normally distributed with zero mean and constant variance. Breusch-Godfrey LM test is conducted to check the serial autocorrelation in our model. Autoregressive conditional heteroskedasticity (ARCH) is conducted to check the autocorrelation in the variance of error term.. So, our models pass all diagnostic tests. The outcomes of all these tests in the same order are given in the tables.

Table 8: Diagnostic Test

Diagnostic Tests of Model-1 [RGDP | RGFCF, TELF, TEC, TGC, TOC, IR]

Test Statistics *	LM Version *	F Version *
* A:Serial Correlation*	CHSQ(1) = 1.6304[.202]	F(1, 21)= .96801[.336]*
* *	*	*
* B:Functional Form *	CHSQ(1) = 3.6478[.066]	F(1, 21)= 2.2968[.145]*
* *	*	*
* C:Normality	CHSQ(2) = 2.1778[.337]	* Not applicable *
* *	*	*
* D:Heteroscedasticity*	CHSQ(1) = .36585[.545]	F(1, 35)= .34953[.558]

Source: Authors' calculation using Microfit 4.1

Table 9: Diagnostic Test

Diagnostic Tests of Model-2 [AGRI | RGFCF, TELF, TEC, TGC, TOC, ACRDT]

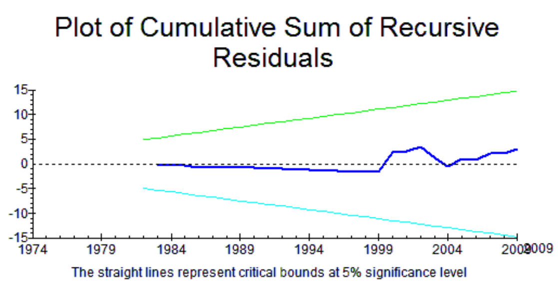
Test Statistics *	LM Version *	F Version *
* A:Serial Correlation*	CHSQ(1) = .53399[.465]*	F(1, 18)= .26358[.614]*
* *	*	*
* B:Functional Form *	CHSQ(1) = 2.5889[.118]*	F(1, 18)= 1.3542[.260]*
* *	*	*
* C:Normality *	CHSQ(2) = 2.4167[.299]	* Not applicable *
* *	*	*
* D:Heteroscedasticity*	CHSQ(1) = .46974[.493]*	F(1, 35)= .45007[.507]*

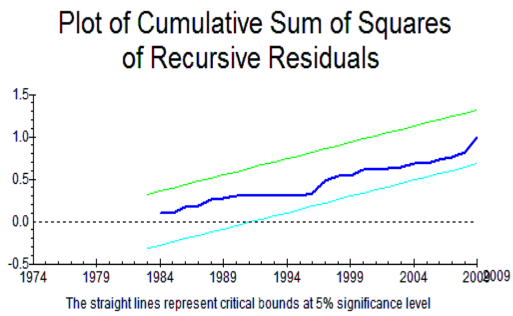
Source: Authors' calculation using Microfit 4.1

Stability Test

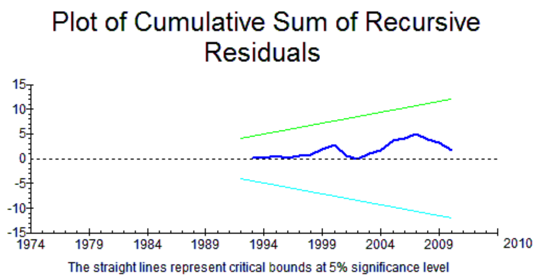
In order to check the stability of the Models, we plot the cumulative sum of recursive residuals CUSCUM and cumulative sum of recursive residuals of square CUSUMS. The results show that coefficients in our estimated models are stable as the graph of CUSUM and CUSUMS statistics lies in the critical bounds. The absence of divergence in CUSUM and CUSUMS graphs confirm that in our ARDL Models, short run and long run estimates are stable.

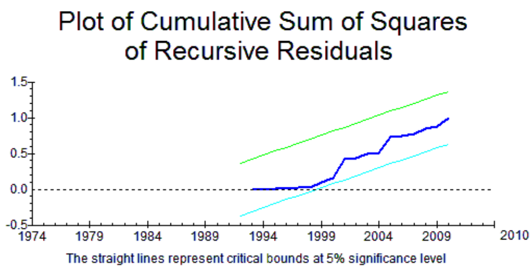
Stability Test for Model-1 [RGDP | RGFCF, TELF, TEC, TGC, TOC, IR]





Stability Test for Model-2 [AGRI | RGFCF, TELF, TOC, TEC, TGC, ACRDT]





5. Conclusions

In this study, we have planned to analyse the impact of disaggregate energy consumption on economic growth and Agricultural output on empirical grounds with respect to Pakistan. Study has used ADF test which indicate mixed results with different order of integration. Existence of long run relationship among variables is examined for both models. Long run estimation and error correction representation of both models have been discussed and their interpretations are made. Findings of the study conclude that disaggregate energy consumption, economic growth and Agricultural output are interlinked with each other in short as well as in long run.

The empirical analysis of disaggregate consumption on economic growth and on agricultural output leads to a numbers of conclusion for policy formulation. Electricity consumption and economic growth puts some essential policy implications on the economy of Pakistan. The unidirectional relationship of electricity consumption to economic growth and Agricultural output leads us to draw a conclusion that shortage of electricity supply at the prevailing level with this breathing economic structure can harm Pakistan's economic growth and Agricultural output. As, consumption of electricity can influence national and Agricultural output as it the main source of energy consumption that why it is significant issue to maintain the supply of electricity according to its demand. And since in cyclical sense economic fluctuation is also sourced from electricity consumption making sure that electricity may be a leading indicator for business cycle. Smooth installation of electricity generation capacity may be placating power for business cycle. Another important implication is that as oil consumption and gas consumption are contributing positively to economic growth and Agricultural growth. therefore, Pakistan energy sources (i.e., oil, coal and gas) other than electricity should be enhanced for sustainable economic growth because Pakistan production sectors like agricultural sector also relying solemnly on electricity consumption mainly and increasing demand of electricity as compared to its supply and insufficient installed capacity reducing Agricultural as well as National output. At the same time, to increase electricity supply, Pakistan government should make better the sources of power generation in order to fulfil the electricity demand.

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