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Disaggregate Energy Consumption and Industrial Output in Pakistan: An Empirical Analysis

Ahmer Qasim Qazi, Khalid Ahmed, and Muhammad Mudassar
Wuhan University of Technology

Abstract The study concentrates on the relationship between disaggregate energy consumption and industrial output in Pakistan by utilizing the Johansen Method of Cointegration. The results confirm the positive effect of disaggregate energy consumption on industrial output. Furthermore, bidirectional causality is identified in the case of oil consumption, whereas unidirectional causality running from electricity consumption to industrial output is observed. Moreover, unidirectional causality has been noticed from industrial output to coal consumption although there is no causality between gas consumption and industrial output. It is obvious that conservative energy policies could be harmful to the industrial production; therefore, the government has to develop innovative energy policies in order to meet the demand for energy. Additionally, the government has to pay serious attention to alternative energy sources such as solar and wind in order to boost the clean industrial growth.

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Keywords Disaggregate energy consumption; industrial output; Johansen cointegration test

Correspondence Ahmer Qasim Qazi, School of Economics, Wuhan University of Technology, 430070 Wuhan, P.R. China; e-mail: ahmer_qazi@yahoo.com

1 Introduction

The level of industrial output is determined by the availability and efficient utilization of energy resources along with inputs of labor and capital. The significant role of the energy in the production process leads researchers to indentify the relationship between energy consumption and economic growth.

The industrial sector of Pakistan is the largest user of energy, consuming about 40% of the energy in total (Pakistan energy year book 2009) and it contributes about 26% to the GDP (CIA World Factbook2010). The industrial sector is employing about 20% of the total labor force (CIA World Factbook2010) which makes it on third place in absorbing the labor force after agriculture and services sector. The industrial sector has enormous capacity to contribute to the economy at a higher level and to absorb more labor force, provided it gets through the socio-economic problems, such as political instability and energy shortages.

The large-scale manufacturing annual growth rate has been dropped from 18.8% in 2004-05 to -8.2% in 2008-09 (Economic Survey of Pakistan 2009-10). An almost similar trend has been seen in most of the small-scale manufacturing industries. The core reasons behind such deteriorating growth in the industrial sector are severe energy shortages (Ministry of Finance and Economic Affairs 2010-2011). Therefore, it is important to conduct a study, particularly for the relationship between industrial output and energy, so that reliable implications could have been drawn in order to sketch the energy policies towards a favorable and clean industrial growth.

The following study concentrates on the relationship between industrial output and disaggregate energy consumption in Pakistan. The study is the first (to best of my knowledge) to analyze the linkage between industrial growth and disaggregate energy use in the case of Pakistan. Previous studies on this topic were made at the aggregate level of the economy (see Aqeel and Butt 2001;Zahid 2008;Jamil and Ahmed 2010; and Shahbaz and Lean 2012). The use of aggregate data would hardly be useful to effectively distinguish between the particular energy impact on output as well the dependency of different energy resources of the particular country (Ramazan et al. 2008 and Yang 2000).

The remainder of the paper is organized as follows: Section 2 provides a short review of the literature, Section 3 introduces the methodology and data, Section 4 discusses and analyzes the results and at the last Section 5 concludes the study with recommendations.

2 Brief Literature Review

The direction of relationship between the energy consumption and income has been the topic of enquiry after the pioneer works of Kraft and Kraft (1978) who conducted the study for the

US and found causality from income to energy use. Since then, plenty of researches have been carried out by adopting different methods and techniques on the topic and obtained mix results. The reasons for mix results could be found in the differences in the availability of energy resources, in infrastructure and in the structure of the economies in the countries studied.

Yu and Choi (1985) conducted a similar study for South Korea and found causality running from income to energy consumption, the same result as of Kraft and Kraft (1978). Following studies were conducted for different countries with different methodologies and ascertained the causality from income to energy use: Erol and Yu (1987) for West Germany, Abosedra and Baghestani(1989) for the US, Masih and Mashi (1996) for Indonesia, Soytas and Sari (2003) for South Korea and Italy, Wolde-Rufael (2005) for five African countries, Narayan and Smyth (2005) for Australia and Lee (2006) for France, Italy and Japan.

At the same time contrast results were obtained in which causality was running from energy consumption to income by Yu and Choi (1985) for the Philippines, Erol and Yu (1987) for Japan, Stern (1993) for the US, Masih and Mashi (1996) for India and Indonesia, Stern (2000) for the US, Soytas and Sari (2003) for Turkey, France, Germany and Japan, Wolde-Rufael (2004) for Shanghai and Lee (2005) for eighteen developing countries.

However, numerous studies evidenced the bi-directional causality for the energy consumption and income,e.g.Erol and Yu (1987) for Japan and Italy, Hwang and Gum (1992) for Taiwan, Masih and Masih (1996) for Pakistan, Asafu-Adjaye (2000) for Thailand and the Philippines, Soytas and Sari (2003) for Argentina, Ghali and El-Sakka (2004) for Canada, Wolde-Rufael (2005) for Gabon and Zambia and Lee (2006) for the US.

There are many studies which did not find cointegration between energy consumption and output. The following studies obtained no causality between the two variables: Akarca and Lon (1980), Yu and Hwang (1984), Yu and Choi (1985), Erol and Yu (1987) for the US, Masih and Masih (1996) for Malaysia, Singapore and the Philippines, Asafu-Adjaye (2000) for Indonesia and India, Soytas and Sari (2003) for nine countries, Altinay and Karagol (2004) for Turkey, Wolde-Rufael (2005) for eleven African countries, Lee (2006) for the UK, Germany and Sweden and Soytas and Sari (2006) for China.

As regards Pakistan, countable empirical researches were conducted at aggregate and disaggregate level. But none has investigated the relationship between industrial output and energy consumption. At the aggregate level, Alam and Butt (2002) and Qazi and Riaz (2008) found the bi-directional causality between the energy consumption and income. Unidirectional causality running from energy consumption to growth was evidenced by Khan and Qayyum (2007) in Pakistan, at the time studies were conducted for South Asian economies.

Aqeel and Butt (2001) conducted a study at the disaggregate energy consumption level in Pakistan to identify the causality between economic growth and disaggregate energy consumption and found unidirectional causality from electricity to growth and economic growth to petroleum consumption. Furthermore, they did not find any causality between gas consumption and economic growth. Zahid (2002) studied the relationship in South Asian countries and found causality running from coal consumption to economic growth and from economic growth to electricity consumption which is opposite to the findings of Aqeel and Butt (2001) for Pakistan. Jamil and Ahmed (2010) found the causality running from economic growth to electricity consumption whereas bi-directional causality was obtained in electricity and economic growth by the Shahbaz & Lean (2012) with some specification changes.

3 Data and Methodology

The annual data has been collected for the period 1972–2010 from the different reliable sources. The industrial output is represented by the value added (INTVA) at the constant 2002 US$ obtained from the World Bank data indicators. The energy consumption (EN) is influenced by the price level. Therefore the price variable is selected to be included in the model.

Since the data for energy prices are not available, we use the Consumer Price index (CPI) to represent the energy prices[1] and the employment rate (EMP) to represent employed labor force.All data areobtained from the World Bank data indicators. Oil in tons (OIL), gas in mm cft (GAS), electricity in Gwh (ELE) and coal in 000 metric tons (COL) are used as disaggregate energy consumption variables and are collected from the different published economic surveys of Pakistan. All data are converted into logarithm forms and adjusted by season.

The study employs the Johansen Maximum Likelihood approach (Johansen 1988; Johansen and Juselius 1990, 1992) to establish the statistical relationship between the variables. The Johansen (ML) procedure allows us to obtain the multiple cointegrating relationships. Besides identifying the long-run association between the variables, the test also provides the long-run coefficients of the variables. The test is based on the VAR (Vector Autoregressive) approach to cointegration in which all variables are considered to be endogenous. The outcome of the Johansen cointegration test is sensitive to the selection of the optimal lags used in the model, therefore Akaike Information Criterion (AIC) is adopted in the model selection.

Once the long-run association has been established through the Johansen (ML) approach, it is equally important to measure the short-run coefficients as well as the direction of causality between the variables. This requires the application of Vector Error Correction Models (VECMs) which are also known as restricted VAR models. Same as in the unrestricted VAR environment, in VECM all variables in the system are considered to be endogenous variables, so the number of equations becomes equal to the number of variables. In our study VECMs could be written as follows:

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[1] Similar proxy of energy prices is selected in the study of G. Hondroyiannis et al (2002).

$$\Delta\, LINTVA_t = \alpha_1 + \sum_{i=1}^{p}\gamma_{1i}\ \Delta\, LINTVA_{t-i} + \sum_{i=1}^{h}\gamma_{1i}\ \Delta\, LEMP_{t-i} + \sum_{i=1}^{z}\gamma_{1i}\ \Delta\, LCPI_{t-i} + \sum_{i=1}^{r}\gamma_{1i}\ \Delta\, LEN_{t-i} + \lambda_1 ECT_{t-1} + u_{1t} \quad (1)$$

$$\Delta\, LEN_t = \alpha_2 + \sum_{i=1}^{p}\gamma_{2i}\ \Delta\, LEN_{t-i} + \sum_{i=1}^{h}\gamma_{2i}\ \Delta\, LEMP_{t-i} + \sum_{i=1}^{z}\gamma_{2i}\ \Delta\, LCPI_{t-i} + \sum_{i=1}^{r}\gamma_{2i}\ \Delta\, LINTVA_{t-i} + \lambda_2 ECT_{t-1} + u_{2t} \quad (2)$$

$$\Delta\, EMP_t = \alpha_3 + \sum_{i=1}^{p}\gamma_{3i}\ \Delta\, LINTVA_{t-i} + \sum_{i=1}^{h}\gamma_{3i}\ \Delta\, LEMP_{t-i} + \sum_{i=1}^{z}\gamma_{3i}\ \Delta\, LCPI_{t-i} + \sum_{i=1}^{r}\gamma_{3i}\ \Delta\, LEN_{t-i} + \lambda_3 ECT_{t-1} + u_{3t} \quad (3)$$

$$\Delta\, CPI_t = \alpha_4 + \sum_{i=1}^{p}\gamma_{4i}\ \Delta\, LINTVA_{t-i} + \sum_{i=1}^{h}\gamma_{4i}\ \Delta\, LEMP_{t-i} + \sum_{i=1}^{z}\gamma_{4i}\ \Delta\, LCPI_{t-i} + \sum_{i=1}^{r}\gamma_{4i}\ \Delta\, LEN_{t-i} + \lambda_4 ECT_{t-1} + u_{4t} \quad (4)$$

where EN represents the particular disaggregate energy variable under consideration and u_{it} are the normally distributed error terms. The term ECT_{t-1} in the equations represents the error correction and its coefficient measures movement away from the long-run equilibrium. The statistically significance of ECT_{t-1} suggests the existence of long-run relationship between the variables.

At last, the direction of causality has been identified of the cointegrating variables under the VECM. The VECM allows us to observe the causality by implying the joint significance of the lagged terms of each of the variables in the equations. Furthermore, joint short- and long-run causality is measured by the joint significance of the ECT_{t-1} and lagged terms of each of the variables.

4 Empirical Results and Discussion

The first and foremost thing to do is to determine whether the series of variables are stationary or not. The regression is said to be spurious or meaningless in the presence of the unit root in the series. The cointegration test is subject to apply when the variables have the same order of integration. Therefore, the study follows the Augmented Dickey Fuller (ADF) (Dickey and Fuller 1979) and Philips–Perron (PP) tests (Philips and Perron 1988)in order to determine the level of integration between the variables. Table 1 shows the results of unit root tests in the series. The tests confirm that all the series of variables become stationary after the first difference. It also shows that all the variables have the same order of integration that is I(1).

Table 1:Results of Unit Root Tests

Variables	ADF		PP		Integration Order
	Level	First Difference	Level	First Difference	
LINTV	-1.602795	-4.616108***	-1.44582	-4.61432***	I(1)
LEMP	-2.778589	-6.345296***	-2.79711	-6.3982***	I(1)
LCPI	-2.173726	-6.167524***	-2.15874	-6.16752***	I(1)
LOIL	-1.525963	-4.058571***	-1.48306	-4.20482***	I(1)
LGAS	-1.529622	-3.377733**	-1.45144	-2.84214**	I(1)
LELE	-0.637163	-5.854672***	-0.63716	-5.85467***	I(1)
LCOL	-0.280722	-7.082369***	-0.26664	-7.01123***	I(1)

Note: All the regressions of unit root with the Intercept term.*** and ** denote significance at the level of 1% and 5%, respectively

The next step that follows after ascertaining the order of integration is an application of Johansen Cointegration test. The study follows two tests statistics developed by Johansen (1988) and Johansen and Juselius (1990). The on is the Trace test and the other is the Maximal Eigenvalue test.Both tests are conducted to find out the cointegrating vectors in an equation. The Trace test is applied on the null hypothesis that is the number of cointegrating vectors is less than or equal to **r**, against the alternative hypothesis that there are more than **r** cointegrated vectors. Whereas the Maximal Eigenvalue test is conducted under the null hypothesis of **r** cointegrating vectors against the alternative hypothesis that there are **r**+1 cointegrating vectors. The result obtained through the Johansen Cointegration test would be delicate to the selection of lags in the model. Therefore we employ the Akaike Information Criterion (AIC) under the VAR environment system to select the optimal lag length used in the model. The AIC confirmed the optimal lag length that is 2. Table2 exhibits the results of Trace Statistics and Maximal Eigenvalue which confirm that the variables have a unique long-run association.

Once the long-run relationship is found, subsequently we can analyze the result of estimated coefficients of the long run. Table 3 shows the long-run coefficients which we can interpret as elasticities because the estimated model is in log linear form. The result shows that the disaggregate energy variables and employment level are all significantly affected to the industrial value added in the long run. The coefficients of LOIL and LCOL are the same that is 0.21 which suggests that a 1% rise in the consumption of oil and coal in the industrial sector would lead to a 0.21% rise in the value added output. The contribution made by the

Table 2: Johansen Cointegration Test Results

Hypothesis	Trace Statistics	Maximum Eigen value
r = 0	168.4058***	57.83301***
r = ≤ 1	110.5728***	43.72134**
r = ≤ 2	66.85145	24.64831
r = ≤ 3	42.20314	15.52144
r = ≤ 4	26.6817	12.39947
r = ≤ 5	14.28223	9.653723
r = ≤ 6	4.628503	4.628503

*** and ** denote the rejection of null hypothesis at the levelof 1% and 5%

Table 3**:** Long-run Estimated Coefficients

Dependent variable: LINTV		
Regressors	**Coefficients**	**t-statistic**
LEMP	0.144	2.54**
LCPI	0.024	0.861
LOIL	0.206	6.47***
LGAS	0.572	5.93***
LELE	0.052	2.93*
LCOL	0.207	2.01*
INTERCEPT	11.87	17.1

***, ** and * denote significance at the level of 1%, 5% and 10%, respectively

consumption of gas is the highest among the other energy sources, the coefficient of LGAS is 0.57, which means that a 1% rise in the gas consumption causes a 0.57% rise in the output level. At the end, a 1% rise in electricity consumption leads on average to a 0.05% rise in the industrial output. The results confirm that the reason for the deteriorating performance of the manufacturing sector (large and small scale) was the acute shortage of the availability of energy (Ministry of Finance and Economic Affairs 2010-2011).

Table 4:Estimated Short-Run Coefficients

Dependent variable: Δ LINTV		
Regressors	**Coefficient**	***t*-statistic**
Δ LEMP (1)	0.031	0.293
Δ LEMP (2)	0.087	0.830
Δ LCPI (1)	0.035	1.555
Δ LCPI (2)	0.002	0.186
Δ LOIL (1)	0.063	2.470**
Δ LOIL (2)	0.108	2.245**
Δ LGAS (1)	0.204	1.599
Δ LGAS (2)	-0.019	-0.10
Δ LELE (1)	0.041	2.475*
Δ LELE (2)	0.003	2.100*
Δ LCOL(1)	-0.15	-1.50
Δ LCOL (2)	-0.16	-1.79
INTERCEPT	0.071	4.000
ECM(-1)	-0.35	-2.959***
DiagnosticTest Statistic	**Test- Stats**	***P*-value**
Serial Correlation	1.440	0.6913
Normality	2.952	0.228503
Heteroskedasticity	0.761	0.5726
ARCH Test	0.0087	0.9247
Remsey	0.0002	0.9821
R-squared	0.5638	

***, ** and * denote significance at the level of 1%, 5% and 10%, respectively

Table 4 exhibits the short-run results based on the VECM. The results suggest that the electricity consumption and the usage of oil products significantly affect he industrial output in the short run as well. Firstly, there has been a decrease in the oil consumption in the industrial sector (Ministry of Petroleum and Natural Resources, 2009) because of high oil prices and the availability of gas as a cheap alternative energy source, but in our results still the oil products could significantly influence the level of industrial output. Secondly, 30.2% electricity has been consumed by the industrial sector (Pakistan Energy Yearbook, 2009) which is a sufficient indicator to confirm our result that the electricity consumption has short-run significant effect on the industrial output. The statistically significance with the negative sign of the coefficient of the error correction term indicates the long-run relationship between the variables. Furthermore, the coefficient of ecm(-1) is -0.35 which shows that when the industrial output would be in an disequilibrium, it gets adjusted by 35% in the first year. It can be concluded that the process of adjustment to the equilibrium is significantly quick enough to respond any shock to the industrial value added equation.

The diagnostic tests are also conducted for the model which is presented at the bottom of Table5. The results show that we can’t reject the null hypothesis of not serially correlated variables. Residuals are normally distributed, residuals are homoscedastic, there is no arch effect and the model is well specified. The R-squared testis reasonable high to confirm the goodness of fit of the model. At last, to check the stability of the model, we employ the cumulative sum of the residual and the cumulative sum of square of the residual methods. The results are presented in Figures 1 and 2. They confirm the stability of the coefficients since the plotted residuals are within the critical bounds at the 5% level of significance.

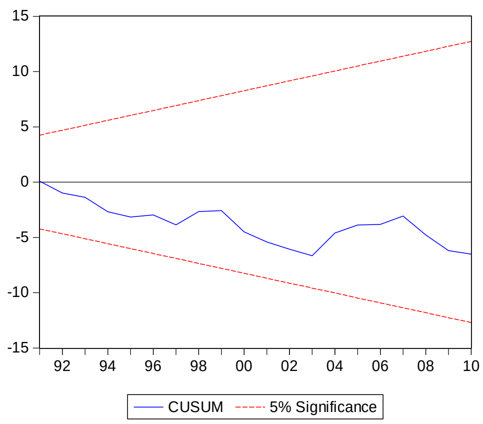

Figure 1.Cumulative sum of recursive residual

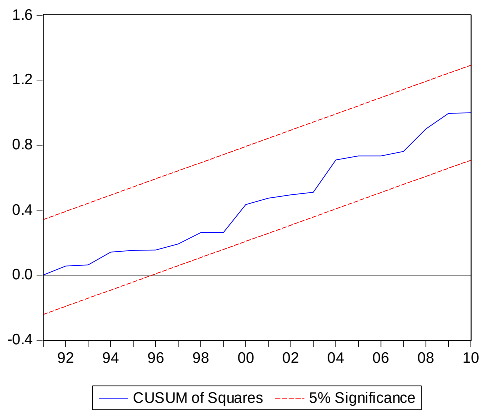

Figure 2.Cumulative sum of Square recursive residual

Table 5:Short-Run Causality Test Results Based on VECM

VariableF-stats									t-stat
	Δ INTV	Δ LEMP	Δ CPI	Δ OIL	Δ GAS	Δ ELE	Δ COL	Δ EN	ECT
Δ INTV	-	0.3640	1.336	4.098**	1.313	4.126*	1.630	4.285**	-2.953***
Δ LEMP	0.302	-	2.557	0.313	0.181	0.162	2.004	0.732	0.060
Δ CPI	0.339	0.064	-	4.789**	0.039	0.958	1.554	0.793	-2.782**
Δ OIL	2.640*	0.624	0.153	-	-	-	-	-	0.323
Δ GAS	0.677	2.259	2.836*	-	-	-	-	-	1.609
Δ ELE	0.735	0.578	0.136	-	-	-	-	-	-0.591
Δ COL	4.547**	1.195	1.199	-	-	-	-	-	3.288**

***, ** and * denote significance at the level of 1%, 5% and 10%, respectively. ECT represents the Error Correction Term

The analyst and, more importantly, the policy makers are concerned about the direction of causality presented between the variables. In this regard, Table 5 exhibits the results of short-run causality test based on the VECM. The results are obtained through the Wald test of joint significance of the variables. The F-statistics show the presence of bidirectional causality between oil consumption and industrial output, whereas unidirectional causality running from electricity consumption to industrial output is obtained. The joint significance test is also applied by combining all disaggregate energy sources and confirms the unidirectional causality from energy usage to output growth. The results also identify the one way causality from output to coal consumption. This result concerns the cement and Brick Kilns industries because their combined coal consumption is about 80% of the total coal usage (Pakistan Energy Yearbook, 2009). There is no surprise to identify the causality from oil consumption to CPI; the rising oil import bill would significantly contribute to the domestic inflation.

Table6:Joint Short-Run and Long-Run Results (F-stat)

Variable	Δ INTV & ECT_{t-1}	Δ LEMP & ECT_{t-1}	Δ CPI & ECT_{t-1}	Δ OIL & ECT_{t-1}	Δ GAS & ECT_{t-1}	Δ ELE & ECT_{t-1}	Δ COL & ECT_{t-1}	Δ EN & ECT_{t-1}
Δ INTV	-	3.143**	3.027*	3.546**	3.103**	3.956**	4.013**	2.302*
Δ LEMP	0.207	-	2.275	0.255	0.155	0.110	1.501	0.744
Δ CPI	3.538**	2.606*	-	3.236**	3.562**	2.760*	4.480**	2.467**
Δ OIL	1.780	0.458	0.104	-		-	-	-
Δ GAS	1.014	2.318	2.451	-	-	-	-	-
Δ ELE	0.660	0.506	0.149	-	-	-	-	-
Δ COL	5.248***	2.391	1.882	-	-	-	-	-

***, ** and * denote significance at the level of 1%, 5% and 10%, respectively

Table6 shows the joint short- and long-run causality results. It is observed that in industrial output equation; disaggregate energy variables, employment and CPI are all statistically significant combined with the error correction term. It is interesting to note that all disaggregate energy consumption significantly causes the inflation of a country in the short and long run. Furthermore, industrial output and employment play also a significant role to cause the CPI. The unidirectional causality is identified from output to coal consumption in combined short- and long-run causality.

5 Conclusion

The energy shortage is one of the main reasons of the downturn of the industrial sector, particularly in the large-scale manufacturing. As a result, plenty of small-scale industries are shut down and many of large-scale industries are moving out of Pakistan. In this regard, the current study is about the relationship between the disaggregate energy consumption and the industrial output. The time series analysis is conducted from the period 1972–2010.

We have employed the Johansen cointegration test in order to realize the long-run relationship between the variables. The long-run estimated coefficients of disaggregate energy consumption are significant and positively affected to the industrial output. On the one hand, VECM is employed to obtain the short-run coefficients in which the oil and electricity consumption are found to be statistically significant. On the one hand, the disequilibrium gets adjusted by 35% from last year to current year.

The short-run bidirectional causality has been seen between the output and oil, whereas unidirectional causality has been identified which is running from electricity consumption to industrial output. This suggests that it would be harmful for the industrial growth if we obtained the energy conservative policies or were unable to fulfill the required demand of the industrial sector. These results also make a request to policy makers to think about the use of alternative energy sources, such as solar and wind etc. in order to respond to the rising energy demand of the industrial sector.

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