

Energy Consumption, Exports, and Economic Growth Nexus in Bangladesh: A Dynamic Causality Linkage

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Abstract: *This study investigates the possible causality among energy consumption, exports and economic growth in Bangladesh covering the period 1972-2014. All series were found stationary at their first difference i.e. $I(1)$. Johansen Co-integration Test revealed that there are long run cointegrating relationships among the series. Then applying VECM based Granger Causality Test, no long run causality among the series was found. On the contrary, a bi-directional short run causality was found between exports and economic growth which implies that both export-led-growth and growth-led-export strategies are true for Bangladesh. We have also found a short-run causality running from economic growth to energy consumption without feedback which implies that the more the economy grows, the more the energy consumption increases. This study has significant implications for the respective policy makers of the government.*

Keywords: *Energy Consumption, Exports, Economic Growth, Cointegration, Bangladesh*

1. Introduction

Bangladesh is one of the Least Developed Countries (LDCs) in South Asia with a market-based economy. Bangladesh is a country of dynamic possibilities and can uphold economic growth because of having required assets, much improved economic fundamentals, a youthful fastest growing workforce, and an established entrepreneurial culture. Bangladesh has already joined the rank of middle income countries (MICs). Bangladesh economy has become the 37th largest economy in the world in 2012 in PPP terms and 36th largest in nominal terms with a GDP of US\$397 billion in PPP terms and US\$ 174 billion in nominal terms and Bangladesh has been included in the Next Eleven (N-11) of Goldman Sachs and Global Growth Generators countries (Wikipedia, 2014). The economy has grown at the rate of 6-7% p.a. over the past few years. Remittances from Bangladeshis working overseas and exports of garments and textiles are the major sources of foreign exchange earnings. Export is consistently contributing to the economic growth of Bangladesh in the form of increase in foreign currency reserve and positive balance of payment. As export oriented industries are playing key role in maintaining GDP growth in a consistent level, government of Bangladesh has taken various plans, programs, and initiated different road map to ensure uninterrupted flow of electricity to the industrial settings.

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Energy security is now seen as an important prerequisite for sustainable economic development of any country. Energy in Bangladesh is indispensable for almost all economic activities, ranging from firm irrigation to the manufacturing of goods. Moreover, sufficient energy is required for attaining the Millennium Development Goals (MDGs) for Bangladesh. Recently published international papers from international agencies have put forward the urgency of developing policy guidelines and initiatives for export as well as power & energy sector development of Bangladesh. That's why it is considerably important to determine the causal relationship among energy consumption, export and economic growth in Bangladesh in order to formulate proper strategies.

The aim of this paper is to carry out causality test among energy consumption, exports and economic growth in Bangladesh for 1972-2014 periods. Based on the findings, it would then be possible to determine which policy is the most appropriate for Bangladesh economy. The current study is the first attempt in Bangladesh analyzing energy consumption, export and economic growth nexus in Bangladesh with a robust data set. To check the unit root of our data set, we have used ADF & PP tests, to see the cointegrating relationships Johansen Co-integration Test have been used, and finally VECM based Granger Causality tests has been used to investigate the short run and long run causality among the variables used.

The rest of the paper is organized as follows: Section 2 gives an overview of empirical literature, Section 3 represents the methodology, empirical results are explained in Section 4 and Section 5 discusses conclusions and makes some important policy implications.

2. Literature Review

A number of empirical studies have been done in the field of causality between energy consumption and economic growth since the pioneering work done by Kraft & Kraft (1978). These studies produced different contradictory results for different countries and different time periods. Nevertheless all the relevant studies are reviewed here briefly in terms of four separate regional segments- Bangladesh, South Asia, Developed, and Developing countries.

2.1 Literature Review of Bangladesh

In Bangladesh, few studies were done to investigate the relationship between energy or electricity consumption and economic growth in Bangladesh. The evidence of unidirectional causality running from electricity consumption to economic growth was found by Masuduzzaman (2013), Ahmad & Islam (2011) and Paul & Uddin (2011) whereas the reverse result that economic growth causes energy consumption was claimed by Amin et al., (2012) and Mazumder & Marathe (2007). Alam & Sarker (2010) got short run causality from electricity generation to economic growth in Bangladesh. On the other hand, Meerza (2012) claimed that Growth causes Exports in case of Bangladesh.

The details of the previous causality studies are presented in Table- 1:

Table- 1: Summary of the previous causality studies

Country	Author(s)	Study period	Methodology	Findings
Bangladesh	Masuduzzaman (2013)	1981-2011	VECM & Granger-causality (GC)	-EC causes growth -EC causes Investment -Inv. causes growth
Bangladesh	Amin et al., (2012)	1976-2007	VECM & GC	-Growth causes ENC -No causality between ENC & CO ₂
Bangladesh	Ahmad & Islam (2011)	1971-2008	VECM & GC	-EC causes growth
Bangladesh	Mozumder & Marathe (2007)	1971-1999	VECM & GC	-Growth causes EC
Bangladesh	Meerza (2012)	1973-2008	VECM & GC	-Growth causes FDI & EXP
India	Paul & Bhattacharya (2004)	1950-1996	ECM	-Bi-directional causality
Pakistan	Ahmad & Jamil (2010)	1960-2008	VECM & GC	-Growth causes EC
Sri Lanka	Morimoto et al., (2004)	1960-1998	VECM & GC	-Bi-directional causality
Nepal	Dhungel (2008)	1980-2004	VECM & GC	-Growth causes ENC
USA	Kraft & Kraft (1978)	1947-1974	Standard GC	-Growth causes ENC
Japan	Sami (2011)	1960-2007	VECM & GC	-Export causes EC -Growth causes EC
Canada	Ghali et al., (2004)	1961-1997	VECM & GC	-Bi-directional causality
Australia	Narayan & Smyth (2005)	1966-1999	ECM & GC	-Growth causes EC -Growth causes Emp.
China	Yuan et al. (2007)	1978-2004	VECM & GC	-EC causes growth
Malaysia	Tang (2008)	1972-2008	ARDL & ECM	-Bi-directional causality
Libya	Khaled et al., (2010)	1980-2007	VECM & GC	-Bi-directional causality

Source: Authors' compilation

2.2 Literature Review of South Asia

In India, Ghosh (2002) found the evidence of unidirectional causality from economic growth to electricity consumption but the same author claimed the opposite result in 2009. A bi-directional causality between energy consumption and economic growth was found by Paul & Bhattacharya (2004). In Pakistan, Ahmad & Jamil (2010) found unidirectional causality from economic growth to electricity consumption. In Sri Lanka, a bi-directional causality between energy consumption and economic growth was found by Morimoto et al. (2004). In Nepal, Dhungel (2008) claimed unidirectional causality that per capita coal, oil and commercial energy causes per capita real GDP whereas per capita real GDP causes per capita electricity consumption. Noor & Siddiqi (2010) analyzing five South Asian countries found that per capita GDP causes per capita energy consumption.

2.3 Literature Review of Developed countries

In USA, Kraft & Kraft (1978) found that growth causes energy consumption but the reverse result was found by Stern (2000). In Japan, Sami (2011) found the causality from export and real GDP per capita to electricity consumption in the long run. Ghali et al., (2004) claimed a bi-directional causality between energy consumption and growth in Canada, but growth causes electricity consumption was the findings of Narayan & Smyth (2005) in case of Australia. That electricity consumption causes growth in short run and bi-directional causality in long run was found by Oh & Lee (2004) in South Korea. But analyzing the G-7 countries, Soyatas & Sari (2003) claimed that growth leads to energy consumption.

2.4 Literature Review of Developing countries

Unidirectional causality from electricity consumption to economic growth was found by Yuan et al. (2007) in China. But the reverse result that economic growth leads to energy consumption was claimed by Twerefo et al., (2008) in Ghana, Lin (2003) in China. On the other hand, Tang (2008) in Malaysia and Fatai et al., (2004) in Philippines found bi-directional causality between economic growth and energy consumption.

It is obvious that the empirical results of the existing literatures are very mixed, inconclusive and even vary for the same country. This is due to the application of different types of econometric methodologies, sample sizes and variables used. No study has been done yet in Bangladesh to find out the causality among Energy consumption, Export & Economic growth. That's why we have selected this topic for the study.

3. Empirical Methodology

3.1 Data Sources, Variables & Data Description

In this study, annual time series data, covering 1972-2014 periods, were obtained from World Development Indicators (WDI). To conduct the study, three variables were used namely- Energy Consumption (ENC), Export (EXPO) and Economic Growth (GDP); and the proxy variables used are Energy use (kg of oil equivalent per capita), Export of goods and services (constant 2005 US\$) and GDP per capita (constant 2005 US\$) respectively. The choice of starting and ending period was constrained by the availability of time series data on Energy consumption. All variables were transformed into natural logarithm in order to avoid the problem of heteroscedasticity.

Table- 2: Summary Statistics

	ENC (Kg of oil equivalent per capita)	EXPO (\$ million)	GDP (\$ per capita)
Mean	127.71	4790 mln	316.19
Median	117.88	2080 mln	272.17
Maximum	204.72	19900 mln	568.73
Minimum	87.07	407 mln	219.28
Std. dev.	33.997	5160 mln	94.51

Table- 2 represents the summary statistics of all series i.e. ENC, EXPO and GDP to get an overall understanding and this table shows that average energy consumption per capita was 127.71 kg oil equivalent, average export was \$4790 million and average GDP per capita was \$316.19 and the standard deviation is also high for all series.

3.3 Unit Root Test

The application of Cointegration and Granger Causality Tests requires that the time series data should be stationary. A data series is said to be stationary if it has a constant mean, variance, and auto covariance (at various lags) over time. If independent series are stationary, then the series are said to be integrated (Engle & Granger, 1987). To test the unit root, we have applied two tests such as Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests. The equation for ADF test is as follows:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^m \Delta Y_{t-i} + \varepsilon_t \dots\dots\dots (i)$$

Where Δ = first difference operator, m = optimal number of lags, ε_t = disturbance term known as a white noise error, t = time or trend variable, Y = time series data of ENC, EXPO and GDP; $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$ and so on. The null hypothesis of the test is $\delta = 0$, and if the coefficient is statistically different from 0, then the hypothesis, Y_t has a unit root, is rejected.

On the contrary, Phillips & Perron (1988) developed a generalized version of Dickey Fuller (DF) test using non parametric statistical method to take care of the serial correlation in the error terms without adding lagged difference terms. The PP model is given below:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 (t - T/2) + \mu_t \dots\dots\dots (ii)$$

Where, T is the number of observations & μ_t is the error term such that $E(\mu_t) = 0$.

3.3 Cointegration Test

The existence of long run cointegrating relationship among the variables can be investigated if they are integrated at the first order i.e. $I(1)$ (Johansen, 1988). Johansen Cointegration Test has been used in this study to accomplish this purpose. Two different likelihood tests proposed by Johansen were used in this study namely- Trace Test and Maximum Eigen Value Test. These models are shown below:

$$\text{Trace Test: } \lambda_{Trace}(r) = -T \sum_{i=r+1}^k \ln(1 - \hat{\lambda}_i) \dots\dots\dots (iv)$$

$$\text{Maximum Eigen Value Test: } \lambda_{Max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \dots\dots\dots (v)$$

Where, T is the sample size and $\hat{\lambda}_i$ represents the estimated values of the characteristic root ranked from largest to smallest.

4.2 Cointegration tests

As the series are integrated of order 1, Johansen Cointegration test was used to investigate long run cointegrating relationship among the variables assuming there is an unrestricted linear deterministic trend in the series. To determine the optimal lag length, we have applied unrestricted VAR model for the first difference of all the series. The optimal lag length is selected according to SIC. The lag length that minimizes SIC is 0. Then we have applied Johansen cointegration test in the first differences of all series with no lag. The outputs of the Trace test and Maximum Eigen Value Test are given in Table- 4. Both of the tests indicate that there are three cointegrating equations significant at 5% level which means that there are long run cointegrating relationships among the series.

Table- 4: Results of Johansen Cointegration Test

Hypothesized No. of CE	H_0	Eigen Value	Trace Test			Maximum Eigen Value Test		
			λ_{Trace}	5% Critical value	P-value	λ_{Max}	5% Critical value	P-value
None*	$r=0$	0.864	175.99	29.80	0.0001	77.85	21.13	0.0000
At most 1*	$r \leq 1$	0.788	98.14	15.49	0.0001	60.41	14.26	0.0000
At most 2*	$r \leq 2$	0.620	37.73	3.84	0.0000	37.73	3.84	0.0000

4.3 VECM based Granger Causality Test:

To investigate the short run & long run direction of causality among the series, VECM based Granger Causality test was used. The F-statistics of lagged explanatory variables indicate the short run causality whereas t-statistics of ECT_{t-1} indicates long run causality as well as the adjustment nature of the relationship if there is any disequilibrium in short run. Table- 5 represents the results of VECM. Here the coefficient of ECT_{t-1} in the GDP equation is negative, but statistically insignificant which means that the error correction term does not contribute to explain the changes in GDP. So, there is no causality in the long run which signifies that the short run dynamics will not be corrected in the long run.

Table- 5: Results of VECM

Dependent Variable	ECT_{t-1}
DLENC	.04306 [1.12398] (0.2681)
DLEXPO	1.3890 [12.8515] (0.0000)
DLGDP	-0.0128 [-0.30574] (0.7615)
Note: [] indicates the t-statistics and () indicates the corresponding p-value	

Then the Granger Causality test was done to identify the short run dynamics among the series. This test depends critically on the number of lagged terms introduced in the model i.e. the direction of causality changes significantly at different lag intervals. That's why we have done this test for four different lag intervals (lag 1 to lag 4) and only the statistically significant results are shown in Table- 6.

Table- 6: Results of Granger Causality Test

Lag	Direction of Causality	F-statistics	P-values	Decision
1	DLGDP → DLEXPO	9.778***	0.0035	Bi-directional causality between GDP & Export
	DLEXPO → DLGDP	10.331***	0.0028	
2	DLEXPO → DLGDP	10.002***	0.0004	Unidirectional causality from Export to GDP
3	DLGDP → DLENC	3.955**	0.0173	Unidirectional causality from GDP to Energy Consumption
	DLGDP → DLENC	3.547**	0.0189	Unidirectional Causality from GDP to Energy Consumption
4	DLGDP → DLEXPO	3.270**	0.0261	Bi-directional causality between GDP & Export
	DLEXPO → DLGDP	2.899**	0.0406	
Note: *, ** and *** represents 10%, 5% and 1% significance level respectively.				

The results of Granger Causality Test indicate that there is a bi-directional short run causality running between export and economic growth, since the estimated F-statistics is significant at 1% level at lag 1 and 5% level at lag 4. This result is consistent with that of Khaled et al., (2010) in case of Libya. No study has found bi-directional short run causality running between export and economic growth in Bangladesh yet. On the other hand, a short run unidirectional causality is found running from export to economic growth at 1% level at lag 2. We also found that there is a short run unidirectional causality from economic growth to Energy Consumption at 5% level both at lag 3 and lag 4. This finding is consistent with the findings of Amin et al. (2012), Mozumder & Marathe (2007), Noor & Siddiqi (2010) and Soyatas & Sari (2003); but inconsistent with Ahmad & Islam (2011) for Bangladesh. This contradiction, however, can be attributed to the different time series and methodologies used.

5. Conclusion & Policy Implications

The objective of the study was to investigate the causality among energy consumption, export and economic growth in Bangladesh covering the period 1972-2014. To check the stationary prosperities in the series, we have used ADF and PP tests which reveal that all series are stationary at their first difference *i.e.* I(1). Satisfying this condition, Johansen Cointegration Test was run and three cointegrating equations were found implying that there are long run cointegrating relationships among the series. VECM based Granger Causality shows that there is no causality in the long run. On the contrary, a bi-directional short run causality is found between export and economic growth which implies that both export-led-growth and growth-led-export strategies are true for Bangladesh. This bi-directional causality signifies that an increase in export of goods and services will contribute to the GDP of Bangladesh leading to the expansion of economic activities

which, in turn, will eventually accelerate the exports. We have also found that there is a short-run causality running from economic growth to energy consumption without feedback which implies that the more the economy grows, the more the energy consumption increases. That means the expansion of economic activities will require a higher level of energy consumption. So the government of Bangladesh should formulate appropriate policies that will foster exports as well as economic growth. The government can provide various incentives such as credit facilities, tax-holidays, cash incentives, depreciation allowances, funds for export promotion, export credit guarantee scheme, export subsidies and can form special economic zone to patronize indigenous export oriented industries. The government should also implement several macro level strategies *i.e.* ensuring political stability, adequately enforcing laws, efficient fiscal management & resource allocation, sound regulatory systems, reduction of corruption, infrastructural development, ensuring skilled workforce and equality of opportunity etc. in order to ensure economic growth and sustainability in the long run.

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