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Impact of Urbanization on Energy Consumption Intensity in Bangladesh: An Empirical Analysis

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Emerging countries undergo economic transformation through urbanization in which to continue modern economic activities, there exists high demand for different energy sources such as electricity, oil, coal, natural gas etc. To the best of our knowledge, no studies have been conducted to investigate the impact of urbanization on energy consumption intensity in Bangladesh and thus, the aim of this paper is to empirically analyze the effect of urbanization on energy consumption intensity with the help to time series data ranging from 1980-2015. Johansen's cointegration test reveals that our variables are co integrated and through Granger Causality test we have found that there is a unidirectional causality running from urbanization to energy consumption intensity in the long run but in short run, Vector Error Correction Model (VECM) confirms no causality among the variables of interest. We employed CUSUM and CUSUMSQ tests to check the stability of the model and have found that the model is stable. Long run estimation results indicate that coefficient value of urbanization is positive and elastic as well. To carry on different economic activities in urban areas, proper policies should be taken to improve the energy sector in Bangladesh.

Field of Research: Economics

1. Introduction

Due to urbanization, relative concentration of population and economic activities increase in city areas of a nation. 50% of the total population of the world lives in urban areas and it is estimated that by 2050 urbanization will absorb total population of the world (World Bank 2010). Urbanization creates a structural transformation in the economy. This causes the change in the pattern of energy consumption. The demand for energy services changes due to modern economic activities. Moreover, urban living as compared to rural living is expected to require more energy consumption.

Urbanization is considered as a dynamic phenomenon in the modern era (Shafi*et al.* 2015). High density of urbanization may bring changes in the structure of the economy and energy resource utilization (i.e. coal, gas, electricity and different types of fuels). On the other hand, physical accumulation due to urbanization within the countries may create environmental problems, increase in cost of living and disparity in

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society. Moreover, it is observed that there is a robust trend of urbanization in the developing or emerging countries compared with the developed countries (Salim & Shafiei 2014). Thus, it is important to gain knowledge about the pattern of energy consumption intensity in Bangladesh. The future urban energy demand-side management cannot be described without knowing the intensity pattern of energy consumption.

Urbanization and energy consumption intensity relationship has been studied extensively in recent years. The causal relationship between these two variables are mix in nature. Shahbaz and Lean (2012) found that there is a bidirectional causality between energy consumption and urbanization in the long run and a unidirectional causality running from urbanization to energy consumption in Tunisia. Salim and Shafiei (2014) investigate the causal relationship between urbanization and energy consumption intensity for OECD countries. Authors found that there is no causality running from fossil energy consumption to urbanization in the short run nor in long run on the other hand, no relation was found between urbanization and renewable energy consumption in the long run and long run. Mishra *et al.* (2009) found a unidirectional causal relationship between urbanization and energy consumption in short run for 9 Pacific countries. O'Neill *et al*. (2012);Zhang and Lin (2012) discovered a unidirectional causality running from urbanization to energy consumption both in short run and long run. Shabaz*et al.* (2015) found unidirectional causality running from urbanization to energy intensity in long run.

To the best of our knowledge, no studies have been conducted to investigate the impact of urbanization on energy consumption intensity in Bangladesh. Thus, the aim of this paper is to empirically analyze the effect of urbanization on energy consumption intensity with the help to time series data ranging from 1980-2015. In doing so we considered the following research questions: What are the long run short run causalities of the variables of interest? Is the proposed model stable? What are the estimated long-run coefficients of the variables?

The rest of the paper is organized as follows. The next section provides the literature review followed by the section that discusses the attributes of data and the methodology of research. Moving on, the subsequent sections provide discussions on econometric results and finally followed by concluding remarks and policy recommendations.

2. Literature Review

According to Shabaz*et al.* (2015) growth rate of urbanization in Malaysia is one of the prime agendas for economic development from the past ten years. Rapid urbanization has caused high demand for different sources of energy. To understand the level of intensity of energy consumption due to urbanization, authorsconducted a time series analysis. Data covered from 1970-2011. The Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT), Autoregressive Distributed Lag Model (ARDL) have been used in the paper. Results show that there is a cointegrating relationship between urbanization and energy consumption. A unidirectional causality was found between urbanization and energy consumption in the long run but not vice versa.

Solarin and Shahbaz (2013) analyzed the long run relationship between economic growth, urbanization and electricity consumption intensity for Angola. Authors found that variables are co integrated in the long run. According to Granger causality test results, there exist a bidirectional causality between urbanization and electricity consumption intensity. Authors concluded that a proper policy frame work is needed construct distribution and transmission channel of electricity in urbanization area to sustain the desired urban growth rate which can ultimately lead to higher economic growth.

To understand the effect of urbanization on urban structure and demand for energy on urbanization, a huge data set of 100 developing and developed countries has been used (Madlener & Sunk, 2011). It was discovered that the demand for energy is influenced by urbanization in an economy. The change in the energy demand is channeled through by urban structure. Moreover, it was seen that urbanization is a component of economic development. As the income changes, demand for energy changes as well which ultimately changes the intensity of energy consumption. Liu (2009) investigated the relationship among population growth, urbanization and energy consumption for China with the help annual data series ranging from 1978-2008. ARDL bound testing approach and factor decomposition model have been used in the paper for econometric analysis. According to the results, there is unidirectional causality running from urbanization to energy consumption both in short run and long run. On the other hand, population does not cause economic growth as well as urbanization in China.

Hossian (2011) explored the relationship among economic growth, urbanization and energy consumption for newly industrialized countries over the period of 1971 to 2007. Results indicated that variables were co integrated. No long run causalities were found among the variables. However, in the short run it was found that energy consumption causes urbanization in newly industrialized countries.

Sadorsky (2013) asserted that energy intensity tends to correlate highly with income. Developing countries have higher energy intensity on average. Moreover, urbanization and industrialization may affect energy intensity in developing nations. Given this fact, author conducted a research on the effect of urbanization and industrialization on energy intensity with the help of panel data (1980-2010) of chosen 76 developing countries. Heterogenous panel regression techniques have been incorporated. According to the results, in the long run, impact of urbanization on energy intensity is mixed. The long-run coefficient of urbanization found to statistically significant and to a certain extent larger than unity with positive sign.

According to Luo (2014), economic growth and the intensity of the electricity consumption change due to the process of urbanization. Thus, it is important to get a clear idea of the relationship between these variables. Author examined the relationship between these variables with the help of time series data ranging from 1980-2009 in China. To create a multivariate frame work, gross capital formulation and employment have been added to the model. According to Vector Error Correction Model (VECM) results, the short run fluctuation of economic growth puts it 78.2% down to electrical input, urbanization, labor and investment input and adjustment by itself. Impulse response function and variance decomposition technology results indicated that with the surge of urbanization, a new round of economic growth and consumption of energy will escalate.

Krey*et al.* (2012) used integrated assessment models to shade light on the impact of urbanization on residential energy use for India and China. Authors found that residential energy use is not very sensitive to urbanization directly. However, the relationship between energy use and urbanization indirectly depends on labor productivity which effects the economic growth. Stern (2012) employed a stochastic production frontier approach to model trends of energy efficiency in 85 countries over the period of 37 years. Results showed that countries with higher factor productivity, undervalued currency and with smaller fuel reserves could achieve energy efficiency. Though the model did not directly have any variables of urbanization but author asserted that unplanned urbanization might affect the efficiency trend.

After the wide discussion of different literatures, we can set our hypothesis relevant to our research question. We have two sets of null hypothesis for both short run and long run. The first set of hypothesis is as follows, H_1: real income does not cause energy consumption intensity and H_2: energy consumption intensity does not cause real income. The second set of hypothesis is as follows, H_1: urbanization does not cause energy consumption intensity and H_2: energy consumption intensity does not cause urbanization. Furthermore, we will also estimate the coefficient values. In this case, we do not need any hypothesis testing.

3. Methodology and Data Set

To check the stationarity of the variables, existence of unit root has to be tested. Macroeconomic and financial data are well known because of their non-stationarity. There are several ways to find out the existence of unit root of the variables. For example, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test are broadly employed. For our study, we have performed the (ADF) test to test the existence of unit root and found that all of the variables are non- stationary at levels and thus cannot be regressed without making them stationary. After the ADF test, we performed cointegration test to investigate possible linear combination of the variables that can be considered stationary. If cointegration is established, then we ran the causality test to check the possible direction of causality between the variables of interest.

Nonstationary data may lead to specious regression in the context of time series analysis unless there is at least one cointegration relationship (Amin, 2011; Amin and Rahman, 2011). The Johansen technique is employed to test for cointegration. A unified framework of estimation and testing cointegration relations are provided in the context of Vector Autoregressive (VAR) error correction models. Here one has to estimate Unrestricted Vector of Autocorrelation of the form:

$$\Delta x_t = \alpha + \theta_1 \Delta x_{t-1} + \theta_2 \Delta x_{t-2} + \theta_3 \Delta x_{t-3} + \cdots + \theta_{k-1} \Delta x_{t-k+1} + \theta_k \Delta x_{t-k} + u_t \quad (1)$$

In the equation above, Δ is the difference operator, $x_t\ (n \times 1)$ is a vector of non-stationary variables (in levels) and is the vector of random errors. The information on long-run relationship is articulated by the matrix θ_k the variables are not cointegrated if the rank of θ_k =0. Nevertheless if rank (usually represented by r) is equal to one, there exists one cointegrating vector and in conclusion if, $1 < r < n$ there are multiple cointegrating vectors. Johansen and Juselius (1990) have derived two tests for cointegration, which are trace test and the maximum Eigen value test. The trace statistic assesses the null hypothesis that there are at most r cointegrating vectors while the maximal eigen value test, estimates the null hypothesis that there are r exactly cointegrating vectors in x_t

If two variables are cointegrated, then there is at least one direction of causality. Granger-causality is one of the important issue that has been enormously studied in empirical finance of macroeconomics. Granger-causality is introduced by Granger (1969, 1980 & 1988). Engle and Granger (1987) asserted that the presence of non-stationary can lead to distorted conclusions in Granger-causality test. In this test, we can only infer long-run relationship between nonstationary time series when the variables are cointegrated.

If x and y are variables of interest, they by applying Granger-causality test we can determine whether past value of y augment the explanation of present values of x given that by information in past values of x itself. y does not Granger cause x if changes past values of y does not explain changes in x values at present. Likewise, we can probe whether x Granger causes y. There are four probable outcomes in the Granger causalitytest:

a. neither variable Granger cause each other
b. y causes xbut not otherwise
c. x causes y but not otherwise
d. both x and y Granger cause each other

Following two sets of equation will be estimated:

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \cdots + \alpha_l x_{t-l} + \beta_1 y_{t-1} + \cdots + \beta_l y_{t-l} + u_t \qquad (2)$$

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots + \alpha_l y_{t-l} + \beta_1 x_{t-1} + \cdots + \beta_l x_{t-l} + v_t \qquad (3)$$

It is for all possible pairs of (x,y) series in the group. The stated F-statistics are the Wald statistics for the joint hypothesis $\beta_1 = \beta_2 = \beta_3 = \cdots = \beta_l = 0$.

Engle and Granger (1987) asserted that a vector error correction model (VECM) is an appropriate method to model the long-run as well as short-run dynamics among the cointegrated variables. Causality inferences in the multi-variate framework are made by estimating the parameters of the following VECM equations.

$$\Delta Y = \alpha + \sum_{i=1}^{m} \beta i \Delta Y_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta X_{t-j} + \sum_{k=1}^{0} \delta \Delta M^s + \sum_{l=1}^{p} \zeta \Delta N + \theta Z_{t-1} + \varepsilon_t \quad (4)$$

$$\Delta X = a + \sum_{i=1}^{m} b_i \Delta Y + \sum_{j=1}^{n} c_j \Delta X_{t-j} + \sum_{k=1}^{0} d \Delta M^s + \sum_{l=1}^{p} e \Delta N + f Z_{t-1} + \xi_t \quad (5)$$

z t-1 is the error-correction term which is the lagged residual series of the cointegrating vector. Deviations of the series from the long run equilibrium relation is measured by the error-correction term. For instance, from equation (4), the null hypothesis that X does not Granger cause Y is rejected if the set of estimated coefficients on the lagged values of X is jointly significant. Furthermore, in those instances where X appears in the cointegrating relationship, the hypothesis is also supported if the coefficient of the lagged error-correction term is significant. Changes in an independent variable may be interpreted as representing the short run causal impact while the error-correction term provides the adjustment of Y and X toward their respective long-run equilibrium. Thus, the VECM representation allows us to differentiate between the short- and long-run dynamic relationships. The Chi-Square test statistic is used to determine the short run causalities between pairs of variables in the model.

Usually, we use CUSUM test to investigate any systematic changes or movements in which there are possibilities of change in values of the coefficient revealing structural instability. Let us assume a linear regression model with K coefficients over the time period t

$$Y_t = X_t \beta_t + \varepsilon_t \text{ , } t = 1,2 ,\ldots, T (6)$$

Estimated coefficient by OLS method based on our time period t will be,

$$\widehat{\beta_t} = (X'_t X_t)^{-1} X'_t Y_t \text{ , } K ,\ldots, T (7)$$

$\widehat{\beta_t}$ of β_t is actually identical to the OLS estimator. Thus, recursive estimators can be written as follows,

$$\widehat{B_{t-1}} = (X'_{t-1} X_{t-1})^{-1} X'_{t-1} Y_{t-1} (8)$$

Therefore, the estimator $\widehat{\beta_t}$ of β_t can be written finally as,

$$\widehat{\beta_t} = \widehat{B_{t-1}} + (X'_{t-1} X_{t-1})^{-1} x_t \frac{y_t - x'^{\widehat{B_{t-1}}}}{1 + [x'_t (X'_{t-1} X_{t-1})^{-1} x_t]} (9)$$

Coefficient stability test based on recursive residuals through one step error prediction approach was proposed by Brown *et al.* (1975). We can write down the one step prediction error term below

$$e_t = y_t - x'_t \widehat{\beta_{t-1}} = x'_t \left(\beta_t - \widehat{\beta_{t-1}}\right) + \varepsilon_t (10)$$

Now recursive residual can be expressed in the form of normalized prediction errors

$w_t = \frac{e_t \gamma_\varepsilon}{\gamma_e} = \frac{y_t - x'^{\widehat{B_{t-1}}}}{\sqrt{1+[x'_t(X'_{t-1}X_{t-1})^{-1}x_t]}}$*(11)*

Existence of any unknown break point results rejecting the specification throughout the period. Through hypothesis testing, we can find out whether the model is stable or not by rejecting or accepting null hypothesis (Farhani, 2012)

$$W_m = \sum_{t=K+1}^{m} \frac{w_t}{\gamma_w} \quad (12)$$

Under null hypothesis W_m must be inside the corridor ($-L_m$toL_m)

$$L_m = \frac{a(2m+t-3k)}{\sqrt{T-K}} \quad (13)$$

We will reject the null hypothesis (i.e. the model is stable) if W_m cuts the given range of corridor. Which actually means the variables are not stable enough. If we want to check sudden or random movements in our model, then CUSUM of Square Test is appropriate. It is based on the squared recursive residuals of the model.

$$S_m = \frac{\sum_{t=K+1}^{m} {w_t}^2}{\sum_{t=K+1}^{T} {w_t}^2} = \frac{s\prime}{\dot{s}} \quad (14)$$

For the null hypothesis S_m is a beta distribution. If S_m crosses the corridor than we will reject the null hypothesis just like the CUSUM Test.

Generalized Method of Moments (GMM) estimation approach was developed by Lars Peter Hansen in 1982. Since then it has become one of the most widely used methods of estimation for models in economics and finance. In contrast to the likelihood estimation (MLE), GMM does not require complete knowledge of the distribution of the data. It only needs specified moments derived from the concerned model. GMM model is far more effective in the log-normal stochastic volatility models. Furthermore, models containing more moment conditions then model parameters, GMM estimation provides a direct way to test the specification of the projected model. This is a main feature that is exclusive to GMM estimation.

$$Y_t = z_t \delta + \varepsilon_t \text{ Where, } t = 1, 2, 3, \ldots, n \quad (15)$$

In equation (15), z_t indicates explanatory variables which can be expressed by L × 1 vector. δ is a vector of unknown coefficient and ε_t is the error term. Equation (15) allows the possibility that some or all elements of explanatory variables are related with the error term. Then endogeneity problem will arise. It is well known that if z_t contains endogenous variables then the least squares estimator of δ in (15) is biased and inconsistent.

Let us assume that we have K × 1 vector of instrumental variables $x_t$that may contain some or all the elements ofz_t. The instrumental variables x_t satisfy the set of K orthogonality conditions.

$$E[g_t(w_t, \delta)] = E[x_t \varepsilon_t] = E[x_t(Y_t - z_t\delta] = 0 \quad (16)$$

Rewriting equation (16) gives,

$$\sum xy = \sum xz\,\delta$$

Where $\sum xy = E[x_t Y_t]$ and $\sum xz = E[x_t z_t]$. For identification of δ, it is required that the K × L matrix $E[x_t z_t] = \sum xz$ has to be full rank L. The solution of δ is ensured by the rank condition. If K=L then, $\delta = \sum xz^{-1} \sum xy$. It is worth mentioning that the number of instrumental variables must be greater or equal to the explanatory variables. If not, then the model will fail to estimate the coefficient values

The Dynamic OLS (DOLS) approach was proposed by Stock and Watson (1993). DOLS is an improvement version of OLS approach where we can deal with small sample size and dynamic sources of bias. It is a robust single equation approach corrects the regressor endogeneity by incorporating lags and leads. DOLS can estimate long-run equilibrium where variables are integrated in same or different order. This is one of the major advantage of this approach. Moreover, it has the same kind of optimality like Johansen distribution. Since our sample size is small, we applied DOLS approach for avoiding false estimation. IfY_t is the dependent variable with regressors $X_{i,t}$=1,2,3…,n then,

$$Y_t = \beta_0 + \beta_1 X_{1,t} + \beta_2 X_{2,t} + \ldots + \beta_k X_{k,t} + \sum \alpha_{i\Delta} X_{1,t-i} + \sum \gamma_{i\,\Delta} X_{2,t-i} + \ldots + \sum \delta_{i\Delta} X_{k,t-I} + \varepsilon_t \quad (17)$$

The paper is based on annual data covering the period of 1980-2015. Data on per capita energy consumption (Kg of oil equivalent), real income per capita (Real GDP per capita) and Urbanization Rate are taken from World Development Indicator (WDI). It should be mentioned here that as Bangladesh got her independence in 1971 and this research paper focuses over the period 1980-2015 for which 35 observations are available at most.

4. Results and Discussions

Unit root tests are conducted to determine the order of integration of the data series. Optimal lag is chosen by *Schwartz Information Criterion (SIC).* Table 1 shows the ADF statistics and corresponding critical values of all the variables in their level and first differenced forms.

Table 1: Augmented Dickey Fuller Unit Root Test for the Variables

Panel 1: Levels			
Variable	**ADF Statistics (Only Constant)**	**ADF Statistics (Constant & Trend)**	**Decision**
LNE	1.148353	-2.205918	Non Stationary
LNRY	2.626660	-0.718855	Non Stationary
LNUR	-0.115333	-0.953562	Non Stationary
Panel 2: First Differences			
Variable	**ADF Statistics (Only Constant)**	**ADF Statistics (Constant & Trend)**	**Decision**
LNE	-7.313449	-7.809703	Stationary
LNRY	-3.754262	-4.777558	Stationary
LNUR	-4.338032	-4.450921	Stationary

Table 2: Mackinnon Critical Values for Rejection of Hypothesis of Unit Root

Critical Value	Levels		First Differences	
	No Trend	With Trend	No Trend	With Trend
1%	-3.632900	-4.243644	-3.639407	-4.252879
5%	-2.948404	-3.544284	-2.951125	-3.548490
10%	-2.612874	-3.209699	-2.614300	-3.207094

Unit root tests have non-standard and non-normal asymptotic distribution. These distributions are extremely affected by the inclusion of deterministic terms such as constant, time trend etc. An extraneous regressor whose enclosure reduces the power of the test is called time trend. Yet if the true data generating process were trend stationery, failing to include a time trend also results in a decline in power of the test. Additionally, this loss of power from without a time trend when it should be present is more severe than the reduction in power associated with including a time trend when it is extraneous. One of the main issues in unit root testing is lag length selection. Including a moderately long lag length and select the model by the usual t-test is one of the approach. When the t-statistics on lag p is insignificant at some stated critical value, the regression should be frequently assessed using a lag length (p-1) until the lag is significantly different from zero. From the unit root test, it is clear that all the variables are found to be stationary at their first differences. From the table, it is clear that the variables would yield spurious results unless the variables are cointegrated. The results, however, allow to proceed to the next stage of testing for cointegration. The Johansen cointegration test results indicate that our variables have cointegrating relationship. Maximum Eigen value test and the trace test (Table 3a and 3b) both point out cointegrating relationships at 90%. After the Cointegration test, we performed Granger Causality Test at lag 2.

Table 3a: Johansen Test for Cointegration (Trace Test)

	Null Hypothesis	Alternative Hypothesis	Statistics	90% Critical Value
LNE, LNRY andLNUR	None	(At Most One)	38.34684 (8.362987)	32.06455 (16.16088)
		At Most Two	2.953625	2.9805545

Table3b: Johansen Test for Cointegration (Maximum Eigen Value Test)

	Null Hypothesis	Alternative Hypothesis	Statistics	90% Critical Value
LNE, LNRY andLNUR	None	(At Most One)	29.71385 (5.779362)	21.87330 (15.00128)
		At Most Two	2.953625	2.9805545

Table 4: Granger Causality Test Results

Variable	**Null Hypothesis**	**F-Statistic**	**P-Value**	**Conclusion**
Granger Causality Test Statistics between LNE and LNRY				
LNE	LNRY does not Granger Cause LNE	0.00371	0.9963	LNE Granger Causes LNRY
LNRY	LNE does not Granger Cause LNRY	9.77355	0.0006	
Granger Causality Test Statistics between LNE and LNUR				
LNE	LNUR does not Granger Cause LNE	3.39891	0.0472	LNUR Ganger Causes LNE
LNUR	LNE does not Granger Cause LNUR	1.23728	0.3052	

From the Table 4, it is clear that causality is running from energy consumption to real income (GDP per capita) but not vice versa (from the first set of null hypothesis: rejecting the second null hypothesis). This unidirectional causality satisfies the growth hypothesis. That means as consumption of energy increases, real income will increase. On the other hand, there is a unidirectional causality running from urbanization to energy consumption (from the second set of null hypothesis: rejecting the first null hypothesis). It indicates, as urbanization increase, energy consumption intensity will increase. As a country goes through developing process, there will be an expansion of urbanization. Therefore, more modern production activities will take place which will directly increase the energy consumption intensity. Furthermore, increased production in urban areas can also intensify the level of informal economy that can be a further source of higher degree of energy use. On the other hand, rural people also migrate to urban cities and as a result, energy consumption intensity increases because more people consume energy for different household activities in urban areas. These results answer the first research question from longrun perspective.

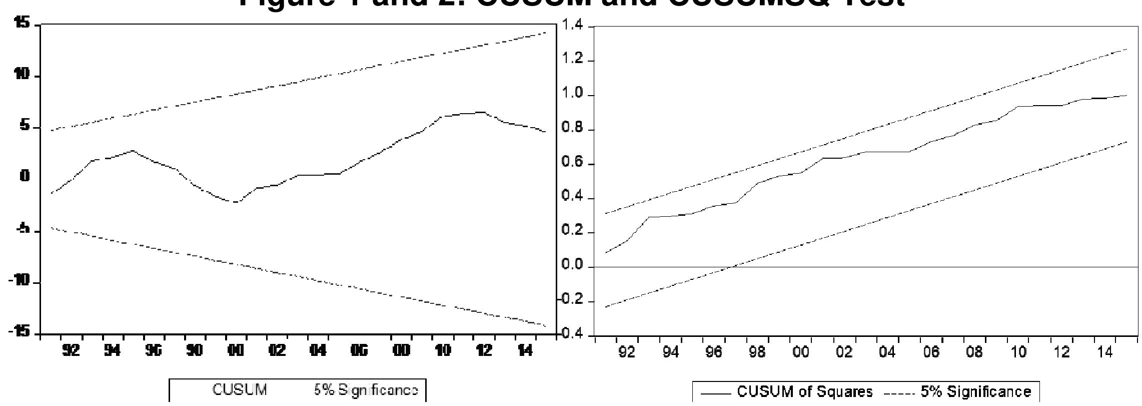
After observing the long run causal relationship, we now move to investigate the short run causal relationship among the variables through VECM approach (with same sets of hypothesis). The results from the VECM approach are given in the Table 5. According to the VECM results, no causality was found between our variables of interest. It answers the first research question (from the short run perspective). One of the possible reasons for this is that the intensity effect of energy consumption is subject to time lag to be observed.

Table 5: VECM Test Results

Variable	Null-Hypothesis	Chi-Square Statistic	P-Value	Conclusion
Causality Test Statistics between LNE and LNRY				
LNE	LNRY does not cause LNE	1.390999	0.2674	No Causality
LNRY	LNE does not cause LNRY	2.781997	0.2488	
Causality Test Statistics between LNE and LNUR				
LNE	LNUR does not cause LNE	0.739960	0.4873	No Causality
LNUR	LNE does not cause LNUR	1.479920	0.4771	

After investigating short run causal relationships, now we can check the stability of the long run parameters with short run movements of the equation through CUSUM CUSUMSQ tests. The tests are relied upon residuals of error correction model.

Figure 1 and 2: CUSUM and CUSUMSQ Test



Both figures show that plot stays within the corridor of 5% critical value indicating that the model is stable in both in terms of systematic and sudden movements. It means that any external changes will not affect the veracity of the model. Both stability test results answer the second research question.

We have employed two estimation approach to estimate the equation. These estimation approaches are GMM and DOLS. For DOLS, fixedleads and lags (lead=1, Lags=1) option is chosen. The results are shown in Table 6. As can be noticed that the R^2 and the standard error of regression value suggest that the model is a good representation of the dynamics between the variables. The coefficient values have expected sign and also values are significant. The estimation results answer the third research question.

Table 6: Results of GMM and DOLS Estimation

Variable	Coefficient (GMM)	Coefficient (DOLS)
LNRY	0.414 (0.0001)	0.437 (0.0010)
LNUR	2.689 (0.000)	2.450 (0.0002)
R^2	0.980866	0.992313
Adjusted R^2	0.980303	0.990161
SE of Regression	0.034861	0.023193

Probabilities in Parenthesis

From the Table 6, we can see that the urbanization coefficient value is highly elastic. That means percentage change in energy consumption intensity will be higher than the percentage change in urbanization. On the other hand, income elasticity is less than one but greater than zero which indicated energy is a normal commodity. However, the nature is inelastic. As a result, percentage change in income will be higher than percentage change in energy consumed.

5. Conclusion

In this paper, we have analyzed the impact of urbanization on energy consumption intensity in Bangladesh with the help of annual data covering from 1980 to 2015. For the analysis, we have used different econometric techniques. We have found that there is a unidirectional causality running from urbanization to energy consumption intensity in the long run but not vice versa. However, no causality was found in the short run. Long run estimation results indicate that the coefficient of urbanization is elastic and has the expected sign (conclusive result is consistent with Sadorsky 2013; Mandlener & Sunk 2011; Luo 2014). Furthermore, the model used in the paper is stable enough as well.

Bangladesh is one of the fastest growing economies of the world. The country is also enlisted in the ‘Next Eleven’ economies for the upcoming decade. To achieve the developmental goals of 2021 and 2041, rapid urbanization is taking place in Bangladesh. As we have seen from our paper that energy intensity relatively increases as urbanization expands, proper policy frame work is needed to ensure access to energy as well as for energy security. For instance, policies regarding development of energy sector should be considered thoroughly. Government can maintain a desired level of speed of urbanization if the there is enough energy production and proper distribution system. Thus, policies in favor of investment in production and distribution system are appropriate for Bangladesh at this moment. Moreover, improvement in energy efficiency is needed to stop excessive use of energy that might affect environment. On the other hand, introduction to renewable energy side by side with conventional energies might come handy as well.

One of the main limitation of the paper is the data constraint. Without this constraint, our empirical results might have been more underpinning in terms of explaining different econometric results. More control variables could have been added like transitions of markets, technology penetration in urban areas, intra sectoral relations in different urban areas and many more. However, data on these variables are not available for most of the developing countries. This paper can be further extended by analyzing the impact of urbanization on disaggregated energy consumption intensity to see how the intensity of different energy sources change due to urbanization. An examination can be done to shade light on how regional urbanization can impact energy intensity and then comparing all the results to come up with popper policies to achieve desired goals.

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