Exploring the Linkages between Energy use and Economic Growth in Pakistan

Ali Kakar[1], Maqsood Ahmed[2], Aamir Mahmood[2], and Bilal Sarwar[1]

[1]Faculty of Management Sciences, [2] Faculty of Engineering, Balochistan University of Information Technology, Engineering and Management Sciences

Abstract

The objective of this study was to investigate the linkages between energy use, and economic activities in Pakistan. This study tested the interrelationship among the variables using the Multiple Regression analysis through the estimation of log-linear model. The empirical results of this study suggest that the electricity consumption is one of the most significant variables in the economic performance of Pakistan followed by the population growth, Foreign Direct Investment and trade openness.

Keywords: Energy, Sustainable development, Economic growth, Regression analysis

Corresponding Author's email: ali.kakar@buitms.edu.pk

INTRODUCTION

The role of energy is critical for any society to achieve the economic prosperity; more energy is needed with growing demands as the world population increases. This is particularly true for the developing countries where it is estimated that the use of energy will increase by 100% in coming few decades, (Hinrichs 2002). Increasing use of non-renewable energy, on the other hand, causes some unpleasant change in our planet earth. This unpleasant or unwanted change is termed as pollution in literature and is extremely dangerous for the stability of the environment as gifted by the nature. The world energy expenditure is mainly from non-renewable sources and accounts for 90% of the total energy consumed globally and is responsible for the increasing emissions of carbon dioxide into the atmosphere and thus increasing the global temperatures, (Hinrichs, 2002, Altinay and Karagol, 2004).

From the beginning of the industrial age in Europe till today, the use of non-renewable energy sources has caused the carbon dioxide absorption in the atmosphere significantly and has ultimately caused the increase in the planet's temperature, which will not only cause the melting of polar ice caps and increased sea-levels but will also force the human settlements to migrate from low-lying regions near the oceans. According to (Apergis and Payne 2009, Hinrichs 2002), more than 5 billion tons of carbon is being added to the atmosphere each year as a result of fossil fuel burning. This is causing an increase in global temperatures and could affect agriculture negatively. On the other hand, fossil fuel burning has also caused acid rains that harm trees, crops and animals. In Europe, for example, acid rains have harmed about 20% of its forests.(Edal et al., 2008)

The IEA predicts that in near future the developing economies from the third world countries will compete for more energy usage to cater for the growing economies of their countries. China and India are particular in this regard. Developing countries like Pakistan will continue to depend upon nonrenewable energy sources to cater their economic demands as access to more environment friendly and renewable energy sources is still out of their reach. Pakistan mainly depends on nonrenewable energy sources to meet its energy requirements and a great share of it comes from imported oil. According to the State of Environment Report

2005, during the last 20 years, the energy consumption in Pakistan has been tripled from 0.6 quadrillion Btu to 1.9 quads in 2001 and the country accounts for only 0.5% of total world energy consumption. It is a fact that economic development and energy consumption are interlinked and that a growing economy requires more energy to sustain the pace of economic development. But it is also important to consider the role of sources for the energy production. Increasing demand for energy in Pakistan which is mainly from nonrenewable sources has placed additional burden on balance of payment. As per World Bank Report 2006, the estimated environmental degradation in Pakistan accounts for minimum 6% of its GDP and is a top-heavy burden on the poor.

Pakistan is mainly depending on imported oil to meet its energy requirements especially in the industrial sector; the rapid increase in oil prices has hindered the Pakistan's industry growth as well. As a result, the country's industrial growth has declined to 3.3% against the projected growth rate of 6.1% during the year 2007-08. The use of fossil fueled energy sources are contributing significant role in enhancing the pace of environmental degradation not only at local but also at global level. The use of other fossil fuels is responsible for the emission of various greenhouse gasses and hazardous fumes which are harming the atmosphere and thus contributing towards the global warming of the earth as a whole.

The empirical work on this important issue related to the field of sustainable development is confined only to the developed countries and is scarce in case of developing countries like Pakistan. So this study is focus on the investigation of associated linkages between energy use and environmental degradation in case of Pakistan. It also seeks to determine the extent of these effects and how it can be minimized through policy interventions in the wider developmental context.

Many research studies have been conducted to find out the relationship between the energy use and economic growth in Pakistan but the causal relationship of both the energy use and economic activities on environmental degradation in Pakistan was relatively scarce. Therefore, there was a need to find out this causal relationship.

MATERIALS AND METHODS

To find out the causal relationship of economic activities on energy consumption, the data was collected from the World Development Indicators (WDI) from a period of 1960 to 2008. Energy consumption is also affected by population, foreign direct investment and trade. So all the data collected from WDI was used to find out the impacts on energy consumption using the Multi Linear Regression (MLR).

Model

Since, there are different factors behind the demand for electricity consumption (as a proxy of energy consumption) in Pakistan for example, rising incomes, population growth, and increase in international trade etc. A model has been present in these studies to explore the energy demand (energy consumption) due to economic activities, population growth and trade openness.

Estimation techniques

In order to explore the above mentioned relations that were intended to establish and estimate such models, not only capable for exploring the existing relationships but which is also helpful for some useful recommendations. Following were the functional form of estimate able models:

ED=f (EA, Pop, OT, FDI)

The model specification of above functional form was as:

In this model the Energy Demand (ED) was dependent variable while Economic activities (EA), Population (Pop), Trade openness (OT) and Foreign Direct Investment (FDI) were the independent variables.

Where ED=Energy Consumption (Electricity Demand in mega watts/year).

EA= Level of Economic Activities *(Real Gross Domestic Product of the Country)*

Pop = Population. *(Annual population of the country)*

OT= Ratio of (Import + Export to GDP) *[Economic openness or Trade intensity]*
FDI = Foreign Direct Investment in US $.

Limitations of the Model

Though energy consumption and energy demand are two different in many aspects, but for convenience of comparison Energy Demand (ED) has been used as a proxy variable for energy use. Real Gross Domestic Product (GDP) alone does not represent the overall economic growth of the country but GDP is used as a proxy for the economic growth.

Although the trade openness is a vast area itself, but the ratio of import and export to the GDP has been used as an indicator of trade openness in this study. Moreover, trade openness means the absence of taxes and trade barriers to a great extant in this research study.

Instead of taking population growth rate which is a common practice in research. Annual population of the country was taken for the convenience of this study.

Source of Data

All the time series data, on above mentioned variables, was extracted from World Development Series from the period of 1960 to 2008. Moreover, Economic Survey of Pakistan 2008-09 was also consulted.

Model:

Where:

ED=Energy Consumption (Electricity Demand in mega watts/year).
EA= Level of Economic Activities *(Real Gross National Product of the Country)*
Pop = Population. *(Annual population of the country)*
FDI = Foreign Direct Investment in *US $)*
OT= (Import + Export to GDP) *[Economics openness or Trade intensity]*
Ln = Natural Log
α_i = Slope coefficients of the Model

The log-log model was estimated to explore the impact of economic activities, population growth, and trade liberalization on energy demand.

Econometric Technique

The multiple linear regression technique (MLR) was used to estimate above mentioned log-linear model because the OLS could not be used here because of more than one independent variable. The key assumptions of MLR are as:

MLR1: The population model is linear in parameters.
MLR 2: A sample, $\{x_{i1}, x_{i2, \ldots\ldots\ldots}, x_{ik,} y_{i1}\}$: i=1,2,…,n}, is random.
MLR 3: E , $(u| x_1, x_2 , \ldots\ldots\ldots x_{k)}= 0$ Zero conditional mean
MLR 4: None of x is content (nonzero sample variation in x). There are no exact linear relationships among x, s.
MLR 5: Homoscedasticity, Variance $(u| x_1, x_2 , \ldots\ldots\ldots x_{k)} = \sigma^2$
MLR 6: the population error, u, is independent of $x_1, x_2 , \ldots\ldots\ldots$ x, u is normally distributed with zero mean and Variance σ^2, u~ Normal $(0, \sigma^2)$.

The estimated model was evaluated on the basis of above mentioned assumptions of MLR.

Prior to estimating the Model, it was important to discuss the expected signs of coefficients of explanatory variables, the expected signs of coefficients were:

The expected sign for the slope coefficient, , capturing the effect of level of economic activities (EA) on energy demand (ED) was positive. So the hypothesis was:
H_0: <= 0 and H_1: > 0 (One tailed test).

It was expected a positive sign for the coefficient, this coefficient was gauging the effect of population on energy demand. So hypothesis for this coefficient was:
H_0: <= 0 and H_1: > 0 (One tailed test).

In modern global economy, no country could survive without international trade and international trade having a direct linkage with the consumption of energy demand. So was used to explore the impact of international trade on energy demand. The expected sign for this coefficient was positive. Therefore the null and alternative hypothesis was;
H_0: <= 0 and H_1: > 0 (One tailed test).

Recently, the role of FDI has become more crucial in economic growth, the slope coefficient was establishing the linkages between FDI and ED. The expected sign for this coefficient was positive. And the hypothesis for this coefficient was:

H_0: <= 0 and H_1: > 0 (One tailed test).

RESULTS AND DISCUSSION

In this study we analyzed the impact of Carbon dioxide emission (CO_2), energy consumption, population, and trade openness on the economic development of Pakistan (GDP). We used two different models to analyze these effects and showed the relations among these variables. The log linear models model and Multi Linear Regression model were used. The results of the models were as below.

Regression Analysis

The estimated equation was:
lnED = 3.25 + 0.0419 ln EA + 0.000065 ln Pop + 2822.26 lnOT + 0.00027 ln FDI +et

The ANOVA Table 1 shows the analysis of variations in the model. As the model was in log-log form, the estimated coefficients were showing the corresponding elasticities of the variables (see Table 1 and Table 2). Trade openness was having the highest impact on energy use; it was because of the time series nature of the data indicating that our energy use has significantly increased due to the activities of imports and exports. Exports normally occur after meeting the domestic demand and may also occur due to more production activities and more production need more energy use, therefore, trade openness has significant effect on the energy demand. The coefficient establishing the linkage between energy demand and population was the smallest but significant as per results of the study. Although it is known that population has significant effect on energy use, but in this research study due to the time series data, the effect of population on energy use is ambiguous. Moreover, we know that FDI has significant effect on the energy use, but FDI affected the energy use negligibly in the results of this study. Furthermore, the Economic Activities (GDP as a proxy for EA) has significant effect on the energy use as shown by the results (see Table 2).

All the estimated coefficients were significant at 5 % level of significance, reflected by their corresponding t-values (see Table 2). The overall model was also significant, reflected by relatively higher “F-value”. The value of coefficient of determination was very high (0.975 or 97.5 %) showing that the model is best fit.

The Table 4 based on Economic Survey of Pakistan 2008-09, shows the annual energy consumption pattern from 1998-99 to 2007-08. This table shows that there was a continuous shift in energy consumption from petroleum products to other sources of energy e.g. coal, gas and electricity. Newly discovered reserves of gas and coal and high prices of petroleum products in the international market were the main reasons. Therefore, the petroleum products experienced a decline in its consumption.

Table 1. Regression Analysis

R^2	0.975	n	48
Adj. R^2	0.972	k	4
		Dependent Variable	ln ED
Std. Error	0.101		

Source: Author's calculation

Table 2. ANOVA Table

Source	*SS*	*df*	*MS*	*F*	*P-value*
Regression	10.8968	4	2.7242	267.39	0.007
Residual	0.2751	27	0.0102		
Total	11.1719	31			

Source: Author's calculation

Table 3. Regression Output

Variables	*coefficients*	*Std. error*	*t-value*	*p-value*
Intercept	3.25	0.3171	10.255	8.25
ln EA	0.042	0.0078	5.389	0.006
ln Pop	0.0065	0.000019	3.354	0.0024
ln OT	2822.26	699.29	4.036	0.0004
ln FDI	0.00027	0.000066	4.165	0.003

Source: Author' Calculation 95% confidence interval

Table 4: The annual energy consumption pattern in Pakistan from 1998 to July-March 2008-09

Annual Energy Consumption								
	Petroleum Products		Gas		Electricity		coal	
Fiscal Year	Tones (000)	Change (%)	(mmeft)	Change (%)	(Gwh)	Change (%)	M.T* (000)	Change (%)
1998-99	16,647		635,891		43,296		3,461.40	
1999-00	17,768	6.7	712,101	12	45,586	5.3	3,167.90	-8.5
2000-01	17,648	-0.7	768,068	7.9	48,584	6.6	4,044.70	27.2
2001-02	16,960	-3.9	824,604	7.4	50,622	4.2	4,408.60	9
2002-03	16,452	-3	872.264	5.8	52.656	4	4,889.90	10.9
2003-04	13,421	-18.4	1,051.42	20.5	57,491	9.2	6,064.50	24
2004-05	14,671	9.3	1,161,043	10.4	61,327	6.7	7,893.80	30.2
2005-06	14,627	-0.3	1,223,385	5.4	67,603	10.2	7,714.00	-2.3
2006-07	16,847	15.2	1,221,994	-0.1	72,712	7.6	7,894.10	2.3
2007-08	18,080	7.3	1,275,212	4.4	73,400	0.9	10,110.60	28.1
Avg. 10 years		1.4		8.2		6.1		13.5
July-March								
2007-08	13,342		955,625		55,208		6,559	
2008-09 (e)	12,892	-3.4	931,700	-2.5	55,614	0.7	4,822	-26.5
e: estimated for coal			Source: Economic Survey of Pakistan (2008-09)					
*** Million Ton**								

REFERENCES

- Altinay G, and Karagol E. (2004) Structural break, unit root, and the causality between energy consumption and GDP in Turkey. Energy Economics 26:985-994.
- Apergis N, and Payne, JE. (2009). Energy consumption and economic growth in Central
- America: Evidence from a panel cointegration and error correction model. Energy Economics 31:211-216.
- Edal G, Erdal H, and Esengun K. (2008). The Causality between Energy Consumption and Economic Growth in Turkey. Energy Policy 36:3838-3842.
- Hinrich R. (2002). Energy Revolution: A Sustainable Netherlands Energy Outlook. European Renewable Energy Council.