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Review Article

The Impact of Macroeconomic Variables on Bangladesh's Economic Growth- A VEC Model and Granger Causality Test Analysis

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Abstract *- This research investigates the impact of macroeconomic variables (official exchange rate, the long term external debt stocks, and terms of trade adjustment) on the economic growth (GDP growth rate) of Bangladesh over 27 years from 1972 to 2018. VEC model and pair-wise Granger causality test is used to understand the type of relationship and the impact of variables on economic development. The study finds that although there is no evidence of short-run causality running from independent variables (OER, ED, and TTA) to GDPG, in long run, OER and ED have a significant positive impact on GDPG, whereas TTA has a significant negative impact, on average, ceteris paribus. Besides, when 1 lag is applied according to all information criteria, the study finds that there is a unidirectional causality running from all independent variables (OER, ED, and TTA) to GDPG.*

Keywords *- GDPG, OER, ED, TTA, VEC MODEL, GRANGER CAUSALITY TEST.*

I. INTRODUCTION

Economic growth refers to the ability of an economy to increase its production capacity through which it becomes more capable of producing additional units of goods and services. This economic growth is also seen as holly grain for economic policies. (Muhammad waqas chughtai, Muhammad waqas malik, and Rashid Aftab. 2015). Various economic indicators such as Human Development Index (HDI), Total Factor Productivity (TFP), and Gross Domestic Product Growth Rate (GD), etc are used to measure the economic growth of a country (Smyth, 1995). Past empirical studies find a mixed result concerning the relationship between macro-economic variables and economic development of various country contexts. Moreover, a few works have been done on Bangladesh to develop a macro-econometric model and examine the relationship between them. Besides, no study has been done yet to develop a model by considering the impact of total reserves minus gold, long-term external debt stocks, and terms of trade adjustment on economic growth as a whole. Thus, this study tries to develop a model to examine the impact of total reserves minus gold, long-term external debt stocks, and terms of trade adjustment on economic growth as a whole. The primary objective of this paper is to analyze the empirical strength of short-run and long-run impact of the macro-economic variables (total reserves minus gold, long-term external debt stocks, and terms of trade adjustment) on the economic development (GDP growth rate) of Bangladesh over the period 1972 to 2018. Unit root test, co-integration tests, vector error correction model, and Wald test is used to examine the dynamic relationships among macro-economic variables. The outcome of the study will help the government to take the right policies, as well as the researchers to do further research. The study uses three independent variables and one dependent variable (table-2) to examine the dynamic relationships among them. The analysis comprises 7 steps: first, descriptive statistics explain the comparative analysis of the mean, standard deviation, maximum and minimum value, second: graphical analysis will discover the trends of each variable, third: correlation coefficient examines the co-relationship among variables, forth: the study examines the data stationary, fifth: it examines the number of co-integration relationships among the macroeconomic variables, and uses the error correction terms from the co-integrating vectors in VEC models; finally, it uses Wald test to discern short-term relationships among the macro variables. The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 discusses the methodology used in this paper. Section 4 presents the data, model specification, and results. Section 5 presents the conclusion.

II. LITERATURE REVIEW

The existing kinds of literature are summarized below:

Table 1. Summary of existing literature

Title, Researcher name & Publication Year	Period & Variables	Estimation model	Summary of result
Impact of Macroeconomic Variables on Economic Growth: Bangladesh Perspective by Yeaseen Chowdhury, Md. Kaysher Hamid, and Rowshonara Akther Akhi in 2019	1987-2015, Dependent variable: GDP growth, Independent variables: inflation (INF), real interest rate (INT), an exchange rate (EXR), and household consumption expenditures growth (HCE)	Correlation and multiple regression analysis	The study finds that GDP is positively correlated with all variables except the real interest rate (INT). It also finds that macroeconomic variables have a significant effect on the economic growth of Bangladesh.
The effect of macroeconomic variables on economic growth: A cross-country Study by Dang Van Dan, and Vu Duck Binh in 2019	1996- 2016, Dependent variable: GDP growth rate, Independent variables: High-level domestic investment, Labor and trade openness, inflation, money supply, and interest rate	GMM (System - Generalized method of moments)	High-level domestic investment, labor, and trade openness have a significant positive effect on economic growth, whereas, inflation, money supply, and interest rate harm growth in developing countries.
Impact of macroeconomic variables on GDP: Evidence from Pakistan by Abid Hussain, Hazoor M. Sabir and Mirza Muhammad Kashif in 2016	1980-2011, Dependent variable: GDP Independent variables: Inflation, Real exchange rate, and interest rate.	Descriptive statistics and multiple regression	Inflation and interest rate have a significant negative impact on GDP, whereas the exchange rate has a significant positive impact on GDP.
Effect of macroeconomic variables on economic growth in Botswana by Strike Mbulawa in 2015	1975-2012, Dependent variables: GDP Independent variables: FDI, Inflation	VEC and VAR model	Maintaining low inflation with the 3-6% target and high levels of FDI are vital for growth.
Impact of macroeconomic variables on economic performance: An empirical study of India and Sri Lanka by Gagan Deep Sharma, Sanjeet Singh, and Gurvinder Singh in 2011	2002-2009, Dependent variables: GDP, and GNI Independent variables: Wholesale price index, Consumer price index, Exchange rates, Bank rates, and Balance of payments	Granger Causality Test, VEC, and Variance Decompositio n Analysis	After applying all the models on the data of both the countries the results do not lead to any clear-cut conclusion.
Impact of macroeconomic factors on economic growth in Ghana: A cointegration analysis by Samuel Antwi, Ebenezer Fiifi Emire Atta Mills and Xicang Zhao in 2013	1980-2010, Dependent variables: Real per capita GDP. Independent variables: Physical capital, Labor force, Foreign direct investment, foreign aid, Inflation, and Government expenditures.	Co-integration analysis	The study found a co-integration relationship between real GDP per capita (economic growth) and its macroeconomic factors.

Impact of major macroeconomic variables on the economic growth of Pakistan by Muhammad Waqas Chughtai, Muhammad Waqas Malik, and Rashid Aftab in 2015	1981-2013, Dependent variable: economic growth; Independent variable: exchange rate volatility; interest rate; inflation;	Multiple linear regression model	The inflation rate and interest rate spread negatively whereas, the exchange rate positively impacts the economy.
Exploring the Impact of Macro Economic Variables on GDP Growth of Pakistan by Umar Kibria, Muhammad Usman Arshad, Muhammad Kamran, Yasir Mehmood, Saima Imdad and Muhammad Sajid in 2014	1980-2013, Dependent variable: GDP growth. Independent variable: Inflation, Interest Rate, Exchange Rates, and FDI.	The correlation coefficient, Regression analysis, and Granger causality test	Inflation, interest rate, exchange rate, and FDI have a significant impact on GDP growth.
Impact of Fiscal Variables on Economic Development of Pakistan by Zaheer Khan KAKAR in 2011	1980-2009, Dependent variables: GDP growth rate. Independent variables: Net taxes revenue, Real interest rate, Public expenditure, Consumer price index, Capital stock, and Population growth rate.	Co-integration, VER, and Granger causality test	Fiscal policy is very important for sustainable economic growth in Pakistan and results also indicates that fiscal Policy measures are more of long-run phenomena rather than short-run.
The Impact of key Macroeconomic factors on Economic Growth of Bangladesh: A VAR Co-integration Analysis by Md. Arphan Ali, Md. Khaled Saifullah, and Fatimah Binti Kari in 2015	1988-2012, Dependent variables: Real GDP Independent variables: capital market, foreign direct investment, and real interest rate	Co-integration and VAR Analysis	In long run, all variables have effects on economic growth, while in the short-run all variables don't have any effects, and the magnitude of effects increases with time.

III. RESEARCH METHODOLOGY

The research methodology comprises of the sample, data Collection Methods, theoretical framework/conceptual framework, explanation of dependent and independent variables, hypothesis, and model developed.

A. Sample

GDP growth rate, official exchange rate, the long term external debt stocks, and terms of trade adjustment of Bangladesh are taken over 27 years from 1972 to 2018.

B. Calculation of Variables

Table 2. Variables

Variables	Short-form	Formulae
GDP growth rate	GDPG	The annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

Official exchange rate	OER	Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).
External debt stocks, long-term	ED	Long-term debt is debt that has an original or extended maturity of more than one year. It has three components: public, publicly guaranteed, and private nonguaranteed debt. Data are in current U.S. dollars.
Terms of trade adjustment	TTA	The terms of trade effect equal capacity to import less export of goods and services at constant prices. Data are in constant local currency.

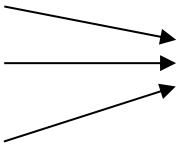
C. Data Collection Methods

Secondary data are used for this study. Data (appendix 1) was collected from the following sources.

a. World bank
b. Bangladesh bank

D. Conceptual Framework

Based on the literature review the conceptual framework is developed as follows:

Independent Variables		Dependent Variable
1. External debt stocks, long-term **2.** Official exchange rate **3.** Terms of trade adjustment		GDP growth rate

E. Model specification

The researcher specifies the economic growth function for Bangladesh as follows: GDP growth rate is a function of the official exchange rate, the long term external debt, and terms of trade adjustment. It is mathematically expressed as follows:

GDPG = f (OER, ED, TTA) ---------- EQ. (A.1)

Thus, our growth function becomes

$$GDPG_t = \beta_1 OER_t + \beta_2 ED_t + \beta_3 TTA_t + \varepsilon_t ------- EQ.(A.2)$$

Where,

$GDPG_t$ Represents the GDP growth rate at time t,

OER_t represents official exchange rate at time t,

ED_t represents External debt stocks, long-term at time t,

TTA_t represents Terms of trade adjustment at time t,

ε_t is the error term.

$\beta_1, \beta_2, and \beta_3$ are the partial elasticity of GDP growth rate concerning $OER_t, ED_t and TTA_t$ respectively.

a) Unit root test

Augmented-Dickey-Fuller (ADF) is important to avoid spurious regression which is a common problem when estimating a regression line with data whose generated process follows a time trend. The equation of the ADF test:

$$\Delta Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_{2t} + \sum_{i=0}^{p} A_1 \Delta Y_{t-1} + Z_t ----------EQ.(A.3)$$

Where,

Y_t is a vector for all-time series variables.

t is a time trend variable.

Δ denotes the first difference operator;

Z_t is the error term.

b) Vector Error correction model (VEC)

The error correction term lagged one period, which integrates short-run dynamics in the long-run growth function is shown below through the error correction model (ECM):

$$\Delta GDPG_t = \alpha_1 + \sum_{i=1}^{p} b_{2i} \Delta GDPG_{t-1} + \sum_{i=0}^{p} c_{3i} \Delta OER_{t-1} + \sum_{i=0}^{p} d_{4i} \Delta ED_{t-1} + \sum_{i=0}^{p} e_{5i} \Delta TTA_{t-1} + \lambda_6 EMT_{t-1} + \varepsilon_{2t} ----EQ.(A4)$$

Where,

EMT_{t-1} –is the error correction term.

ε_{2t} is similar to that of ε_{1t}

Δ represents the first-differenced form of the variables in the model.

b2i, c3i, d4i, e5i, are the impact multipliers that measure the immediate impact that a change in the explanatory variable has on a change in the dependent variable.

λ represents the speed of the adjustment parameter. The value of λ must between the range-1 ≤ λ ≤ 0 and must be statistically significant.

IV. RESULT AND DISCUSSIONS

A. Descriptive statistics

Table 3. Descriptive statistics

Statistics	GDPG	OER	ED	TTA
Mean	4.522673	44.53271	1.33E+10	-3.41E+10
Median	5.077288	40.27832	1.44E+10	-2.89E+09
Maximum	9.591956	83.46620	3.67E+10	1.51E+11
Minimum	-13.97373	7.700184	78648255	-2.09E+11
Std. Dev.	3.483847	23.90446	8.89E+09	8.15E+10
Skewness	-3.502509	0.095574	0.336713	-0.993944
Kurtosis	18.68783	1.712011	2.545899	3.389016

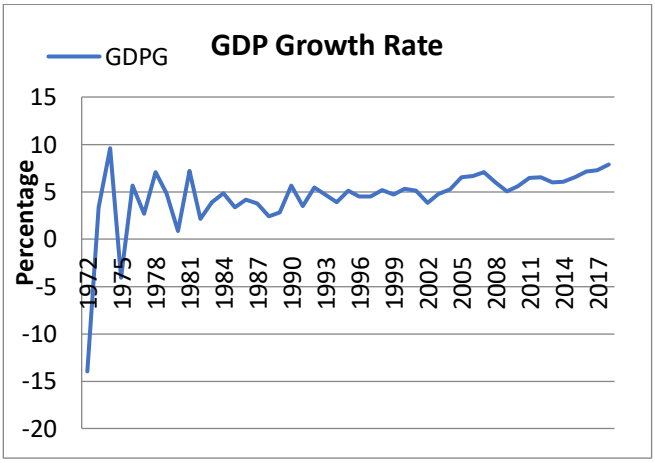
Jarque-Bera	578.0578	3.320266	1.291932	8.035101
Probability	0.000000	0.190114	0.524156	0.017997
Sum	212.5656	2093.037	6.25E+11	-1.60E+12
Sum Sq. Dev.	558.3108	26285.48	3.64E+21	3.06E+23
Observations	47	47	47	47

Source: Author's calculation (using Eviews)

The above table describes the descriptive statistics of all dependent and independent variables for 27 years. The highest mean value is observed for OER that is 44.53 with an std. deviation of 23.90, compared to the lowest mean value of TTA that is -33,80,00,00,000 with an std. deviation of 81,70,00,00,000. The mean value and std. deviation of ED is 13300000000 and 8890000000 respectively. The average GDP growth rate for the stipulated period is 4.52% with an std. deviation of 3.483847. The range value for GDPG, OER, ED, and TTA are 23.565686, 75.766016, 36621351745, and 360,00,00,00,000 respectively.

B. Graphical Analysis of the variables

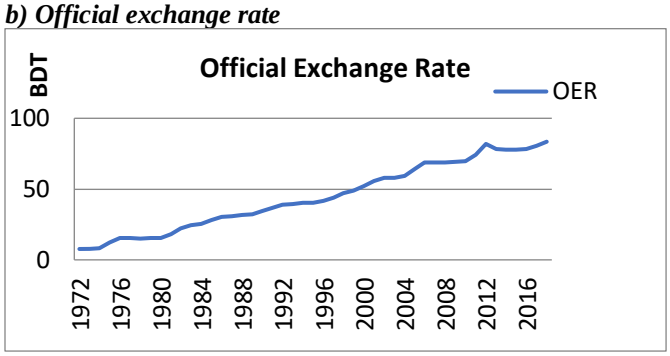
a) GDP growth rate



Graph A.1: GDP growth rate

The negative growth rate (-13.98%) of GDPG is observed in the following year after the independence of Bangladesh and in 1975 which is -4.09%. Also, the growth rate of GDP is largely fluctuated (drastically increased and decreased) from 1972 to 1982. After then, the GDPG followed a steady growth with a little fluctuation. From 1990 to 2018 the rate lies between 4.00% and 7.86%. In 2013, the rate was 6.01% that increased to 6.06% in 2014 and 6.55% in 2015. The percentage increase in GDPG is 2.40% and 7.90% in 2017 and 2018 respectively. To sum up, the growth rate of GDP is upward sloping.

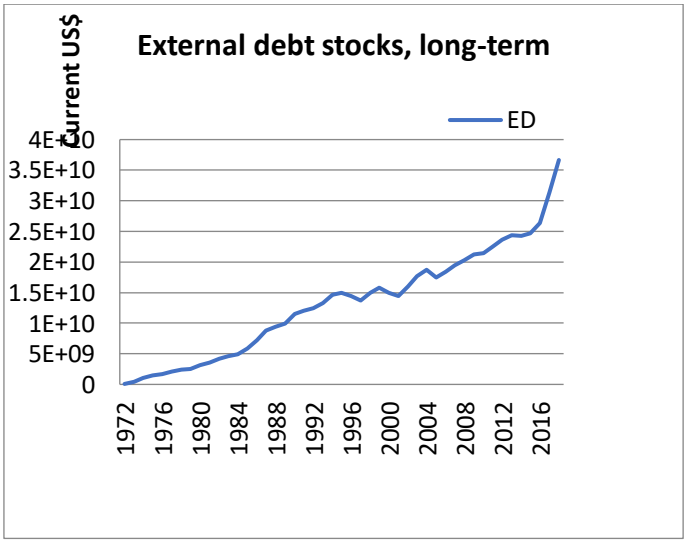
b) Official exchange rate



Graph A.2: Official Exchange Rate

The above graph describes the trend of the official exchange rate of Bangladesh over 27 years from 1972 to 2018. From the above graph, it is evident that the growth rate of the official exchange rate is upward sloping. The official exchange rate is BDT 7.70 in 1972 and gradually increased to 83.47 in 2018. The annual percentage growth of the exchange rate was negative in 1977, 1978, 1980, 2008, 2013, and 2014 over the 27 years. The annual growth rate of the exchange rate in 1977, 1978, 1980, 2008, 2013 and 2014 were -0.00156298, -0.02334836, -0.0062929, -0.00084659, -0.00401598, -0.04592354, and -0.00591303 respectively. The annual percentage growths of the official exchange rate for the last four years are 0.39%, 0.67% 2.51%, and 3.77% respectively.

c) External debt stocks, long-term

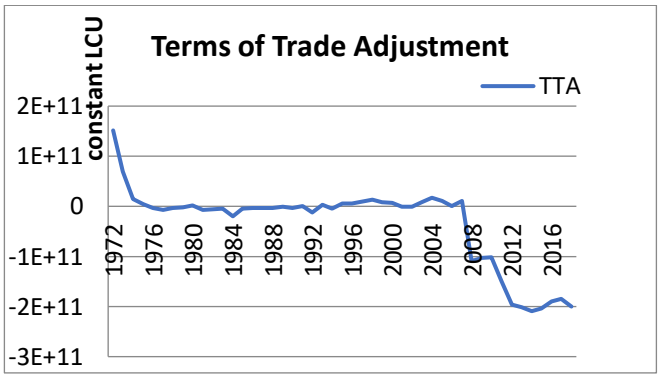


Graph A.3: External debt stocks, long-term

The above graph describes the trend of total long term external debt stocks of Bangladesh over 27 years from 1972 to 2018. Overall, the variable follows an upward sloping trend. The variable drastically increased to $421896516.2 from 78648255 in 1973. Also, the annual percentage of growth was 436.43% in 1973. After then, the annual growth

rate is gradually decreased over the period and reached 16.87% in 2018. The long term external debt stocks were $24418750928, $24276138563, $24717584825, $26347527780, $31370889913, $36664122916 in 2013, 2014, 2015, 2016, 2017, and 2018 respectively.

d) Terms of trade adjustment (constant LCU)



Graph A.4: Terms of Trade Adjustment

The above graph describes the trend of terms of trade adjustment of Bangladesh over 27 years from 1972 to 2018. Overall, the variable follows a downward sloping trend. The graph also shows how terms of trade adjustment (constant LCU) varies by year. The highest value of the Terms of Trade Adjustment of BDT 151440000000 is observed in 1972 compared to the lowest value of BDT -209272000000 in 2014. The average annual growth rate of terms of trade Adjustment is -7.02%.

C. Correlation Matrix:

Table 4. Correlation Coefficient Matrix

	GDPG	OER	ED	TTA
GDPG	1			
OER	0.4681357736006181	1		
ED	0.4638516743053491	0.9685873033730199	1	
TTA	-0.4948593070216746	-0.7468496601201199	-0.7597960608809244	1

The correlation coefficient shows the direction and degree of association between the variables. The highest positive correlation (96.86%) prevails between ED and OER, compared to the lowest positive correlation (46.38%) between ED and GDPG. The correlation coefficient between GDPG and ED is 46.38% which means that ED is positively correlated with GDPG. All the variables except TTA are positively correlated with GDPG. The correlation coefficient between GDPG and TTA is -49.48% that indicates a negative correlation between GDPG and TTA. Besides, all variables are negatively correlated with TTA.

D. Test of stationary

The ADF test is performed to examine the stationary of the variable. At first, the Augmented Dickey-Fuller test is performed at their primary level. If the probability is less than.05, then the null hypothesis is rejected. Alternatively, if the absolute value of the ADF test is more than the tabulated critical value of the ADF test at a 5% level of significance, then the null hypothesis is rejected. The hypothesis developed in this context is:

H_0 : The data is not stationary (there is a unit root)

H_1 : The data is stationary (there is no unit root)

Table 5. ADF test of the reliability of variables at the primary level

Variables	Statistics	Probability	Result
GPP growth rate (GDPG)	-0.290558	0.9176	Non-stationary
Official exchange rate (OER)	-0.002051	0.9534	Non-stationary
Long term external debt stocks (ED)	1.944488	0.9998	Non-stationary
Terms of trade adjustment (TTA)	-1.334761	0.6055	Non-stationary

Based on the output of the ADF test, the variables are non-stationary at a 5% level of significance. So, there is a stochastic trend and variables are non-stationary. As variables must be stationary within the first difference to conduct the Granger casual analysis, the ADF test is done again at their first difference to make variables stationary and deal with stochastic trends.

Table 6. Result of the ADF test of the reliability of variables at first difference

Variables	**Statistics**	**Probability**	**Result**
GPP growth rate [D(GDPG)]	-3.874782	0.0048	Stationary
Long term external debt stocks [D(ED)]	-3.082651	0.0352	Stationary
Official exchange rate [D(OER)]	-6.277457	0.0000	Stationary
Terms of trade adjustment [D(TTA)]	-6.329634	0.0000	Stationary

The above table summarized the output of the ADF test at their first difference. As the probabilities of each variable are less than.05, the null hypothesis is rejected for each variable at a 5% level of significance. So, there is no stochastic trend and variables are now stationary at a 5% level of significance

E. Optimal Lag Length

The study uses the Schwarz information criterion to determine the leg length. From the below table it is found that the study uses 1 leg for all tests.

Table 7. Optimal Lag Length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2372.577	NA	1.19e+43	110.5384	110.7023	110.5989
1	-2186.764	328.4132*	4.45e+39*	102.6402*	103.4593*	102.9423*
2	-2174.863	18.82036	5.49e+39	102.8308	104.3053	103.3746
3	-2160.373	20.21877	6.21e+39	102.9011	105.0309	103.6865
4	-2152.082	10.02555	9.87e+39	103.2596	106.0448	104.2867

F. Co-integration analysis:

To examine the long-run relationship between variables Johansen long-run co-integration test is performed. The co-integration test is done by using 1lag according to all information criteria and performed on the level form. The hypothesis developed for this test is:

H_0 : **There are no co-integration relationship**

H_1 : **There is at least 1 co-integration relationship.**

Decision criteria: If the value of the Trace and Max statistics is greater than the 5% critical value then we reject the null hypothesis, which will mean that there is no co-integration relationship between the variables. Likewise, if the p-value is smaller than .05 we reject the null hypothesis. The summarized result of Johansen long-run co-integration test is presented in the below table:

Table A.8: Result of Johansen long-run co-integration test

Statistics	Hypothesized No. of CE(s)	Eigenvalue	Trace/Max statistics	Critical value at the 0.05 level	Probability
Trace	None *	0.808911	93.12806	47.85613	0.0000
	At most 1	**0.187466**	**18.65226**	**29.79707**	**0.5181**
	At most 2	0.150323	9.310368	15.49471	0.3375
	At most 3	0.043044	1.979908	3.841466	0.1594
Maximum Eigen-value	None *	0.808911	74.47580	27.58434	0.0000
	At most 1	**0.187466**	**9.341893**	**21.13162**	**0.8039**
	At most 2	0.150323	7.330460	14.26460	0.4508
	At most 3	0.043044	1.979908	3.841466	0.1594

Both Trace and Max-eigenvalue tests indicate that there is a 1cointegration equation for variables at a 5% level of significance. In the long run, OER and ED have a positive impact, while TTA harms GDPG, on average, ceteris paribus. The coefficients are statistically significant at the 1% level. So, the null hypothesis of no co-integration is rejected against the alternative of a co-integrating relationship in the model.

The normalized vector for long run relationship is estimated as follows:

$$ECT_{T-1} = 1.00\text{GDPG}_{t-1} + 0.042931 \times OER_{t-1} + 0.0000000000012 \times \text{ED}_{t-1} - 0.00000000000107 \times \text{TTA}_{t-1} - 2.897396$$

(0.02630) (7.6E-11) (2.2E-12)

In the long run, a percentage change in OER is significantly associated with a 4.29% increase in GDPG, on average, ceteris paribus. Similarly, a percentage change in ED will result in a significant little increase of 0.00000000012% in GDPG, on average, ceteris paribus in the long run. Also, a percentage change in TTA is associated with a 0. 0000000791% significant increase in GDPG, on average, ceteris paribus in the long run. To sum up, all the independent variables have a significant impact on GDPG on average, ceteris paribus in the long run.

The VECM model with GDPG as target variable is as follows

$$\Delta GDPG_t = -1.984278 ECT_{t-1} + 0.332550 GDPG_{t-1} - 0.030291 OER_{t-1} + 0.0000000000674 \text{ED}_{t-1} + 0.00000000000791 \text{TTA}_{t-1} + 0.005017$$

Table A.9: Vector error correction model short term result

Dependent Variables		Coefficient	Std. Error	t-Statistic	Prob.
D(GDPG)	**C(1)**	**-1.984278**	**0.158199**	**-12.54290**	**0.0000**
	GDPG	0.332550	0.075633	4.396912	0.0001
	OER	-0.030291	0.113910	-0.265919	0.7917
	ED	6.74E-11	2.31E-10	0.291520	0.7722
	TTA	7.91E-12	9.14E-12	0.865089	0.3923
	Constant	0.005017	0.337732	0.014854	0.9882
D(OER)	**C(7)**	**0.145659**	**0.219296**	**0.664212**	**0.5105**
	GDPG	-0.057330	0.104842	-0.546817	0.5876
	OER	0.153517	0.157902	0.972231	0.3369
	ED	-2.07E-10	3.20E-10	-0.645978	0.5221
	TTA	3.14E-12	1.27E-11	0.247848	0.8056
	Constant	**1.626742**	**0.468165**	**3.474718**	**0.0013**
D(ED)	**C(13)**	**31436625**	**1.11E+08**	**0.282323**	**0.7792**
	GDPG	9838616.	53234751	0.184816	0.8543
	OER	69694225	80176340	0.869262	0.3900
	ED	0.696941	0.162705	4.283472	0.0001
	TTA	0.003112	0.006432	0.483800	0.6312
	Constant	**2.27E+08**	**2.38E+08**	**0.953791**	**0.3461**
D(TTA)	**C(19)**	**1.96E+09**	**2.55E+09**	**0.767654**	**0.4473**
	GDPG	-1.58E+09	1.22E+09	-1.297464	0.2021
	OER	4.57E+08	1.84E+09	0.248453	0.8051
	ED	-2.110828	3.730854	-0.565776	0.5748
	TTA	0.090385	0.147494	0.612806	0.5436
	Constant	-3.85E+09	5.45E+09	-0.705840	0.4845

The previous period's deviation from long-run equilibrium is corrected in the current period at an adjustment speed of 198.4% that is statistically significant at a 1% level of significance. Also, c(1) is negative and significant which shows there is evidence of long-run causality running from independent variables (OER, ED, and TTA) to GDPG.

A percentage change in OER is insignificantly associated with a 3.03% decrease in GDPG, on average, ceteris paribus in the short run. Moreover, A percentage change in ED will result in an insignificant increase of .00000000674% in GDPG, on average, ceteris paribus in the short run. Besides, a percentage change in TTA is associated with .000000000791 insignificant increase in GDPG, on average, ceteris paribus in the short run.

Table 10. Wald Test

Test Statistic	Value	Df	Probability
F-statistic	0.326256	(3, 39)	0.8064
Chi-square	0.978769	3	0.8064

The result of the Wald test accepts the null hypothesis that Independent variables (OER, ED, and TTA) does not Granger cause GDPG in the short run. So, there is no evidence of short-run causality running from independent variables (OER, ED, and TTA) to GDPG.

a) Testing the model

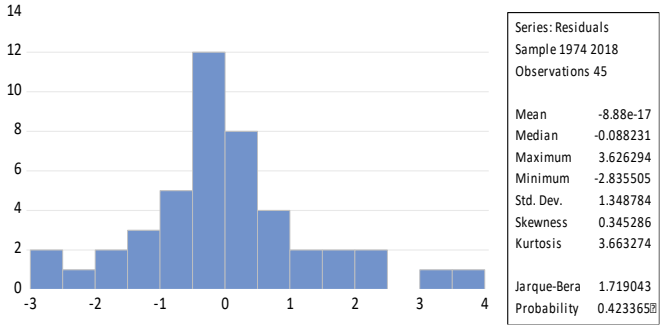
VEC Residual Serial Correlation LM Tests

The VEC Residual Serial Correlation LM Tests accept the null hypothesis that "No serial correlation at lag h". That means that there is no serial correlation problem in this model.

Table 11. VEC Residual Serial Correlation LM Tests

Lag	LRE* stat	df	Prob.	Rao F-stat	Df	Prob.
1	25.06131	16	0.0688	1.650794	(16, 98.4)	0.0697

b) Normality test:



Graph A.5: the normal curve of the residuals

The histogram conveys that the residuals are normally distributed for the overall model. The probability value of Jarque-Bere is more than 5% that rejects the null hypothesis and concludes that overall, for the entire model, the residuals are normally distributed.

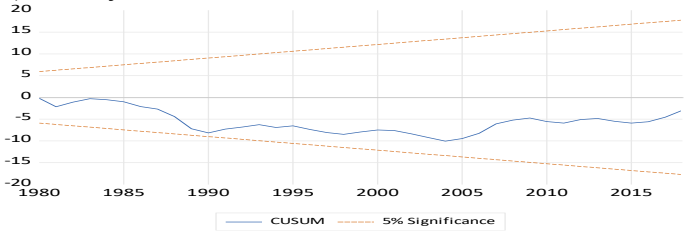
c) VEC Residual Heteroskedasticity Tests:

Table 12. VEC Residual Heteroskedasticity Tests (Includes Cross Terms)

Joint test:		
Chi-sq	df	Prob.
204.5852	200	0.3971

The probability value of the Chi-sq test is more than 5% which means that the model is not heteroskedastic.

d) Stability test:



Graph A.6 the result of the CUSM test

The CUSM test indicates that the model is stable at a 5% level of significance.

G. Pair-wise Granger causality test:

Granger causality test is used to examine the structure of the relationship between variables. Additionally, it is a hypothesis test to determine the ability of one-time series data to forecast other time-series data. The Granger causality test is done by using 1 lag according to the AIC/Schwarz information criterion. If the probability value or P-value is less than 5%, then the null hypothesis would be rejected ted and the alternative hypothesis would be accepted.

Table 13. Result of Granger Causality test:

Null Hypothesis:	Obs	F-Statistic	Prob.
OER does not Granger Cause GDPG	46	18.8045	9.E-05
GDPG does not Granger Cause OER		0.57838	0.4511
ED does not Granger Cause GDPG	46	18.2393	0.0001
GDPG does not Granger Cause ED		0.01023	0.9199
TTA does not Granger Cause GDPG	46	7.83573	0.0076
GDPG does not Granger Cause TTA		2.51888	0.1198
ED does not Granger Cause OER	46	1.05775	0.3095
OER does not Granger Cause ED		1.01302	0.3198
TTA does not Granger Cause OER	46	0.59743	0.4438
OER does not Granger Cause TTA		2.16564	0.1484
TTA does not Granger Cause ED	46	2.49046	0.1219
ED does not Granger Cause TTA		1.44474	0.2360

From the above table, when 1 lag is applied according to AIC/Schwarz information criterion, the study found that there is a **unidirectional** causality running from all variables (OER, ED, TTA) to GDPG.

The study found unidirectional causality running from OER to GDPG at a 1% level of significance. And the hypothesis that GDPG does not Granger Cause OER cannot be rejected at a 1% level of significance. There is also a unidirectional causality running from ED to GDPG. Similarly, the hypothesis that TTA does Granger Cause GDPG and GDPG does not granger cause TTA rejected and accepted at a 1% level of significance respectively. So, there is a unidirectional causality running from TTA to GDPG. All other hypothesizes are accepted at more than a 10% level of significance.

V. CONCLUSION

The study uses three independent variables and one dependent variable to examine the dynamic relationships between macro-economic variables (OER, ED, TTA) and the economic development (GDPG) of Bangladesh. The highest mean value is observed for OER that is 44.53 with an std. deviation of 23.90, compared to the lowest mean value of

TTA that is -33,80,00,00,000 with an std. deviation of 81,70,00,00,000. The range value for GDPG, OER, ED, and TTA are 23.565686, 75.766016, 36621351745, and 360,00,00,00,000 respectively. The graphical analysis concludes that all the variables except TTA are upward sloping. In terms of correlation, the highest positive correlation (96.86%) prevails between ED and OER, compared to the lowest positive correlation (46.38%) between ED and GDPG. Also, all the variables except TTA are positively correlated with GDPG. Unit root test indicates that all variables are stationary within their first difference. Both Trace and Max-eigenvalue tests indicate that there is a 1cointegration equation for variables at a 5% level of significance. The previous period's deviation from long-run equilibrium is corrected in the current period at an adjustment speed of 198.4% that is statistically significant at a 1% level of significance. In addition, there is evidence of long-run causality running from independent variables (OER, ED, and TTA) to GDPG. The result of the Wald test accepts the null hypothesis that Independent variables (OER, ED, and TTA) does not Granger cause GDPG in the short run. So, there is no evidence of short-run causality running from independent variables (OER, ED, and TTA) to GDPG. Furthermore, when 1 lag was applied according to all information criteria, the study found that there is a unidirectional causality running from all variables (OER, ED, TTA) to GDPG.

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APPENDIX A- ANALYZED DATA

Year	GDPG	OER	ED	TTA
1972	-13.97372870204391	7.700184168149499	78648255	151439708461.1804
1973	3.325680198783943	7.84981599931742	421896516.2	69738318238.76101
1974	9.591956300418445	8.22600224121538	1092747747.5	14130199898.26669
1975	-4.08821409181661	12.186180036989	1476222179.8	4869902782.040405
1976	5.66136120119667	15.3991686037548	1715457427.3	-2891727919.066559
1977	2.673056050019838	15.3750999994167	2050904857	-7384728274.579696
1978	7.073837732606919	15.01611666575	2448475243.5	-2792290464.314552
1979	4.801634600556625	15.5519249993333	2511352006.3	-1696290769.260429
1980	0.8191418688989103	15.4540583325	3166017459.9	1401205580.767006
1981	7.233943694907226	17.9866916658333	3516928364	-6907655973.030326
1982	2.134327835770748	22.1178833323333	4183903175.6	-5568425885.402611
1983	3.881046399817151	24.6154249995	4610914302.899999	-5185978990.548752
1984	4.803310015254383	25.35393338508331	4946492994.7	-19995259152.31176
1985	3.342014654154141	27.9945916666667	5875143938.6	-4101469320.514779
1986	4.173382559003997	30.4069	7249992405	-3514830843.989441

1987	3.772401852527054	30.9498333333333	8823135432.200001	-3105768068.071328
1988	2.416256855662226	31.7332485981559	9386544711.799999	-2986252087.058861
1989	2.836582129079261	32.27000000000001	9914962123.9	-1408994471.888771
1990	5.622258161607021	34.5688083333333	11510306592.7	-3760408440.923454
1991	3.485227815355202	36.5961833333333	12052093948.3	-70729703.01924134
1992	5.442685550721294	38.9507583333333	12462815387.6	-12865657861.19997
1993	4.711561724494473	39.56725749999999	13290060170.6	3424435622.903427
1994	3.890126440656431	40.21173916666671	14626859288.4	-4691362020.790421
1995	5.121277897161619	40.2783183333333	14914016246.4	5606426102.132004
1996	4.522919217623439	41.79416833333331	14489520831.9	5984040976.092988
1997	4.489896497356313	43.8921158333333	13710476215.1	8812429336.191743
1998	5.177026873452561	46.9056516666667	14938523575.9	13583840674.22299
1999	4.670156368278654	49.0854	15815248943.9	7998157818.343263
2000	5.293294718460402	52.1416666666667	14991732770.3	7141343313.180602
2001	5.077287775973119	55.8066666666667	14412428211.1	-191121595.7911682
2002	3.833123940056083	57.888	15983195571.8	-550446629.0137634
2003	4.739567399164457	58.15004	17682397657.6	8405174448.43509
2004	5.239532910452695	59.5126583333333	18700983878.1	16682428307.88037
2005	6.535944940523521	64.32747500000001	17441396955.5	10251965288.30432
2006	6.671904981481475	68.9332333333333	18437277215.8	10302677656
2007	7.0585993565727	68.874875	19484943090	10406828577.83753
2008	6.013789759233064	68.598275	20333430921.5	-109482007366.2478
2009	5.045124794177383	69.0390666666667	21243497803	-103518259020.7598
2010	5.571802273968657	69.6492916666667	21452652639.8	-101864710326.4479
2011	6.464383880475168	74.1524	22446592237.5	-150442040270.535
2012	6.52143507837333	81.8626583333333	23597735586.4	-196557982100.043
2013	6.013610365360194	78.103235	24418750927.9	-201376682664.6077
2014	6.061059359039575	77.6414083333333	24276138563.3	-209271677278.5337
2015	6.552639878692034	77.9469083333333	24717584824.5	-203349327500.8345
2016	7.113502459743899	78.4680916666667	26347527780	-189787349004.3052
2017	7.284184091951132	80.4375416666667	31370889913.2	-185341859519.9324
2018	7.863708892575417	83.4662019166667	36664122915.5	-200332932744.9971

Source: World Bank Website 1972-2018