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Original Research Article

GDP and Energy Usage: Causality Analysis from the Viewpoint of Bangladesh

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Abstract: The relationship between energy use and GDP is a hotly debated topic in energy economics. In this study, an attempt is made to explain the link between the variables from the perspective of Bangladesh. Using data from 1976- 2014, a Johansen co-integration and Granger causality test are carried out to determine whether there is a causal connection concerning Bangladesh. According to the findings of the Johansen co-integration test, there is co-integration between GDP and energy use. The VECM estimate establishes no short-run relationships between variables. The Granger causality test reveals a unidirectional causal relationship between GDP and energy consumption. Therefore, initiatives that promote energy saving may not impede the nation's overall economic development.

Keywords: Bangladesh, energy consumption, co-integration, vector error-correction model.

Background and Literature Review

The topic that receives the most attention in energy economics is the connection between total energy use and GDP. There are a number of theories concerning the relationship that attempt to provide an answer to the issue of the causal link that exists between these two variables. The hypotheses can be identified and explained according to the direction in which causality operates. The empirical findings point to the following causal relationships: GDP to energy consumption (conservation hypothesis; which states that the conservation of energy does not hinder GDP growth), energy consumption to GDP (growth hypothesis; which states that the conservation of energy hiders GDP growth), and bi-directional relationships between the two variables (feedback hypothesis; it is both way relationship that states any change in GDP growth causes energy consumption to increase or decrease and vice versa). One of the most common hypotheses is known as the neutral hypothesis, which states that these two variables do not have any relationship. This indicates that the former denies the existence of any link or correlation between these two variables. If the inquiry is, "which hypothesis is correct?" concluding would be quite challenging. The reason behind this ambiguous conclusion is that a wide variety of theories and connections have surfaced as a consequence of the findings of various studies conducted by researchers in a variety of nations and even for the same country throughout varying periods (Soytas *et al*, 2006).

The original proponent of the argument, (Karft *et al*, 1978) attempted to find an answer of correlation for the United States by analyzing data from 1947 to 1974. They discovered unidirectional causation from GNP to GEI (gross energy input). The same kind of relationship was found for Turkey from the yearly data analysis from 1970 to 2003 (Lise *et al*, 2007). The study discovered a correlation over the long term (unidirectional causality from GDP to energy consumption). A panel co-integration study of the causation between per capita energy usage and per capita GDP for 11 oil-exporting nations (Mehrara, 2007) revealed that the two variables do indeed co-integrate over the long run. The use of the granger causality test within a panel structure in the research allowed for identifying a unidirectional causal association between GDP and energy consumption in both the long and the short run.

In support of the growth hypothesis, a long-run steady-state link between energy usage and GDP had been discovered (Lee, 2005) that allowed for a country's particular influence using panel co-integration on yearly data from 18 developing nations. The statistics on capital creation were taken into account during the regression analysis. Still, it was determined that they were unimportant (the elasticity of capital is less than energy consumption: FMOLS). The causality test

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revealed a one-way, or unidirectional, causal connection between GDP and energy use. Using yearly data ranging from 1971 to 2004 to investigate the co-integration of PCGDP and PCEC in the country of Tunisia from Johansen's maximum likelihood co-integration tests, one co-integrating equation between these two variables was discovered (Belloumi, 2009). He found that there was a unidirectional short-run causation from per capita energy consumption to per capita GDP when he estimated VECM but that there was a bidirectional long-run causality between the two variables.

Using yearly data from 1981 to 2007 for 25 OECD countries, the long-run connection between the typical components of energy consumption per capita, real GDP per capita, and energy prices was determined (Belke *et al*, 2010). Using the modified Johansen co-integration test, this association was determined. According to the panel causality test results, the link between the two variables is causal in both directions.

The feedback hypothesis is supported by the demonstration of long-run bidirectional causation between energy and GDP as well as short-run unidirectional causation from energy to GDP using data spanning 1970-1999 for Korea's Multivariate VECM (Oh & Lee, 2004).

Analyzing the information from all sixteen G-7 countries, unidirectional causation between GDP and energy consumption in Italy and Korea, as well as bidirectional causality between energy consumption and GDP in Turkey, France, Germany, and Japan had been discovered. The study identified bidirectional causality for Argentina. Seven of the sixteen nations were found to have a co-integration vector in the co-integration test. By carrying out the VDCs test, they were also able to establish that the validity of the causation of the variables extended beyond the sample period (Soytas *et al*, 2006).

A disaggregated examination of the causal link between the consumption of fossil fuels and real gross domestic product (GDP) utilizing annual data from 1949 to 2006 using Toda-Yamamoto's causality test indicates assuming two distinct equations to test the four hypotheses and showed long-run unidirectional causality from GDP to natural gas (conservation hypothesis), but no relation (neutral hypotheses) between coal consumption and real GDP is found for the United States of America (Payne, 2011). This suggests that the Toda-Yamamoto test between GDP and natural gas does not support the neutral hypothesis.

As a consequence of this, it is abundantly clear that there is no universal relationship that is applicable to all countries. It's possible to find diverse patterns of causation in various nations. We were unable to locate any material that dealt specifically with the situation in Bangladesh. Bangladesh is classified as the least developed country yet has one of the world's economies that is growing at the quickest rate. How does this growth relate to the amount of energy that is consumed? Which hypothesis about the nation is supported by the evidence we have? Does there exist causation that holds true both in the long run and in the short run? The purpose of this study is to respond to these questions.

The remaining parts of this work are structured in the following manner. The second section will provide the data and methods. Section 3 offers empirical data and diagnostic testing. The final observations can be found in Section 4.

DATA AND METHODOLOGIES

This analysis considered GDP per capita as a proxy for GDP (at constant USD 2010) and energy use (kg of oil equivalent per capita) as a proxy for energy consumption. The global development indicator published by the World Bank was used as the basis for the compilation of the data. For the purpose of the research, annual data collection was carried out from 1976 to 2014. The form of the natural logarithm is used to represent each variable.

The historical statistics collected over the course of the year show that both GDP per capita (PGDP) and energy usage per capita (PEC) have been on an upward trajectory (Figure 1). Therefore, there is primary evidence suggesting that there may exist a positive correlation between the variables. But in order to demonstrate this, we will need to do an appropriate analysis using econometric methods. Even if the variables may be independent, the results of any regression of time-series variables will show high R^2 values. This indicates that the results may be false. Phillips (1986) demonstrated a variety of potential causes for this erroneous outcome. Therefore, to verify the link, if there is any, we need to remove the influence of trend and seasonality from the variables. We will need to follow several very particular steps to complete the process. Among methods of establishing a co-integration relationship, Granger causality has been employed in this study.

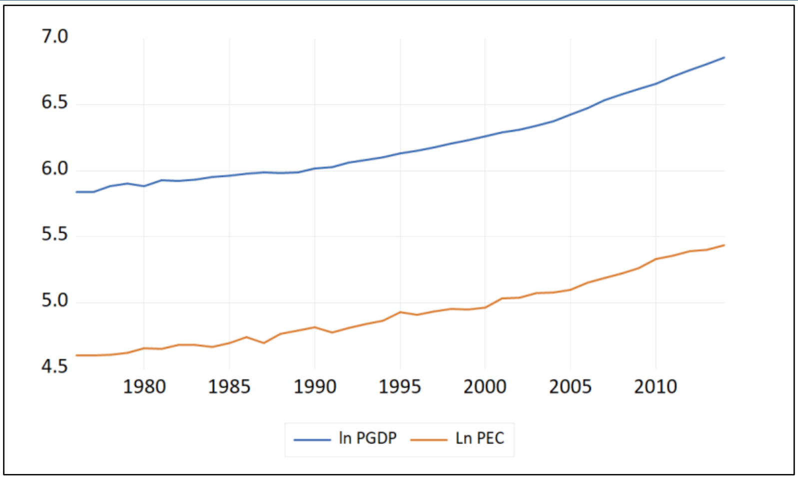

Figure 1: in PGDP and in PEC

The procedure has been followed for a univariate model

$$lnPGDP = f(\ln PEC)$$

The log-linear time series specification of the model is

$$ln\ PGDP_t = \alpha + \beta\ \ln PEC_t + \varepsilon_t$$

The very first step of the process is to test the stationarity of data. Testing the stationarity of the data if the data are found to be non-stationary, the next phase of the process is to take the lag of the data in order to make the data stationary (Stock *et al*, 1989). The Augmented Dicky Fuller test was utilized in the research project in order to verify the stationary. In the subsequent phase, it is necessary to test for cointegration, and for this purpose, the maximum likelihood approach (Johansen, 1988), (Johansen *et al*, 1990)] has been employed. To identify the short-run and long-run connections, specific instruments are needed. The VECM and Granger causality tests (Granger, 1988) are used in order to achieve the desired results. And lastly, some sort of diagnostic test must be performed to determine whether or not the model is stable. The acceptability of the estimated model was investigated by the use of the normality test, the autocorrelation LM test, and the heteroskedasticity test in this work.

EMPIRICAL RESULTS AND DIAGNOSTIC TESTS

Unit Root Test and Order of Integration

Table: Unit root test; Augmented Dicky Fuller test

Variables	**Level**		**1st difference**	
	No trend	**With trend**	**No trend**	**With trend**
Ln PEC	2.2695 (0.9999)	1.5738 (0.7846)	7.6402 (0.0000) *	8.6053 (0.0000) *
Ln PGDP	6.4048 (1.00)	0.9546 (0.9998)	3.8111 (0.0061) *	6.8454 (0.0000) *

*Note: * denote rejection of null hypotheses of a unit root at 1% level of significance*

The null hypothesis in the context of the augmented dicky fuller test is that the variable (or variables) in question have a unit root. The test result indicates that all of the variables are non-stationary (at a significance level of 1 percent) at the level form. However, the hypothesis of non-stationarity or the presence of unit root is rejected with a confidence level of 99 percent when the trend is taken into account while taking the first difference of the data. As a result, in both the situation where there is an existing trend and the scenario where there is no existing trend, all variables is integrated with order one, I (1). The data for the co-integration test is thus prepared using the initial lag of the variables.

Johansen's Co-Integration Test

The Johansen co-integration test is utilized to investigate whether or not there is a connection in the long run between the per capita energy consumption (PEC) and the per capita GDP (PGDP). The Schwarz Bayesian Criterion (SBC) and the minimal lag requirement for stability were utilized to arrive at the conclusion that one lag would be the ideal lag length for all variables. Trace statistics and Maximal Eigen Value statistics are computed under the presumption that the data follow a linear deterministic trend, that the co-integration equation has both an intercept and a trend, and that the VAR equation does not contain an intercept. The following is a presentation of the test's results:

Table: Results of Johansen's co-integration test between variables

Null Hypothesis	Alternative Hypothesis	Trace Test			Maximum Eigenvalue test		
		Statistics	Critical Value (5%)	Prob.	Statistics	Critical Value (5%)	Prob.
r = 0	r = 1	30.5150	15.4947	0.0001 *	28.3158	14.2646	0.0002 *
r ≤1	r = 2	2.1992	3.8415	0.1381	2.1992	3.8415	0.1381

*Note 2: r denotes the number of co-integrating relations, and * denotes rejection of the null hypothesis at 1% level of significance.*

At the one percent level of significance, the Trace test, as well as the Max.-eigenvalue test, suggests that there is one co-integrating equation. The fact that there is a co-integration connection between the variables indicates that there is a relationship between PGDP and PEC that lasts over a longer period of time.

Vector Error Correction Model

Estimation of VECM is preferable to a VAR when performing a typical Granger causality test (Granger, 1988). The short-run adjustment dynamics of the endogenous variables converging to their long-run co-integrating connection are likewise captured by this model. The following is an example of a possible form for the VECM representation of the model:

$$\Delta \ln \mathrm{PGDP} = C_0 + C_1 EC_{t-1} + C_2 \Delta ln\ PGDP_{t-1} + C_4 \Delta lnPEC_{t-1}$$

Error correction term C_1 quantifies the rate at which the system adjusts to equilibrium. The estimated model is as follows:

$$\Delta \ln \mathrm{PGDP} = 0.034334 + 0.0464 EC_{t-1} - 0.2519\ \Delta ln\ PGDP_{t-1} - 0.0126\ \Delta lnPEC_{t-1}$$

The fact that the Error correction term, which represents the pace of adjustment toward equilibrium, is 0.0464, and the fact that this value is positive indicates that there will be no adjustment in the short run, it may be stated that there is a short-run adjustment that is the model converges to the long-run relationship if the error correction component has a negative sign and is substantial. This allows us to say that the model converges to the long-run relationship.

Diagnostic Tests

We carried out a number of diagnostic tests, including the normality test, the autocorrelation LM test, and the heteroskedasticity test, so that we could determine whether or not the model was suitable for use.

Check for Normalcy: All orthogonalization approaches, such as Cholesky of covariance (Lutkepohl), suggest that one should not reject the null hypothesis if one uses the Jarque-Bera test statistics and the related p-value. When null is used, the residuals follow a normal distribution.

The autocorrelation Test for LM: Because the LM statistics and their related P-values imply that the null hypothesis should be rejected, the Serial Correlation LM test verifies that there is no evidence of serial correlation in the residuals of the ECM regression up to 10 lags. Where there is none, there is no sequential connection.

Heteroskedasticity Tests: The result of the heteroscedasticity test demonstrates that the test cannot reject the null hypothesis that there is no heteroskedasticity at a significance level of 5 percent. This is because the null hypothesis states that there is no heteroskedasticity.

Granger Causality Test

The findings of the causality test show that, at a significance level of 5%, GDP per capita Granger causes the Energy usage (kg of oil per capita), however PEC does not ganger cause of PGDP. This indicates that there is a unidirectional connection between PGDP and PEC.

Table: Pairwise Granger Causality Tests (F-statistics; Sample: 1976-2014; Obs 36, Lags 2)

Regression	F statistics	P value	Implication
Δ ln PEC on Δ ln PGDP	1.4435	0.2515	ln PEC causing ln PGDP (not significant at 10% level)
Δ ln PGDP on Δ ln PEC	4.0004	0.0285	ln PGDP causing ln PEC (significant at 5% level)

CONCLUDING REMARKS & POLICY RECOMMENDATIONS

The impact of energy use is a subject that attracts considerable attention. Multiple studies provide evidence in support of the preceding ideas, indicating a range of causal relationships between these two variables. This article has tried to answer, using Bangladesh as an example, which hypotheses are supported by the causal relationship.

Using data from each year between 1976 and 2014, using the Johansen co-integration test and the VECM, the results only support long-run co-integration, and Granger causality finds a unidirectional causal relationship between Bangladesh's GDP per capita and energy usage (conservation hypothesis).

This study provides further evidence that the GDP is not dependent on the amount of energy use. Therefore, it is possible that the policy of energy conservation would not have any effect whatsoever on the GDP of the nation, but it may lower the emission of greenhouse gas, thereby paving the path for the Sustainable Development Goals. The amount of energy that is used has an impact on the outcome of the study as the fact is indigenous sources, natural gas; provide 62 percent of the demand for energy (Ministry of Power, Energy and Mineral Resources, 2021). This study omits the usage of natural gas. There is possibility that analysis of the gas usage and GDP supports growth hypothesis. Whether it is or not, we are aware that the reserve of these sources is not infinite. The utilization cannot be carried out over an extended period of time since it is impossible. If the rising demand for energy continues to climb and no new sources of natural gas have been identified, some projections indicate that we may run out of natural gas in the year 2030 (Hassan Shetol *et al*, 2019). This is a very real possibility. Therefore, in this sense, we are in a position to advocate the following two fundamental policies:

1. We are required to use our non-renewable energy sources in a manner that is environmentally friendly.
2. We require more research and development in order to discover additional renewable sources of energy and to improve the efficiency with which we consume energy.

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