Cointegration Analysis and Forecasting of the Export Function of Bangladesh Using the Error Correction Model

K M Saemon Islam (saemoninc@gmail.com)
Bangladesh Bank https://orcid.org/0000-0002-7093-3514
Gautam Kumar Biswas
Bangladesh Bank

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Cointegration Analysis and Forecasting of the Export Function of Bangladesh Using the Error Correction Model

Gautam Kumar Biswas

Deputy Director, Sustainable Finance Department, Bangladesh Bank (the Central Bank of Bangladesh)

K M Saemon Islam

Deputy Director, Debt Management Department, Bangladesh Bank (the Central Bank of Bangladesh)

Abstract

In this paper, we examined the relationship between the growth of the Gross Domestic Product of the United States, the export value index, and the export of Bangladesh over 37 years between 1980 and 2016. The results of our preliminary tests showed that there was indeed a long-run relationship between these variables. Based on our preliminary analysis, we employed an error-correction model to identify the relationship between the variables. The error-correction term with the expected negative sign was statistically significant, and it confirmed that in the case of disequilibrium, the convergence towards the equilibrium happened in the subsequent periods. Additionally, the econometric estimates exhibited that the two-period lagged values of the growth in export of Bangladesh and the growth of the Gross Domestic Product of the United States were also statistically significant.

Keywords: Export function, International trade, Cointegration, Error Correction Model.

JEL Classification: C22, C5, F41.

1. Introduction

Export is one of the major indicators of international trade for a country. As suggested by Altintas and Türker (2014), different countries have been focusing on regional trade integrations since the 1950s. Understandably, for trade balance as well as the accumulation of foreign exchange, export plays a crucial role. For a developing country like Bangladesh, the aggregate value of export is arguably even more significant. Ahmed et al. (1993) investigated the aggregate export-demand function of Bangladesh and found price and income to be inelastic. Numerous other studies have also focused on the export functions of different countries to identify the potential roles of other macroeconomic variables. As suggested by Balassa et al. (1989), the responsiveness of exports to different variables has been deemed to be fundamental in evaluating how effective were the policy measures.

In this paper, we aim to develop a small macro-econometric model for the aggregate export-growth function of Bangladesh. The following sections of this study are as follows: Section 2 of this study reviews the existing econometric pieces of literature to identify and observe the contribution of different macroeconomic variables on export. Section 3 specifies the econometric model of this study, and Section 4 describes the source and outline of the data. The following section 5 focuses on the empirical analysis and the evaluation of the results. Section 6 of this paper provides us the diagnostic assessments of the econometric model employed. Section 7 illustrates the impact of different components and forecasts the growth of the export of Bangladesh over the following periods, whereas section 8 provides the concluding remarks based on the findings.

2. Review of Existing Empirical Works of Literature

As discussed above, export is considered one of the major determinants for the economic growth of a country, especially for developing countries. Over the past few decades, several studies have been conducted to estimate the export function of different countries around the world.[1] In this section, we review some of the empirical literature on the export demand function.

Using cointegration analysis and multivariate Granger causation analysis, Altintas and Türker (2014) estimated the import and export functions of Turkey. In their export model, they found the existence of a one-way short-term Granger-causal link from foreign income, real exchange rate and export price

[1] *See, for example, Murad, S. M. Woahid (2012), Balassa, B., Voloudakis, E., Fylaktos, P., & Suh, S. T. (1989), Haider, J., Afzal, M. & Riaz, F. (2011), Kabir, R (1988), Dutta, D. and Ahmed, N. (2004) and Islam, T. (2016).*

towards export and foreign income, foreign direct investment, real exchange rates, and the export price are the Granger causes of export in the long run. In contrast, in the import model, they showed that there exists a Granger-causality link from Turkey's real GDP, foreign direct investment, and real exchange rate towards import in the long run. Additionally, single way causality links have been observed from foreign direct investment, real exchange rate, and import price to import.

Sandu and Ghiba (2011) analyzed the effect of the exchange rate on export volumes of Romania. By employing Vector Autoregressive Model (VAR), they found that exports of Romania have a negative relationship with the first lag of the exchange rate, and it is statistically significant, and in their study, they used quarterly data between 2003Q2 -2011Q1. Using the annual data from 1970 to 2006, Khattak and Hussain (2010) estimated the determinants of exports of Pakistan. In their study, they used the Johansen Cointegration test to find the long-term relationship among total exports, primary commodities exports, semi-manufacturers, and exports of manufactured goods. Furthermore, using Ordinary Least Squares (OLS), they found that an increase in primary commodities exports, semi-manufacturers, and exports of manufactured goods caused an increase in total export volume in Pakistan.

On the other hand, Cheung and Sengupta (2013) conducted a study to examine the effects of the Real Effective Exchange Rate (REER) on specific types of exports instead of total exports. Using data from 2000 to 2010, they determined the effects of the REER on the share of exports of Indian non-financial sector firms. They revealed that firms with small export shares are more affected by the real effective exchange rate fluctuations. In contrast, Sarker (2018) attempted to estimate the import and export demand functions of Bangladesh on a bilateral basis. In his study, he used the Johansen cointegration test approach and vector error correction mechanism, and he found that income is an important determinant of both import and export demand of Bangladesh, whereas price was a less important factor for both export and import demand of Bangladesh.

3. Model Specification of the Growth of Export in Bangladesh

In this section, we focus on developing the econometric specification to model the growth of the export of Bangladesh. Based on the existing empirical literature we reviewed, we understood that several macroeconomic indicators (e.g., foreign GDP, export value index, trade openness, etc.) might have a crucial role to play on the export function of Bangladesh.

According to Houthakker and Magee (1969), trading partner's income is another dominant factor to influence the volume of export to the trading partner. Since the 1980s, the United States (US) has been the predominant export partner of Bangladesh.[2] So, we have considered the US GDP as one of the major determinants of exports in our model. In contrast, the conventional demand theory says that the consumer is postulated to maximize utility subject to a budget constraint. In this respect, the export demand function is also contingent on the price of exports. In our study, we use the export value index as a proxy of export price.

Therefore, in our estimation, we focus on integrating the growth of US GDP with the export function of Bangladesh. Furthermore, the value of export in proportion to the base period in US Dollar (i.e., the export value index) could be an important variable too in understanding the relationship between the export function of Bangladesh and the growth of US GDP. Therefore, in our study, the export-growth function of Bangladesh is specified as a function of the US GDP and export value index.

Considering the aforementioned factors, the model that we will be focusing on is the following:

$$l\_export_t = \alpha_0 + \alpha_1 * l\_usgdp_t + \alpha_2 * l\_xvi_t + \mu_t \quad (1)$$

Where, for the period t,
l_export = log of export
l_usgdp=log of US GDP
l_xvi = log of export value index and
μ = error term.

[2] *See:https://wits.worldbank.org/CountryProfile/en/Country/BGD/StartYear/1989/EndYear/2015/TradeFlow/Export/Partner/BY-COUNTRY/Indicator/XPRT-PRTNR-SHR#*

4. Data and Software

For estimating the export function of Bangladesh, we obtain the annual data of the export of Bangladesh expressed in constant LCU from the International Monetary Fund's (IMF) various issues of *International Financial Statistics* (IFS). We also collect data on the export value index of Bangladesh and gross domestic product (GDP) of the US from 1980 to 2016 from the World Bank's data bank. As a statistical package, we use *Gretl* to perform all statistical and graphical operations. The details of the tests are available as appendices.

4.1. Summary Statistics of Data

The summary of the data related to l_export, l_usgdp and l_xvi is shown in the table-1. The table shows their means, standard deviation (SD), Coefficient of Variation (CV), skewness, and excess Kurtosis.

Table-1: Summary Statistics, using the observations 1980 – 2016

Particulars	**Variable**		
	l_export	l_usgdp	l_xvi
Mean	12.39	15.956	4.3316
Median	12.537	16.02	4.3964
Minimum	9.2769	14.865	2.6711
Maximum	14.899	16.745	6.1512
Standard Deviation (SD)	1.6668	0.55735	1.113
Coefficient of Variation (CV)	0.13453	0.03493	0.25694
Skewness	-0.1004	-0.327	0.04769
Excess Kurtosis	-1.1827	-1.0873	-1.2773

4.2. Time-Series Plot

The time-series plotting of l_export, l_usgdp and l_xvi is displayed in the Figure-1 below:

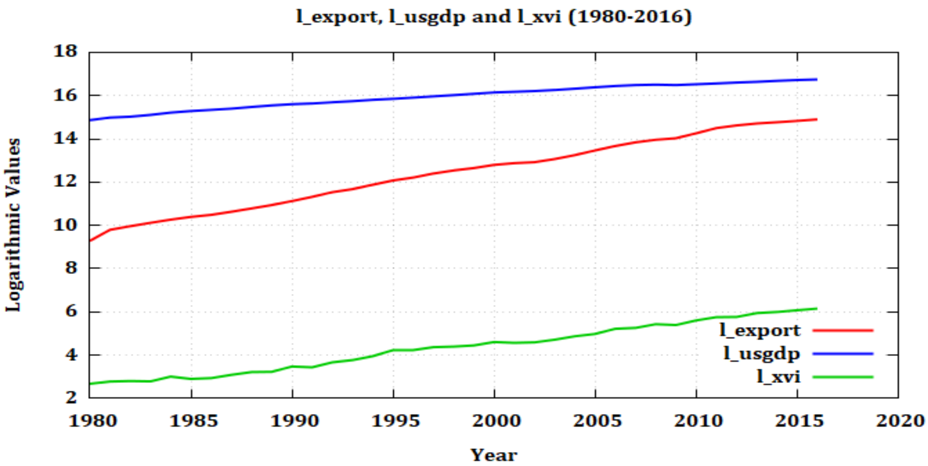

Figure-1: Graphical Plotting of l_export, l_usgdp, and l_xvi

The initial eye-balling of the graph indicates a probable non-stationarity suggesting the variables may contain a trend.

5. Empirical Analysis

5.1. Stationarity Checking

Although eye-balling indicated a probable non-stationarity among the variables, to formally check for the stationarity, in this section, we analyze the data by plotting the correlograms on levels and by performing Augmented Dickey-Fuller tests both on levels and first differences of l_export, l_usgdp, $and\ l\_xvi$.

5.1.1. Correlogram

The Figure-2 below shows the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) of the three variables:

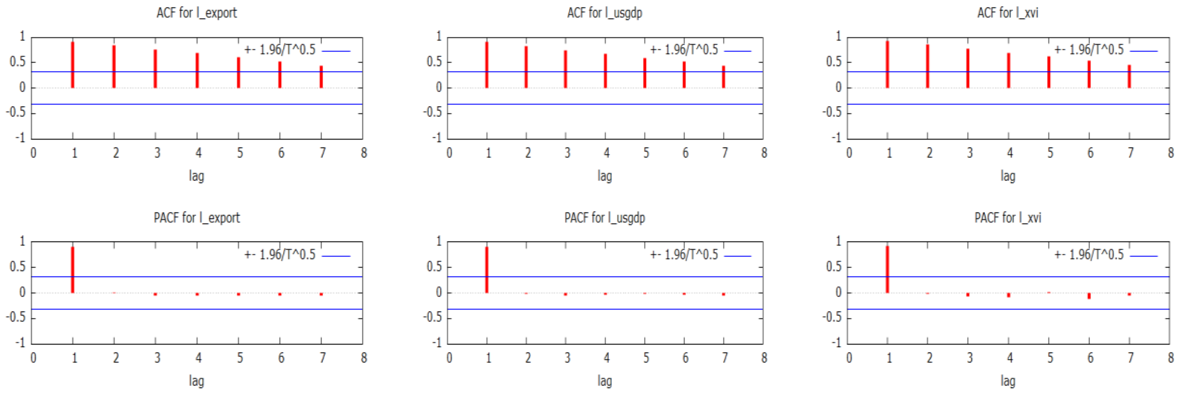

Figure-2: Correlograms of l_export, l_usgdp and l_xvi

From Figure-2, for all three of the variables, it becomes clear that the ACFs do not die down and significant at 5% levels for all of them. Therefore, the inspections of the correlograms also point to a non-stationarity.

5.1.2. Unit-root test

At this stage, we employ the Augmented Dickey-Fuller (ADF) to check for the non-stationarity of variables. The Table-2 below shows the ADF tests both on levels and first differences of *l_export, l_usgdp, and l_xvi* and the conclusions:

Table-2: Augmented Dickey-Fuller (ADF) test for l_export, l_usgdp and l_xvi

Variable	Parameter	ADF Statistics	Asymptotic P-Value	Decision
l_export	Level	-1.05673	0.9345	I(1)
	First diff.	-7.22703	5.422e-007	
l_usgdp	Level	-2.03729	0.5802	I(1)
	First diff.	-4.17009	0.002471	
l_xvi	Level	-2.99321	0.134	I(1)
	First diff.	-8.69248	2.321e-008	
H_0: the variable has a unit root				
Testing down from 4 lags, criterion AIC				

The ADF tests confirm that all three variables are non-stationary at levels but stationary at first differences. Therefore, the test confirms that all the variables are integrated at the order one [I(1)].

5.2. Collinearity Checking

To inspect for the probable collinearity between the first differences of the variables, we perform a collinearity checking. The results of the Belsley-Kuh-Welsch test are stated below in the Table-3:

Table-3: Belsley-Kuh-Welsch Collinearity Diagnostics

lambda	cond	Const	d_l_export	d_l_usgdp	d_l_xvi
3.450	1.000	0.011	0.010	0.009	0.026
0.367	3.064	0.028	0.013	0.032	0.938
0.108	5.663	0.696	0.573	0.006	0.008
0.075	6.777	0.265	0.403	0.953	0.027

As the conditions (cond) are less than 10, the results show that there is no evidence of excessive collinearity between them.

5.3. Vector Autoregression (VAR) Lag-Length Selection

Before performing a VAR model (and a probable VAR with error correction), we perform the operations to calculate different information criteria to identify the suitable lag(s) for our models. Table-4 below summarizes the data of the calculation:

Table-4: Calculation of Information Criteria for VAR Lag Selection			
lags	**AIC**	**BIC**	**HQC**
1	-11.018092	-10.473907*	-10.834990
2	-11.376456	-10.424133	-11.056028
3	11.327490	-9.967029	-10.869736
4	-11.836434*	-10.067834	-11.241354*

Based on the Akaike Information Criterion (AIC), the lag-length (p) of a VAR analysis should be 4 (indicated by the asterisk) as it minimizes the AIC value. Therefore, for the Johansen cointegration test, the lag-length of (p-1) or 3 seems like a rational selection.

5.4. Cointegration Tests

Before the selection of the model, we need to check the variables for cointegration, i.e., if there exists a stationary long-run relationship concerning their movements from each other. To check for cointegration, in this section, we employ the Engle-Granger test and the Johansen test.

5.4.1. Engle-Granger Test

Based on Engle and Granger (1987), in this section, we check for the stationarity of the residuals. The summary of the Engle-Granger test is stated below:

Table-5: Engle-Granger Test for Cointegration	
Unit-root $H_0: a = 1$ Model: (1-L)y = (a-1)*y(-1) + e	Estimated value of (a - 1): -0.673247 Test statistic: tau_c(3) = -5.02535 The p-value 0.004799

Here, the p-value < 0.05, therefore the Engle-Granger test rejects the null hypothesis at a 5% significance level. This means, there is at least 1(one) cointegrating relationship between the variables.

5.4.2. Johansen Cointegration Test

Based on Johansen (1988), in this section, we conduct the cointegration test. As stated above, for the Johansen cointegration test, the lag-length of three would be our selection. Now, corrected for sample size, the details of the trace test and eigenvalue test are shown below:

Table-5: Johansen Cointegration Test				
Rank	**Trace Test**		**λ_{max} Test**	
	Test stat	**p-value**	**Test stat**	**p-value**
0	34.157	0.0307	18.181	0.1263
1	15.976	0.0549	9.3699	0.2624
2	6.6059	0.0152	6.6059	0.0102

As per the standard practice, the trace test outcomes take precedence over the λ_{max} (eigenvalue) test. So, at 5% significance level, we reject the $H_0: Rank\ 0$, which means that there exists one long-run relationship between the variables. The long-run relationship under there parameters is denoted by the following equation (derived from the renormalized vector):

$$l\_export = 0.94687 \times l\_usgdp + 0.91169 \times l\_xvi$$

5.5. Vector Error Correction Model (VECM)

As the variables l_export, l_usgdp and l_xvi show the presence of a cointegration relationship between them, we need to formulate our model incorporating an error-correction term into it. Theoretically, the model now becomes,

$$\Delta l\_exp = \alpha_0 + \sum_1^n \alpha_{1\,i}\, \Delta l\_exp_{t-i} + \sum_1^n \alpha_{2\,i}\, \Delta l\_usgdp_{t-i} + \sum_1^n \alpha_{3i}\, \Delta l\_xvi_{t-i} + \alpha_4\, EC_{t-1} + \mu_t \quad (2)$$

Where, EC_{t-1} = the error correction term lagged one period.

The results of the VECM is shown below:

Table-6: Δl_exp					
Variables	**Coefficient**	**Std. Error**	**t-ratio**	**p-value**	**Significance**
α_0	−1.90493	0.616359	−3.091	0.0047	***
Δl_exp_{t-1}	0.684124	0.211369	3.237	0.0033	***
Δl_exp_{t-2}	−0.0330907	0.133698	−0.2475	0.8065	
Δl_usgdp_{t-1}	−0.701877	0.500416	−1.403	0.1726	
Δl_usgdp_{t-2}	−1.25386	0.569316	−2.202	0.0367	**
Δl_xvi_{t-1}	−0.208487	0.101467	−2.055	0.0501	*
Δl_xvi_{t-1}	0.0120836	0.0920498	0.1313	0.8966	
EC_{t-1}	−0.312381	0.0961600	−3.249	0.0032	***
*Note: *, ** and *** denotes significance at 10%, 5% and 1% significance level respectively*					

The statistical measures of this model are stated below:

Table-7: Statistical Measures of the Model			
Mean of Dependent Variable	0.145301	SD of Dependent Variable	0.052875
Sum of Squared Residuals	0.044214	SE of Regression	0.041237
R-squared Value	0.520766	Adjusted R-squared value	0.391742
Rho	−0.006499	Durbin-Watson Value	2.005787

The results from the model (in Table-6) show that the error-correction term EC_{t-1} is statistically highly significant (even at a 1% significance level), and expectedly it has a negative sign. This points to the soundness of our equation (1), indicating that between the variable, there is indeed a long-term equilibrium relationship. The coefficient of EC_{t-1} (-0.312381) shows that in case of a deviation, the variables converge to the equilibrium by adjusting the preceding period's disequilibrium at over 31% in the following period.

Furthermore, the intercept, Δl_exp_{t-1} and Δl_usgdp_{t-2} are significant at a 5% significance level. In contrast, $\Delta l_xvi_{t-1}$is significant at a 10% significant level. Concerning the coefficients, the elasticity of the two-period lagged value of the change in the growth of the US GDP is more than unit-elastic (-1.25386). However, although it is less than unity (0.684124), the sign is positive for the one-period lagged value of the change in the growth of the export (as we would expect from the economic standpoint) indicating that the current period's value increases at a lesser rate.

From Table-7, we see that the R-squared and the adjusted R-squared values are 0.520766 and 0.391742, respectively. Furthermore, the Rho of −0.006499 and the Durbin-Watson (DW) value of around 2 indicates the presence of an insignificant autocorrelation in the model.

6. Diagnostic Tests

Although the initial diagnostics (stated above) show no apparent misspecification with very little sign of autocorrelation in our model (with the DW stat of 2.005787), we perform additional diagnostic tests to check for probable conditional heteroskedasticity and non-normality.

6.1. Autoregressive Conditional Heteroskedasticity (ARCH) Test:

To check for the probable conditional heteroskedasticity in our model, we conduct the test for the presence of ARCH. The results of the ARCH test is stated in the table below:

Table-8: Results of the ARCH Test

Lag	LM	df	p-value
1	47.057	36	0.1027
2	81.559	72	0.2064
3	119.110	108	0.2187

The test results from the Table-8 show that the ARCH test fails to reject the null hypothesis (H_0: $No\ conditional\ heteroscedasticity$) at a 5 % significance level. Thus, the test confirms that there is no problem with conditional heteroscedasticity in our model.

6.2. Normality Test

The test to check for the normality in the model is crucial, as it would ensure the forecasting-ability of our model. To check for a probable non-normality, we perform the Doornik-Hansen test. The results of the test are stated below:

Table-9: Results of the Doornik-Hansen Test

Test Stat	p-value
Chi-square(6) = 7.67642	0.2628

The test result from the Table-9 states that the Doornik-Hansen test fails to reject the null hypothesis at a 5 % significance level. Therefore, the test confirms that the residuals are normally distributed.

7. Forecasting

In this section, we focus on the variance decomposition of the forecast, the impulse responses to innovations, and the forecasting of l_export over the periods following our study.

7.1. Decomposition of Variance

As we know, the variance decomposition of forecasting measures how each type of shock impacts the error variance of the forecast. The Table-10 below shows the variance decomposition of l_export:

Table-10: Variance Decomposition for l_export

Period	Standard Error	l_export	l_usgdp	l_xvi
1	0.036061	100.0000	0.0000	0.0000
2	0.0625141	98.8653	0.6535	0.4812
3	0.0863231	87.4304	6.8454	5.7242
4	0.109012	75.4082	13.0470	11.5449
5	0.126999	68.0547	15.2993	16.6459
6	0.139833	64.1491	15.0935	20.7574
7	0.14957	61.9289	13.9987	24.0724
8	0.157964	60.5371	12.7519	26.7110
9	0.166016	59.4897	11.5903	28.9200
10	0.174118	58.5210	10.5523	30.9267

The following Figure-3 graphically represents the variance decomposition of the forecast for l_export:

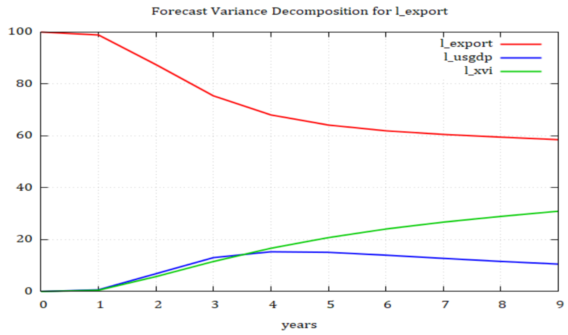

Figure-3: Forecast of Variance Decomposition for l_export

As illustrated by Table-10 and Figure-3, although initially higher, the innovation in the growth of the US GDP has a lesser effect comparing to the growth of the export value index in the long run.

7.2. Impulse Response Functions

To check for the impact of a one standard deviation shock to the model, we check for the impulse response functions. The responses are graphically shown in the figure below:

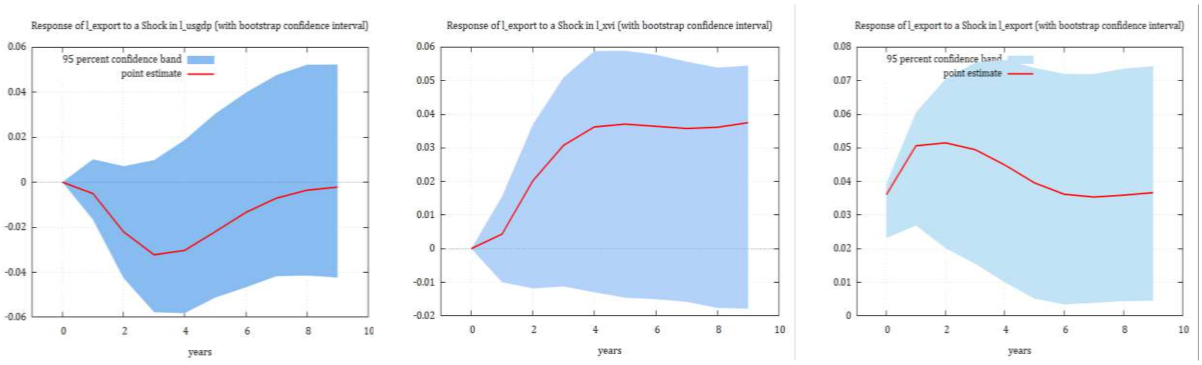

Figure-4: Impulse Response Functions of l_export (with 95% Confidence Band)

As it is evident from the Figure-4, the impacts on l_export to a shock to l_usgdp and l_export are of a short-run nature. In contrast, a shock to l_xvi has a longer-term impact on l_export. In contrast, the response of l_export to a shock to l_usgdp is negative, unlike the other two.

7.3. Forecasting of the Growth in Export

As our model passed our diagnostic tests, in this section, we forecast the growth in export for the subsequent five periods (2017-2021). The representation below in the Figure-4 includes the fitted values for the pre-forecast range to illustrate the fit of our model graphically.

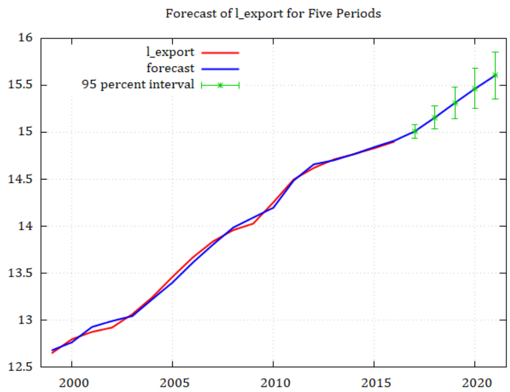

Figure-4: Forecast of l_export (Including Fitted Values for Pre-forecast Range)

As illustrated by Figure-4, our model forecasts a steady increase in the growth of export over the forecasting period of five years subsequent to our analysis period between 1980 and 2016.

8. Conclusion

In this study, we examined the impact of the growth of US GDP and the export value index on the growth of the export of Bangladesh. We focused on the period between 1980 and 2016 in our analysis. As a standard method of dealing with time-series data, we initially focused on identifying a probable non-stationarity of the variables. Apart from the inspection of correlograms, the subsequent ADF tests confirmed the presence of a non-stationarity among all three variables in question. Therefore, before selecting our desired model, we conducted the Engle-Granger test and the Johansen test to observe whether there exists a cointegration between the variables. The empirical analysis showed that there is a long-run relationship between the variables, as evident by the results.

In the presence of a long-run relationship between the variables, we modeled the variables using an error-correction model. After defining the parameters and running the model, we conducted the diagnostic checks that indicated no significant presence of a serial correlation, conditional heteroskedasticity, or non-normality in our model. Following our diagnostic tests, we inspected the impulse response functions and found out that the impacts on the growth of export to a shock to the growth of the US GDP were of a short-run nature, whereas the impact to a shock to the growth of the export value index was a longer-run one. Furthermore, our error-correction rate of over 31% showed that in the case of disequilibrium in the preceding period, the adjustment to the equilibrium would happen at a significant rate. And, according to our forecast, assuming these existing conditions hold, we would expect the growth rate of the export of Bangladesh to increase at a steady rate over the periods following our study.

Bibliography

Ahmed, Syed Mushtaque; Hoque, Md Nazmul; Talukder, Md Sherajul Islam (1993): Estimating Export Demand Function for Bangladesh. An Application of Cointegration and Error-correction Modelling, *The Bangladesh Development Studies* 21 (4), pp. 89–104.

Altintaş, Halil; Türker, Oğuzhan (2014): The Dynamics of Export and Import Functions in Turkey. Cointegration and Multivariate Granger Causation Analysis, *International Journal of Asian Social Science* 4 (5), pp. 676–689.

Balassa, Bela; Voloudakis, Evangelos; Fylaktos, Panagiotis; Suh, Suk Tai (1989): The Determinants of Export Supply and Export Demand in Two Developing Countries- Greece and Korea, *International Economic Journal* 3 (1), pp. 1–16.

Cheung, Yin-Wong; Sengupta, Rajeswari (2013): Impact of Exchange Rate Movements on Exports: An Analysis of Indian Non-Financial Sector Firms, *Journal of International Money and Finance* 39, pp. 231–245.

Dutta, Dilip; Ahmed, Nasiruddin (2004): An Aggregate Import Demand Function for India: A Cointegration Analysis", *Applied Economics Letters*, 11:10, 607-613.

Engle, Robert F.; Granger, Clive W. (1987). Co-integration and Error Correction: Representation, Estimation, and Testing, *Econometrica: Journal of the Econometric Society*, 251-276.

Haider, Jahanzaib; Afzal, Muhammad; Riaz, Farah (2011): Estimation of import and export demand functions using bilateral trade data: The case of Pakistan, *BEH- Business and Economic Horizons*, Volume 6, Issue 3, pp. 40-53.

Houthakker, Hendrik S.; Magee, Stephen P. (1969): Income and Price Elasticities in World Trade, *Review of Economics and Statistics,* May, 51(2).

Islam, Touhidul (2016): An Empirical Estimation of Export and Import Demand Functions Using Bilateral Trade Data: The Case of Bangladesh, *Journal of Commerce & Management Thought*, 7(3), 526–551.

Johansen, Søren (1988). Statistical Analysis of Cointegrating Vectors, *Journal of Economic Dynamics and Control*, 12, 231–254.

Kabir, Rezaul (1988): Estimating import-demand and export-demand functions: The case of Bangladesh, *Bangladesh Development Studies*, 16(4), 115-127.

Khattak, Naeem Ur Rehman; Hussain, Anwar Hussain (2010): Determinants of Exports in Pakistan. An Econometric Analysis (1970-2006), *University Library of Munich*, Germany.

Murad, S. M. Woahid (2012): Bilateral Export and Import Demand Functions of Bangladesh: A Cointegration Approach, *Bangladesh Development Studies*, Vol. XXXV, March 2012, No. 1.

Sandu, Carmen; Ghiba, Nicolae (2011): The Relationship between Exchange Rate and Exports in Romania Using a Vector Autoregressive Model, *Annales Universitatis Apulensis: Series Oeconomica* 13 (2), p. 476.

Sarker, Mohammad Monirul Islam (2018): Export and Import Demand Functions of Bangladesh: A Disaggregated Approach, *International Journal of Economics, Finance and Management Sciences* 6 (2), p. 66.

Appendices

Appendix-A

Collinearity Checking

Belsley-Kuh-Welsch collinearity diagnostics:

		Variance proportions			
lambda	**cond**	**const**	**d_l_export**	**d_l_usgdp**	**d_l_xvi**
3.450	1.000	0.011	0.010	0.009	0.026
0.367	3.064	0.028	0.013	0.032	0.938
0.108	5.663	0.696	0.573	0.006	0.008
0.075	6.777	0.265	0.403	0.953	0.027

lambda = eigenvalues of inverse covariance matrix (smallest is 0.0751256)
cond = condition index
note: variance proportions columns sum to 1.0
According to BKW, cond >= 30 indicates "strong" near-linear dependence, and cond between 10 and 30 "moderately strong". Parameter estimates whose variance is mostly associated with problematic cond values may themselves be considered problematic.
Count of condition indices >= 30: 0
Count of condition indices >= 10: 0
Result: No evidence of excessive collinearity

Appendix-B

VAR Lag-Length Selection

VAR system, maximum lag order 4:
The asterisks below indicate the best (that is, minimized) values of the respective information criteria.
AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and
HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	193.79852	-	-11.018092	-10.473907*	-10.834990
2	208.71153	0.00047	-11.376456	-10.424133	-11.056028
3	216.90359	0.05928	11.327490	-9.967029	-10.869736
4	234.30116	0.00006	-11.836434*	-10.067834	-11.241354*

Appendix-C

Engle-Granger Test for Integration

Step 1: cointegrating regression

Cointegrating regression -
OLS, using observations 1980-2016 (T = 37)
Dependent variable: l_export

	coefficient	std. error	t-ratio	p-value	
const	−13.2355	1.95650	−6.765	8.90e-08	***
l_usgdp	1.38686	0.141488	9.802	1.94e-011	***
l_xvi	0.807377	0.0708539	11.39	3.72e-013	***

Mean dependent var	12.39008	S.D. dependent var	1.666790
Sum squared resid	0.247564	S.E. of regression	0.085330
R-squared	0.997525	Adjusted R-squared	0.997379
Log-likelihood	40.12885	Akaike criterion	−74.25771
Schwarz criterion	−69.42496	Hannan-Quinn	−72.55394
rho	0.326753	Durbin-Watson	1.068633

Step 2: testing for a unit root in uhat

Augmented Dickey-Fuller test for uhat
testing down from 4 lags, criterion AIC
sample size 36
unit-root null hypothesis: a = 1

test without constant
including 0 lags of (1-L)uhat
model: (1-L)y = (a-1)*y(-1) + e
estimated value of (a - 1): -0.673247
test statistic: tau_c(3) = -5.02535
p-value 0.004799
1st-order autocorrelation coeff. for e: 0.146

There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables, and
(b) the unit-root hypothesis is rejected for the residuals (uhat) from the cointegrating regression.

Appendix-D

Johansen Cointegration Test
Number of equations = 3
Lag order = 3
Estimation period: 1983 - 2016 (T = 34)
Case 3: Unrestricted constant

Log-likelihood = 318.372 (including constant term: 221.884)

Rank	Eigenvalue	Trace test	p-value	Lmax test	p-value
0	0.41418	34.157	[0.0139]	18.181	[0.1263]
1	0.24087	15.976	[0.0407]	9.3699	[0.2624]
2	0.17658	6.6059	[0.0102]	6.6059	[0.0102]

Corrected for sample size (df = 24)

Rank	Trace test	p-value
0	34.157	[0.0307]
1	15.976	[0.0549]
2	6.6059	[0.0152]

eigenvalue 0.41418 0.24087 0.17658

beta (cointegrating vectors)

l_export	-13.597	1.5495	-20.569
l_usgdp	12.875	-17.014	17.941
l_xvi	12.396	5.6541	22.230

alpha (adjustment vectors)

l_export	0.022974	-0.010382	-0.0043334
l_usgdp	0.0066546	0.0030564	-0.0039392
l_xvi	9.9322e-005	-0.021941	-0.023001

renormalized beta

l_export	1.0000	-0.091067	-0.92529
l_usgdp	-0.94687	1.0000	0.80703
l_xvi	-0.91169	-0.33232	1.0000

renormalized alpha

l_export	-0.31238	0.17665	-0.096334
l_usgdp	-0.090482	-0.052002	-0.087570
l_xvi	-0.0013505	0.37331	-0.51133

long-run matrix (alpha * beta')

	l_export	l_usgdp	l_xvi
l_export	-0.23933	0.39469	0.12976
l_usgdp	-0.0047197	-0.036998	0.012203
l_xvi	0.43778	-0.038071	-0.63416

Appendix-E

VECM Estimation

VECM system, lag order 3
Maximum likelihood estimates, observations 1983-2016 (T = 34)
Cointegration rank = 1
Case 3: Unrestricted constant
beta (cointegrating vectors, standard errors in parentheses)

l_export 1.0000
(0.00000)
l_usgdp -0.94687
(0.26794)
l_xvi -0.91169
(0.12839)

alpha (adjustment vectors)
l_export -0.31238
l_usgdp -0.090482
l_xvi -0.0013505

Log-likelihood = 213.8966
Determinant of covariance matrix = 6.8899718e-010
AIC = -10.8174
BIC = -9.4707
HQC = -10.3582

Equation 1: d_l_export

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−1.90493	0.616359	−3.091	0.0047	***
d_l_export_1	0.684124	0.211369	3.237	0.0033	***
d_l_export_2	−0.0330907	0.133698	−0.2475	0.8065	
d_l_usgdp_1	−0.701877	0.500416	−1.403	0.1726	
d_l_usgdp_2	−1.25386	0.569316	−2.202	0.0367	**
d_l_xvi_1	−0.208487	0.101467	−2.055	0.0501	*
d_l_xvi_2	0.0120836	0.0920498	0.1313	0.8966	
EC1	−0.312381	0.0961600	−3.249	0.0032	***

Mean dependent var	0.145301	SD dependent var	0.052875
Sum squared resid	0.044214	SE of regression	0.041237
R-squared	0.520766	Adjusted R-squared	0.391742
rho	−0.006499	Durbin-Watson	2.005787

Equation 2: d_l_usgdp

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−0.559423	0.235158	−2.379	0.0250	**
d_l_export_1	0.00337318	0.0806435	0.04183	0.9670	
d_l_export_2	0.106251	0.0510097	2.083	0.0472	**
d_l_usgdp_1	0.612569	0.190923	3.208	0.0035	***
d_l_usgdp_2	−0.542343	0.217210	−2.497	0.0192	**
d_l_xvi_1	−0.101971	0.0387126	−2.634	0.0140	**
d_l_xvi_2	−0.0142083	0.0351196	−0.4046	0.6891	
EC1	−0.0904822	0.0366878	−2.466	0.0206	**

Mean dependent var	0.050654	SD dependent var	0.021402
Sum squared resid	0.006436	SE of regression	0.015733
R-squared	0.574221	Adjusted R-squared	0.459588
rho	0.026758	Durbin-Watson	1.924665

Equation 3: d_l_xvi

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.148535	1.20797	0.1230	0.9031	
d_l_export_1	0.806810	0.414251	1.948	0.0623	*
d_l_export_2	−0.164848	0.262028	−0.6291	0.5348	
d_l_usgdp_1	0.343830	0.980736	0.3506	0.7287	
d_l_usgdp_2	−1.83494	1.11577	−1.645	0.1121	
d_l_xvi_1	−0.710820	0.198860	−3.574	0.0014	***
d_l_xvi_2	−0.0262760	0.180403	−0.1457	0.8853	
EC1	−0.00135048	0.188459	−0.007166	0.9943	

Mean dependent var	0.098516	SD dependent var	0.097714
Sum squared resid	0.169824	SE of regression	0.080819
R-squared	0.461024	Adjusted R-squared	0.315915
rho	0.154804	Durbin-Watson	1.690158

Cross-equation covariance matrix:

	l_export	l_usgdp	l_xvi
l_export	0.0013004	0.00018117	0.0015134
l_usgdp	0.00018117	0.00018929	0.00023565
l_xvi	0.0015134	0.00023565	0.0049948

Determinant = 6.88997e-010

Appendix-E

Normality Test

Residual correlation matrix, C (3 x 3):

1.0000	0.36516	0.59383
0.36516	1.0000	0.24235
0.59383	0.24235	1.0000

Eigenvalues of C:

0.389669
0.790058
1.82027

The Doornik-Hansen test: Test for null hypothesis of normal distribution
Chi-square(6) = 7.67642 [0.2628]

Appendix-F

Forecasting for 5 Periods:

For 95% confidence intervals, z(0.025) = 1.96

Obs	l_export	prediction	std. error	95% interval
2017	undefined	15.0082	0.0360610	(14.9376, 15.0789)
2018	undefined	15.1548	0.0625141	(15.0323, 15.2773)
2019	undefined	15.3121	0.0863231	(15.1429, 15.4812)
2020	undefined	15.4637	0.109012	(15.2500, 15.6773)
2021	undefined	15.6043	0.126999	(15.3554, 15.8532)

Figures

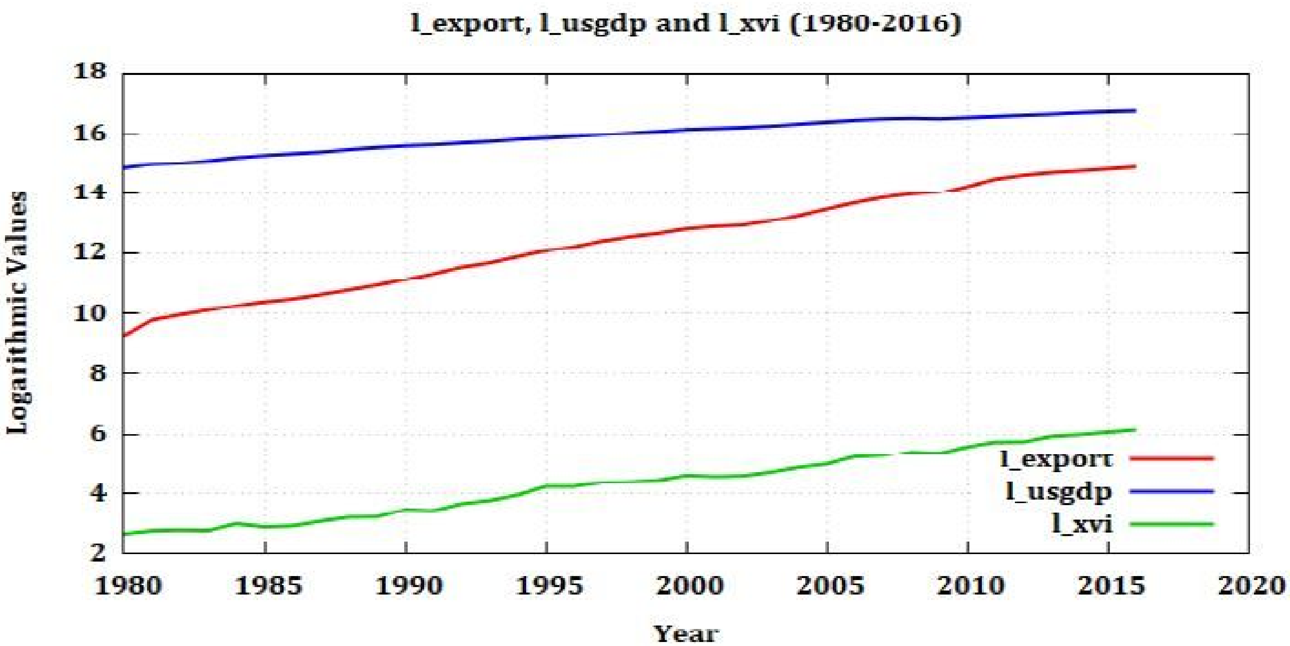

Figure 1

Graphical Plotting of l_export, l_usgdp, and l_xvi

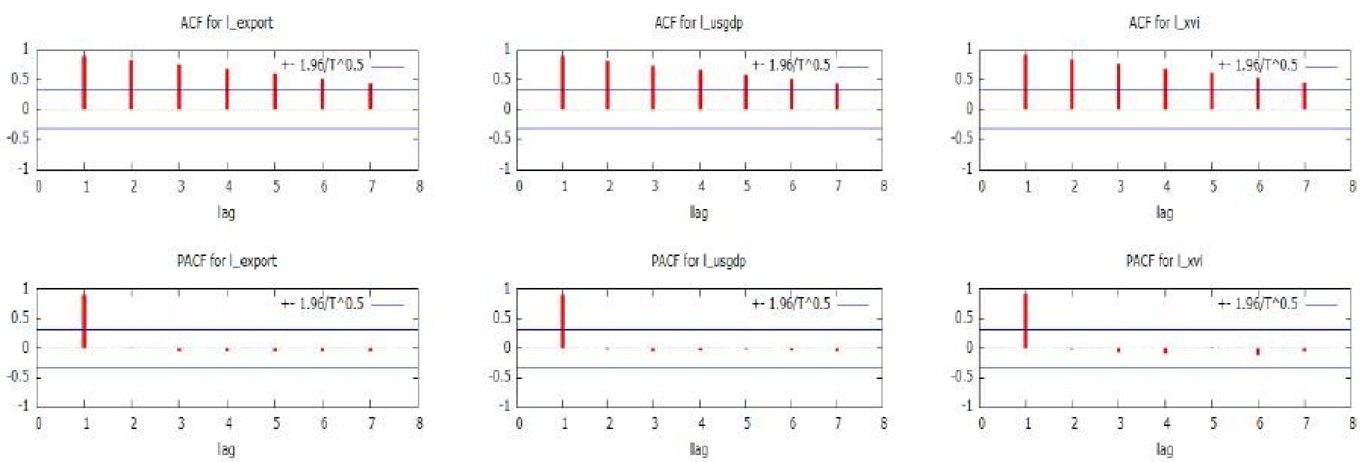

Figure 2

Correlograms of l_export, l_usgdp and l_xvi

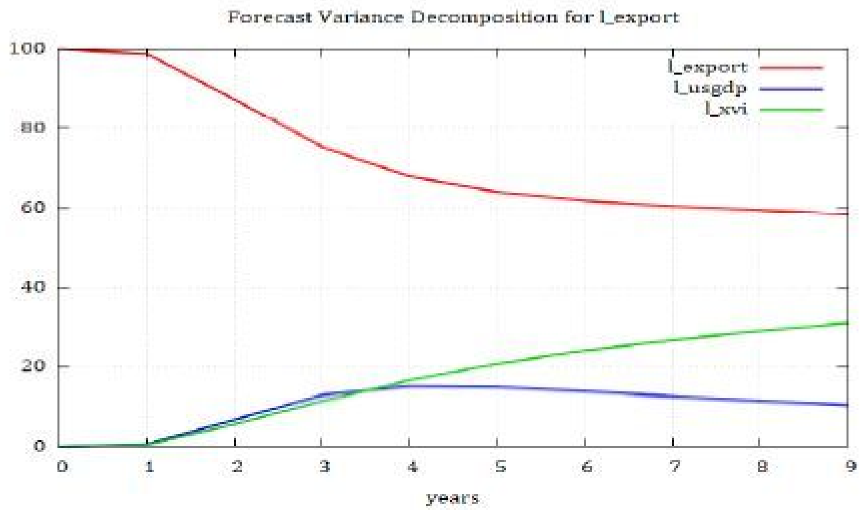

Figure 3

Forecast of Variance Decomposition for l_export

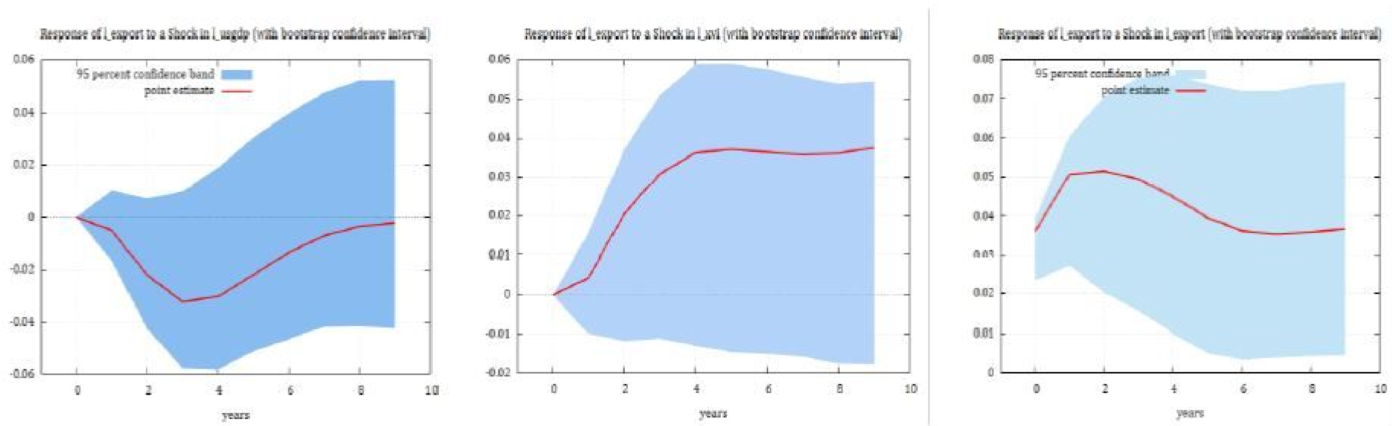

Figure 4

Impulse Response Functions of l_export (with 95% Confidence Band)

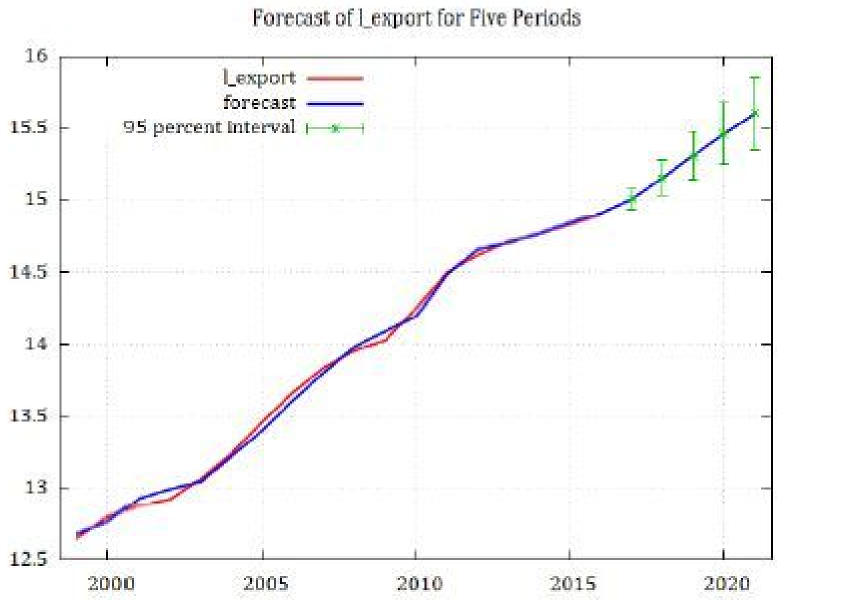

Figure 5

Forecast of l_export (Including Fitted Values for Pre-forecast Range)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Acknowledgment.pdf