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Abstract

Economic growth is energy-intensive. Nonetheless, in developing countries like Pakistan, the present use of energy use in agriculture is not strictly commensurate with energy consumption trends. Sharp increases in energy prices in Pakistan have renewed interests in the effects of energy on economic growth. Using time series data from 1972 to 2005, this study shows that in the non trended model the null of unit root for all variables is accepted while in the trended model, except for GDP, the null of unit root is accepted for the remaining variables. Thus all variables are non stationary in their level form. The result of the Φ_3 test implies that all variables have unit root with no trend, excluding the CPI that is trend stationary. In first difference form the null of unit root is not accepted, meaning that all variables are first difference stationary while the CPI is stationary after taking second difference. The Cointegration analysis found only one cointegrating vector for oil, electricity, and gas hence, there exists a long run equilibrium relationship between these variables and agricultural growth. The causality analysis implies that gas consumption has bidirectional causality, meaning that gas, a natural resource, has important implications for agricultural growth in Pakistan and vice versa. However, there is no causal relationship found, in any direction, for petroleum and electricity with agricultural growth.

Keywords: Energy Consumption; Agricultural growth; Cointegration; Causality; Pakistan.

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I. Introduction:

Productivity is closely associated with direct and indirect use of energy as an input. The importance of energy can not be denied as one of the basic inputs to economic growth process. The consumption of energy has been among the critical indicators of the level of development of any country. It is observed that usually the developed countries use more energy per unit of economic output and far more energy per capita than developing countries. This reflects the adoption of increasingly more efficient technologies for energy production and utilization as well as changes in the composition of economic activities. This, largely, needs a shift in energy use (Cheng and Lai, 1997). When this shift in the composition of final energy use is taken into account energy use and the level of economic activity are found to be tightly coupled.

The prospect of large reduction in the energy use intensity of economic activity seems limited. So, the accelerated demand results in the scarcity of energy and increasing cost have severe implications for economic growth. This ever increasing role of energy in the present day scenario underlines the need to increase the supply of energy and to find some new alternative energy sources and energy conservation techniques.

In order to meet the expected growth momentum of the economy (more then 6 percent over the past few years and projected to be more in the coming years), Pakistan needs a comprehensive National Energy Plan to meet her future needs (GOP, 2005). It is also clear that energy is one of the important inputs for production, conversion, processing and commercialization activities. Like other developing countries, Pakistan is also an energy intensive economy and as in most other non-petroleum producing countries its energy needs met by imports. The consumption of petroleum products has been increasing by an average rate of 2.5 % per annum from 1990-91 to 2003-04. While the consumption of gas and electricity has increased at an average rate of 4.9 and 5.1 percent per annum respectively.

II. Energy use in Agriculture Sector:

Even though, the present use of energy inputs in agriculture is not strictly commensurate with energy consumption trends in developed countries, our agricultural productivity heavily depends on proper availability and prices of energy inputs. Most importantly, almost 67.5 percent of country's population living in rural areas is directly or indirectly[1] depend on agriculture for their livelihood (GOP, 2005).

The share of energy consumption in agriculture has continuously decreased from 19 % and 14 % in 1972 to 11 % and 1 % in 2005 in the case of electricity and petroleum respectively. The share of gas consumption in fertilizer production in the country has also decreased from 19.9 % in 1972 to 16.4 % in 2005 (GOP, 2005). Besides these trends in agricultural energy consumption, the share of costly energy inputs in total farm expenses also has severe implications for future energy policies for agriculture sector.

In Pakistan, per capita energy consumption in the agriculture sector is low and this is one of the basic reasons behind continued low productivity and thus impaired economic growth. As economic growth process is highly energy-intensive, therefore, energy supplies in the country must avoid constraints, but Pakistan faces both energy constraints from the supply side and demand management policies (Riaz, 1984).

Sharp increases in energy prices in recent years have renewed interests in the effects of energy on economic growth. Although, it is well known that a strong correlation exist between energy consumption and growth. The significance of any direction of causality, either bi-directional or unidirectional, may provide an insight for the policy makers. For example, if the causality running from energy consumption to income, then this denotes an energy-dependent economy such that energy is an impetus for income increase, implying that a shortage of energy may negatively affect income (Masih and Masih, 1998). On the other hand, if causality is running from income to energy, this denotes a less energy-dependent economy such that energy conservation policies may be implemented with little adverse or no effects on income (Jumbe, 2004). Finally, the finding of no causality in either direction, the so-called 'neutrality hypothesis' means that energy conservation policies do not affect income (Yu and Choi, 1985).

1. Direct use of energy in agriculture can be seen as in agricultural mechanization e.g. tractor use in a number of land preparation functions and harvesting/carriage of agricultural produce, tube wells, bulldozers, combine harvesters; and plants/factories engaged in processing of agricultural produce e.g. ginners, sugar mills etc. Indirect consumption of energy in agriculture sector is primarily described as gas consumption in fertilizer plants for the production of nitrogen based chemical fertilizers. Petroleum and gas use in rural transportation and household fuel can also be categorized under indirect energy consumption in agriculture sector.

Following the importance of energy in the economy, this study critically reviews the growth trends of energy consumption in the agriculture sector in a developing country context, Pakistan. Using well established tools of time series econometrics the study applied Augmented Dickey Fuller test (ADF) for unit root and stationarity issues of the data while, empirically detecting the long-run relationship of agricultural energy consumption, economic growth and energy prices using Cointegration approach. As well as, the direction of causality is checked between agricultural energy consumption and economic growth by applying Granger causality test.

III. Brief Review of Literature:

The association between energy consumption and economic growth has been extensively investigated since the late 1970s. The pioneering study of Kraft and Kraft (1978) found that there is a unidirectional causality running from energy consumption to GNP for the United States for the period of 1947–1974 by employing Sims methodology. On the other hand, Akarca and Long (1979) showed no evidence of causality between energy consumption and GDP when the investigated period is shortened. Errol and Yu (1987) employed Sims and Granger causality tests and found unidirectional causality running from energy consumption to income for West Germany while bi-directional causality for Italy and Japan, and no evidence of causality for UK, Canada and France.

Hwang and Gum (1992) examined the causality between energy consumption and GNP for Taiwan Province of China. A bi-directional causality was observed in Taiwan for the period of 1955–1993. On the other hand, Cheng and Lai (1997) applied Hsiao's version of Granger causality methodology to investigate the causality between energy consumption and GDP for Taiwan for the period of 1955–1993. The study showed that causality runs from GDP to energy consumption without feedback in Taiwan. Yang (2000) re-examined the causality between energy consumption and GDP for Taiwan using updated data for the 1954–1997 period. The finding of this paper does not confirm the findings of Cheng and Lai (1997) of unidirectional causality from GDP to total energy consumption. They found evidences of bi-directional causality between total energy consumption and GDP.

Aqeel and Butt (2001) investigated the causal relationship between energy consumption, economic growth and employment in Pakistan and resulted that economic growth causes total energy consumption. Soytas and Sari (2003) pointed out that there is bi-directional causality in Argentina and they found that causality runs from energy consumption to GDP in Turkey, France, Germany and Japan. Based on these mixed results, it is improper to make any type of generalizations of the potential relationship between GDP and energy consumption. Thus, in designing a recovery policy aimed at facilitating the energy consumption and promoting economic growth, it is necessary to consider the case of each country separately by keeping its pace and stage of development.

IV. Data:

In the present study per capita real agricultural GDP measured in Pakistani rupees (Pak Rs.), used as a proxy for agricultural growth, real GDP was calculated with the help of GDP deflator by setting 2000-01 as a base year. For the empirical measurement of agricultural energy consumption, three major components of energy i.e. oil, electricity, and gas used each on per capita consumption basis. Per capita oil was measured in Kilograms (Kg) of oil per head; while electricity as kilo watt per hour (KWh^{-1}) and gas as cubic feet (cft) on per head basis. However, consumer price index served as a proxy for the prices of above mentioned energy components due to non-availability of time series data about energy prices and was based on year 2000-01. Data for all the variables was used from 1972-2005 and all the variables transformed to logarithmic form. Data was derived from Pakistan Economic Survey, Pakistan Energy Yearbooks, Food and Agriculture Organization (FAO) statistical database and International Monetary Fund (IMF) statistical database.

V. Mathematical Model:

The demand for per capita agricultural oil consumption was assumed to be a function of per capita real agricultural GDP and general price level. In the same manner per capita electricity and gas consumption in agriculture was assumed as a function of per capita real agricultural GDP and general price level. Thus the general form of consumption demand function was specified in log form as follows;

$$\ln OC_t = \alpha_0 + \beta_1 \ln Y_t + \beta_2 \ln P_t + \mu_{0t} \quad (1)$$

$$\ln EC_t = \alpha_e + \beta_1 \ln Y_t + \beta_2 \ln P_t + \mu_{et} \quad (2)$$

$$\ln GC_t = \alpha_g + \beta_1 \ln Y_t + \beta_2 \ln P_t + \mu_{gt} \quad (3)$$

Where; $\ln OC_t$ = Natural logarithm of per capita oil consumption, $\ln EC_t$ = Natural logarithm of per capita electricity consumption, $\ln GC_t$ = Natural logarithm of gas consumption in agriculture sector on per capita basis, $\ln Y_t$ = Natural logarithm of per capita real GDP in the agriculture sector as measured in Pakistani Rupee (base year, 2000-01 = 100 for GDP deflator), $\ln P_t$ = Natural logarithm of consumer price index (base year, 2000-01 = 100 for CPI) and μ_{it} = Stochastic error term for oil, electricity and gas. It is assumed to be identically independently and normally distributed (IID) with zero mean and constant variance.

VI. Testing for Unit Root:

A time series data is said to be stationary if it's mean, variance and covariance remain constant over time and hence, usual statistical techniques to analyze the data is not appropriate. Most econometric time series are trended over time and regressions between trended series may produce significant results with high R square, but may be spurious or meaning less (Granger and Newbold, 1974).

The initial solution to the analysis of integrated series in derived from the work of Box and Jenkins (1970, 1976), who formulate regressions in which the variables are expressed in first differences. However, this process of differencing results in the loss of valuable long-run information among the series (Davidson, *et al.*, 1978). In general, the Box-Jenkins approach assumes that non-stationary data can be differenced repeatedly until stationarity is achieved. Granger and Newbold (1974) suggested that for regression with high R^2 and low *DW*-statistics, regression should be run on the first differences of the variables. The number of times a series needs to be differenced in order to achieve stationarity depends upon the number of unit roots it contains. If a series becomes stationary after differencing d times, it contains *d* unit roots and is said to be integrated of order *d*, denoted as *I (d)*.

There are number of approaches to test the unit root hypothesis but the Dickey-Fuller (DF) test (Dickey and Fuller, 1979, 1981) is most commonly used. The DF-test requires estimating the following by OLS:

$$\Delta Y_t = \alpha + \beta\tau_t + (\Phi - 1)Y_{t-1} + \mu_t \qquad \textbf{(4)}$$

Here the series Y_t has both stochastic and deterministic trends and can be used as a DF-equation for testing the unit root hypothesis i.e. H_o: $(\varphi - 1) = 0$. The DF-test is based on the assumption that μ_t is white-noise. But if the error term is not white-noise, there is auto-correlation in the residuals of the OLS regression in the above equation. To solve this problem Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1981) is adopted by adding lagged values of depended variable as;

$$\Delta Y_t = \alpha + \beta\tau_t + (\Phi - 1)Y_{t-1} + \sum_{i=1}^{K}\theta_1 \Delta Y_{t-1} + \mu_t \quad \textbf{(5)}$$

The DF/ADF-tests are based on the assumption that there is only one unit root in the process (Dickey, et al., 1986). However, if there is more than one unit root, the standard testing procedure is to test first for a unit root in the levels of the series Y_t. If the hypothesis of the presence of a unit root is not rejected, we test the first difference (i.e. ΔY_t) for the presence of a second unit root and so on.

VII. Testing for Cointegration:

The basic idea of cointegration is to identify equilibrium or a long-run relationship between variables. In this case, two conditions must be satisfied. First, the series for at least two of the individual variables are integrated of the same order and second, a linear combination of the variables exists which is integrated to an order lower than the individual variables (Hansen and Juselius, 1995).

The economic interpretation of cointegration is that if in the long run two or more series Y_t and X_t are linked together to form an equilibrium relationship, then even though Y_t and X_t themselves are trended (i.e. non-stationary) they will nevertheless move together closely over time and the difference between them is constant i.e. stationary.

Johansen's full information maximum likelihood (FIML) approach (Johansen, 1988; Johansen and Juselius, 1990) is used for testing the cointegration. The Johansen method allows the estimation of all possible cointegrating relationship and develops a set of statistical tests to test hypotheses about how many cointegrating vectors exists and how they work in the system. Because the series were integrated of the same order, Johansen's procedure (Johansen, 1988) can be used to test the presence of a co integrating vector between agricultural energy consumption, agricultural GDP and energy prices. The procedure was based on maximum likelihood estimation of the error correction model;

$$\Delta Z_t = \delta + \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t+2} + \Lambda + \Gamma_{p-1} \Delta Z_{t-p+1} + \Pi Z_{t-p} + \mu_t \qquad \textbf{(6)}$$

Where; $Z_t = [C_t, Y_t, P_t]$. C_t is total energy consumption in the agriculture sector and all the other variables are the same as specified previously. $\Delta z_t = z_t - z_{t-1}$, and Π and Γ_i are $(n \times n)$ matrices of parameters with $\Gamma_i = -(1 - A_1 - A_2 \ldots - A_i)$, $(i = 1, \ldots, k-1)$, and $\Pi = 1 - \Pi_1 - \Pi_2 \ldots - \Pi_k$. The term Πz_{t-p} provides information about the long-term equilibrium relationship between the variables in Z_t, information about the number of co integrating relationships among the variables in Z_t be given by the rank of the Π-matrix. If Π is of reduced rank, the model is subject to a unit root; and if $0 < r < n$, where r is the rank of Π, Π can be decomposed into two $(n \times r)$ matrices Π and Πz_t, where Πz_t is stationary.

The likelihood ratio test (LR-test) constructed for detecting the presence of a single cointegrating vector is trace test statistic. The equation for this trace test is as following;

$$\lambda_{trace} = -2\ln Q = -T \sum_{i=r+1}^{p} \ln(1-\lambda) \qquad \textbf{(7)}$$

Under this test we check the null hypothesis of at most r cointegrating vectors against the alternative that it is greater than r, the critical value for this test has been derived by Monte Carlo simulations and tabulation by Johansen (1988) and Osterwald-Lenum (1992).

VIII. Granger Causality Test:

If cointegration is established, then Engle and Granger (1987) error correction specification can be used to test for Granger causality. If the series C_t and Y_t are $I(1)$ and cointegrated, then the ECM model is represented by the following equations;

$$\Delta C = \alpha_0 + \sum_{i=1}^{n} \beta_i \Delta C_{t-1} + \sum_{i=1}^{n} \beta_j \Delta Y_{t-1} + \delta ECT_{t-1} + \mu_t \qquad \textbf{(8)}$$

$$\Delta Y = \varphi_0 + \sum_{i=1}^{n} \sigma_i \Delta Y_{t-1} + \sum_{i=1}^{n} \sigma_j \Delta C_{t-1} + \lambda ECT_{t-1} + \varepsilon_t \qquad \textbf{(9)}$$

where Δ is difference operator, μ_t and ε_t are the white noise error terms, ECT_{t+i} is the error correction term derived from the long-run co integrating relationship, while n is the optimal lag length orders of the variables which are determined by using the general-to-specific modeling procedure (Hendry and Ericsson, 1991). The null hypotheses are: Y_t will granger - cause C_t if $\mu_t \neq 0$. Similarly, C_t will granger cause Y_t if $\varepsilon_t \neq 0$. To implement the Granger-causality test, F-statistics are calculated under the null hypothesis that in above equations all the coefficients of μ_t and $\varepsilon_t = 0$.

XI. Results and Discussion:

A. Critical Review of Energy Use in Agriculture Sector of Pakistan

The patterns of energy consumption in the agriculture sector are very erratic. Presently, our agriculture sector is consuming about 11 per cent of country's electricity and the share of agricultural oil in total consumption is meager i.e. just above one per cent. Moreover, around 16 per cent of our total gas is being consumed for the manufacturing of nitrogen based fertilizers. This share has been halved since 1971 from nearly 20 to 11 per cent in 2005. The average annual growth rate of agricultural electricity consumption was very irregular during the period 1996-2000. The serious fluctuations in annual growth rates may be due to many factors; among them, the electricity prices might play a big role. The relative share of agricultural petroleum in the total consumption has steadily decreased but the annual growth rate of agricultural petroleum has also been diminishing over time. Since last few years, we have seen a severe negative trend in the growth rate of petroleum consumption in the agriculture sector. In the year 2005, petroleum consumption in the sector has registered a historic down dip of about – 23 per cent. Low consumption rate of petroleum may be due its substitution with some other fuels like CNG (compressed natural gas).

Agricultural consumption of gas has steadily increased over time comparing with the decreasing trend of other energy components in this sector. This may be due to relatively cheep and stable prices of gas. Although the fertilizer manufacturing is not fully meeting the need of agriculture sector, the farming is going more and more dependent on nitrogen based chemical fertilizers. Gas has been substituted for petroleum used in the vehicle. Nevertheless, the use of CNG in tractors is still a far-fetched idea.

A very cursory review of the energy use in agriculture sector over time seems to suggest that the constant shrinkage of oil and electricity consumption may have serious effects on productivity by hampering mechanization in agriculture.

B. Unit Root Result:

Three steps procedure is used to determine the possible causal relationship between the concern variables and economic growth. As most time series data exhibit trends that is the mean of a series changes over time and are termed non-stationary (Nelson and Plosser, 1982; Perron, 1988). It is often the case that an economic time series has a unit root when its first difference is stationary. In the first step all the data series were tested for the presence of possible unit roots and to identify the order of integration of the variables. Agricultural energy consumption i.e. individual series of agricultural petroleum, electricity and gas, agricultural GDP and consumer price index were tested for the period 1972-2005. The results of unit root tests are presented in following table 2.

Table 2 presents the results of the series (in logarithms) for unit root using ADF test both with and without linear trend. In non-trended model, the absolute values of the ADF statistic for all the five variables are well below the 95 per cent critical value of the test (2.97) and hence the null hypothesis that all variables have unit root is firmly accepted. Thus, all the series are non-stationary in level form. In the trended model the absolute value of ADF statistics for four variables except LY are well below the 95 per cent critical value of the test (3.57) and thus, the null hypothesis of unit root is accepted for these four variables. Hence, these variables have unit roots. But in the case of per capita GDP (LY), the ADF statistics value is greater than 95% critical value. This implies that LY series is stationary in the trended model.

Tables 2: Augmented Dickey-Fuller (ADF) unit root test results

Variables	Trended Model			Non-trended Model
	Test statistics	Trend	Φ_3 Test	
LOC	-1.14	-1.36	1.42	-0.74
LEC	-1.84	0.79	1.84	-2.05
LGC	-1.62	1.07	2.16	-2.38
LY	-4.08	3.36	5.63	-0.46
LCPI	-2.59	-1.36	10.03	-0.59
Critical Value	-3.57	2.85	7.24	-2.97

First/second-differenced ADF unit root test results

Variables	Trended Model	Non-trended Model
DLOC	-4.67	-4.64
DLEC	-4.05	-3.79

DLGC	-5.18	-4.56
DLY	-6.90	-5.93
DLCPI	-2.63	-2.75
DDLCPI	-5.97	-6.09
CV 5%	-3.58	-2.97

Note: critical values (95% confidence level) are taken from Fuller (1976, pp. 373)

These results direct us toward the more authenticated test called Φ_3 test. The null hypothesis in the Φ_3 test is that the variables observed have unit root with no trend against the alternative hypothesis that the variables are trend stationary. The values of F-statistics for four variables except LCPI are below the 95 per cent critical value of the $\Phi3$ test (7.24); therefore, we accept the null hypothesis that all the variables have unit root and no trend. But in case of LCPI, the F-statistics in greater than critical value so we reject the null of unit root and no trend and conclude that LCPI is trend stationary.

In short, the only time series of GDP seems stationary in the trended model and its trend is also significant as the above results make it clear. However, relying on the more authenticated Φ_3 test showed that the GDP series are non-stationary and with no trend, we finally conclude that all the series involved in the analysis are as a whole non-stationary.

Table 2 indicates the first differenced results in both non-trended and trended models. The first differenced absolute values of test-statistics for four variables are well above the 95 per cent value of their critical tests. Therefore, the null hypothesis is rejected means that these four variables have no unit roots; and become stationary after first difference i.e. I (1). Only LCPI did not become stationary after first difference and we have to take second difference in order to reject the null of non-stationary or to make it stationary.

After testing for unit root, the next step is to test for cointegration. Now, stepwise cointegration analysis is presented for the entire three models previously specified.

C. Oil Consumption Model:

Johansen's procedure was applied to test the cointegration between the variables in the oil consumption model. The first step in Johansen's procedure is the selection of order of Vector Auto Regressive (VAR). Adjusted LR-test on the VAR with a maximum of four lags were carried out. According to the Table 3, the adjusted LR-test selects the order one because at order one the parenthesis value of adjusted LR is greater than 0.05. The values of both AIC and SBC are maximum at first order and hence, select the order of VAR equal to one.

Table 3: Cointegration test based on Trace of stochastic matrix

List of variables included in the cointegrated vector LOC LY LCPI				
Ho	H1	Model 2	Model 3	Model 4
Trace Test				
r = 0	r = 1	79.37 (34.87)	29.02 (31.54)*	34.23 (42.34)
r <= 1	r = 2	13.20 (20.18)	7.42 (17.86)	12.62 (25.77)
r <= 2	r = 3	2.87 (9.16)	2.85 (8.07)	2.93 (12.39)

Note: The values in the parenthesis are p-values significant at 95% level.

According to the Table 3, there is one co integrating vector at 95 per cent critical value because first statistical value of Trace test is greater than its 95 per cent critical value. When we reach at model 3 by moving left to right, we find that the hypothesis of no cointegration is accepted. So according to Harris (1995), the number co integrating vector will be one because null is rejected for the first time. Finally, it can safely be said that the trace test indicates there is only one co integrating vector present in the concerned series and the appropriate model for further analysis would be two.

Electricity Consumption Model:

In the Table 4, the highest values of AIC and SBC and also the adjusted- LR statistics indicates that the order of VAR should be one because the first critical value above 0.05 is in line with VAR is equal to one.

For the presence and number of co integrating vector; and the selection of appropriate model for further analysis, we consider the trace test statistics listed in the table. The number of co integrating vector is one and appropriate model for further analysis of electricity consumption is two.

Table 4: Cointegration test based on Trace of stochastic matrix

List of variables included in the cointegrated vector LEC LY LCPI				
Ho	H1	Model 2	Model 3	Model 4

Trace Test				
r = 0	r = 1	81.77 (34.87)	31.08 (31.54)*	42.24 (42.34)
r <= 1	r = 2	12.99 (20.18)	7.06 (17.86)	18.09 (25.77)
r <= 2	r = 3	2.73 (9.16)	2.18 (8.07)	4.15 (12.39)

Note: The values in the parenthesis are p-values significant at 95% level.

Gas Consumption Model:

From the table 5 the highest values of AIC and SBC respectively correspond to VAR of order 4 and 1. Since we have a short time series (30 observations) so, we can not take the risk of over-parameterization and therefore choose 1 as order of VAR. In such situations it is, however, important to check the residuals of individual equations in the VAR for possible serial correlation. An inspection of the results suggests that this is not a problem in present application.

The table 5 guides us toward the selection of one co integrating vector and model 3 as the appropriate model for our analysis. Quite naturally, when we move from left to right or from most restricted model 2 towards least restricted model 4, we explore that the null of no cointegration is rejected under model 4 where the number of cointegrating vector is one. Thus, the appropriate model, as contrast with previous two finding, here is the third for further analysis.

Table 5: Cointegration test based on Trace of stochastic matrix

List of variables included in the cointegrated vector LGC LY LCPI				
Ho	H1	Model 2	Model 3	Model 4
Trace Test				
r = 0	r = 1	84.06 (34.87)	33.01 (31.54)	39.67 (42.34)*
r <= 1	r = 2	17.88 (20.18)	11.22 (17.86)	17.81 (25.77)
r <= 2	r = 3	6.24 (9.16)	1.41 (8.07)	7.16 (12.39)

Note: The values in the parenthesis are p-values significant at 95% level.

Causality Analysis:

The results of causality between GDP and different components of energy are presented in the table 6 as under. According to table 6, lag value of one has been selected for all the analysis. In the first row of the table we see that the F-statistics is non-significant so there may be no Granger causality running from per capita real GDP to oil consumption in the agriculture sector. The reverse of it is also non-significant even at the 24 per cent level of significance. These results show that there is no causality running from oil consumption to agricultural GDP. Thus, it can safely be said that consumption of oil in the agriculture sector of the country has no causal relationship with its GDP in either direction.

Exactly, the mirror results have been found for electricity consumption and GDP. In case of electricity consumption, the highly non-significant values of F-statistics for Granger causality, both from GDP to electricity and from electricity to GDP, seems to suggest that there may not be any causal relationship between electricity and agricultural GDP.

Table 6: Granger Causality Results

Causality	Lags	F-statistics	P-value
LY → LOC	1	0.53	0.66
LOC → LY	1	1.50	0.24
LY → LEC	1	0.46	0.71
LEC → LY	1	1.31	2.29
LY → LGC	1	4.18	0.01
LGC → LY	1	2.76	0.06

'→' shows direction of causality.

In contrast with the above results, the F-statistics for gas consumption is significant. We conclude a strong causality relationship between gas consumption and GDP. The direction of causality is both ways i.e. bidirectional. The F-statistics for causality from GDP to gas consumption is significant even at 1 % level and reverse is significant at about 6 % level of significance.

The bidirectional causality between gas and GDP in the agriculture sector proves that gas is an important input for agricultural production process. The GDP from agriculture is strongly linked with gas consumption in this sector.

X. Conclusion and Recommendations:

Since the share of agriculture in the total GDP is shrinking over time, then it is natural to expect a constant decline in the share of agricultural energy consumption in country's total energy consumption.

The study using data from 1972-2005 applied ADF test for possible unit roots present in the variables and it is found that all the variables are first difference stationary except consumer price index that is stationary after second differencing. The possible step after unit root test in time series analysis to test for cointegration among the variables of the model and the result of the Johanson's cointegration suggest there exists long run equilibrium relation among concerned variables and GDP. As cointegration is established, the third step is to find the possible direction of causal mechanism. For this Granger causality test is applied and result suggest that a bidirectional causality relationship exists for gas and GDP while neutrality hypothesis proved for the electricity and oil consumption.

As result of causality test implies that agricultural oil and electricity consumption did not show any causal relationship with agricultural GDP. Thus an important implication of this result is that if government attempts to subsidize rural and agricultural electricity, it would not significantly enhance GDP share from these areas.

The strong causality link between gas consumption and agricultural GDP seems to suggest that whenever the effort of boosting agricultural GDP is to be carried out there must be a resultant increase in the per capita gas consumption while the reverse is also true. Thus, energy policy experts should pay attention to gas consumption because its increased level will determine per capita agricultural GDP and increased per capita agricultural GDP will also have feed back effect on per capita gas consumption.

Another important implication is that in case of agricultural oil and electricity, they may not project future energy demand just on the basis of agricultural GDP. But in the case of agricultural gas consumption, there is possibility that future demand of gas may be calculated on the basis of agricultural GDP.

Gas consumption in the agriculture sector suggests that in order not to adversely affect GDP; policy that aims at curtailing gas use must rather find ways of reducing consumer demand. This can easily be achieved by judicious mix of policies for taxes and subsidies.

APPENDIX A:

Table 1: LR-test on VAR with maximum of four lags (For Oil Consumption)

List of variables included in the unrestricted VAR LOC LY LCPI			
List of deterministic / exogenous variables (A)			
Order	AIC	SBC	Adjusted RL-test
4	123.31	95.98	------
3	125.05	104.04	8.21 (0.513)
2	128.47	113.75	14.55 (0.692)
1	132.44*	124.03*	20.25 (0.820)
0	22.89	20.79	154.60 (0.000)

AIC = Akaike information criterion *SBC = Schwarz Bayesian criterion*

Note: The values in the parenthesis are p-values significant at 95% level.

Table 2: LR-test on VAR with maximum of four lags (For Electricity Consumption)

List of variables included in the unrestricted VAR LEC LY LCPI			
List of deterministic / exogenous variables (A)			
Order	AIC	SBC	Adjusted LR-test
4	136.14	108.82	------
3	143.34	122.32	2.04 (0.991)
2	142.29	127.58	13.42 (0.766)
1	144.51*	136.10*	21.11 (0.781)
0	28.52	26.41	162.77 (0.000)

AIC = Akaike information criterion *SBC = Schwarz Bayesian criterion*

Note: The values in the parenthesis are p-values significant at 95% level.

Table 3: LR-test on VAR with maximum of four lags (For Gas Consumption)

List of variables included in the unrestricted VAR LGC LY LCPI			
List of deterministic / exogenous variables (A)			
Order	AIC	SBC	Adjusted LR test
4	144.44*	117.12	------
3	139.16	118.14	11.46 (0.246)
2	142.01	127.29	22.36 (0.216)
1	143.50	135.09*	30.15 (0.307)
0	28.81	26.71	355.23 (0.000)

AIC = Akaike information criterion *SBC = Schwarz Bayesian criterion*

Note: The values in the parenthesis are p-values significant at 95% level.

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