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Does Foreign Aid Reduce Energy and Carbon Intensities in Bangladesh? An Empirical Investigation

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Foreign aid has been existing since the formation of national states. The rich developed countries or agencies are always helping the developing countries through different types of foreign aids. It not only effects growth but also helps to improve different socio economic aspects of the recipient country. The aim of this paper is to explore the impact of foreign aid on energy consumption intensity and carbon intensity as no studies have been conducted in this context in Bangladesh. We used time series data from 1980 to 2015 for our empirical analysis. Johansens's cointegration test confirms our variables are cointegrated in the long run. We used Dynamic Ordinary Least Square (DOLS) and Generalized Method of Moments (GMM) to check impact of foreign aid on energy consumption intensity and carbon intensity. According to the results of these estimation approaches, we found that foreign aid reduces energy consumption and carbon intensity in Bangladesh. However, the effect on energy consumption intensity is much lower than the effect on carbon intensity.

Field of Research: Economics

1. Introduction

Bangladesh is a rapidly growing economy. The country witnessed an annual GDP growth rate of 7.1% and GDP of 221.4 billion in USD in the year of 2016 (World Development Indicators 2016). In fact, a major part of the country lies in the Ganges-Brahmaputra-Meghna Delta (GBM Delta) which is the largest delta in the world. As a result, the country is also the most populated delta in the world. Low-lying deltas such as Bangladesh are more likely to suffer adverse effects of climate change due to sea level rises. The people residing in the low lying parts of southeast Bangladesh are usually the most vulnerable and unprepared during flood prone seasons (Brouwer *et al.* 2007). In reality, the coastal areas of Bangladesh are hit by at least one major cyclone every three years which results in storm surges as tall as 10 meters (Dasgupta *et al.* 2014). Since a substantial part of Bangladesh is still rural and dependent on agriculture, climate change can have detrimental effects on its growing economy and population.

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Ever since the liberation war, the country has been a regular recipient of foreign aid. In the days following the war, the country received aid mostly in the form of food aid. However, over the years, the country started to receive aid in forms of grants and loans. The amount of net ODA (official development assistance) received has shown an overall increase till today and the country received a net official development assistance of 157.6 billion USD in 2016 (World Development Indicators 2016).

Bangladesh is the 6th most affected country by climate change in the period between 1997 and 2017 among other countries like Haiti, Philippines and Pakistan (David et al 2018). In fact, among the top ten most affected countries during the period of 1997 to 2017, nine were low income or lower income developing countries. In addition, 62% of carbon emission results from developing countries. This is because developing countries are more engaged in producing goods and products for exports therefore these countries consume more energy and release more carbon into the atmosphere. Bangladesh is a low income country on its way of becoming a middle income country. The elasticity between urbanization-emission is unitary for low income countries and a little less than one but positive for lower middle income countries (Martinez-Zarzoso 2008).

From 1988, the development assistance committee started monitoring the objectives of the Rio Conventions (targets environmental sustainable goals) to mitigate climate change using markers. In the 2009, the committee came up with a new marker to assess the aid allocated towards climate change adaptation. In the year 2009, over 9 billion USD of bilateral aid was allocated for climate change (the Organization for Economic Co-operation and Development 2011). In fact, Bangladesh played a crucial role in mobilizing the Green Climate Fund which will bring in 100 billion USD addressed towards climate change initiatives for developing countries from rich countries starting from the year 2020.

The main aim of this paper is to identify whether foreign aid coming to Bangladesh can lead to energy efficiency and reduce carbon emissions through technological advances. To the best of our knowledge, an empirical relationship between the variables has not been looked in terms of Bangladesh before. Thus, by using the resources at our disposal we want to check whether such a relationship exists in Bangladesh, and if it does, the extent to which this relationship may affect Bangladesh. Our research question as follows: are the variables cointegrated in the long run and what are the long estimated coefficients of foreign aid with respect to energy and carbon intensity separately?

The rest of the paper has the following structure. Section 2 discusses the relevant literature reviews. Section 3 widely presents the methodology and data set used in our paper. Section 4 shows the results and discussion and section 5 is our conclusion.

2. Literature Review

OECD countries are allegedly outsourcing their carbon emissions to developing countries. Over the years, carbon intensity of energy has been increasing a lot more when compared to richer nations. 73% of global carbon emission growth came solely from the least developed and developing nations in the year of 2004 whereas total emissions accounted from these nations accounted to only 41% globally (Raupach*et* *al.* 2007). The OECD countries can be labeled as net importers of embodied carbon whereas the developing nations can be termed as net exporters (OECD 2016). This is because the OECD nations have conveniently transferred their carbon emissions to the poorer nations. The consumption emissions in the OECD nations are higher than their production emissions. However, the increase in emissions in the developing nations is not just merely because of exports, the developing countries consume a lot of energy supplies for domestic production. Even though the consumption of energy supplies in OECD is ten times higher compared to developing countries; India and China consume three times more energy supplies than other low income countries (US Congress 1991).

The OECD countries, therefore, bear most of the responsibility of increasing carbon pollution globally. Thus, it is open to question whether more generous funds aimed towards climate change can reduce energy and carbon intensities in developing countries. Energy efficiency is more pronounced in developing nations because of technological transfers and this justifies policy instruments like the Clean Development Mechanism. However, there is an argument whether foreign direct investment from major multinational companies can aid in improving energy efficiency in developing countries. Hubler & Keller (2009) criticize this notion with their study by using macro level data from sixty developing countries. Moreover, they state that development aids directing towards energy efficiency are more relevant.

The relationship between foreign aid and climate change has received very little attention in previous studies. A study by Arvin et al (2006) mentions that all developing nations lack a consistent pattern of heterogeneity and thus it is difficult to determine the relationship between foreign aid and environmental impacts in these countries. On the other hand, a study by Bouwer & Aerts (2006) states that climate change financing in developing countries can be done by two different approaches. One approach is to follow the 1992 United Nations Framework Convention on Climate Change (UNFCCC). The latter approach is by developing and maintaining climate risk management techniques in the concerned nations. In fact, on every platform, people in support of the developing world insist that rich countries bear the cost of carbon reduction.

There is almost no literature available looking into effects of official development aid on energy and climate related goals. It is for certain that foreign aid can affect both energy and the environment in direct and indirect means. Energy intensity is a measure of energy efficiency, that is, the measure of energy required for per unit of GDP. High energy intensity indicates that the cost of converting energy into one unit of GDP is very high. In contrast, low energy intensity indicates higher energy efficiency. Therefore, technical projects in aid receiving countries focused on energy can bring in direct impacts. However, Yamaguchi (2005) had reviewed Japan's Official Development Assistance and stated that little changes had been made ever since 1980 towards environmental friendly projects in the energy sector. Indirect effects of foreign aid can be in the form of work which helped raise the per capita income of recipient countries. A study by Hansen & Tarp (2001) looks at the relationship between foreign aid and growth in real GDP per capital. By using panel data, they find that foreign aid does positively affect growth via investment. However, when investment and human capital are controlled, no positive effect of aid is found. They suggest that more theoretical work in need to identify the effects of aid on growth. Similarly, other studies have also found mixed results when it comes to positive effect on growth induced by foreign aid (Ekanayake & Chatrna 2010; Doucouliagos & Paldam 2009).

Carbon intensity measures the amount of carbon emitted for per unit of energy. A study by Boly (2017) looks at the effect of foreign aid on particularly carbon emissions in 112 recipient countries. The author found that multilateral aid was more effective in bringing down carbon emissions compared to bilateral aid. Thus, it can be deduced that foreign aid can most likely lead to a fall in carbon intensity of energy.

Kretschmer et al (2011) also looks at the effects of foreign aid on energy and carbon intensity in developing countries using a very similar technique. The results showed that foreign aid can be effective in reducing the energy intensity of GDP; however, it is not effective when it comes to carbon intensity of energy. But singling out Bangladesh from the rest of the developing nations, we find that foreign aid can lead to a reduction to both energy and carbon intensity. However, the magnitude of foreign aid on energy intensity is much lower when compared to carbon intensity of energy.

In this paper we will investigate the degree of impact of foreign aid on carbon emission and energy intensity. Thus, we will apply two econometric estimation approaches (GMM and DOLS). It is worth to mention that hypothesis testing is no necessary in any estimation process.

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 (expect foreign aid) 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.

Non stationary data may lead to specious regression in the context of time series analysis unless there is at least one cointegration relationship (Amin, 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 & 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

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.

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

In equation (2), 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 (2) allows the possibility that some or all elements of explanatory variables are related with the error term. Then endogenity problem will arise. It is well known that if z_t contains endogenous variables then the least squares estimator of δ in (2) 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.

$$E[g_t(w_t,\delta) = E[x_t\varepsilon_t] = E[x_t(Y_t - z_t\delta] = 0 \quad (3)$$

Rewriting equation (3) gives,

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

Where $\sum xy$= $E[x_tY_t]$ and $\sum xz$ =$E[x_tz_t]$. For identification of δ, it is required that the K × L matrix $E[x_tz_t] = \sum xz$ 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 value.

The Dynamic OLS (DOLS) approach was proposed by Stock & 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. If Y_t is the dependent variable with regressors $X_{i,t}$i=1,2,3…,n then,

$$Y_t = \beta_1 X_{1,t} + \beta_2 X + \cdots + \beta_k X_{k,t} + \sum \alpha_{i\Delta} X_{1,t-1} + \sum y_{i\Delta} X_{2,t-1} + \cdots + \sum \delta_{i\Delta} X_{k.t-1} + \varepsilon_t \quad (4)$$

The paper is based on annual data covering the period of 1980-2015. Data on carbon emission (kilo ton) per capita, energy use per capita (kg of oil equivalent, real income GDP) and foreign aid 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 36 observations are available at most. Small sample size might be problematic in finding the long run relationship.

4. Results and Discussions

Table 1 shows the ADF statistics and corresponding critical values of all the variables in their level and first differenced forms. Optimal lag is chosen by *Schwartz Information Criterion (SIC).*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 stationary, 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.

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

Panel 1: Levels			
Variable	**ADF Statistics (Only Constant)**	**ADF Statistics (Constant & Trend)**	**Decision**
LNEC	1.148353	-2.205918	Non Stationary
LNAID	-2.8226	-4.1335	Non Stationary at constant but Stationary at constant and trend
LNGDP	2.6266	-0.7189	Non Stationary
LNCO	-1.144677	-4.657326	Non Stationary at constant but Stationary at constant and trend
Panel 2: First Differences			
Variable	**ADF Statistics (Only Constant)**	**ADF Statistics (Constant & Trend)**	**Decision**
LNEC	-7.313449	-7.809703	Stationary
LNAID	-10.36316	-10.17134	Stationary
LNGDP	-3.7543	-4.7776	Stationary
LNCO	-5.323884	-5.425058	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

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 three cointegrating relationships at 90%.

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

	Null Hypothesis	Alternative Hypothesis	Statistics	90% Critical Value
LNEC, LNGDP, LNCO and LNAID	None	(At Most One)	85.46 (43.41)	50.52 (32.27)
		At Most Two	21.67	17.98
		At Most Three	6.67	7.56

Table 3b: Johansen Test for Cointegration (Maximum Eigen Value Test)

	Null Hypothesis	Alternative Hypothesis	Statistics	90% Critical Value
LNEC, LNGDP, LNCO and LNAID	None	(At Most One)	49.08 (21.84)	26.92 (20.05)
		At Most Two	15.49	13.90
		Ay Most Three	6.07	7.56

Now, we move to check the long run coefficient results as per our research question. As mentioned above, we have used DOLS and GMM for long run estimation. For DOLS approach fixed leads and lag has been chosen. The adjusted R^2, standard error of regression value suggest that the proposed model is significant. On the other hand, the coefficient values have expected sign as well as significant.

Table 4a: Results of GMM and DOLS Estimation

Variable (Dependent= LNEC)	Coefficient (GMM)	Coefficient (DOLS)
LNAID	-0.18 (0.000)	-0.22 (0.0005)
LNGDP	0.35 (0.000)	0.38 (0.0000)
Adjusted R^2	0.91	0.92
SE of Regression	0.077	0.066

Probability in ( )

Table 4a shows the first part of the estimation results. Here, energy consumption intensity is the dependent variable. We can see that the coefficient of foreign aid has a negative sign (expected) and significant as well. Moreover, coefficient value is highly inelastic (from both estimation approach). Thus, a percentage change in energy consumption intensity will be much lower than the percentage change in the foreign aid. On the other hand, the coefficient of GDP (real income) is also inelastic and significant as well. However, the value is higher than the value of foreign aid coefficient. As the value is positive, it infers that energy is a normal commodity and increase in real income would increase consumption of energy in the long run.

Table 4b: Results of GMM and DOLS Estimation

Variable (Dependent=LNCO)	Coefficient (GMM)	Coefficient (DOLS)
LNAID	-0.75 (0.000)	-0.89 (0.000)
LNGDP	1.103 (0.001)	1.14 (0.000)
Adjusted R^2	0.89	0.95
SE of Regression	0.24	0.12

Probability in ( )

Now, Table 4b shows the second part of estimation results, where carbon emission intensity is the dependent variable. From the table, we can see that the coefficient of foreign aid is negative in sign and significant as well. On the other hand, the value (from the both estimation approach) is inelastic meaning that percentage change in carbon emission intensity will be less than percentage change in foreign aid. The coefficient value of GDP (real income) is elastic and significant as well. The value is also positive which indicates that parentage change in carbon emission will be higher than the percentage change in real income of the nation. The positive relation between GDP and carbon emission is consistent with Kuznets hypothesis for developing countries as well.

5. Conclusion

In this paper we have examined the impact of foreign aid on energy consumption and carbon emission intensity with the help of annual data ranging from 1990-2015. We found that variables are cointegrated in the long. Estimated long run coefficient of energy consumption intensity is negative and inelastic as well as significant. The result is similar to (Nunnenkamp et al 2010). Carbon emission intensity is negative and inelastic as well as significant which is different from the former stated study where it was found that foreign has no effect of carbon emission intensity. The results answer our research question.

As Bangladesh is of the emerging countries of the world, still different types of aid might be needed to fulfil the development objectives of the government. As we have seen from our results that both carbon and energy intensity has a negative relation with aid, proper policies should be taken so that mechanisms are introduced to reduce carbon intensity and energy conservation to attract different types of foreign aid from different donors around the world. However, to attract aid, energy consumption conservation and low carbon emission should not affect the on-going development process.

Lack of data availability is one of the main limitations of this paper. We have used a small sample data. No credible data were available before 1971 as Bangladesh got independence in 1971. This paper can be further extended by looking at the effect of foreign aid on energy consumption at disaggregated level to come up with effective policy frame work. On the other hand, an analysis can be done to examine effect of foreign aid on sectoral carbon emission as well. The paper can be even extended by exploring the impact of foreign aid on energy and carbon intensity in South Asian region or in Asian region to make generalization.

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