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# Estimation of Trade Elasticities: An Application of Johansen's Cointegration Method to the Bangladesh Trade Data

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This paper employs Johansen's cointegration method to estimate import and export demand elasticities for Bangladesh. Based on the graphical display of the data in the log of levels, the cointegrating vectors were estimated assuming a linear trend in the non-stationary part of the model, both for the import demand and the export demand equations. Trace test as well as λ-max test suggest that only a single statistically significant cointegrating vector is present among the variables of the import demand and the export demand equations. Normalizing the cointegrating vector for the import demand with respect to the log of the import variable and the export demand with respect to the log of export variable the estimated elasticity with respect to price change originating from exchange rate movement were about –3 and 2.4 respectively, implying the comfortable fulfillment of the Marshall-Learner condition. So currency depreciation or devaluation, given relative prices and income, will improve trade balance for Bangladesh in the long run.

## 1. Introduction

In fixed exchange rate system government uses exchange rate as a policy tool to influence trade pattern favorably, whereas in a managed floating system government occasionally intervene in the currency market to change the exchange rate in the desired direction. Whatever may be the method the success of the government in influencing trade flow crucially depends on the trade elasticities. Measuring trade elasticities is not new, but in most cases the estimates are based on misspecified model or wrong methodology. Since time series data almost invariably show non-stationarity, estimates based on simple ordinary least square (OLS) method on level data may be misleading. Again differencing the data and running OLS on the resulting

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differenced series only is not also appropriate. By differencing we lose long-run information contained in the level data of the variables. The correct methodology here is to find if there exists any cointegrating relationship among the variables, and if so, combine the differenced and the level variables into an error-correction framework to estimate the desired coefficients. A common strategy is to follow the two-step Engle-Granger (1987) methodology. But when there are more than two variables, as will be case here, the above method is not able to detect the presence of multiple cointegrating vectors. Moreover, power of such tests in small samples has been found to be low. The present study employs maximum likelihood based technique of estimating cointegrating vectors as proposed by Johansen (1988), and Johansen and Juselius (1990). An attractive and useful feature of this model is that it can find out, and at the same time estimate, the multiple cointegrating vectors that may be present among the data series.

The paper is structured as follows. After briefly highlighting the objectives of the paper in section II, existing literature regarding the estimation of trade elasticities are reviewed in section III. Section IV discusses the methodological issues and analyzes the result. Summary and some concluding remarks are contained in the final section.

## 2. Objectives

Empirically modelling equilibrium relationship as well as determining the dynamic adjustment process toward equilibrium is important both for policy purpose and understanding the economic system in hand. From a set of variables that have theoretically meaningful relationship, the paper attempts to find out the number of cointegrating combinations among these variables and build empirical model to estimate short-run and long-run trade elasticities. These elasticity estimates are important in that they help us infer about the fulfilment of the Marshal-Learner condition and potential for improvement of trade balance through devaluation.

## 3. Literature Review

At the macroeconomic level the findings about the effects exchange rate changes on trade balance is not conclusive. Depending the type of methodology used researchers have reached mixed conclusions. Cooper

(1971) made some early theoretical contributions on the effects of devaluations in developing countries. The upshot of his analysis was that devaluations in developing countries are likely to be deflationary in the first instance and thus may make room for improvement in balance on goods and services. For a group of developing countries Kamin (1988) tried to explain some stylized facts of devaluation. He observed that immediately after devaluation, export growth tends to rise sharply, import growth continues to fall, and output growth remains more or less stable (short-run effects). Subsequently, export growth rises somewhat more before stabilizing, import growth rebounds to surpass the pre-devaluation rates, and output growth slowly rises to match its earlier performance (long-run effects). His result suited well for the average countries, but there were considerable discrepancies in the results when individual countries were considered.

Gylfason and Risager (1984) estimated the trade elasticities from a macro model and found that devaluations improve trade balance. On the other hand Marquez (1990) used band spectrum analysis and found that for the developing countries the sum of export and import elasticities is not sufficient for devaluations to improve trade balance.

Some literature in the context of Bangladesh is also available. Ball and Feldstein (1998) used a numerical analysis and inter temporal general equilibrium model to explain various macroeconomic shocks including devaluation using Bangladesh parameters. They got positive results for output from reduced government expenditure and a moderate devaluation. In a similar vein Ahammad (1995) used a computable general equilibrium model incorporating key institutional features of the Bangladesh economy. His simulation result, using the data for the year 1989, for different macroeconomic shocks including devaluation explained how the structure and growth of industries were affected by these shocks. Empirical analysis of exchange rate change on Bangladesh external sector using time series data is severely lacking. The present study is directed toward fulfilling that gap.

## 4. Data, Methodology, and Results

The analysis is based on a yearly dataset of the Bangladesh economy over the period 1973-2005. For most of the variables used in the study, data comes from the International Financial Statistic (IFS) CD ROM, various issues of the Statistical Yearbook of Bangladesh, and the IMF online database. All the variables are in log form as we are assuming the presence of multiplicative effects among the variables. To estimate the relevant trade elasticities, import and export demand functions of the following forms, as suggested by Dornbusch, et. al. (2004), were considered:

$$\log M_t = \beta_{11} \log\left(\frac{P}{P^w}\right)_t + \beta_{12} \log E_t + \beta_{13} \log Y_t \qquad (1)$$

and

$$\log X_t = \beta_{21} \log\left(\frac{P_x}{P_x^w}\right)_t + \beta_{22} \log E_t + \beta_{23} \log Y_t^w \qquad (2)$$

A description of the relevant variables and their unit of measurement are given below the dataset in appendix A. The first equation assumes that import depends on relative price, nominal exchange rate, and home income, while in the second equation export depends on relative price, exchange rate, and world income. Since the United States is Bangladesh's major trading partner and world macroeconomic events are closely tied up with the US economy, the relevant US variables were used as proxies for the world variables. As regard signs of the coefficients, the price term (domestic price relative to import price) and the income term in the import demand function are expected have positive signs, whereas the coefficient on the nominal exchange rate is likely to have negative sign. For the export demand function, nominal exchange rate and income term are expected to have positive signs, and the price term (export price relative to world price) to have negative sign.

We want to find if there is any statistically significant long-run equilibrium relationship among all or some of the variables in equations (1) and (2). In both the equations, since there are more than two variables, there may exist more than one equilibrium relationship in the cointegrating space spanned by the multiple cointegrating vectors. Such additional relationships are often dictated by economic theory (King, et. al. 1991). For example, the cointegrating vector in equation (1) might be [0 $\beta_{11}$, $\beta_{12,}$ 0] or [0 $\beta_{21}$, $\beta_{22,}$ 0] in equation (2), which would indicate the purchasing power parity relationship.

The first step in our approach to cointegration is to test the relevant variables for stationarity. If all the variables are stationary then OLS method will be sufficient to extract the long-run relationship among the variables under consideration. Whereas if some or all of the variables are non-stationary, we need to find out if some linear combinations of them are stationary. Augmented Dicky-Fuller test was performed on each of the variables separately to determine whether they are individually non-stationary. The Dicky-Fuller test statistic values and the corresponding 5% and 1% asymptotic critical values are reported in table 1.

**Table 1: Testing for stationarity of the variables**

| Variables | No. of lags* | Test values ($\tau$) | 5% Critical Values | 1% Critical values |
|---|---|---|---|---|
| ln m | 0 | -3.39 | -3.60 | -4.38 |
| ln x | 0 | -2.35 | -3.60 | -4.38 |
| ln e | 0 | -2.97 | -3.60 | -4.38 |
| ln (P/Pw) | 0 | -0.37 | -3.60 | -4.38 |
| ln (Px/Pxw) | 0 | -2.68 | -3.60 | -4.38 |
| ln Y | 5 | -3.82 | -3.60 | -4.38 |
| ln YUS | 2 | -3.46 | -3.60 | -4.38 |

**Note:**

- Lag lengths are selected in such a way that Akaike Information Criterion (AIC) and Swartz Crieterion (SC) are minimized.
- Test values are the estimated coefficients ($\alpha_2$) from the following equation:

$$\Delta x_t = \alpha_0 + \alpha_1 t + \alpha_2 x_{t-1} + \sum_{j=1}^{k} \Delta x_{t-j} + \varepsilon_t$$

i.e. the data are assumed to have a drift term and a time trend, and the critical values are obtained accordingly.

The decision rule here is if the computed absolute values of the $\tau$-statistics (column 3 in table 1) exceed the Dicky-Fuller critical value, we reject the null hypothesis of non-stationarity and conclude that the data are stationary. Otherwise the data are treated as non-stationary. Except for ln Y, all the variables are non-stationary at 5% level of significance. But the above variable is non-stationary at 1% level of significance. The non-stationary nature of the data, with shifting mean and/or variance, is also apparent in the plot of these data in appendix B. Hence we treat all the variables as non-stationary and try to find out if there are any long run relationships among these variables as specified in the import demand and export demand equations.

The Johansen's method starts with the p-variable vector autoregressive equation of the form:

$$X_t = \Pi_1 X_{t-1} + \cdots + \Pi_k X_{t-k} + \mu + \varepsilon_t \qquad (3)$$

Where X's are the vector of variables and k is the lag length, $\mu$ is the constant term, and $\varepsilon_t \sim N_p(0, \Lambda)$, i.e. the error term is a p-dimensional multivariate normal distribution with zero mean vector and covariance matrix, $\Lambda$. The above equation can be alternatively written as (see Johansen and Juselius, 1990)

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \cdots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-1} + \mu + \varepsilon_t \qquad (4)$$

Where $\Gamma_i = -(I - \Pi_1 - \cdots - \Pi_i)$, i = 1,2, ….., k-1

and $\Pi = -(I - \Pi_1 - \cdots - \Pi_k)$

The key coefficient matrix in equation (4) is the $\Pi$ matrix which contains information about the long-run relationship among the variables. There are three possibilities:

1. Rank ($\Pi$) = p implies that the vector process in equation (3) is stationary and we can run the model in level form.

2. Rank ($\Pi$) = 0 implies that model (4) without the $\Pi X_{t-1}$ term is appropriate, i.e. the vector autoregressive model in differenced form can be used.

3. 0 < Rank ($\Pi$) < p implies that the variables are non-stationary, but there are some long-run cointegrating relationship among them. Technically $\Pi$ can be written here as $\Pi = \alpha\beta'$ where $\alpha$ and $\beta$ are p×r matrices (r < p). The appropriate model to be used here should be in error correction form.

Therefore our main hypothesis is about the number of cointegating vectors (i.e. the value of r) in the $\beta$ matrix. We maintain

$H_0$: r = p (in model 3), against

$H_1$: $\Pi = \alpha\beta'$ (i.e. r < p in model 4)

Where α and β are p × r matrices and r < p. If $H_1$ is accepted we estimate the model (4) under the hypothesis Π = αβ′ and the resulting model will be in vector error correction form. We should note that the r-vectors in the β matrix are not identified. The columns of β span the whole cointegrating space. Hence the data determine only the cointegrating space, and the space spanned by α. Since any non-singular transformation of a set of basis vectors represents another set of basis vectors for the same space we will present the result in normalized form.
The maximum likelihood estimation of the unrestricted model (4) involves two critical steps:
4. Regress $\Delta X_t$ on $\Delta X_{t-1}$, …, $\Delta X_{t-k+1}$, and 1. Then obtain the residuals $R_{0t}$
5. Regress $\Delta X_{t-k}$ on the same set of variables as above and obtain residuals $R_{kt}$
Now consider the following expression

$$S_{ij} = T^{-1}\sum_{t=1}^{T} R_{it}R'_{jt} \quad \text{(where i, j = 0, k)}$$

The $S_{ij}$ matrix thus obtained is very useful in estimating the parameters in Π of equation 4 under the restriction $H_0$: Π = αβ′. Theorem 3.1 in Johansen and Juselius (1990) shows this to be

$$\hat{\Pi} = S_{0k}S_{kk}^{-1} \qquad (5)$$

A Shazam procedure developed by Diana Whistler (2000) was used to get the estimates of equation (5) as well as the various other estimates derived later in this paper.

**Table 1: Estimation of the Π matrix**

| Import Demand Equation | | | | |
|---|---|---|---|---|
| log M | -1.1631 | 0.8168 | -2.1708 | 5.0250 |
| log $(^{P}/_{P^{w}})$ | -0.6481 | 0.3758 | -1.2305 | 1.1829 |
| log E | -0.0254 | 0.0326 | -0.4830 | 0.2287 |
| log Y | 0.4366 | -0.1364 | -0.1241 | -0.3510 |

| Export Demand Equation | | | | |
|---|---|---|---|---|
| log X | -0.1215 | 0.1954 | 0.1073 | 0.0913 |
| log $(^{Px}/_{Px^{w}})$ | 0.3372 | -0.4054 | 0.3165 | -0.6422 |
| log E | -0.0993 | 0.0968 | -0.7829 | 0.7501 |
| log $Y^*$ | 0.0864 | -0.0349 | 0.0669 | -0.2525 |

The key feature of the Π matrix is that the rank of this matrix is equal to the number of linearly independent cointegrating vectors. If rank (Π) = r < p, there are r independent cointegrating vectors. The rank of this matrix can be found by testing for the number of nonzero characteristic values (or eigenvalues) it posses. If all the roots of the characteristic polynomial are zero, the rank of Π will also be zero and the variables will not be cointegrated. Rank (Π) > 0 would imply that at least one of the roots will be significantly different from zero and the corresponding eigenvectors associated with these roots would indicate the long-run relationship among the variables. All other eigenvectors (which are p-r in number) can be expressed as a linear combination of the eigenvectors associated with nonzero eigenvalues.

The Maximum Likelihood estimates of the cointegrating vectors β under the hypothesis $H_0 : \Pi = \alpha\beta'$ is obtained by first solving the following equation

$$\left| \lambda\, S_{kk} - S_{k0} S_{00}^{-1} S_{0k} \right| = 0$$

for various eigenvalues λ's and then for the corresponding eigenvectors $\widehat{V} = (\widehat{v}_1, \cdots, \widehat{v}_p)$ which are normalized such that $\widehat{V} S_{kk} \widehat{V} = I$ .

**Testing for the Number of Cointegrating Vectors (r):**

Two tests, namely the trace test and the λ-max test are performed to determine the number of cointegrating vectors. Both tests are based on the eigenvalues calculated above. The calculated eigenvalues and the corresponding eigenvectors are reported in table 2.

**Table 2: Estimated Eigenvalues ($\hat{\lambda}$), Eigenvectors ($\hat{v}$), and Weights ($\hat{\alpha}$)**

Import Demand Equation
Eigenvalues, $\hat{\lambda}$
(0.0442 0.4018 0.5933 0.7649)

| | Eigenvectors ($\hat{v}$) | | | | Weights ($\hat{\alpha}$) | | | |
|---|---|---|---|---|---|---|---|---|
| log M | -10.4761 | 5.9470 | -14.2535 | 3.8553 | 0.0491 | -0.0245 | 0.0371 | 0.0067 |
| log $(^{P}/_{P}{}^{w})$ | 7.0579 | -5.6709 | 8.5408 | 2.1812 | 0.0766 | 0.0484 | 0.0118 | 0.0067 |
| log E | -31.2452 | 24.2425 | -1.2556 | 0.3292 | 0.0028 | -0.0168 | -0.0084 | -0.0045 |
| log Y | 23.7721 | -15.8944 | 12.8723 | -1.2558 | -0.0464 | -0.0662 | -0.0228 | 0.0049 |

Export Demand Equation
Eigenvalues, $\hat{\lambda}$
(0.0287 0.2544 0.7153 0.7591)

| | Eigenvectors ($\hat{v}$) | | | | Weights ($\hat{\alpha}$) | | | |
|---|---|---|---|---|---|---|---|---|
| log X | -2.7571 | -4.0849 | 7.9541 | 2.5010 | 0.0098 | 0.0017 | -0.0149 | 0.0125 |
| log $(^{Px}/_{Px}{}^{w})$ | -0.0289 | 1.9647 | -10.4234 | 2.9419 | 0.0242 | -0.0241 | 0.0362 | 0.0069 |
| log E | 3.8644 | -14.1116 | -3.7895 | 2.9759 | -0.0359 | 0.0456 | -0.0010 | -0.0015 |
| log $Y^{*}$ | 3.3998 | 18.9443 | -6.4382 | -5.7784 | -0.0125 | -0.0107 | 0.0012 | -0.0006 |

The likelihood ratio test statistic for $H_1$ in $H_0$ is

$$-2\ln\left(Q \mid H_1 \; in \; H_0\right) = -T\sum_{i=1}^{p}\ln\left(1-\hat{\lambda}_i\right)$$

Similarly, the likelihood ratio test statistic for testing $H_1(r)$ in $H_1(r+1)$ is

$$-2\ln\left(Q \mid H_1(r) \; in \; H_1(r+1)\right) = -T\sum_{i=1}^{p}\ln\left(1-\hat{\lambda}_{r+1}\right)$$

The calculated test statistics are reported in table-3 as trace test and λ-max test respectively. The 95% quantiles are taken from Johansen and Juselius (1990).

**Table-3: Trace and λ-max test statistics with 95% quantiles**
(Import Demand Equation)

| Null, $H_0$ | Alternative | Trace | 95% quantiles | Null, $H_1$ | Alternative | λ-max | 95% Quantiles |
|---|---|---|---|---|---|---|---|
| r≤3 | r=4 | 1.403 | 8.1 | r≤3 | r=4 | 1.402 | 8.1 |
| r≤2 | r≥3 | 17.332 | 17.3 | r≤2 | r=3 | 15.931 | 14.6 |
| r≤1 | r≥2 | 45.221 | 31.3 | r≤1 | r=2 | 27.889 | 21.3 |
| r=0 | r≥1 | 90.104 | 48.4 | r=0 | r=1 | 44.889 | 27.3 |

**Trace and λ-max test statistics with 95% quantiles**
(Export Demand Equation)

| Null, $H_0$ | Alternative | Trace | 95% quantiles | Null, $H_0$ | Alternative | λ-max | 95% Quantiles |
|---|---|---|---|---|---|---|---|
| r≤3 | r=4 | 0.904 | 8.1 | r≤3 | r=4 | 0.904 | 8.1 |
| r≤2 | r≥3 | 10.006 | 17.3 | r≤2 | r=3 | 9.102 | 14.6 |
| r≤1 | r≥2 | 48.949 | 31.3 | r≤1 | r=2 | 38.944 | 21.3 |
| r=0 | r≥1 | 93.070 | 48.4 | r=0 | r=1 | 44.121 | 27.3 |

If all the eigenvalues are near zero, the value of both the trace test ,$-T\sum \ln\left(1-\hat{\lambda}_i\right)$ , and the λ-max test, $-T\ln\left(1-\lambda_{r+1}\right)$, values will be close to ln(1) and hence to zero. The variables will not be cointegrated in this case. On the other hand, if one of the λ's (say $\lambda_1$) is in the range $0<\lambda_1<1$, then the first term of trace test will be negative, and when multiplied by –T will turn it into positive giving the trace statistic value which can be compared to the tabulated 95% quantiles to test for its statistical significance. The larger the value of λ, the larger will be the value of the test statistic. The difference between the two test is that while in case of trace test the alternative hypothesis is in general form ($H_0$: rank (π) =r against $H_1$: rank (π) ≤ r), the λ-max formulates the alternative in more specific form ($H_0$: rank (π) =r against $H_1$: rank (π) ≤ r+1).

Critical values of these tests are obtained by Monte Carlo simulation approach and have been reported in various places (see for example, Osterwald and Lenum, 1992, Johansen and Juselius, 1990, Enders, 2004). The theoretical distributions, and hence the critical values, depend on the number of non-stationary components under the null (i.e. p-r), and assumptions about the constant term μ in equation (3).

To test the null hypothesis $H_0$: r = 0, against the general alternative $H_1$: r ≥ 1, we use the trace test, whose value is found to be 90.104 from the bottom of table 3. This value should be compared with the critical value obtained from a theoretical distribution which is constructed under the null hypothesis that there is a zero cointegating vector (i.e. p-r = 4) and that the constant term is unrestricted. The value thus obtained is 48.4 which is far below the test value indicating that the null is not binding (i.e. we reject the null) and encourages us to sequentially test for the second null $H_0$: r = 1, against $H_1$: r ≥ 2. Similar comparison this time also leads us to the rejection of the null indicating that there must be at least two cointegrating vectors among the variables used in the import demand function. Since in the third step the alternative is accepted we naturally reach the conclusion that there are two cointegrating vectors in the import demand equation. λ-max test also takes us to the same conclusion of two cointegrating vecors. Examining the results in the lower panel of table 2 also confirm us about the existence of two cointegrating vectors in the export demand equation.

Since there are two statistically significant cointegrating vectors one of the eigenvectors from table 2 could be used to represent the long-run import demand function. The first vector seems promising in this context and we normalize it so that the coefficient of the import variable becomes –1. The resulting relationship is

$$\log M_t = 0.6737 \log\left(\frac{P}{P^w}\right)_t - 2.9825 \log E_t + 2.2691 \log Y_t$$

Similarly the export demand function will have the representation (also choosing the first vector from the lower panel of table 2)

$$\log X_t = -0.0184 \log\left(\frac{P_x}{P_x^w}\right)_t + 1.4016 \log E_t + 1.3056 \log Y_t^w$$

All the estimated coefficients in both the long-run equations (import demand and export demand) are of appropriate sign. The coefficients of the log $E_t$ term suggest that nominal devaluations, given relative prices, domestic and foreign income level, do affect trade flow favorably in the long-run. Moreover since the sum of the absolute values of the import and export demand elasticity coefficients is |-2.9825| + |1.4016| or 4.341 > 1, the Marshal-Learner condition for improving trade balance is satisfied comfortably.

So the message conveyed by the above analysis to the policymakers of Bangladesh is that whenever they are concentrating on improving trade balance through exchange rate management, success will depend on the following two circumstances:

1. While taking devaluation measure and maintaining it (i.e. not reversing the devaluation decision later), how well they can contain relative prices at the pre-devaluation level. Currency depreciation often lead to increase in domestic inflation if the country is import dependent and import demand elasticity is greater than one, which is the case here.
2. Changes in the world economic environment can also affect the ultimate effect of devaluation. If the outside world falls into recession world price is also likely to fall and world income will decline at the same time. Thus through relative price effect and income effect the positive effects of nominal devaluations may be concealed.

For completeness the above long-run analysis needs to be supplemented by short-run adjustment process. The adjustment coefficients are already reported in the right hand side of table 2. Since we found r = 2, we should have two linearly independent $\alpha_i$ vectors. The second vector in the adjustment coefficient matrix seems appropriate in explaining the import demand equation. With this vector the error correction model is

$$\Delta X_t = \alpha\beta' X_{t-1}$$

where $\Delta X_t = \left( \Delta \ln M_t \quad \Delta \ln \left( P/P_W \right)_t \quad \Delta \ln E_t \quad \Delta \ln Y_t \right)'$

and $X_{t-1} = \left( \ln M_{t-1} \quad \ln \left( P/P_W \right)_{t-1} \quad \ln E_{t-1} \quad \ln Y_{t-1} \right)'$

$\alpha = (-0.26 \quad 0.51 \quad -0.18 \quad -0.69)'$ (after normalization. Note: Since β was normalized by dividing all of its elements by 10.4761, for consistency α has been normalized here by multiplying all its elements by 10.4761)

$\beta = (-1 \quad 0.6737 \quad -2.9825 \quad 2.2691)'$ (normalized with respect to log import)

In detail the vector error correction model now becomes

$$\begin{bmatrix} \Delta \ln M_t \\ \Delta \ln \left( P/P_W \right)_t \\ \Delta \ln E_t \\ \Delta \ln Y_t \end{bmatrix} = \left[ \begin{pmatrix} -0.26 \\ 0.51 \\ -0.18 \\ -0.69 \end{pmatrix} \begin{pmatrix} -1 & 0.67 & -2.98 & 2.27 \end{pmatrix} \right] \begin{bmatrix} \ln M_{t-1} \\ \ln \left( P/P_W \right)_{t-1} \\ \ln E_{t-1} \\ \ln Y_{t-1} \end{bmatrix}$$

Or

$$\begin{bmatrix} \Delta \ln M_t \\ \Delta \ln \left( P/P_W \right)_t \\ \Delta \ln E_t \\ \Delta \ln Y_t \end{bmatrix} = \begin{bmatrix} -0.26\ \beta' X_{t-1} \\ 0.51\ \beta' X_{t-1} \\ -0.18\ \beta' X_{t-1} \\ -0.69\ \beta' X_{t-1} \end{bmatrix}$$

The above system indicates that if actual import exceeds the equilibrium import some year, 26 per cent of the gap is closed in the next year. The second equation shows that import above equilibrium level induces relative price increases which may be attributed to the high import content of the Bangladesh GDP. The third equation implies that a million dollar excess import induces an 18 percent fall in the value of taka. Finally GDP also falls by 69 percent in a year in response to excess import in the previous year which also helps to restore import balance as import declines with falling income.

## 5. Summary and Conclusion

The estimation framework and inference procedure used in the study is due to Johansen and his coauthors. The step begins with estimating a k-th order VAR in p-variables. The likelihood that there are r-cointegrating vectors, H(r), against p-cointegrating vectors, H(p), is tested using the so called trace test and the λ-max test. Larger value of the test is evidence against H(r) and for H(p>r), whereas small value of the test is not evidence against H(r) and the cointegrating rank is taken as equal to or less than r. Both methods suggest the presence of two cointegrating vector in both the export and import demand equations. We have chosen the vectors that theoraticlaly resembles these two functions The estimated long-run coefficients of the exchange rate variables are encouraging for relying on exchange rate base measures for improving trade balance. The estiamated income elasticity coefficient of greater than unity is also consistent with the fact that Bangladesh is integrating with the world economy at a faster rate than the rate at which the country is growing.

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## Appendix A: The Dataset

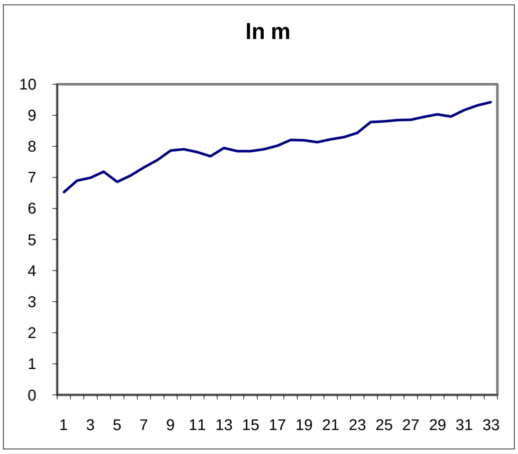
| Year | E | P | PM | PX | X | M | Y | PXUS | YUS | PUS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 7.85 | 6.692 | 55.11 | 61.01 | 260.33 | 682.71 | 45.11 | 35.349 | 1382.73 | 25.797 |
| 1974 | 8.226 | 9.407 | 89.52 | 72.41 | 357.73 | 986.39 | 71.09 | 45.132 | 1499.98 | 28.643 |
| 1975 | 12.186 | 16.095 | 104.21 | 58.4 | 347.91 | 1078.42 | 125.74 | 50.483 | 1638.33 | 31.259 |
| 1976 | 15.399 | 12.253 | 89.52 | 64.92 | 327.24 | 1321.25 | 107.46 | 52.159 | 1825.28 | 33.052 |
| 1977 | 15.375 | 11.856 | 82.84 | 75.68 | 400.77 | 952.15 | 105.36 | 54.051 | 2030.92 | 35.196 |
| 1978 | 15.016 | 15.464 | 83.73 | 72.43 | 475.69 | 1163.12 | 146.37 | 57.78 | 2294.7 | 37.888 |
| 1979 | 15.552 | 17.462 | 76.13 | 82.77 | 548.47 | 1512.6 | 172.82 | 65.726 | 2563.3 | 42.156 |
| 1980 | 15.454 | 28.002 | 102.89 | 107.99 | 658.68 | 1908.36 | 280.78 | 74.644 | 2789.52 | 47.8513 |
| 1981 | 17.987 | 30.091 | 116.76 | 93.74 | 758.51 | 2598.96 | 322.14 | 81.508 | 3128.43 | 52.788 |
| 1982 | 22.118 | 33.514 | 122.12 | 80.67 | 790.63 | 2699.08 | 361.74 | 82.427 | 3255.02 | 56.04 |
| 1983 | 24.615 | 36.51 | 115.74 | 82.18 | 769.44 | 2463.87 | 408.31 | 83.292 | 3536.67 | 57.84 |
| 1984 | 25.354 | 42.021 | 114.09 | 96.98 | 724.5 | 2164.77 | 489.79 | 84.427 | 3933.17 | 60.337 |
| 1985 | 27.9946 | 46.483 | 117.27 | 117.49 | 931.43 | 2825.23 | 561.94 | 83.779 | 4220.25 | 62.486 |
| 1986 | 30.407 | 49.971 | 101.34 | 85.21 | 998.78 | 2542.35 | 632.69 | 84.589 | 4462.82 | 63.647 |
| 1987 | 30.95 | 55.169 | 92.5 | 88.34 | 879.92 | 2546.1 | 727.71 | 86.053 | 4739.47 | 66.028 |
| 1988 | 31.733 | 58.94 | 94.032 | 103.35 | 1067.09 | 2715.08 | 799.93 | 92.1113 | 5103.75 | 68.675 |
| 1989 | 32.27 | 64.008 | 100 | 100 | 1290.98 | 3041.42 | 890.6 | 94.522 | 5484.35 | 71.99 |
| 1990 | 34.569 | 67.625 | 105.97 | 103.24 | 1304.87 | 3650.36 | 1003.29 | 95.3878 | 5803.07 | 75.876 |
| 1991 | 36.596 | 72.086 | 110.49 | 110.04 | 1671.34 | 3618.1 | 1105.18 | 96.246 | 5995.92 | 79.089 |
| 1992 | 38.951 | 74.231 | 107.41 | 108.42 | 1688.84 | 3411.91 | 1195.42 | 96.3417 | 6337.75 | 81.485 |
| 1993 | 39.567 | 74.444 | 110.91 | 115.88 | 2097.84 | 3731.54 | 1253.7 | 96.883 | 6657.4 | 83.89 |
| 1994 | 40.212 | 77.252 | 114 | 122.35 | 2277.94 | 3994.16 | 1354.12 | 98.942 | 7072.23 | 86.077 |
| 1995 | 40.278 | 82.927 | 124.18 | 129.59 | 2660.74 | 4602.47 | 1525.18 | 103.925 | 7397.65 | 88.492 |
| 1996 | 41.794 | 86.438 | 149.1 | 149.02 | 3173.11 | 6501.54 | 1663.24 | 104.492 | 7816.82 | 91.086 |
| 1997 | 43.892 | 89.109 | 151.53 | 153.24 | 3297.23 | 6621.11 | 1807.01 | 103.075 | 8304.33 | 93.215 |
| 1998 | 46.906 | 93.809 | 162.99 | 168.04 | 3778.4 | 6898.41 | 2001.77 | 99.675 | 8746.98 | 94.662 |
| 1999 | 49.085 | 98.176 | 178.5 | 178.54 | 3831.27 | 6973.77 | 2196.97 | 98.417 | 9268.43 | 96.733 |
| 2000 | 52.142 | 100 | 180.07 | 178.46 | 3921.92 | 7694.39 | 2370.86 | 100 | 9816.97 | 100 |
| 2001 | 55.807 | 101.587 | 193.62 | 182.75 | 4690.68 | 8359.92 | 2535.46 | 99.158 | 10127.9 | 102.826 |
| 2002 | 57.888 | 104.834 | 208.18 | 187.06 | 6102.36 | 7780.13 | 2732.01 | 98.175 | 10469.6 | 104.457 |
| 2003 | 58.15 | 109.58 | 224.31 | 191.74 | 7050.13 | 9491.99 | 3005.8 | 99.733 | 10960.7 | 106.828 |
| 2004 | 59.513 | 114.227 | 240.24 | 199.51 | 8150.68 | 11157.1 | 3329.73 | 103.575 | 11712.5 | 109.688 |
| 2005 | 64.328 | 119.958 | 256.29 | 200 | 9186.22 | 12291.7 | 3684.76 | 106.875 | 12455.8 | 113.41 |

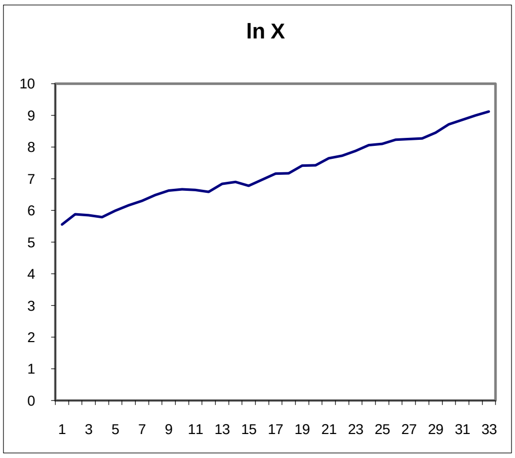
**Variable Description:**

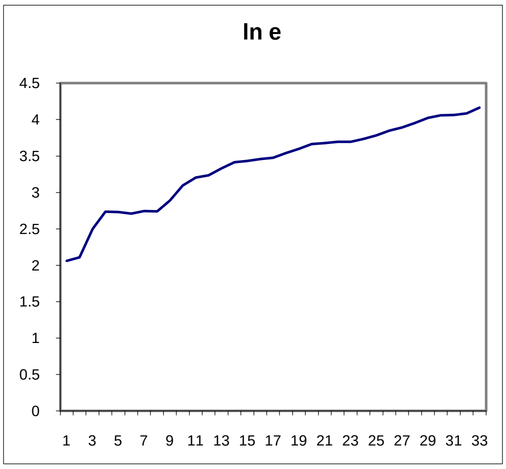
E=Exchange Rates, taka per us dollars
P=GDP deflator (2000=100) of Bangladesh
PM=Import Price Index
PX=Export Price Index
X=Export (millions of us dollars)
M=Import (millions of US dollars)
Y=GDP of Bangladesh (billion taka)
PUS=Consumer Price Index of the USA, (used as proxy for world price $P^W$)
PXUS=Export Price Index of the USA (used as proxy for world export price $P_X^W$)
YUS=US GDP (billions of US dollars) (used as proxy for world income Y*)

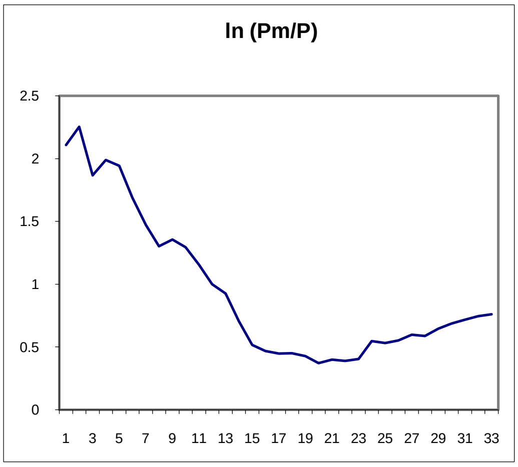
# Appendix B

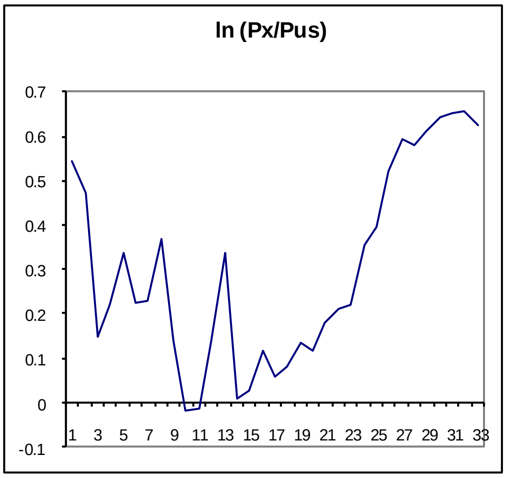
## Plot of the Series

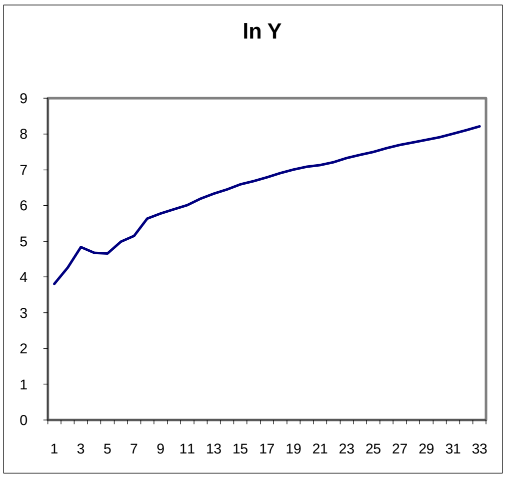


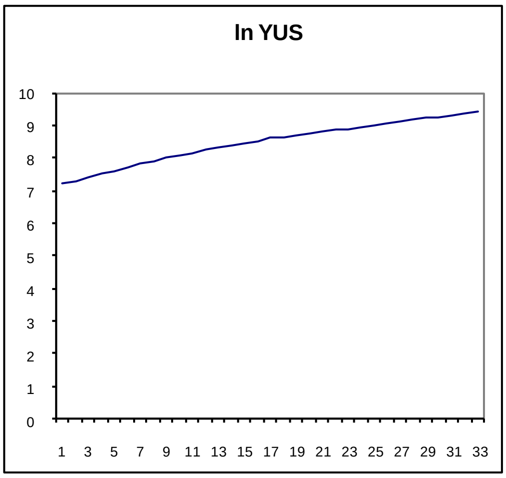




ln (Px/Pus)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33


ln Y
9
8
7
6
5
4
3
2
1
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33


ln YUS
10
9
8
7
6
5
4
3
2
1
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33