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ENERGY CONSUMPTION AND GDP IN SELECTED ASIAN COUNTRIES: A COINTEGRATED PANEL ANALYSIS

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ABSTRACT

Explain the relationship between energy consumption and economic growth can play a significant role in setting and adjustment of policies on energy sector. Given the close relationship between Energy consumption and economic growth in selected countries, determination of quality of the relationship between these two variables helps effectively to explain of policies of the energy sector. This paper studies the causality relationship between energy consumption and GDP in 7 Asian countries, using panel cointegration, and panel-based error correction models from annual data covering the period of 1980 to 2010. The results of this study show that there are significant and positive relationship between economic growth and energy consumption in these selected countries.

Keywords: Energy consumption, Economic growth, Panel cointegration, Causality.

JEL Classification: Q43; C32.

1. INTRODUCTION

Growth and energy are correlated in both directions. Energy is a normal good, so more income leads to more spending on energy. During recent five decade, there has been considerable worry about the increasing ratio of GDP devoted to energy expenditure. So, much research has focused on the determinants of energy expenditure. The factor that has been identified as the most dominant is real GDP. The literature concerning the relationship between energy consumption and economic growth has led to the emergence of two opposite views. One point of view suggests that energy use is a limiting factor to economic growth. The other point of view suggests that energy is neutral to growth. This is known in the literature as the 'neutrality hypothesis' which proposes that the cost of energy is a small proportion of GDP, and so it should not have a significant impact on output

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growth. It has also been argued that the possible impact of energy use on growth will depend on the structure of the economy and the stage of economic growth of the country concerned. As the economy grows its production structure is likely to shift towards services, which are not energy-intensive activities [1, 2]; [3].

The relationship between energy consumption and income has been a popular issue of debate in economic development and the environment, yet a consensus has been lacking regarding the permanent as well as transitional relationship. To date, the causality may run in either direction. For example, if there is exists causality running from energy consumption to income, then this denotes an energy-dependent economy such that energy is an impetus for income, implying that a shortage of energy may negatively affect income [4, 5]. On the other hand, if there is a reverse chain of causality from income to energy, then this denotes a less energy-dependent economy such that energy conservation policies may be implemented with little adverse or no effects on income [5].

There are a large number of papers examining the neutrality hypothesis between energy use and economic growth. The original study by Kraft and Kraft [6] finds evidence in favor of causality running from income to energy consumption in the United States, by using data for the period 1947–1974. This implies that energy conservation policies may be initiated without deteriorating the economic side effects. For example, instead of relying on the standard Granger causality test, Masih and Masih [7], Glasure and Lee [8], and Asafu-Adjaye [3] present an entire review of recent studies covering this topic. The goal of these studies is to estimate the causal relationship between energy consumption and income for developing countries, using cointegration and error-correction techniques. The results have been mixed and conflicting [5]. Soytas and Sari [9] estimate the causal relationships for emerging markets for the period 1950–1992. Their result indicates bi-directional causality for Argentina, but the cointegration vector is rejected for Indonesia and Poland.

Our paper differs from previous studies by applying the new heterogeneous panel cointegration technique to investigate the relationship between energy consumption and GDP across 7 Asian countries. This paper contributes the following. First, we use a cointegration test for a panel of countries which provides more powerful tests and allows us to increase the degrees of freedom compared to the cross-section approach. Next, we use the full-modified OLS (FMOLS) technique to estimate the cointegration vector for heterogeneous cointegrated panels, which correct the standard OLS for the bias induced by the endogeneity and serial correlation of the regressors. Finally, we specify and estimate an error correction model appropriate for heterogeneous panels, which distinguishes between long-run and short-run causality. In this paper we use a different direction to overcome the short span of data and the distortions of a small sample. Since the power of an individual unit root test can be distorted when the span of data is short [10], we use a panel unit root test. The power of the traditional cointegration test [11] is that multivariate systems with small sample sizes can be severely distorted. To this end, we need to combine information from time series and cross-section data once again, and thus we use a panel unit root test and heterogeneous panel cointegration tests.

In this paper, we intend to examine the relationship between energy consumption and economic growth for 7Asian countries according to Lee [5] article. The purpose of this paper is to empirically examine the long-run and short run relationship and the causal relationship between energy consumption and GDP in a multivariate model with energy consumption (EC), real GDP (GDP), and real capital stock (K). We combine cross-sectional and time series data to examine the relationship between energy consumption and GDP, using updated data for 7 Asian countries for the years 1980–2010.

The paper is organized as follows: In Section 2 we provide a brief discussion of the panel unit root test and the panel cointegration procedure. Empirical results are provided in Section 3. Final section contains the conclusions.

2. METHODOLOGY

2.1. The Panel Unit Roots Test

In order to investigate the possibility of panel cointegration, it is first necessary to determine the existence of unit roots in the data series. For this study we have chosen the Im, et al. [12], which is based on the well-known Dickey-Fuller procedure. Investigations into the unit root in panel data have recently attracted a lot of attention. Levine and Lin [13] proposes a panel-based ADF test that restricts parameters γ_i by keeping them identical across cross-sectional regions as follows:

$$\Delta y_{it} = \alpha_i + \gamma_i y_{it-1} + \sum_{j=1}^{k} \alpha_j \Delta y_{it-j} + e_{it} \quad (1)$$

where t =1,. . ., T time periods and i =1,. . .N members of the panel. LL tests the null hypothesis of γ_i=γ =0 for all i, against the alternate of $\gamma_1 = \gamma_2 \ldots = \gamma < 0$ for all i, with the test based on statistics $t_\gamma = \hat{\gamma}/s.e.(\hat{\gamma})$. One drawback is that c is restricted by being kept identical across regions under both the null and alternative hypotheses [5].

The next step is to test for the existence of a long-run cointegration among GDP and the independent variables using panel cointegration tests suggested by Pedroni [14]. The panel cointegration tests Pedroni [14] considers the following time series panel regression

$$y_{it} = \alpha_{it} + \delta_{it}\, t + X_i B_i + e_{it} \quad (2)$$

where y_{it} and X_{it} are the observable variables with dimension of $(N * T) \times 1$ and $(N * T) \times m$, respectively. He develops asymptotic and finite-sample properties of testing statistics to examine the null hypothesis of non-cointegration in the panel. The tests allow for heterogeneity among individual members of the panel, including heterogeneity in both the long-run cointegrating vectors and in the dynamics, since there is no reason to believe that all parameters are the same across countries [5]. Two types of tests are suggested by Pedroni. The first type is based on the within dimension approach, which includes four statistics. They are panel υ-statistic, panel ρ statistic, panel PP-statistic, and panel ADF-statistic. These statistics pool the autoregressive coefficients across different members for the unit root tests on the estimated residuals.

The second test by Pedroni is based on the between-dimension approach, which includes three statistics. They are group ρ statistic, group PP-statistic, and group ADF-statistic. These statistics are based on estimators that simply average the individually estimated coefficients for each member. In the presence of unit root variables, the effect of superconsistency may not dominate the endogeneity effect of the regressors if OLS is employed. Pedroni [15] shows how FMOLS can be modified to make an inference in being cointegrated with the heterogeneous dynamic. In the

FMOLS setting, non-parametric techniques are exploited to transform the residuals from the cointegration regression and can get rid of nuisance parameters [5].

3. EMPIRICAL RESULTS AND DISCUSSION

Our study uses annual time series for the 7 Asian countries include Iran, Iraq, UAE, Saudi Arabia, Oman, Kuwait and Qatar. Annual data for real GDP (2000=100), energy use in kilotons of equivalent oil, and real gross capital formation (2000=100) are obtained from World Development Indicators [16]. The unit is expressed in US dollars. The empirical period depends on the availability of data, where the time period used is 1980–2010. All variables used are in natural logarithms. Table 1 presents the panel unit root tests. At a 5% significance level, all statistic of the level model confirm that three series have a panel unit root. Using these results, we proceed to test GDP, EC, and K for cointegration in order to determine if there is a long-run relationship to control for in the econometric specification. Table 1, presents the results of the panel unit root test at level indicating that all variables are $I(1)$ in the constant plus time trend of the panel unit root regression. Therefore, we can conclude that most of the variables are non-stationary in with and without time trend specifications at level by applying the Panel unit root test which is also applied for heterogeneous panel to test the series for the presence of a unit root. The results of the panel unit root tests confirm that the variables are non-stationary at level.

Table-1. Panel unit root tests

Variable	LL		IPS		Hadri	
	No time effects	Time fixed effects	No time effects	Time fixed effects	No time effects	Time fixed effects
GDP	-2.69	0.90	-1.32	-1.41	6.70	5.00
K	-2.29	-2.50	-2.29	-2.48	3.36	3.98
EC	0.61	2.87	0.87	-1.29	5.56	3.70
ΔGDP	-4.85	-8.18	-6.49	-4.92	3.58	4.69
ΔK	-9.93	-8.33	-9.24	-7.62	3.45	21.94
ΔEC	-7.51	-9.54	-7.08	-6.30	0.40	3.73

Δ denotes first differences. All variables are in natural logarithms.
Data Source: WDI [16]

We can conclude that the results of panel unit root tests reported in Table1 support the hypothesis of a unit root in all variables across countries, as well as the hypothesis of zero order integration in first differences. At most of the 1 percent significance level, we found that all tests statistics in both with and without trends significantly confirm that all series strongly reject the unit root null. Given the results of IPS test, it is possible to apply panel cointegration method in order to test for the existence of the stable long-run relation among the variables.

We first implement the following equation:

$$GDP_{it} = \alpha_i + \delta_i t + \beta_i EC_{it} + c_i K_{it} + \varepsilon_{it} \quad (3)$$

Where it allows for cointegrating vectors of differing magnitudes between countries, as well as country (α) and time (δ) fixed effects. Table 2 reports the panel cointegration estimation results. for the all statistics significantly we cannot reject the null of no cointegration. Thus, it cannot be seen that the GDP, EC, and K move together in the long run. That is, there is not a long-run steady state relationship between energy consumption and GDP for a cross-section of countries. The next step is an estimation of such a relationship.

Table-2. Panel cointegration tests

	No time effects	Time fixed effects
Panel variance	1.12	1.38
Panel ρ	-1.02	0.73
Panel PP	-1.38	-1.01
Panel ADF	-2.04	-2.89
Group ρ	-0.63	1.47
Group PP	-1.12	-1.19
Group ADF	-2.69	-2.79

Statistics are asymptotically distributed as normal. The variance ratio test is right-sided, while the others are left-sided.

Table 3 reports the results of the individual and panel FMOLS. The panel estimators with and without common time dummies are shown at the bottom of the table. The coefficients of EC and K are statistically significant at the 5% level, and the effect is positive as expected by the theory. The elasticity of energy consumption and capital stock with respect to GDP are significantly smaller than 1. This implies in short run, energy is an important ingredient for economic development. The FMOLS estimates of the elasticity of energy consumption with respect to GDP range from 0.37 (Iraq) to 0.81 (Qatar). The coefficient of capital stock is positive and statistically significant in all countries; that is, an increase in capital stock tends to promote GDP. Once the three variables are cointegrated, the next step is to implement the Granger causality test. We use a panel-based error correction model to account for the long-run relationship using the two-step procedure from Engle and Granger [17]. The first step is the estimation of the long-run model for Eq. (5) in order to obtain the estimated residuals,

Table-3. Full modified OLS estimates (dependent variable is GDP)

Country groupings	EC	K
Iran	0.58 (6.23)	0.18 (2.21)
Iraq	0.37 (4.12)	0.09 (1.29)
Saudi Arabia	0.54 (5.32)	0.16 (2.29)
UAE	0.61 (4.48)	0.20 (2.63)
Oman	0.38 (4.18)	0.10 (1.42)
Qatar	0.81 (10.11)	0.24 (3.38)
Kuwait	0.44 (1.89)	0.17 (2.83)
Panel (without time dummies)	0.82 (37.28)	0.15 (13.19)
Panel (with time dummies)	0.42 (28.54)	0.18 (15.24)

Data Source: WDI [16]

The second step is to estimate the Granger causality model with a dynamic error correction:

$$\Delta GDP_{it} = \alpha_{1j} + \sum_{i=1}^{k} \beta_{11ik} \Delta GDP_{it-k} + \sum_{i=1}^{k} \beta_{12ik} \Delta EC_{it-k} + \sum_{i=1}^{k} \beta_{13ik} \Delta K_{it-k} + \delta_{1i} ECT_{it-1} + u_{1it} \quad (4)$$

$$\Delta EC_{it} = \alpha_{2j} + \sum_{i=1}^{k} \beta_{21ik} \Delta GDP_{it-k} + \sum_{i=1}^{k} \beta_{22ik} \Delta EC_{it-k} + \sum_{i=1}^{k} \beta_{23ik} \Delta K_{it-k} + \delta_{2i} ECT_{it-1} + u_{1it} \quad (5)$$

where Δ denotes first differencing and k is the lag length and is chosen optimally for each country using a step-down procedure up to a maximum of two lags. The capital stock equations are omitted, because they are not relevant. The sources of causation can be identified by testing for the significance of the coefficients of the dependent variables in Eqs. (4) and (5). First, the short-run effect can be considered transitory. For short-run causality, we can test $H_0: \beta_{12ik} = 0$ for all i and k in Eq. (4) or $H_0: \beta_{21ik} = 0$ for all i and k in Eq. (5). Next, the long-run causality can be tested by looking at the significance of the speed of adjustment δ, which is the coefficient of the error correction term, ECT_{it-1}. The significance of k indicates the long-run relationship of the cointegrated process, and so movements along this path can be considered permanent. For long-run causality, we can test $H_0: \lambda_{1i} = 0$ for all i in Eq. (4) or $H_0: \lambda_{2i} = 0$ for all i in Eq. (5). Finally, we can use the joint test to check for a strong causality test, where variables bear the burden of a short-run adjustment to re-establish a long-run equilibrium, following a shock to the system. Because all variables enter the model in stationary form, a standard F-test can be used to test the null hypothesis, which shows that none of the estimated country-specific parameters are significant. Table 4 shows the result of a panel causality test between GDP and energy consumption. We find that the energy equations are not significant at the 1% level, implying a lack of long-run causalities. In addition, there are short-run causal relationships running from energy to GDP and vice versa. The unidirectional causality shows that energy conservation may harm economic growth in developing countries regardless of being transitory or permanent. The relationship also refutes the neutrality hypothesis advanced in respect of these countries for the energy- income relationship in long run.

Table-4. Panel causality tests

Dependent variable	**Source of causation (independent variable)**				
	Short run		Long run		
	ΔGDP	ΔEC	ε	$\varepsilon/\Delta GDP$	$\varepsilon/\Delta EC$
ΔGDP	-	0.00	0.25	-	0.41
ΔEC	0.02	-	0.18	0.36	-

Data Source: WDI [16]

4. CONCLUSIONS

This paper employs data on 7 Asian countries from 1980 to 2010 to examine the causal relationship between GDP and energy consumption. The panel cointegration and the resulting panel-based error correction models are conducted to answer the question. The full-modified OLS deals with the problem of endogeneity. Our evidence shows results suggesting that there is a short run steady-state relationship between energy consumption and GDP for a cross-section of countries and vice versa.

Previous studies having used time series data may yield unreliable and inconsistent results due to the short time spans of typical datasets. By contrast, this paper applies the new heterogeneous panel cointegration technique to investigate the relationship between energy consumption and GDP across these countries. According to the long-run dynamics of energy consumption and GDP, we refute the neutrality hypothesis advanced in respect of these countries for the energy–income relationship. Energy consumption is found to Granger cause GDP, and vice versa. The results of a bidirectional short-run causal relationship from energy to GDP show that energy consumption leads economic growth. Our results support current as well as past changes in energy consumption that have a significant impact on a change in income in these countries. It is clear for these countries in general that in short run energy is an important ingredient for economic development.

Our empirical results suggest that energy is an essential factor for economic growth in developing countries. This implies that the relation between energy consumption and economic growth are an integral part of development process. Thus, the link between energy consumption and economic growth provide useful information to policymakers in these countries for designing effective energy policies. The findings suggest that all sampled developing countries should focus on making long-term energy policy, increase the investment in energy infrastructure to boost energy efficiency and continue to promote renewable energy sources. Future research will be needed to incorporate the other economic factors (such as labor force, net fixed capital stock and energy price etc.) and carbon dioxide emission within the relation between energy consumption and economic growth.

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