Estimation of Export Supply Model of Bangladesh: Cointegration and Vector Autoregressive Approaches

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ABSTRACT

The broad objective of this study is to empirically estimate the export supply model of Bangladesh. The techniques of Cointegration, Engle-Granger causality, Vector Error Correction and Vector Auto-regression are applied to estimate the models of this study. Structural breakpoint or stability of the variables and impulse responses are also conducted in this study. The econometric analysis is done by using the time series data of the variable of interest which is collected from the secondary sources. The study has empirically tested the hypothesis and long run relationship and casualty between variables of the models. The study findings reveal that the trend growth rate of aggregate export is higher in post-liberalization period as compared to the pre-liberalization period. The Cointegration analysis shows that all the variables of the study are cointegrated at their first differences meaning that there exists long run relationship among the variables.

Key words: Engine of Growth, Cointgration, Granger Causality, VECM, VAR.

Prelude

Trade is considered as the 'Engine of Growth' because of its role that facilitates a country to specialize in the production of goods and services following the theory of comparative advantage or revealed comparative advantage. Foreign trade plays a very important and crucial role in economic development of a country. Economic theories suggest that it reduces the dependency on foreign aid, augments the base of industrialization, increases foreign exchange earnings, creates employment opportunities, helps in transformation of the economic structure etc. Empirical evidence supports that there exist positive correlation and strong causality between foreign trade and economic growth and development of

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many countries.[1] Since independence Bangladesh has been facing chronic deficit in the balance of trade. The main reasons have been identified as increasingly large dependence on import of capital goods and machineries, industrial raw materials, fuel, food grain and a wide variety of consumer items on import side and low volume of few traditional export items, low valued products, high concentration on traditional markets, and low level of product diversification on the export front.

Though Bangladesh has been suffering chronic trade deficit since independence but there are a number of remarkable achievements in improving trade-GDP ratio, export-GDP ratio, import-GDP ratio, export diversification in terms of items and markets, increased imports of intermediate goods and industrial raw materials and capital goods. The significant increase in trade-GDP ratio of Bangladesh reflects greater degree of openness of the economy to the external world. The structure of export has changed significantly, shifting from primary goods to manufacturing goods and from traditional to non-traditional items. The structure of imports also changed significantly in terms of commodity and sources. The government initiated extensive trade reform programs to increase export of newly developed non-traditional and higher value added products. The major elements of the policy reforms included liberalization of imports and simplification of import procedures, rationalization of tariff structure, reduction in tariff rates and quantitative restrictions, pursuit of a flexible exchange rate policy, allowing IMF-consistent counter trade, and provision of specific and transparent export promotion measures. The Five Year Export Policy and the Five Year Import Policy Orders were adopted by the government during the Fifth Five-Year Plan period (1997-2002) to improve the foreign trade sector of Bangladesh with emphasis on product diversification and quality improvements, backward linkages, foreign investment etc on export side and import of raw materials, capital machinery on the import side. The foreign trade of Bangladesh had been protected by high tariff and non-tariff barriers in the mid-80s to support the domestic manufacturing industries.[2] The economy has been more open and liberal in the recent years as compared to the situation during 1970s and 1980s. The study is intended to examine the export demand and export supply models of Bangladesh using modern time series econometric modelling.

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[1] B. Balassa, "Exports and Economic Growth: Further Evidence", *Journal of Development Economics,* vol. 5 (1978) and P.C.Y. Chow, "Causality Between Export and Industrial Performance: Evidence from NICs", *Journal of Development Economics,* vol. 18 (1987).

[2] A.R. Bhuyan and M.A. Rashid, *Trade Regimes and Industrial Growth: A Case Study of Bangladesh,* (Dhaka: Bureau of Economic Research, University of Dhaka, 1993).

It is observed that Bangladesh has been experiencing chronic trade deficit in spite of reforms. Exports grew at an annual rate of 14.7 per cent in the 1990s which was 9.1 per cent in the 1980s. The lower growth rate of export (11.8 per cent) achieved during FY 2001-2009 as compared to the same in the 1990s (14.7 per cent) can be satisfactorily explained in the context of global economic slowdown and recession in 2002 and 2007-2008. Despite a number of challenges the double digit growth rate of export in the consecutive years signifies the resilience of export sector. The GDP growth rate still remains a single digit level at around 5%-6%. The economy is characterized by low income, low export-gdp ratio, low import-gdp ratio, low foreign exchange reserve, persistent balance of trade deficit, and deficit in current account of balance of payment. The trade deficit can be reduced to a tolerable level or eliminated through substantial increase in exports and reduction of unnecessary and luxurious goods particularly consumption goods. Exports can be boosted by mainly devaluation of domestic currency, increase of productive capacity, diversification of both products and markets.[3] There are also opposing views of trade liberalization that reduction of import duty, removal of tariff and non tariff barriers encourage excessive imports over exports.[4] Both the exports and imports of Bangladesh are on an increasing trend. Generally it is said that trade reforms or trade liberalization augments the increasing growth of exports and imports. Exports have increased at double-digit rates, and imports have increased in parallel, leaving the trade balance largely unchanged in dollar terms. These exports have been heavily concentrated in the garment industry, which is an industry well-suited to Bangladesh's comparative advantage in view of its heavy use of abundant unskilled labour. GDP growth has accelerated.

Export Scenario of Bangladesh

After independence Bangladesh continued the ISS policy. As a war devastated newly born country Bangladesh experienced very low exports for the first couple of years of its independence. The annual export growth rates were volatile with negative rate in some year upto 1986-87. Since then Bangladesh has continued to achieve substantially high and positive growth rates in exports with few exceptions. The export earnings, growth rates and its share in GDP have been shown in Table- 1:

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[3] Robert J. Gordon, *Macroeconomics* (8th ed.; USA: Wesley Longman Inc., 2000).

[4] Richard T. Froyen, *Macroeconomics: Theories and Policies* (5th ed.; USA: Prentice Hall, 1996).

Table- 1: Exports of Bangladesh during 1972-73 to 2008-2009

Year	Exports (in Million US$)	Growth Rate (%)	Exports as % of GDP
1972-1973	369.7	-	4.0
1977-1978	489.8	21.0	5.0
1982-1983	686.0	9.58	5.6
1987-1988	1231.0	14.6	6.4
1992-1993	2383.0	19.5	9.9
1997-1998	5172.0	16.8	15.2
2002-2003	6548.44	9.38	17.5
2006-2007	12177.86	15.6	22.8
2008-2009	15565.19	10.31	18.5

Source: Export From Bangladesh 1972-73 to 1999-2000 and Export Statistics, various issues, Export Promotion Bureau.

It is evident from the above table that exports of Bangladesh increased manifold over the years. The annual growth rates of exports were 21% in 1977-1978, 9.58% in 1982-1983, 14.6% in 1987-1988, 19.5% in 1992-1993, 16.8% in 1997-1998, 9.38% in 2002-2003, 15.6% in 2006-2007 and 10.31% in 2008-2009. The share of exports in GDP has also increased substantially. The shares of exports in GDP recorded a 5% increase in 1977-1978, 5.6% in 1982-1983, 6.4% in 1987-1988, 9.9% in 1992-1993, 15.2% in 1997-1998, 17.5% in 2002-2003, 22.8% in 2006-2007 and 18.5% in 2008-2009.

Structural Changes of Exports

Structural changes took place in the exports of Bangladesh during 1972-1973 to 2007-2008. The changes were characterized mainly by the changes in commodity compositions and direction of export destinations.

Table- 2: Percentage Shares of Exports of Major Items

Year	Jute and Jute Goods	Tea	Leather and Leather Goods	Frozen food	RMG
1972-1973	90.7	2.7	4.6	1.3	-
1981-1982	66.2	6.3	10.6	8.8	1.2
1991-1992	21.6	1.8	8.3	7.3	59.3
1999-2000	6.3	0.3	3.7	6.4	81.5
2005-2006	4.8	0.11	2.4	4.4	75.1
2007-2008	3.6	0.13	2.1	4.0	75.6

Source: Export From Bangladesh 1972-73 to 1999-2000, Export Statistics, various issues, Export Promotion Bureau.

It is observed from the table that Jute and Jute goods was the major export item of Bangladesh. It constituted 90.7% of total exports in 1972-1973, 66.2% in 1981-1982. Since 1991-1992 RMG took the position of Jute and Jute goods. The shares of Tea, Leather and Leather goods and Frozen foods have declined in subsequent years. If we classify the export items as primary commodities and manufactured commodities, we observe that the share of primary commodities gradually decreased and the same for manufactured commodities increased over the years. The share of primary commodities was recorded as 41.41% in 1973-1974 which decreased in the subsequent years as 34.45% in 1977-1978, 30.75% in 1979-1980, 33.88% in 1984-1985, 21.20% in 1989-1990, 13.02% in 1994-1995, 7.95% in 1998-1999, 8.16% in 1999-2000, 7.34% in 2005-2006 and 7.51% in 2007-2008 . On the other hand the share of manufactured items of total exports was recorded as 58.54% in 1973-1974 which was subsequently recorded as 65.55% in 1977-1978, 69.25% in 1979-1980, 66.12% in 1984-1985, 87.80% in 1989-1990, 86.98% in 1994-195, 92.05% in 1998-1999, 91.84% in 1999-2000, 92.66% in 2005-2006 and 92.49% in 2007-2008. The structural change in the composition of exports is a major breakthrough in our export sector over the period 1981-2000. The share of RMG and Knitwear in total exports increased from less than 1% in 1981 to about 40% in 1990 and 76% in 2000. The share of traditional export declined from 74% in 1981 to 33% in 1990 and only 6% in 2000.The share of manufacturing exports in total exports increased from 57% in 1972-1973 to 66% in 1977-1978, 77% in 1987-1988, 88% in 1995-1996 and 90% in 1997-1998.

Methodology and Data of the Study

Annual Time Series Data for the period from 1972-1973 to 2008-2009 for the relevant variables are collected from the various publications of the government of Bangladesh, World Tables of World Bank, International Financial Statistics of IMF etc. The study applies time series econometric techniques such as Cointegration, Vector Error Correction and Vector Autoregressive (VAR) modeling strategy. These techniques are chosen because they provide a formal framework for investigating the existence of both long-run and short-run relationship among variables, each of which may individually be non-stationary. The economic interpretation is that even though the variables contain stochastic trend meaning non-stationary they are linked to form long run equilibrium. This framework helps identify the long-run relationship as well as the short-run dynamics between external sector variables and other macroeconomic variables for trade policy modeling. Time series properties of all concerned variables in the models used in this study have been identified by Augmented Dickey- Fuller (ADF 1981)[5] and Philips-Perron (PP 1988)[6] tests respectively. In unit root test if the variables are found to be on-stationary at their respective levels then we proceed to Cointegration tests[7] developed by Engle and Granger (1987). The Co-integration test is performed by either Johansen[8] (1988) or Johansen and Juselius[9] (1990) multivariate Cointegration approach. For the time series data the following steps are generally chosen.

Stationarity Analysis

A set of time series data is stationary when its mean, variance and auto-covariances (at different lags) are fixed. Regression estimation using non-stationary time series data leads to spurious or nonsense results. As a result, classical t test and F test are not valid (Fuller 1985). So regression estimation is to be done using stationary data so that classical t test and F test will provide valid results. A time series data has a unit root meaning that the data is non stationary or

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[5] D. A. Dickey and W. A. Fuller, "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica*, (1981), vol. 49, pp.1075-72.

[6] P.C.B. Philips and P. Perron, "Testing for a Unit Root in Time Series Regressions", *Biometrica*, (1988), vol. 32, pp. 301-18.

[7] R.F. Engle and C.W.J. Granger, "Co-integration and Error Correction: Representation, Estimation and Testing", Econometrica, (1987) , vol. 55(2), pp. 251-76.

[8] S. Johansen, " Statistical Analysis of Co-integration Vectors", *Journal of Economic Dynamics and Control*, (1988), vol. 12, pp. 231-54.

[9] S. Johansen and K. Juselius, " Maximum Likelihood Estimation and Inference on Co-integration with Application to Demand for Money", *Oxford Bulletin of Economics and Statistics*, (1990), vol. 12, pp. 231-54.

the data has random walk. So the first attempt would be to check whether a particular time series data has a unit root or not. This study uses annual time series data. To avoid "spurious regression", we check a unit root process by integrating procedure. A linear combination of individual non-stationary variables may be stationary when they are co-integrated.

There are generally three tools to track the presence of unit root. They are:

1) Testing the order of integration of the series of the selected variables. If a variable is found I(0) at its level form then the variable is considered as stationary.
2) If a variable is not found I(0) at its level form then the variable is considered as non-stationary. But if the first difference of the non-stationary variable is found I(0) then it is of I(1) and it becomes stationary.
3) The Stationarity of the series of a variable can be examined by the Dicky Fuller (DF) unit root test, Augmented Dicky Fuller (ADF) unit root test or by Philips-Perron (PP) unit root test.

Unit Root Testing:

So it is important to check stationarity of data before proceeding with estimates[10] (Gujrati, D. N., 1995). Hence a stationary variable is integrated of order (I(0)), a variable which must be differentiated once to become stationary is to be I(1) co-integrated of order one. In applied work co-integration possess a formal framework for activating long run equilibrium relationships. When a set of I (1) variables are co- integrated then regressing one on the others should produce residuals that are I (0).

The Augmented-Dicky Fuller test (ADF) is superior to Dickey Fuller (DF) test as it can remove the serial autocorrelation successfully. So, in this study Augmented Dickey Fuller (ADF) statistics will be used to trace out whether the time series has a unit root or not. Philips-Perron Unit root test (PP test) is another technique to identify whether there is a unit or not. To test for stationarity, both ADF and PP test can be conducted. If there arises any contradiction, ADF results are preferred over Phillips-Perron test (Campbell and Perron 1991)

[10] Damodar N Gujarati, Basic Econometrics, (McGraw Hill: New York: 2003), 4th ed. pp.792-815.

Co-integration Analysis

The concept of co-integration was developed by Engle and Granger in 1987. As we have mentioned earlier, stationarity in time series data is necessary to have a valid t statistics and F statistics. But it has been identified that two or more time series data can be cointegrated although each of which is individually non-stationary or random walk. Cointegration tells us about the presence of long run relation among two or more variables. When we go for running cointegration analysis, we assume that all variables are non-stationary. Secondly they are all integrated in the same order. Even, if the variables are not integrated in the same order, we still can continue with cointegration analysis. We call this situation 'Multicointegration' There are indeed two tools to identify whether there exists a long run relation among variables. They are:

1. Engel-Granger's Residual based test
2. Johansen-Juselius (JJ) test.

Since Engel-Granger's Test suffers from some shortcomings, Johansen-Juselius (JJ) test is preferred for cointegration analysis. While doing Johansen-Juselius Test, if there comes up a different result between trace statistic and maximum eigenvalue test, maximum eigenvalue result is preferred (Banerjee et al 1993).

Pairwise Granger Causality Tests

Pairwise Granger causality tests are conducted to examine whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row is the statistic for joint significance of all other lagged endogenous variables in the equation[11]. When we estimate a VEC, the lagged variables that are tested for exclusion are only those that are first differenced. The lagged level terms in the cointegrating equations (the error correction terms) are not tested.

VAR and VECM Techniques

Generally the structural approach to time series modeling uses economic theory to examine the relationship among the variables of the model because economic theory can not sufficiently provide a dynamic specification that identifies all of these relationships. Moreover, estimation and inference are complicated by the

[11] EViews User Guide, Chapter 20. Vector Autoregression and Error Correction Models , p.523

fact that endogenous variables may appear on both the left and right sides of equations. These problems lead to alternative, non-structural approaches to modeling the relationship among several variables such as the estimation and analysis of vector autoregression (VAR) and the vector error correction (VEC) models. These models are used for testing the presence of cointegrating relationships among several non-stationary variables. The vector autoregression (VAR) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables.

The VAR approach sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. The mathematical representation of a VAR is as follows:

$$y_t = A_1 y_{t-1} + \ldots \ldots + A_p y_{t-p} + Bx_t + e_t$$

where yt is a k vector of endogenous variables, x_t is a d vector of exogenous variables, and $A_1 \ldots\ldots A_P$ and B are matrices of coefficients to be estimated, and e_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables. Since only lagged values of the endogenous variables appear on the right-hand side of the equations, simultaneity is not an issue and OLS yields consistent estimates. Moreover, even though the innovations may be contemporaneously correlated, OLS is efficient and equivalent to GLS since all equations have identical regressors. Using the tools and procedures in EViews and other Softwares we can define the structure of VAR.

A Vector Autoregrsion (VAR) system of n^{th} order formed by N-dimensional vector of a non-stationary variable, as for example, Yt can be represented as follows:

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots\ldots\ldots\ldots\ldots + \Pi_n Y_{t-n} + \eta + e_t; (t= 1,2,\ldots.T) \ldots.. \quad (1)$$

Here, e_T is N-dimensional vector of innovations which are independently and identically distributed with mean zero and constant variance. The vector η represents a vector of constant terms consisting of two parts such as 'intercept' in the co-integrating equation and the 'trend term'.

The above VAR system can be transformed into VECM by using first difference operator Δ as follows:

$$\Delta Yt = \Pi_1 Y_{t-1} + \sum \Gamma Y_t + \eta + e_t \ldots\ldots\ldots\ldots \quad (2)$$

Here, Π represents the parameter Matrix and the rank of the matrix r(Π) shows the number of co-integrating vectors that exists in the n^{th} order VAR system. If $0<r<N$, parameter matrix Π can be expressed as $\Pi = \alpha\beta/$ where α is the speed of adjustment vector and β/ is the co-integrating vector. If r equals to N the vector Y_t is stationary i.e. I(0). If r equals to 0, the parameter matrix Π is null and the vector is non-stationary i.e. I(1). It is important to note here that the estimated coefficients of α determines the short run dynamics of n^{th} order VAR system, i.e. stability, direction and the speed of adjustment towards long run equilibrium. If the coefficient is less than unity ($\alpha <1$) then the short run behavior is stable and any deviation from short run from its long run will be corrected within a reasonable span of time and it will lead to the long run equilibrium again. The number of Cointegrated vector(s) , if any, can be identified by two test statistics namely Trace Statistic(λ_{Trace}) and the Maximum Eignvalue Statistic(λ_{Max}).

Variables for Aggregate Export Supply Model

- Nominal Value of Merchandise Exports in log form (LRX)
- Relative Price of Exports (LRPX)
- Real Gross Domestic Product in log form (LRGDP)
- Real Gross Capital Formation in log form (LRGCF)
- Liberalization Dummy Variable for Regime Change (LIBD)

Justification for choosing explanatory variables

Relative Price of Exports (LRPX): The relative price of exports is a major determinant of any demand and supply model. It indicates the relative competitiveness of exports and imports of any country. The general demand law states that other things remaining the same when price goes up quantity demanded goes down and vice versa. The law of supply states that other things remaining the same when price goes up quantity supplied goes up and vice versa.

Real Gross Domestic Product in log form (LRGDP): Production capacity is an important variable to determine the responsiveness of export of a country. It shows how a country is able to produce exportables. To measure the production capacity, real GDP of Bangladesh has been taken into account as a proxy variable of production capacity in absence of data of production index of exportables.

Real Gross Capital Formation in log form (LRGCF: Gross Capital Formation indicates the level of productive investment in the production of goods and services.

Dummy Variable for Regime Change (LIBD): A liberalization dummy variable 'LIBD' is taken as an explanatory variable to capture the distinction (if any) between pre and post liberalization periods with respect to trade performance. The dummy variable shows the effect of regime change. It takes value '0' for pre-liberalized period and '1' for post-liberalized period.

Specification of Model

The Export Supply Model of Bangladesh: $LRX_t = \alpha_1 + \alpha_2 LRPX_t + \alpha_3 LRGDP_t + \alpha_4 LRGCF_t + \alpha_5 LIBDt + \varepsilon_t$; $(\varepsilon_t \sim N(0, \sigma^2)$ [LRX_t = Real Exports in log form, $LRPX_t$= Relative Price of Exports in log form, $LRGDP_t$ = Real GDP in log form, $LRGCF_t$ = Real Gross Capital Formation in log form, $LIBD_t$ = Liberalization Shift Dummy, ε_t = Error Term, α = Coefficients] All the dependent and independent variables are taken in log form except dummy variable in both models. So the estimated coefficients of all independent variables represent respective elasticities.

Findings of the Study

Growth Trend of Exports

The compound growth rate and compound annual growth rate of exports are estimated separately for the pre-liberalized and post-liberalized regimes as well for the entire study period from 1972-1973 to 2009-2010. The estimates are presented in Appendix Table A.1. It is observed that the compound growth rate of exports in the pre-liberalization regime i.e. 1972-1973 to 1989-1990 is 8.81 per cent while the same is 11.90 per cent in the post-liberalization period i.e. 1990-1991 to 2009-2010. The CGR for the whole study period i.e. 1972-1973 to 2009-2010 is estimated at 11.56 per cent. It indicates that the growth rates of exports are higher in the post-liberalization period.

On the other hand it is observed that the compound annual growth rate of exports in the pre-liberalization regime i.e. 1972-1973 to 1989-1990 is 8.54 while the same is 11.88% in the post-liberalization period i.e. 1990-1991 to 2009-2010. The CAGR for the whole study period i.e. 1972-1973 to 2009-2010 is estimated at 10.63%. It can be concluded that trade reforms or trade liberalization in Bangladesh has positive impact on exports in Bangladesh.

Test of Hypothesis: Using t-test the following hypothesis is tested to find out whether trade liberalization has positive impact on export growth in Bangladesh.

H_0 : There is no change in export growth between pre and post trade liberalization regime.

H_1 : There is significant positive change in export growth between pre and post trade liberalization regime.

The t-test is performed on the basis of trend regression of the pre-liberalization and post-liberalization periods.

$$t_{37df} = (b_1 - b_2)/ \sqrt{(seb_1)^2 + (seb_2)^2}$$

Here, b1 = slope coefficient of time variable in the pre-liberalization period, b2 = slope coefficient of time variable in the post-liberalization period, se = standard error of slope coefficient. Now by putting the values in the formula t-statistic is computed as:

$$t_{37df} = (0.037 - 0.049) /\sqrt{(0.002)^2 + (0.002)^2}$$

$$= -4.26$$

Decision: The table value of t-statistic at 37 degree of freedom is 1.65 and the absolute value of calculated t-statistic is 4.26. Since the calculated value is higher than the critical t-value so the null hypothesis H_0 is rejected and the alternative hypothesis H_1 is accepted at 5 per cent significance level implying that the export has significantly increased in the post-liberalization regime.

Chow Breakpoint Test: The structural change in export of Bangladesh to the liberalization of trade is tested by Chow Test using the F-test which can be formulated as:

$$F = \frac{(RSS - (RSS1 + RSS2)/k)}{(RSS1 + RSS2) / (n1 - n2 - 2k)}$$

Chow Breakpoint test is conducted based on 1989-90 and it is found that F-statistic is greater than F critical value at 2, 34 degree of freedom and the p-value 0.00 indicates that the null hypothesis H_0 of structural stability is rejected.

Test of Stationarity of the Variables of Aggregate Export Supply Model

To check the Stationarity of the variables, the liberalization dummy, standard Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests have been conducted both at levels and at the first difference of each variable of the Aggregate Export Supply Model of Bangladesh. The test results are summarized in Table- 3.

Table- 3: ADF Unit Root Test Results
Null Hypothesis: H_0; The concerned variable has a unit root

Variables	Level / First Difference	Intercept	Intercept and Trend	Conclusion
LRX	Level	-0.729 (0.825)	-5.934 (0.000)	I(1) and I(0) Inconclusive
	First Difference	-5.972 (0.000)	-5.919 (0.000)	I(0) and I(0) Stationary
LRPX	Level	-2.944 (0.050)	-5.348 (0.005)	I(0) and I(0) Stationary
	First Difference	-9.849 (0.000)	-9.741 (0.000)	I(0) and I(0) Stationary
LRGDP	Level	-0.652 (0.845)	-2.079 (0.539)	I(1) and I(1) Non-stationary
	First Difference	-6.555 (0.000)	-6.471 (0.000)	I(0) and I(0) Stationary
LRGCF	Level	-2.310 (0.174)	-7.420 (0.176)	I(1) and I(0) Inconclusive
	First Difference	-5.637 (0.000)	-5.785 (0.000)	I(0) and I(0) Stationary

Note: 1. ADF test Critical Values for model with intercept: -3.62 for 1% level of significance, -2.94 for 5% level of significance and -2.61 for 10% level of significance.

2. ADF test Critical Values for model with intercept and trend: -4.23 for 1% level of significance, -3.54 for 5% level of significance and -3.20 for 10% level of significance.

3. Unit Root Tests are performed by Econometric Software E-Views 5.0.

It is observed from the above ADF test that most of the variables are non-stationary at the level for model with intercept and intercept and trend. But it is interesting to note that all the variables are I(0) i.e. stationary at the first difference for model with intercept and intercept and trend. Similar test result is found in case of Phillips-Perron test.

Correlation Analysis of the Variables: It is wise to check the correlation among variables before proceeding to the cointegration analysis. The correlation coefficients are shown in the Table- 4.

Table- 4: Correlation Matrix of Aggregate Export Supply Model

	LOG(RX)	**LOG(RPX)**	**LOG(RGDP)**	**LOG(RGCF)**
LOG(RX)	1.00	0.86	0.95	0.96
LOG(RPX)	0.86	1.00	0.77	0.89
LOG(RGDP)	0.95	0.77	1.00	0.90
LOG(RGCF)	0.96	0.89	0.90	1.00

The correlation coefficients in Table- 4 reveal that real export is positively correlated with relative price (0.86), real GDP (0.95) and real foreign exchange reserve (0.96). Relative price is highly correlated with real GDP (0.77) and real foreign exchange reserve (0.89). Real GDP is positively correlated with real foreign exchange reserve (0.90).

Co-integration Analysis

The Co-integration test is conducted to examine whether there are any long run relationship among the variables of Aggregate Export Supply Model. Johansen and Juselius co-integration test is applied here. Two tests i.e. the trace test and the maximum eigenvalue test are used to determine the number of cointegrating vectors. The cointegration test results are shown in the Table- 5 and Table -6.

Table- 5: Johansen Co- integration Test Based on Maximum Eigenvalue

Hypothesis		Eigenvalue	Max-Eigen Statistics	5% Critical Value	p-value**
Null	Alternative				
r* = 0	r = 1	0.634	35.23	27.58	0.004
r ≤ 1	r = 2	0.390	17.31	21.13	0.157
r ≤ 2	r = 3	0.234	9.340	14.26	0.258
r ≤ 3	r = 4	0.011	0.411	3.841	0.521

Note: Trend assumption: Linear deterministic trend, Unrestricted Cointegration Rank Test (Maximum Eigenvalue), Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level.
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Johansen Cointegration test based on maximum eigenvalue confirms that there is one cointegrating vector meaning the cointegration relationship between the dependent variable and the independent variables of the model. The null hypothesis, r = 0, against the alternative hypothesis, r = 1, is rejected at the 5% level of significance.

Table- 6: Johansen Co- integration Test Based on Trace Test

Hypothesis		Eigenvalue	Trace Statistics	5% Critical Value	p-value**
Null	Alternative				
r* = 0	r = 1	0.634555	62.30271	47.85613	0.0013
r ≤ 1	r = 2	0.390302	27.07037	29.79707	0.0999
r ≤ 2	r = 3	0.234234	9.752651	15.49471	0.3003
r ≤ 3	r = 4	0.011699	0.411881	3.841466	0.5210

Note: Trend Assumption: Linear Deterministic Trend, Unrestricted Cointegration Rank Test (Trace), Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Johansen Cointegration test based on trace test confirms that there is one cointegrating vector meaning the Cointegration relationship between the dependent variable and the independent variables of the model. The null hypothesis, r = 0, against the alternative hypothesis, r = 1, is rejected at the 5% level of significance.

Long Run Cointegrating Relationship: Based on the cointegration test the long run estimates of the cointegrating vectors are presented in the Table- 7.

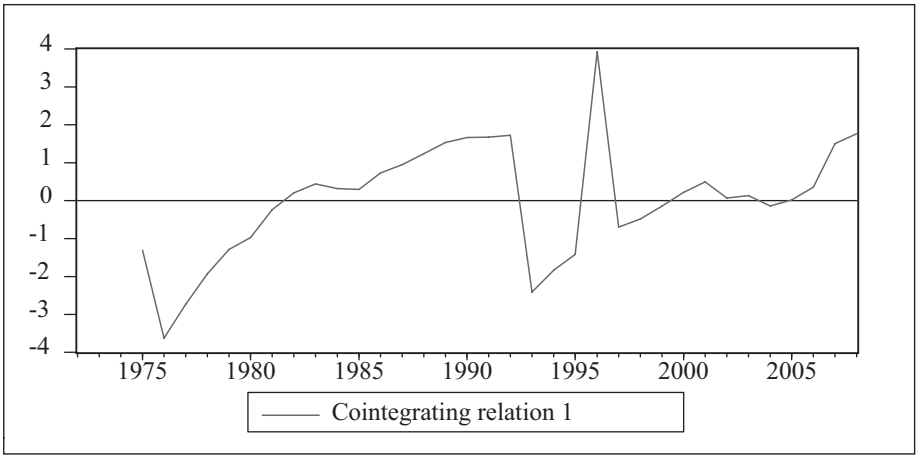
Table- 7: Long Run Relationship of Variables of Export Supply Model

LOG(RX)	LOG(RPX)	LOG(RGDP)	LOG(RGCF)
1.00	0.204	0.318	1.37
Standard Errors	(0.427)	(0.168)	(0.243)
T-statistics	0.477	1.89	5.63
Significance Level	Not Significant	Significant at 5%	Significant at 1%

Note: Log Likelihood 101.2528

The long run estimates show that elasticity of real export supply (RX) are 0.20 with respect to relative price of export (RPX), 0.318 with respect to real GDP (RGDP) and 1.37 with respect to real gross capital formation (RGCF). The export supply responded very well to real gross capital formation. The cointegrating relations among the variables are shown in Figure- 1. The curve indicates the long run convergence relationship among the variables.

Figure- 1: Cointegrating Relations of Aggregate Export Supply Model



Granger Causality Test: On the basis of test statistics the direction of causality is shown in Table- 8.

Table- 8: Direction of Causality Based on Granger Test

Null Hypothesis	Results	Conclusion
H_0 : 1	Accepted	Relative Price has no Granger cause to Real Export Supply Price.
H_0 : 2	Rejected	Real Export Supply has Granger cause to Relative Price.
Direction of Causality		Uni-directional
H_0 : 3	Accepted	GDP has no granger cause to Real Export Supply.
H_0 : 4	Accepted	Real Export Supply has no Granger cause to GDP.
Direction of Causality		No casual relationship
H_0 : 5	Accepted	Real Gross Capital Formation has no Granger cause to Real Export Supply
H_0 : 6	Rejected	Real Export Supply has Granger cause to Real Gross Capital Formation
Direction of Causality		Uni-directional
H_0 : 7	Accepted	Real GDP has no Granger cause to Relative Price
H_0 : 8	Accepted	Relative Price has no Granger cause to Real Gross Capital Formation
Direction of Causality		No casual relationship
H_0 : 9	Accepted	Real Gross Capital Formation has no Granger cause to Relative Price
H_0 : 10	Rejected	Relative Price has Granger cause to Real Gross Capital Formation
Direction of Causality		Uni-directional
H_0 : 11	Accepted	Real Gross Capital Formation has no Granger cause to Real GDP
H_0 : 12	Rejected	Real GDP has Granger cause to Real Gross Capital Formation
Direction of Causality		Uni-directional

Estimation of Export Supply Model by OLS: Since all the variables are stationary at the first difference and they are cointegrated the export supply model is run by OLS method. The estimated equation is as follows:

$$LRX = -6.55 + 0.25LRPX + 0.50LRGDP + 0.73LRGCF + 0.16LIBD$$

All estimated coefficients are found in expected sign but all are not statistically significant (Table A.2). The R-squared (R2) of the model is very high i.e. 0.969 and adjusted-R2 is 0.965. It signifies that about 97 per cent variation in the dependent variable i.e. supply of real export (RX) is explained by the independent variables i.e. relative price of export supply (RPX), real GDP (RGDP) and real gross capital formation (RGCF). The DW statistic is low i.e. 1.10. The F-statistics of the model is computed at 255.92. The mean of the dependent variable in logarithm is found to be 6.59 and the standard deviation is 1.33. The relative price of real export is positively related to the supply of real export as expected but the relationship is not statistically significant meaning that relative price is not an important determinant of export supply.

The coefficient of real GDP is positive, meaning that the supply of real export is positively related with real GDP and the relationship is statistically significant. The coefficient of real gross fixed capital formation is positive, meaning that the supply of real export is positively related with real gross fixed capital formation and the relationship is statistically significant. The coefficient of liberalization dummy is positive; meaning that the supply of real export has increased in post-liberalization regime but the relationship is not statistically significant. Since all the variables except dummy variable are taken in natural logarithm form, the estimated coefficients represent the respective elasticity of export supply of Bangladesh. The price elasticity of export supply is estimated at 0.25, the income elasticity of export supply is estimated at 0.50 and the gross fixed capital formation elasticity of export supply is estimated at 0.73. The estimated coefficient of liberalization dummy is very low (0.16) which is insignificant meaning that liberalization of trade has no significant impact on the export supply performance of Bangladesh. Therefore, the policy makers should be more cautious in designing the trade policy reforms in Bangladesh for reaping the full benefit of trade liberalization.

Vector Error Correction Model (VECM) for Aggregate Export Supply Model

The estimated coefficients of VECM for aggregate export supply function are shown

in Table Appendix Table A.3. The short run elasticity of real export supply is 0.672 with respect to real export at one lag and it is statistically significant at 5 per cent. The short run elasticity of real export supply is 0.159 with respect to relative price at one lag but it is not statistically significant. The short run elasticity of real export supply is 0.109 with respect to real GDP at one lag but it is also not statistically significant. The short run elasticity of real export supply is 0.232 with respect to real gross capital formation at one lag but it is not statistically significant.

Vector Auto-regression Model (VAR) for Aggregate Export Supply Model

The estimated coefficients of VAR for aggregate export supply function are shown in Appendix Table A.4. The elasticity coefficient of real export supply is 0.672 with respect to real export at one lag and it is statistically significant at 5 per cent. The elasticity coefficient of real export supply is 0.16 with respect to relative price at one lag and it is statistically significant at 5 per cent. The elasticity coefficient of real export supply is 0.13 with respect to real GDP at one lag but it is not statistically significant. The short run elasticity of real export supply is 0.23 with respect to real gross capital formation at one lag and it is statistically significant at 5 per cent.

Long Run and Short Run Elasticity of the Aggregate Export Supply Model: The long run and short run elasticity of aggregate export supply model is presented in Table 9. The short run elasticity is coefficients of independent variables at one lag in VECM and the long run elasticity is estimated by dividing the respective lag one level coefficient of independent variables by lag one level coefficient of dependent variable.

Table- 9: Long Run and Short Run Elasticities of Aggregate Export Supply Model

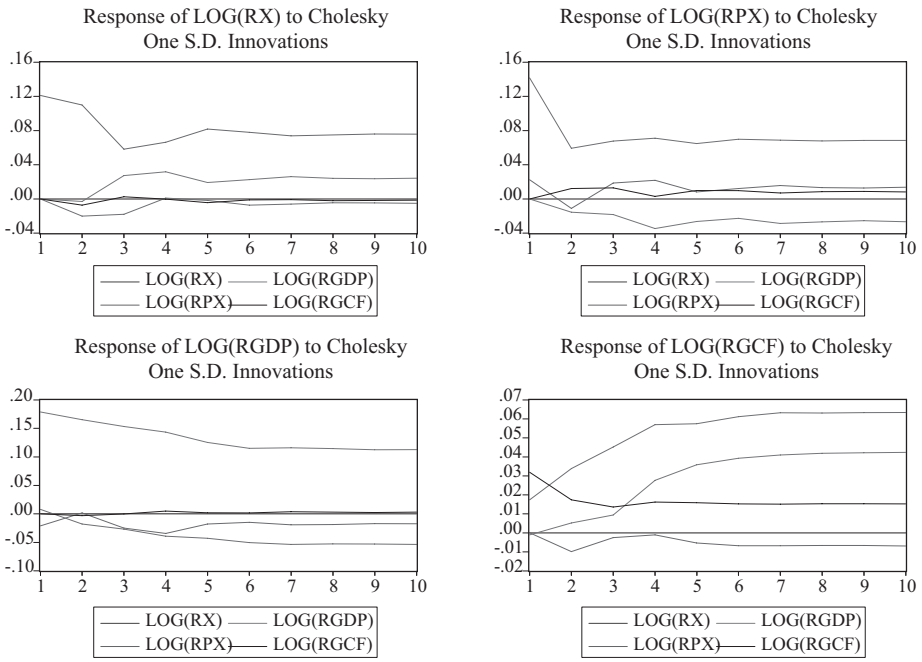
Dependent Variable: LRX		
Variables	**Short Run**	**Long Run**
Log(RPX)	0.16	0.24
Log(RGDP)	0.11	0.16
Log(RGCF)	0.23.	0.34
LIBD	0.02	0.03

Source: Researcher's Own Estimation.

The short run elasticity of real export supply is 0.16 with respect to relative price, 0.11 with respect to real GDP, 0.23 with respect to real gross capital formation and 0.02 with respect to liberalization dummy. The long run elasticity of real export supply is 0.24 with respect to relative price, 0.16 with respect to real GDP, 0.34 with respect to real gross capital formation and 0.03 with respect to liberalization dummy.

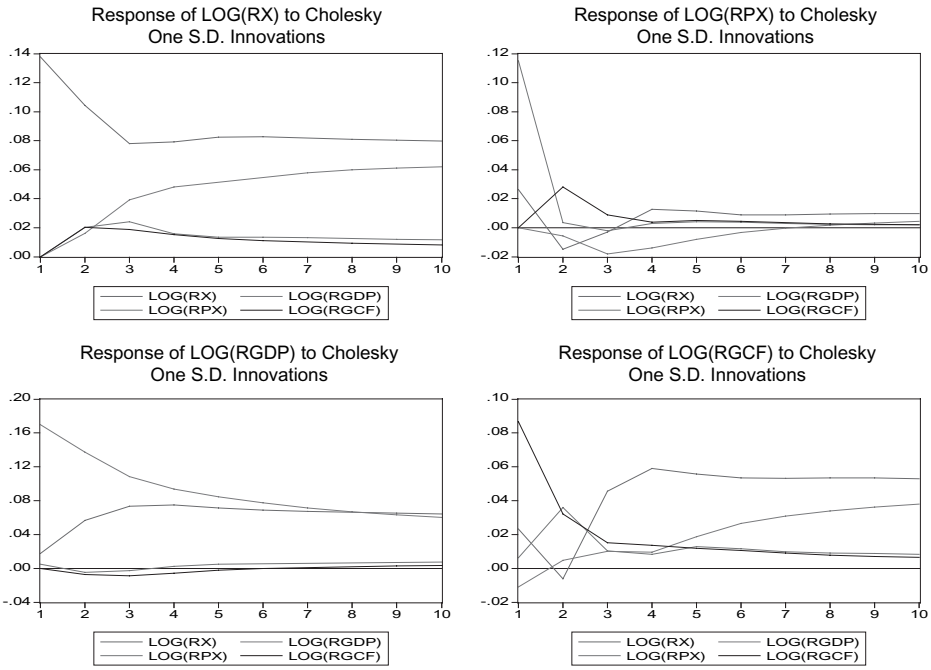
Impulse Response of the variables based on VECM: The impulse response of the variables based on VECM is shown in Figure 2. The effect of a one-time shock on one of the innovations on current and future values of the endogenous variables can be traced out by an impulse response function. A shock to the i-th variable not only directly affects the i-th variable but is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the VAR. The response of real export is correlated with other variables in the dynamic structure of VAR. In response to real export the other three independent variables are convergent in the long run. In case of relative price, real export and real gross capital formation are convergent but real GDP moves divergently. The response of real GDP shows that all independent variables strongly responded and are convergent. The response of real gross capital formation shows that all variables move divergently.

Figure- 2: Impulse Response of the variables based on VECM



Impulse Responses based on VAR: The impulse response of the variables based on VAR is shown in Figure 3. The response of real export is correlated with other variables in the dynamic structure of VAR. In response to real export real GDP is convergent and relative price and real gross capita formation are convergent. In case of relative price, real export, real GDP and real gross capital formation are convergent and all variables strongly responded. The response of real GDP shows that real export moves in convergent way with real GDP and relative price and real gross capital formation are found convergent. The response of real gross capital formation shows that all variables tend to be long run convergent.

Figure- 3: Impulse Response of the variables based on VECM



Conclusion

It is revealed from the study that relative price of export is not an important determinant of export supply of Bangladesh meaning that Bangladesh, as a small open country, is a price taker in the international market. The export supply is positively related with GDP but its contribution in increasing export supply is very low. The gross capital formation appears as the most important determinant of the

export supply of Bangladesh. So the enhancement of export supply of Bangladesh is largely dependent on gross capital formation meaning that more investment in exportable sector could significantly contribute in this sector. The policy makers should give proper attention to the gross capital formation in designing our export policy. The liberalization dummy variable for regime change from inward looking strategy to export led growth strategy is found negative and insignificant. Therefore, the policy makers should also be more cautious in formulating policies under trade liberalization programs.

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Appendix A

Table A.1: Compound Growth Rates and Compound Annual Growth Rates for Exports

Period	Estimated Trend Regression	CGR[1] (%)	CAGR[2](%)
Pre-liberalization 1972-1973 to 1989-1990	LX= 5.71 + 0.084T	8.81	8.54
Post-liberalization 1990-1991 to 2009-2010	LX= 5.45 + 0.112T	11.90	11.88
Overall 1972-73 to 2009-2010	LX= 5.50 + 0.109T	11.56	10.63

Note: 1. CGR = [Anti-log of estimated b – 1] X 100, log means natural logarithm
2. CAGR = [Ending Value/Beginning Value]1/N – 1

Source: Author's own calculation.

Table A.2: Regression Results of Aggregate Export Supply Model

Dependent Variable: LRX(Real Export in logarithm)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.55	1.30	-5.03	0.000
LRPX	0.25	0.38	0.66	0.516
LRGDP	0.50	0.16	3.24	0.003
LRGCF	0.73	0.14	5.32	0.000
LIBD	0.16	0.20	0.82	0.419

Test Statistics

R-squared	0.96	Mean dependent var	6.59
Adjusted R-squared	0.96	S.D. dependent var	1.34
S.E. of regression	0.24	Akaike info criterion	0.17
Sum squared resid	1.95	Schwarz criterion	0.39
Log likelihood	1.85	F-statistic	255.93
Durbin-Watson stat	1.80	Prob (F-statistic)	0.000

Source: Author's own calculation.

Table A.3: Vector Error Correction Model (VECM) Results

Dependent Variable: ΔLog (RX)

Regressors	Coefficients	t-statistics	Test Statistics	
C (Intercept)	-0.176	-1.38	R-squared	0.376
ΔLog(RX)(-1)	0.672	3.34	Adj. R-squared	0.141
ΔLog(RX)(-2)	0.039	0.24	Sum sq. resids	0.352
ΔLog(RPX)(-1)	0.159	0.73	S.E. equation	0.121
ΔLog(RPX)(-2)	0.017	0.076	F-statistic	1.603
ΔLog(RGDP(-1)	0.109	0.68	Log likelihood	29.46
ΔLog(RGDP)(-2)	0.074	0.46	Akaike AIC	-1.145
ΔLog(RGCF)(-1)	0.232	1.00	Schwarz SC	-0.696
ΔLog(RGCF)(-2)	-0.068	-0.43	Mean dependent	0.125
ΔLIBD	-0.015	-0.155	D.W	1.86
EC(-1)	-0.007	-0.35	HET.	0.141

Source: Researcher's Own Calculation

Table A.4: Vector Auto-regression Model (VAR) Results

Regressors	Coefficients	t-statistics	Test Statistics	
C (Intercept)	-1.76	-1.38	R-squared	0.990
Log(RX)(-1)	0.67	2.33	Adj. R-squared	0.987
Log(RX)(-2)	0.196	0.76	Sum sq. resids	0.494
Log(RPX)(-1)	-0.362	-0.15	S.E. equation	0.137
Log(RPX)(-2)	-0.266	1.42	F-statistic	340.41
Log(RWY)(-1)	1.019	0.80	Log likelihood	24.87
Log(RWY)(-2)	-0.464	-0.39	Akaike AIC	-0.907
Log(RWY)(-1)	1.01	0.80	Schwarz SC	-0.507
Log(RWY)(-2)	-0.464	-0.39	Mean dependent	6.73
LIBD	0.095	0.96	D.W	1.67

Source: Researcher's Own Calculation.