DATABASE AND METHODOLOGY

This chapter seeks to outline the database and methodology used in the present study entitled “Sources of Instability, Diversification of Exports and Economic Growth in India”. The study is based on secondary data and conducts a detailed analysis of India’s exports based on commodity wise and destination wise classification of exports. The study has examined the pattern of growth, structure, concentration and instability of India’s exports (both commodity wise and geographical). Besides, the study also examined the sources or causes of export instability and relationship between export instability and economic growth.

The pattern of growth of India’s total exports and its categories/ sub categories (commodity wise and destination wise) was examined for the period of 1987-88 to 2012-13 (at current as well as constant prices). The structure of India’s exports was also analysed for the above mentioned study period. The analysis of commodity wise export instability was used to measure export fluctuations for over all period of study (i.e. 1987-88 to 2012-13) as well as for the sub periods i.e. period I (i.e. 1987-88 to 1999-00) and period II (i.e. 2000-01 to 2012-13). Geographical export instability of selected commodities to principal countries (i.e. exports of seventeen major commodities to eleven principal countries) has also been analysed for the period 1990-91 to 2012-13. Commodity concentration of exports was studied for the period 1987-88 to 2012-13 (category wise and sub category wise) and geographical concentration of selected commodities to principal countries India’s exports for the period 1990-91 to 2012-13. Various significant causes/sources of export instability were examined for the period 1987-88 to 2012-13. The analysis of causality between export instability and economic growth has been analysed for the long time span i.e. 1971-72 to 2012-13.

Data Source

The data has been taken from Directorate General of Commercial Intelligence and Statistics (DGCIS) published by Reserve Bank of India in Handbook of Statistics on Indian Economy (2012-13) for the period 1987-88 to 2012-13.
The data for total exports and also for its categories/ sub categories were collected at current prices. The data were deflated by using common base year i.e. 1999-00, for studying growth structure of India’s exports at constant prices. Therefore, exports Unit Value Indices (UVI) have been used to deflate export values. The formula to convert exports series at 1999-2000 constant prices is as follows:

\[
\text{Deflated (i.e. constant) value of export} = \left( \frac{\text{Current value of export}}{\text{unit value index of export}} \right) \times 100
\]

**Methodology**

In the present study, data has been analysed by calculating growth rates, percentage shares, regression equations, various indices (instability and concentration) etc. with the help of appropriate method. The methodology used for various types of analysis is explained below:

1) **Growth Rates of Exports**

In order to study the growth pattern of Indian exports (commodity wise and destination wise), the compound growth rates have been calculated for the period 1987-88 to 2012-13 and decade wise i.e.1991-92 to 2000-01 and 2001-02 to 2010-11 at current as well as constant prices with the base year 1999-00. The growth rates have been calculated by fitting the exponential function as shown below:

\[
Y_t = ab^t e^u
\]

Transforming the equation in linear form

\[
\log Y_t = \log a + t \log b + U \log e
\]

Where, \(Y_t\) = value of exports in year \(t\)
\(t = \) trend variable
\(u = \) disturbance term
\(a, b = \) constants.

From the estimated values of regression co-efficient ‘\(b\)’ the compound rate of growth ‘\(r\)’ was calculated as follows:

\[
r = (\text{antilog } \hat{b} - 1) \times 100
\]

Where, \(\hat{b}\) = estimated value of \(b\).

In case of commodity wise exports, Unit Value Indices (UVI) with base year 1999-00 were used for deflation. As we have non- availability of Unit Value Indices
(UVI) with common base year of 1999-00 for whole time series, so base year was shifted by using base shifting method of index number.

II) Structure of Exports

For analyzing the structure of India’s exports, the share of various commodities i.e. categories/ sub categories and destination wise exports was calculated in the form of percentages. The commodity wise exports share of India’s exports measured at current as well as constant prices (base year 1999-00) at all points of time during 1987-88 to 2012-13.

III) Measures of Export Instability

In order to find out the extent of export instability, nine different measures of instability has been used in the analysis. These measures are given by different economists in the literature. These different indices of instability are used to measure export fluctuations for over all period of study (i.e. 1987-88 to 2012-13) as well as for the sub periods i.e. period I (i.e. 1987-88 to 1999-00) and period II (i.e. 2000-01 to 2012-13). The detail of these measures of export instability as shown in below:

1) Coppock (1962) measure of instability index is based on log-variance. This index of instability is defined as:

\[ \text{Export Earning Instability Index (EEII)} = \text{antilog} \left( (V \log)^{1/2} \right) \]

Where \( V_{\log} \) is

\[ \sum_{t=1}^{n-1} \left[ \log \left( \frac{X_{t+1}}{X_t} \right) - m \right]^2 / (n - 1) \]

and m is defined as

\[ \sum_{t=1}^{n-1} \left[ \log \left( \frac{X_{t+1}}{X_t} \right) \right] / (n - 1) \]

Here, \( X_t \) is observed value of the export commodities in time period t, n stands for number of years in the series of data used for analysis.
2) Massell (1964) calculated instability index as trend corrected index, which refers an average annual change export commodity. The export instability index EEII₂ can be written as

\[
\text{Export Earning Instability Index (EEII}_2) = 100 \times \frac{\sum_{t=2}^{n} W_t}{n-1}
\]

Where \( W_t = \frac{|u_{t+1} - u_t|}{100 \times \text{mean}(X_{t+1})} \)

\( u_t = X_t - \hat{X}_t \) i.e. subtracting estimated value of exports from actual value of exports; \( \hat{X}_t = b_0 + b_1 t \); estimated value of exports; and \( n \) is the number of years in the series.

3) Kingston (1973) calculated export instability indices as follows:

\[
\text{Export Earning Instability Index (EEII}_3) = \frac{\sum_{t=1}^{n} |X_t - \hat{X}_t| \times 100}{n}
\]

\( X_t \) refers to actual value of the export of specific commodity group in time period \( t \);
\( \hat{X}_t \) refers the antilog of the logarithmic least squares estimate of the secular trend value for the time period \( t \);
\( n \) is the number of time periods (years) over which the instability index is computed.

4) Glezakos (1973) measured instability index by using arithmetic mean of the absolute values of the yearly changes in a time series, duly corrected for the trend and expressed as a percentage of the average of all observations.

\[
\text{Export Earning Instability Index (EEII}_4) = \frac{100}{\sqrt{y}} \times \frac{\sum_{t=2}^{n} X_t - X_{t+1} - \hat{\beta}_1}{n-1}
\]

Where \( X_t = \beta_0 + \beta_1 t \) fitted by the OLS method;
\( \hat{\beta}_1 \) is the estimated slope of the linear trend.

5) Cubby and Della Valle (1979) measured the instability index

\[
\text{Export Earning Instability Index (EEII}_5) = CV(1 - R^2)^{1/2}
\]

Where \( CV \) refers to the coefficient of variation = \( (\sigma / \ddot{X}) \times 100 \);
In which, \( X \) is the value of export of specific category, is the mean value of export and \( \sigma \) is the standard deviation.
is adjusted coefficient of determination calculated by fitting linear trend; n is number of years in the series; k is the number of estimated parameters.

6) Ray (1983) measured instability index with the help of standard deviations of the natural log of the ratio of successive values. The index of instability is defined as:

**Export Earning Instability Index (EEII) = SD \[\ln \left(\frac{X_{t+1}}{X_t}\right)\]**

Where SD is refers to standard deviation; \(X_t\) is the value of particular commodity in the current period \(i.e. t\); \(X_{t+1}\) is for the succeeding year \(i.e. t+1\).

7) Glezakos (1984) measured the instability index through log linear trend. The measure is defined as:

**Export Earning Instability Index (EEII) = \frac{100}{\bar{X}} \times \frac{\sum_{t=1}^{n} X_t - (1+r)X_{t-1}}{n-1}**

Where, \(r\) refers to the growth rate of exports calculated with the help of exponential trend.

8) Export instability can also be measured with the help of “Normalized Standard Error” which is expressed as the Standard Error of Estimate. Standard Error of Estimate can be measure by fitting linear trend as well as exponential trend. The measure based on linear trend is as follows:

**Export Earning Instability Index (EEII) = \left(\frac{SEE}{\bar{X}}\right) \times 100**

Where \(SEE = \left[\sum e_i^2 / (n-k)\right]^{1/2}\)

\(e_i = (X_i - \alpha - \beta t)\) expressed as the difference between observed and estimated values in year \(t\);

\(n\) is number of years and \(k\) is number of variables.

Thus, \(\frac{\sum (\frac{X_t}{\bar{X}} - \alpha - \beta t)^2}{n-k}^{1/2} \times \frac{100}{\bar{X}}\)

The estimated value of \(Y_t\) can be measured by estimating the values of intercept \(i.e. \alpha\) and slope \(i.e. \beta\), while average of export commodity is defined as \(\bar{X} = \frac{\sum X}{n}\).

In this measure the OLS equation is \(X_t = \alpha + \beta t + \mu\),
Where, \( \mu \) is the error term;
n is number of observations in the series. This measure of instability is independent of the rate of growth of country’s exports. In other words, this method estimates the coefficient of variation of the values, corrected for trend.

9) The calculation of export instability through exponential trend is similar to the measure based on linear trend. The instability measured through linear trend has one major shortcoming that it imagines a constant absolute increase in data which may or may not be true. Hence, it would be quite improper if the data shows exponential trend path.

Therefore, the measure based on exponential trend has been calculated as:

\[
\text{Export Earning Instability Index (EEII)}_9 = \left( \frac{\text{SEE}}{\bar{X}} \right) \times 100
\]

Where SEE is defined as

\[
\left[ \frac{\sum e_i^2}{N} \right]^{1/2} \times \frac{100}{\bar{X}}
\]

\[
e_i = (X_t - \alpha e^{\beta t})
\]

\[
\left[ \frac{\sum (X_t \alpha e^{\beta t})^2}{N} \right]^{1/2} \times \frac{100}{\bar{X}}
\]

Most of the measures are based on trend corrected variations (EEII_2, EEII_3, EEII_4, EEII_7, EEII_8, EEII_9) and some of them measure the variability (EEII_1, EEII_5, EEII_6). We have used all these measures in order to have broader idea regarding the extent of export instability in India. However, export instability index based on exponential trend is considered the best measure of instability. In the instability indices analysis EEII_1 and EEII_6 tend to have very low values at constant as well as current prices as compared to other export instability indices. Various measures sometimes give results in different directions. In order to have a comparative picture of pattern of instability of various categories and sub categories of exports, they are classified into four groups by using range method. These groups are very high instability group, high instability group, medium instability group and low instability group.
IV) Measures of Concentration

In the literature various measures of concentration are available. Appropriateness of a measure depends upon the nature of data and the purpose of using the measure (Erlat and Akyuz, 2001; Bailey and Boyle, 1971; Togan, 1994). In the analysis of commodity concentration, the present study uses five concentration measures for commodity wise as well as destination wise data. All these concentration measures are based on the shares of individual commodities/category or destination in India’s total exports for every year of the study period.

The share of each commodity or destination in total exports of India for the year t expressed as:

\[ P_{it} = \frac{Q_{it}}{Q_t} \]

Here, \( i = 1 \ldots m \) and \( t = 1 \ldots n \)

Let \( m \) represents the number of commodity groups and \( Q_{it} \) represents the export of \( i^{th} \) commodity or exports to \( i^{th} \) country at time \( t \). The sum of \( Q_{it} \) from 1 to \( m \) will be \( Q_t \).

In the present analysis for category wise exports of India \( m \) is equal to 11, for major-category wise study and 43 for sub-category wise study. In destination wise analysis of exports \( m \) is equal to 50, while selected commodities to principal countries are eleven. The value of \( n \) is equal to 26 (total number of years in the analysis).

First group comprises of discrete measures of concentration. In such kind of concentration measures, only a few commodities’ or destinations’ shares have been taken for the analysis. Within discrete measures, the first measure is concentration ratio that can be expressed as follows:

1) Concentration Ratio (CR) – It shows the total share of \( k \) commodities/destination, which have the largest shares in total exports of India. Therefore, it considers the share of first few commodities/destinations to measure the concentration levels in exports.

It is denoted by \( CR(k) \) and calculated as:

\[ CR \ (k)_t = \sum_{i=1}^{k} P_{it} \]
Where \( k \) is less than the total number of export commodities/countries.

This measure ranges from zero to one. If the value of Concentration Ratio is near zero that implies that the largest category/destination of exports let’s say, Y is contributing a relatively very low share in the total export income. In other words, the value of concentration closes to zero showing low concentration. If Concentration Ratio is near unity that implies that the largest category/destination of exports let’s say, Y is responsible for almost entire export earnings. In the category wise analysis, CR (2), CR (4) and CR (8) has been measured. For sub-category wise analysis CR (4), CR (8) or CR (16) has been measured. In destination wise analysis of exports, CR (2), CR (4) and CR (8) have been measured. In case of analysis of exports of selected commodities to principal countries, concentration ratio has been measured by CR (2) and CR (4) has been used. The value of \( k \) is determined arbitrarily on the basis of number of categories included in the analysis.

In the concentration analysis, second group includes measures which are known as summary measures. These are as follows:

2) **Hirschman-Herfindhal Index (HH)** – The Hirschman- Herfindhal index (HH) is calculated by taking the square of export shares of all export commodities/destinations in the study. In simple terms, this measure of concentration consists of the sum of shares of exports commodities/destinations (i.e. Pit’s) weighted by themselves. This measure is calculated as below:

\[
HH_t = \sum_{i=1}^{m} P_{it}^2
\]

In this index, greater weight has been given to the larger export categories/country and even it reaches a value of unity i.e. one when the export of only one category or sub category (high concentration).

3) **Rosenbluth-Hall-Tideman (RHT)** – As per this measure of concentration, exports share of each commodities (i.e. Pit) are arranged in descending order as Pit are weighted by their ranks, i.

\[
RHT_t = \frac{1}{2 \sum_{i=1}^{m} (i . P_i) - 1}
\]

The value of RHT ranges between \(1/(2m-1)\) to 1.
4) **Entropy Index** – As per this measure of concentration, shares of exports/countries are weighted by the natural logs of the inverse of Pit’s:

\[
E_t = \sum_{i=1}^{m} P_{it} \ln \left( \frac{1}{P_{it}} \right)
\]

As per this measure, if one/few commodities/countries have very high share in total exports, the value of weight i.e. log of reciprocal of share will be very low. This will lead to a very low value of the index. Hence, a lower value of entropy index shows high concentration. Similarly a high value of entropy index reflects diversification. However to make this measure compatible with other measures, we have taken the inverse of antilog of \( E_t \) as a measure of concentration as given below:

\[
H_t = \frac{1}{\text{antilog } (E_t)}
\]

\( H_t \) is a direct measure of concentration i.e. high the value of index higher will be concentration and vice-a-versa.

Third group of concentration measures have collective features of both discrete as well as summary measures. Under which we have:

5) **Comprehensive Measure of Concentration Index (CCI)** – As similar to the measure of concentration RHT, CCI requires the export share \( P_i \) to be sorted in descending order. However, CCI’s main focus is on the largest \( P_{it} \) i.e. \( P_{1t} \) which is the highest share of a category/country in total exports. The remaining \( P_{it} 's \) are used to adjust according to the formula:

\[
\text{CCI}_t = P_{1t} + \sum_{i=2}^{n} P_i^2 \left[ 1 + \left( 1 - P_{it} \right) \right]
\]

This index also produces a value of unity in the case of high concentration.

V) **Sources of Export Earning Instability**

Multiple regression analysis has been applied to find out the significant sources of export instability in India. For this purpose, we have developed the following model:

\[
I_{TE} = f (I_{PX}, I_{CX}, I_{EX}, I_{TX}, I_{PEX}, CC_X, GC_X)
\]

Where, \( I_{TE} = \) Total Export Earning Instability in India

\( I_{PX} = \) instability index of primary exports
$I_{CX} =$ instability index of chemical and related products exports  
$I_{EX} =$ instability index of engineering exports  
$I_{TX} =$ instability index of textile& textile products exports  
$I_{PEX} =$ instability index of Petroleum products exports  
$CC_X =$ commodity concentration index of exports  
$GC_X =$ geographical concentration index of exports  

Here, $I_{TE}$ is dependent variable, while other variables (i.e. $I_{PX}$, $I_{CX}$, $I_{EX}$, $I_{TX}$, $I_{PEX}$, $CC_X$ and $GC_X$) are independent variables in the analysis.

**Measure of Year Wise Export Instability Indices**

Generally, export instability is a measure which captures the uncertainty faced by exporters due to unpredictable fluctuations in the export earnings. Various economists have used a number of statistical indices for measuring export instability, but most widely used measure of instability in the literature is the absolute percentage deviation from a trend in time series (MacBean and Nguyen, 1980 and Love, 1985). In this analysis of sources of export instability in India, yearly export instability index has been calculated as absolute percentage deviation of actual value of total commodity exports earning from the estimated values of the same commodities exports by using exponential trend line. Instability index of total exports of India has been calculated as:

$$I_{TE} = \left| \frac{X_t - \bar{X}_t}{\bar{X}_t} \right|$$

Here $t = 1$ to $26$

Where $I_{TE}$ is instability index of total export earnings in year $t$, $X_t$ is the actual value of total exports in year $t$ and $\bar{X}_t$ stands for estimated value of total exports in year $t$.

There are several types of functional forms (liner, polynomial and exponential) for estimating the export instability and can be chosen according to the theoretical and empirical reasons (Hanom, 2009). In general, exponential trend is the best fit to measure export instability in India. Massell (1970) gives the justification in favor of exponential trend by saying that countries tend to plan in terms of growth rates, not in terms of absolute increment.

$I_{PX}$ is calculated as:
\[ I_{PX} = \left| \frac{P_X - \hat{P}_X}{\hat{P}_X} \right| \]

Where \( I_{PX} \) is instability index of primary exports, \( P_X \) is actual value of primary exports in year \( t \), \( \hat{P}_X \) is estimated value of primary exports in year \( t \) using exponential trend.

Similarly, \( I_{CX} \) is export instability index of chemical and allied products category. It is calculated as:

\[ I_{CX} = \left| \frac{C_X - \hat{C}_X}{C_X} \right| \]

Where \( C_X \) is actual value of chemical and allied products exports in year \( t \), \( \hat{C}_X \) is estimated value of chemical exports in year \( t \).

\( I_{EX} \) is export instability index of engineering products category

\[ I_{EX} = \left| \frac{E_X - \hat{E}_X}{E_X} \right| \]

Where \( E_X \) is actual value of engineering product exports in year \( t \), \( \hat{E}_X \) is estimated value of engineering product exports in year \( t \).

\( I_{TX} \) is instability index of textile & textile products calculated as:

\[ I_{TX} = \left| \frac{T_X - \hat{T}_X}{T_X} \right| \]

\( T_X \) is actual value of textile & textile products exports in year \( t \) and \( \hat{T}_X \) is estimated value of textile exports in year \( t \).

\( I_{PEX} \) is instability index of petroleum products calculated as:

\[ I_{PEX} = \left| \frac{PE_X - \hat{PE}_X}{\hat{PE}_X} \right| \]

\( PE_X \) is actual value of petroleum products exports in year \( t \) and \( \hat{PE}_X \) is estimated value of Petroleum exports in year \( t \).

**Measures of Concentration**

Two types of measures are used for measuring concentration; one for measuring commodity concentration and other for geographical concentration of exports. “Export concentration indicates the degree to which a country’s exports are
concentrated on a small number of commodities or a small number of trading partners. A country that exports one product to only one trading partner has a perfectly concentrated export portfolio. Conversely, countries whose exports comprise of a larger number of products and that trade with a lower number of trading partners have a least export concentration ratio (ECR). In other words, that specific country has more diversified exports sector” (www.undp.org).

**Commodity Concentration Index**

The commodity concentration index is calculated as below:

\[
CR(k)_t = \sum P_{it}
\]

\[
P_{it} = Q_{it}/Q_t
\]

\(Q_{it}\) represents the export of the i\(^{th}\) commodity at time t. Then the sum of \(Q_{it}\) from 1 to m will be \(Q_t\) and the share of each commodity in total exports of India for the year t. Here k is less than the total number of export commodities m, while in the present study value of k is 16.

The measure ranges from zero to one. It the CR is close 0 it means that the largest X category is earning a small share of the total export earnings. When CR is close to 1 or unity, this means that the largest X category is contributing a very high share in total exports thereby reflecting high concentration. The value of k is determined arbitrarily on the basis of number of categories included in the analysis. These ratios are widely used because of its simplicity of calculation and limited data requirements (Meilak, 2008).

**Geographical Concentration Index**

Geographical concentration index refers to the degree of concentration of country’s exports on different destination to which commodities are exported. The commonly used measure of geographical concentration is as follows:

\[
GC(k)_t = \sum P_{it}
\]

Here, \(k = 8\)

A high degree of geographical concentration of country’s exports is commonly considered as a source of export instability. In other words, the export earnings of
the country will depend on the economic and non-economic conditions of the one or few countries (Hanom, 2009).

**VI) Relationship between Economic Growth, Exports and Export Instability**

Further, an attempt was made to measure the relationship between exports, export instability and economic growth by using various techniques including multiple regression, co-integration analysis and causality analysis. Both Johansen cointegration and Granger causality analysis require long term data and for that purpose the period 1970-71 to 2012-13 has been selected.

In order to study the impact of exports, export instability, gross capital formation on economic growth, multiple regression analysis has been used for different time periods. The regression analysis has been conducted for very long time period 1970-71 to 2012-13 and also for the time period 1987-88 to 2012-13. The analysis for the time span of 1987-88 to 2012-13 was conducted as this was the time span when export liberalization and fast export growth happened in India. Export liberalization started in mid-80s in India while further impetus was given to liberalization after 1991. Another reason was variation in results with the change in selected time period.

The regression model is as follows:

\[
\ln Y_t = \alpha_0 + \alpha_1 \ln X_t + \alpha_2 \ln XI_t + \alpha_3 \ln IN_t + u_t
\]

where, variables used in the study are \(\ln Y_t\) is the log of real gross domestic product, \(\ln X_t\) is a log of real export earnings, \(\ln XI_t\) is the log of export instability (as per I\(_{TE}\) measure) and \(\ln IN_t\) is real investment. All variables used in the analysis are at constant prices (i.e. at 1999-00 prices).

The present study makes an effort to identify the causal relationship between export, export instability and economic growth. “In order to know the causal relationship between variables, there are mainly three steps. The first step is to test for stationarity of the series with the help of unit root tests. The second step is to test for cointegration only if the considered variables are non-stationary in their levels and stationary in first difference. Once the cointegration has been established
amongst the variables, the third step is to formulate the causal relationship between export instability and economic growth (Kaushik and Klein, 2007)."  

1) Tests of Stationarity  

In order to investigate the stationarity of the data, a uni-variate analysis of each of the time series variables is carried out by testing for the presence of unit root. We have used Augmented Dickey-Fuller tests and PP (Phillips-Perron), which are mostly used to test for unit root, for every individual time series.  

**Augmented Dickey-Fuller Test**  

"Augmented Dickey-Fuller (ADF) unit root test is used to examine the stationarity of the data series. It consists of running a regression of the first difference of the series against the series lagged once, lagged difference terms and optionally, a constant and a time trend" (Mishra, 2011 and Gujrati & Sangeetha, 2010).  

\[ \Delta Y_t = \beta_0 + \beta_1 t + \beta_2 Y_{t-1} + \sum_{i=1}^{m} \alpha_j \Delta Y_{t-i} + \varepsilon_t \]

Where \( Y_t \) is the variable under consideration, \( t \) stands for time trend and \( \varepsilon \) is white noise residual while \( \beta_0, \beta_1, \beta_2, \alpha_1, \ldots, j \) are the parameters.  

The null hypothesis implies unit root or non stationary and alternative hypothesis implies stationarity. These can be written as:  

\[ H_0: = 0 \] (the variable is non-stationary)  
\[ H_1: \neq 0 \] (the variable is stationary)  

2) Cointegration Test  

"Cointegration, an econometric property of time series variable, which predicts the existence of a long run relationship between two or more variables having unit root which is integrated of order one \( i.e. \) I(1). When variables are stationary at first difference, we can investigate the relationship among them by using cointegration test. The idea is to test whether long run relationship among variables is present or not. In this case two tests are considered, \( i.e. \) the Trace test and Maximum Eigenvalue test. As per these tests two possibilities are assumed; null hypothesis assumes no cointegration, while the alternative implies cointegration" (Johansen & Juselius, 1990 and Greene, 2003).
### Trace Test

\[
\tau_{\text{trace}} = -T \sum_{i=r+1}^{M} \ln(1 - \lambda_i)
\]

where \(\lambda_i\) is the \(i\)th largest eigenvalue of matrix \(\Pi\) and \(T\) is the number of observations. In the trace test, the null hypothesis is that the number of distinct cointegrating vector(s) is less than or equal to the number of cointegration relations \((r)\).

### Maximum Eigenvalue Test

“The maximum eigenvalue test evaluates the null hypothesis of exactly \(r\) cointegrating relations against the alternative of \(r + 1\) cointegrating relations with the test statistic:

\[
\tau_{\text{max}} = -T \ln (1 - \lambda_{r+1})
\]

Here \(\lambda_{r+1}\) is the \((r+1)\)th largest squared Eigenvalue. According to Johansen and Juselius (1990) the maximum eigenvalue test is more influential than the trace test” (Mishra, 2011).

### 3) Granger Causality Analysis

The standard Granger causality test determines whether past values of a variable help to predict changes in another variable. In addition, it also says that variable \(Y\) is Granger caused by variable \(X\) if variable \(X\) assists in predicting the value of variable \(Y\). If this is the case, it means that the lagged values of variable \(X\) are statistically significant in explaining variable \(Y\). “The idea behind the causality technique is not to find the relationship between the variables, but to test the causality between them. The standard Granger causality test seeks to determine whether past values of a variable help to predict changes in another variable. A variable (in this case export instability \(i.e.\) \(X\)) is said to Granger cause another variable GDP (economic growth) if past and present values of export instability help to predict GDP” (Granger, 1969, 1988).

\[
X_t = \sum_{j=1}^{p} \alpha_j X_{t-j} \sum_{j=1}^{p} \beta_j Y_{t-j} + \mu_t
\]

\[
Y_t = \sum_{j=1}^{p} \eta_j X_{t-j} \sum_{j=1}^{p} \gamma_j Y_{t-j} + \vartheta_t
\]
The alternative hypothesis is specified as

\[ H_1: \eta_j = 0, \quad j=1\ldots p, \] which means that \( X \) does not cause \( Y \) \ldots 

\[ H_1: \beta_j = 0, \quad j=1\ldots p, \] which means that \( Y \) does not cause \( X \) \ldots 

“If none of the hypothesis is rejected, it means that \( X \) do not Granger cause \( Y \) and \( Y \) also do not Granger cause \( X \). It indicates that the two variables are independent of each other. If the first hypothesis is rejected, it shows that \( X \) Granger causes \( Y \). Rejection of the second hypothesis means that the causality runs from \( Y \) to \( X \)” (Jordan and Eita, 2007).