THE RELATIONSHIP BETWEEN ENERGY CONSUMPTION AND ECONOMIC GROWTH IN PAKISTAN

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This paper investigates the causal relationship between energy consumption and economic growth and energy consumption and employment in Pakistan. By applying techniques of co-integration and Hsiao's version of Granger causality, the results infer that economic growth causes total energy consumption. Economic growth also leads to growth in petroleum consumption, while on the other hand, neither economic growth nor gas consumption affect each other. However, in the power sector it has been found that electricity consumption leads to economic growth without feedback. The implications of the study are that energy conservation policy regarding petroleum consumption would not lead to any side-effects on economic growth in Pakistan. However, an energy growth policy in the case of gas and electricity consumption should be adopted in such a way that it stimulates growth in the economy and thus expands employment opportunities.

The relationship between energy consumption and economic growth is now well established in the literature, yet the direction of causation of this relationship remains controversial. That is, whether economic growth leads to energy consumption or that energy consumption is the engine of economic growth. The direction of causality has significant policy implications. Empirically it has been tried to find the direction of causality between energy consumption and economic activities for the developing as well as for the developed countries employing the Granger or Sims techniques. However, results are mixed. The seminal paper by Kraft and Kraft (1978), supported the unidirectional causality from GNP growth to energy consumption in the case of the United States of America for the period 1947-1974. Erol, and Yu, (1987), tested data for six industrialized countries, and found no significant causal relationship between energy consumption and GDP growth and, energy and employment. Yu, et. al. (1988), found no relationship between energy and GNP, and

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between energy and employment in the case of the United States. When they used the Granger method, however, they detected that energy consumption negatively effected employment by employing Sim's techniques. Yu, and Chai, (1985), also found causality from energy to GDP in the Philippines, but this causality is reversed in the case of the Republic of Korea. A bi-directional causality between growth of energy consumption and GNP growth was observed in Taiwan Province of China by Hwong, et. al. (1991), while Cheng, and Lai, (1997), found causality from economic growth to energy consumption and from energy consumption to employment without feedback in Taiwan Province of China. A similar study would be beneficial in the case of Pakistan to design an economic policy framework for the energy and other sectors.

Like other developing countries Pakistan is also an energy intensive growing economy, and as in most other non-oil producing countries its energy needs are met by large quantities of imports. The ACGR (annual consumption growth rate) of net consumption of total energy is 6.4 per cent. The share of oil, gas and electricity is 48 per cent, 30 per cent (of which more than half is used for electricity) and 15 per cent respectively. The share of imported oil was 92 per cent of net consumption of oil in 1995-1996, which is about 44 per cent of total net consumption of energy in the country. Thus to meet its growing needs of energy, Pakistan faces both energy constraints from the supply side and demand management policies. (Riaz, 1984, and Chisti and Mahmood, 1980). However, for any such policy making it is essential to determine the causal relationship between energy consumption and general economic activities. The purpose of this study is to determine such a relationship for Pakistan. This is accomplished by examining Granger Causality between growth in energy consumption and GDP growth and between growth in energy consumption and employment growth by employing cointegration technique and Hsiao's version of Granger Causality. To further enrich our study we have also analyzed the sectoral relationship viz, petroleum, gas and electricity consumption growth with that of GDP growth. Since energy consumed consists of both domestic and imported sources, it would be useful to outline appropriate policies regarding each component.

The paper is organized as follows. Section I discusses the methodology and model. Empirical findings are presented in section II. The final section contains concluding remarks.

I. METHODOLOGY

Traditionally to test for the causal relationship between two variables, the standard Granger (1969) test has been employed in the relevant literature. This test states that, if past values of a variable Y significantly contribute to forecast the value of another variable X_{t+1} then Y is said to Granger cause X and vice versa. The test is based on the following regressions.

$$Y_t = \beta_0 + \sum_{k=1}^{M} \beta_k Y_{t-k} + \sum_{l=1}^{N} \alpha_l X_{t-1} + U_t \qquad \text{--------} \quad 1$$

$$X_t = \gamma_0 + \sum_{k=1}^{M} \gamma_k X_{t-k} + \sum_{l=1}^{N} \delta_l Y_{t-1} + V_t \qquad \text{--------} \quad 2$$

Where Y_t and X_t are the variables to be tested, and U_t and V_t are mutually uncorrelated white noise errors, and t denotes the time period and *'k'* an *'l'* are number of lags. The null hypothesis is $\alpha_1 = \delta_i = 0$ for all i's versus the alternative hypothesis that $\alpha i \neq 0$ and $\delta i \neq 0$ for at least some i's. If the coefficient α_i's are statistically significant but δ_i's are not, then X causes Y and vice versa. But if both α_i and δ_i are significant then causality runs both ways.

Recent developments in the time series analysis have suggested some improvements in the standard Granger test. The first step is to check for the stationarity of the original variables and then test cointegration between them. According to Granger (1986), the test is valid if the variables are not cointegrated. Second, the results of Granger causality are very sensitive to the selection of lag length. If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag length is more, the irrelevant lags in the equation cause the estimates to be inefficient. To deal with this problem Hsiao (1981) has developed a systematic autoregressive method for choosing optimal lag length for each variable in an equation. This method combines Granger causality and Akaike's Final Prediction Error (FPE), defined as the (asymptotic) mean square prediction error[1].

Both the cointegration technique and Hsiao's version of Granger causality tests, were employed to determine the causal relationship between GDP and energy, GDP and various components of energy (oil, gas and electricity) consumption, and finally between employment and energy consumption. The basic model relates economic growth (or employment) to energy consumption. The model is:

$$\log Y = f(\log X_i)$$

Where Y is GDP (or employment) and X is energy consumption. All the variables are in per capita log form. The relevant data were available for the period 1955-1956 to 1995-1996 from Pakistan Economic Surveys and Energy Yearbooks. The procedures to estimate the model are discussed below.

[1] Previous studies had tried various different lag lengths in their model and they got conflicting results, hence Hasio's methodology was preferred. See Cheng and Lai (1997).

Cointegration

The concept of cointegration among the variables can be defined in simple words as follows. Two or more variables are said to be cointegrated if they share common trends i.e. they have long run equilibrium relationships. The technique of cointegration involves three steps. The first step requires a determination of the order of integration of the variables of interest. We have for this purpose used two popular tests: namely Dickey – Fuller (DF) and Augmented Dickey Fuller (ADF) test based on H_0:X_t is not I(0) which are given by the following equations.

$$\text{(DF)}\ \Delta X_t = a + bX_{t-1} + \varepsilon_t \qquad \text{--------}\ \ 3$$

Where X_t denotes the variables GDP, total energy consumption, employment, petroleum, consumption, gas, and electricity consumption. All the variables are real and in log form. Δ is the difference operator, a and b are parameters to be estimated.

$$\text{(ADF)}\ \Delta X_t = a + bX_{t-1} + \sum_{i=1}^{\gamma} c\Delta X_{t-i} + \varepsilon_t \qquad \text{--------}\ \ 4$$

a, b, and c are the parameters to be estimated and where γ is selected such that t is white noise. The tests are based on the null hypothesis (H_0) is: X_t is not I(0), If the calculated DF and ADF statistics are less than their critical values from Fuller's table, then the null hypothesis (H_0) is rejected and the series are stationary or integrated or order one i.e. I(1).

In the second step we estimate cointegration regression using variables having the same order of integration. The cointegration equation estimated by the OLS method is given as:

$$Y_t = a_0 + a_1 X_{ti} + Z_t \qquad \text{--------}\ \ 5$$

Where Y_t is per capita real GDP and X_{ti} is the ith component of energy consumption. For the employment equation Y_t is employment and X_t is total energy consumption.

In the third step residuals (Z_t) from the cointegration regression are subjected to the stationarity test based on the following equations.

$$\text{(DF)}\ \Delta Z_t = \alpha + \beta_0 Z_{t-1} + V_t \qquad \text{--------}\ \ 6$$

$$\text{(ADF)}\ \Delta Z_t = \alpha + \beta_0 Z_{t-1} + \sum_{i=1}^{k} \beta_1 \Delta Z_{t-i} + V_t \qquad \text{--------}\ \ 7$$

Where, Z_t is the residual from equation 5. The null hypothesis of non-stationarity is rejected if β is negative and the calculated DF or ADF statistics is less than the critical value from Fuller's table. That means there is a long run stable relationship between the two variables and causality between them is tested by the error correlation model. On the other hand, if the null hypothesis of non-stationarity is rejected and the variables are not cointegrated then the standard Granger causality test is appropriate.

Hsiao's granger causality

More recently many studies like Thornton and Batten (1985), Hwang et. al. (1991) and Chang and Lai (1997) have found Hsiao's Granger Causality test provides more robust results over both arbitrary lag length selection and other systematic methods for determining lag length. Hsiao's procedure involves two steps. The first step follows a series of autoregressive regressions on the dependent variables. In the first regression, the dependent variable is lagged once. In each succeeding regression, one more lag on the dependent variable is added. The M regressions we estimated are of the form.

$$d(Y_t) = \alpha + \sum_{i=1}^{m} \beta d(Y_{t-i}) + \varepsilon_{1t} \qquad \text{--------} \quad 8$$

Where, the value of i is from 1 to m, the choice of lag length is based on the sample size and underlying economic process. It is better to select m as large as possible. As the energy sector has a long gestation period, especially of hydro power generation in Pakistan, we have set maximum m = 10. Then we computed the FPE for each regression in the following way:

$$FPE(m) = \frac{T + m + 1}{T - m - 1} ESS(m) \big/ T \qquad \text{--------} \quad 9$$

Where T is sample size and EPE and ESS are the final prediction error and the sum of squared errors respectively.

The optimal lag length, m*, is the lag length which produces the lowest FPE. In the second step, once m* has been determined, regressions are estimated with the lags on the other variable added sequentially in the same manner used to determine m*. Thus we estimate ten regressions of the form;

$$d(Y_T) = \alpha + \sum_{i=1}^{m^*} \beta\, d(Y_{t-i}) + \sum_{j=1}^{n} \gamma d(X_{t-j}) + \varepsilon_{2t} \qquad \text{--------} \quad 10$$

Where, j ranges from 1 to 10. We then compute FPE for each regression as:

$$FPE(m^*, n) = \frac{T + m^* + 1}{T - m^* - 1} ESS(m^*, n)/T \qquad \text{--------} \quad 11$$

We choose the optimal lag length for X, n* as the lag length which produces the lowest FPE.

To test for causality FPE (m*) which excludes the X variable is compared with FPE m*, n* which contains the X variable in the model. If FPE (m*) < FPE (m* n*) energy (X_t) does not Granger cause GDP (Y_t) on the other hand FPE (m*) > F(m*n*) X_t Granger causes Y. Once the test is performed with GDP (Y_t) as the dependent variable a similar test with energy (X_t) as the dependent variable is done. To test the causality from GDP to energy consumption, all these regressions are repeated for every component of energy consumption with GDP and also for employment energy consumption.

II. EMPIRICAL RESULTS

The results of our estimations are presented step by step and are as follows:

Test for unit roots

The degree of integration of each variable involved has been determined in our analysis, based on equations 3 and 4 for both DF and the ADF test statistics respectively. The results are reported in table 1. In the level form, both the DF and ADF class of unit root tests are rejected for all the variables except that for employment. However, both the tests reject the null hypothesis of non-stationarity for all the variables when they are used in the first difference. This shows that, except for employment, all the series are stationary in the first difference, and integrated of order I(1).

Test for cointegration

The variables which have been tested for the order of integration and found to have the same order, are used to estimate cointegration regression. Table 2 reports the results of the DF and ADF tests applied to the residuals of the cointegration equations based on equation 5 and given in equations 6 and 7. The absolute values of the calculated test statistics for all the residuals are less than its critical value at the 5 per cent level. Neither of the series are cointegrated. Therefore the standard Granger test (Granger, 1669) is appropriate.

Hsiao's version of granger causality test

By following the estimations based on equations 8 to 11, we are able to reach the results of Hsiao's Granger causality test reported in table 3. The results indicate that economic growth causes total energy consumption as shown by the total

Table 1. Unit root tests

	Levels		*First Difference*	
	DF	*ADF*	*DF*	*ADF*
GDP	-2.32	-2.61	-5.88*	4.57**
TENG	-2.14	-2.17	-5.61*	-4.14**
PTL	-0.63	-0.43	-6.94*	-4.68*
GAS	-1.82	-1.44	-4.70*	-4.86*
ELEC	-1.30	-1.66	-4.54*	-3.81*
EMP	-4.40*	-4.05**	–	–

GDP = Gross Domestic Product
TENG = Total Energy Consumption (in TOE)
PTL = Petroleum Consumption (in TOE)
GAS = Gas Consumption (in TOE)
ELEC = Electricity Consumption (in TOE)
EMP = Employment
All the variables are in per capita log form.
* Significant at 1 per cent
** Significant at 5 per cent

Table 2. Cointegration results

	DF	*ADF*
GDP, TENG	-3.84	-3.17
GDP, PTL	-2.56	-2.61
GDP, GAS	-2.77	-2.72
GDP, ELEC	-3.26	-3.06

The critical values for DF and ADF for 1 per cent and 5 per cent are -4.74 and -4.03 respectively. The absolute values of the calculated test statistics in the table are less than the critical values which indicates acceptance of the null hypothesis of No-Cointegration.

energy equation, where F(m*) > F(m*, n*). Also, by observing the petroleum equation we see that economic growth leads to petroleum consumption and not vice versa. On the other hand, for the gas sector, the results show neither economic growth nor gas consumption affecting each other. However, the results reported for electricity consumption and GDP states that electricity consumption leads to economic growth without feedback. The table also indicates that energy consumption causes employment but not conversely as shown in the employment equation. Where F(m*) > F(m*, n*), the lag of 6 in the employment equation may be indicative of the capital intensity of

Table 3. Results of Hsiao's version of the causality tests

	F(m)*		*F(m*, n*)*	
The GDP Equation	0.42978×10^3 (1)	<	0.44228×10^3 (1)	Total energy consumption does not cause economic growth
The Total Energy Equation	0.12942×10^2 (1)	>	0.12450×10^2 (1)	Economic growth cause total energy consumption
The GDP Equation	0.42978×10^3 (1)	<	0.44767×10^3 (1)	Petroleum consumption does not cause economic growth
The Petroleum Equation	0.19450×10^2 (1)	>	0.18264×10^2 (1)	Economic growth causes petroleum consumption
The GDP Equation	0.42978×10^3 (1)	<	0.45231×10^3 (1)	Gas consumption does not cause economic growth
The Gas Equation	0.44478×10^2 (9)	<	0.47236×10^2 (1)	Economic growth does not cause gas consumption
The GDP Equation	0.42978×10^3 (1)	>	0.41632×10^3 (1)	Electric consumption causes economic growth
The Electricity Equation	0.35503×10^2 (9)	<	0.37793×10^2 (1)	Economic growth does not cause electric consumption
Employment Equation	0.33001×10^3 (6)	>	0.32612×10^3 (1)	Energy consumption cause employment
Total Energy Equation	0.12942×10^2 (1)	<	0.13415×10^2 (1)	Employment does not cause energy consumption

The values in parenthesis are the optimum lags.

the energy sector especially those of petrochemical industries where demand for employment is low[2].

Some logical inferences could be drawn from the above results. It seems that increased economic activity causes growth in energy consumption and since petroleum products are largely imported, is also affected by growth in GDP. While gas consumption does not by itself affect GDP and vice versa, but since it is being mostly used in the power sector, it may have its affect on GDP through electricity

[2] According to Irfan (1982) evidence during the past two decades shows that employment generation has lagged behind the growth in output and investment in the manufacturing sector in the developing countries. While estimating a demand function of labour for Pakistan, he is of the opinion that an appropriate lag of an employment function is difficult to determine a priori.

consumption which is stimulating economic growth in Pakistan. Moreover, as economic growth is boosting energy consumption the later is also causing generation of employment in the economy as well.

III. CONCLUSION

In this paper we attempted to find the direction of the causal relationship between energy consumption and economic activity in Pakistan. More specifically we investigated the casaul relationship between growth in energy consumption and growth in GDP. Additionally, to explore the possibility of further information on the direction of causality we disaggregated energy consumption into its components of petroleum, gas and electricity consumption. Subsequently, causality was sought for employment and energy consumption. The methodology was based on the Granger causality test which has been found appropriate by using the cointegration technique and finding out that there is no cointegration between the variables concerned. For selection of optimum lag length Hsiao's version of Granger causality tests was used which employ differenced data and the FPE criterion.

The estimated results infer that economic growth causes total energy consumption. Further investigation indicates that economic growth leads to the growth in petroleum consumption, while in the case of the gas sector, neither economic growth nor gas consumption effect each other. However, in the power sector it has been found that electricity consumption leads to economic growth without feedback. Finally, energy consumption also directly causes employment.

The paper has important policy implications. Since Pakistan pays a high oil import bill, petroleum imports were $1.53 billion in 1999/00 and in the preceding year $1.57 billion. In 2000/01 petroleum imports may be close to $2.5 billion or around 25 per cent of total imports (Dawn 18-23 April 2000). Therefore, using oil more efficiently and substituting gas for oil wherever possible could be a good policy measure. The implications of the present study suggest that an energy conservation policy regarding petroleum consumption would not lead to any adverse side-effects on economic growth in Pakistan, whereas energy growth policy in the case of gas and electricity consumption, should be adopted in such a way that, growth in these sectors stimulates economic growth. Such growth would lead to expand employment opportunities in the country.

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