



## **Export and Economic Growth in India: Causal Interpretation**

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The relationship between export and economic growth has been an important issue of discussion among scholars and economist throughout the world. The existence of nexus in between export and economic growth can be examined in several ways like growth rates relating to GDP and export, proportion of export to growth, several policies relating to accelerate economic growth and export etc. The effective way to explore nexus in export and economic growth would be the causal analysis between two variables. Scholars and economist like Michaely (1977), Kavoussi (1984), Jung (1985), Chow (1987), Darrat (1987), Hasio (1987), Afexention and Serletis (1991), Esfahani (1991), Bahmani-Oskoei, Mohtadi and Shabsingh (1991), Bahmani-Oskoei and Alse (1993), Love (1998), Jin (1996), Riezman, Whiteman and Summers (1996), Ghatak and Price (1997), Marjit and Raychaudhuri (1997), Asafu-Adjaye and Chakroborty (1999), Dhawan and Biswal (1999), Anwer and Sampath (2001), Chandra (2001) and Sharma and Panagiotidis (2004) have attempted in their respective studies to establish causal relationship in between export and economic growth.

The present paper has been discussed in seven subsections. In section two data and research methodology has been presented. Section three deals with unit root tests / stationarity tests pertaining to Indian export and GDP. In section four, cointegration tests have been employed for Indian export and GDP. Engle Granger test for causal relation in Indian exports and GDP is contained in section five. Error correction model related to Indian export and GDP has been performed in section six. Major findings emerging from present empirical study are presented in section seven.

### **II Data and Research Methodology**

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In the present paper, an attempt has been made to explore the relationship in between export and economic growth in Indian economy with the help of technique of causality and error correction mechanism. For this purpose, data relating to export and GDP for the period 1950-51 to 2001-02 have been taken into account. Data regarding GDP has been taken for the period 1950-51 to 2001-02 at current prices as well as at constant prices. Moreover, in order to examine causality in between export and economic growth, GDP and its components (at current and constant prices) as (1) NDP at factor cost, (2) GDP at market prices, (3) NDP at market prices, (4) GNP at factor cost, (5) NNP at factor cost, (6) GNP at market price, (7) NNP at market prices have been taken in the present study (Handbook of Statistics on Indian Economy, Economic Survey). Thus, in the present study, an attempt has been made to explore causal relation in Indian exports and eight variants of GDP (at current prices) and eight variants of GDP (at constant prices) separately.

## II.1 Stationarity test: The Unit Root (Dickey Fuller) Test

The Dickey Fuller test for unit root may be conducted in the following two steps: First of all, runs OLS regression of following type:

$$\Delta Y_t = \delta Y_{t-1} + \epsilon_t \quad \dots \quad (2.1)$$

and save the  $t_\delta$  ratio as mentioned in equation 2.1. And secondly, the existence of unit root in the time series data  $Y_t$  according to the following hypothesis.

$$H_0 : \delta = 0, \text{ for non stationarity if } t_\delta > \tau \quad \dots \quad (2.2)$$

$$H_a : \delta < 0, \text{ for stationarity, if } t_\delta < \tau$$

Where  $\tau$  is the critical value as given by Fuller (1976). On the basis of Monte-Carlo simulations, and under the null hypothesis of the existence of a unit root in the process of generating of time series, Dickey and Fuller have tabulated critical values (Fuller, 1976) for the  $t_\delta$  statistic, which they called them as the  $\tau$  (tau) statistics. More recently, these critical values have been extended by Mackinnon (1991) through Monte-Carlo Simulations. In other words, for a time series to be stationary the  $t_\delta$  value must be much negative. Otherwise, the time series is non-stationary. Dickey and Fuller have tabulated  $\tau$  critical values when regression equation contains constant also i.e. when equation 2.1 becomes:

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \epsilon_t \quad \dots \quad (2.3)$$

Further, when the regression equation contains a constant and linear trend, equation 2.1 is written as

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \epsilon_t \quad \dots \quad (2.4)$$

For equation 2.3 the corresponding critical value called  $\tau_\mu$  and for equation 2.4 the corresponding critical value and called  $\tau_t$ . Fuller has presented these critical values in his book “Introduction to Statistical Time Series”.

## II.2 Stationarity Test: The Unit Root (Augmented Dickey Fuller) Test

In order to detect unit root in a time series data as given by equations 2.1, 2.3 and 2.4, some modification have been made by Dickey and Fuller (1981). These modifications indicate how many additional terms relating to first difference of the variables should be added in equations 2.1, 2.3 and 2.4. This is known as Augmented Dickey Fuller Model. For equations 2.1, 2.3 and 2.4 as used in Dickey Fuller test the corresponding equation for Augmented Dickey Fuller test will be

$$\Delta Y_t = \delta Y_{t-1} + \sum_{j=2}^q \delta_j \Delta Y_{t-j+1} + \epsilon_t \quad \dots \quad (2.5)$$

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \sum_{j=2}^q \delta_j \Delta Y_{t-j+1} + \epsilon_t \quad \dots \quad (2.6)$$

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \sum_{j=2}^q \delta_j \Delta Y_{t-j+1} + \epsilon_t \quad \dots \quad (2.7)$$

Since, Dickey Fuller test as given by equations 2.1, 2.3 and 2.4 has been augmented with the lagged difference term to produce equations 2.5, 2.6 and 2.7, the usual D.F. test applied to the later equations (2.5, 2.6 and 2.7) took the name Augmented Dickey Fuller test. In fact, the critical values for DF,  $\tau$  statistics still holds for the ADF test and the testing of hypothesis is still that as given in equation 2.2. In equations 2.5, 2.6, 2.7 the number of additional lagged differenced term will depend on the minimum value of AIC and SIC (Akaike, 1973 and Schwartz, 1989). In the present paper, equation 2.4 and 2.7 has been used for stationarity test.

## II.3 Cointegration Test

For univariate time series, Unit Root Test is performed for stationarity, while cointegration deals with the relationship among the group of variables where (unconditionally) each has a unit root (Dickey, Janson and Thornton, 1991). Two time series  $Y_t$  and  $X_t$  are said to be cointegrated of order  $(d,b)$  where  $d \geq b \geq 0$ , if both time series are integrated of order  $d$ , and there exists a linear combination of these two time series, say  $a_1 Y_t + a_2 X_t$ , which is integrated of order  $(d-b)$ . In mathematical terms, this definition is written:

If  $Y_t \sim I(d)$  and  $X_t \sim I(d)$ , then  $Y_t X_t \sim CI(d,b)$  if  $a_1 Y_t + a_2 X_t \sim I(d-b)$  .... (2.8)  
Where CI is the symbol of cointegration.

#### II.4 Cointegration Test: Engle-Granger Test

Engle Granger test is applied in order to test if the two variables  $Y_t$  and  $X_t$  are cointegrated. The entire procedure is based on several steps. First of all, the order of the integration of both variables using the unit root methodology is obtained. If the order of integration of two variables is same, then the concept of cointegration emerges. If the order of integration of two variables is different, it may be concluded that two variables are not cointegrated. Secondly, if the two variables are integrated of same order say  $I(1)$ , estimate with OLS the long run equilibrium equation

$$Y_t = \beta_0 + \beta_1 X_t + e_t \quad \dots \quad (2.9)$$

which is called cointegration regression and save the residuals  $e_t$ , as are estimate of the equilibrium error,  $e_t$ .

In the third step, for the two variables to be cointegrated the equilibrium errors must be stationary. In order to test this stationarity the unit root methodology in form of DF test and ADF test may be applied. For example, the DF test for error term, which involves the estimation of a version of the following equation with OLS will be:

$$\Delta e_t = \delta e_{t-1} + v_t \quad \dots \quad (2.10)$$

And finally, conclusion about the cointegration of two variables may be obtained (Dickey, Janson and Thornton, 1991) according to following hypothesis.

$H_0$ :  $\delta = 0$ , for non-stationarity of  $e_t$ , i.e. for non-cointegration, if  $t_\delta > \tau$ .... (2.11)

$H_a$ :  $\delta < 0$ , for stationarity of  $e_t$ , i.e. for cointegration, if  $t_\delta > \tau$

## II.5 Engle-Granger Causality Test

This section attempts to explain Engle Granger causality in between two variable X and Y. Thus, the Engle Granger causality test (Love, 1994) involves the estimation of two regression equation which are given below:

$$Y_t = a + \sum_{i=1}^M \alpha_1 Y_{t-1} + \sum_{i=1}^N \alpha_2 X_{t-1} + u_t \quad \dots \quad (2.12)$$

$$X_t = b + \sum_{i=1}^j \beta_1 X_{t-1} + \sum_{i=1}^k \beta_2 Y_{t-1} + u_t \quad \dots \quad (2.13)$$

Equation 2.12 postulates that current value of Y is related to past values of Y itself as well as of X. Similarly equation 2.13 postulates a similar behaviour. In order to detect causality from X to Y in equation 2.12 involves, first, treating the dependent variable in equation 2.13 as a one dimensional autoregressive process and regression it on its own lagged values (Love, 1994). The Akaike FPE is estimated as

$$FPE(m) = \frac{T + m + 1}{T - m - 1} \cdot \frac{S(m)}{T} \quad \dots \quad (2.14)$$

Where T = number of observation,

m = order of lags from 1 to M

and S(m) = sum of squared residuals.

The value of m, which minimizes FPE, is the optimum number of lags  $m^*$ .

In the second stage Y is controlled with the order of lags given  $m^*$  and X is regarded as a manipulated variables with the order of lags varying from 1 to N. The resulting FPE is given as:

$$FPE(m^*, n) = \frac{T + m^* + n + 1}{T - m^* - n - 1} \cdot \frac{S(m^*, n)}{T} \quad \dots \quad (2.15)$$

The optimum number of lags on n,  $n^*$  is determined as that which minimize FPE ( $m^*$ , n). Conclusion on causation are derived from comparisons of FPE ( $m^*$ ) and FPE ( $m^*$ ,  $n^*$ ). If FPE ( $m^*$ ,  $n^*$ ) < FPE ( $m^*$ ), X is taken to cause Y. F test for the joint significance of the coefficient may then be constructed on the basis of the sums of squared residuals in the first stage constrained equation and in the second stage unconstrained equation. The direction of causation is determined by the sign of the

sum of coefficient  $\sum_{i=1}^n \alpha_{2i}$  for causation from X to Y and  $\sum_{i=1}^k \beta_{2i}$  for causation from Y

to X. With respect to causality from Y to X equation 2.13 the same procedure is repeated with X as the controlled variables and Y as the manipulated variable.

## II.6 Error Correction Mechanism

There exist long run equilibrium relationship between two variables if they are cointegrated. But in the short run there may be disequilibrium. Therefore, one can treat the error term in equation 2.9 as the equilibrium error (Griffiths, Hill and Judge, 1993). One can use the error term to tie the short run behaviour of variable  $Y_t$  in equation 2.9 in its long run value. The error correction mechanism (ECM) was first used by Sargan (1964) and later popularized by Engle and Granger (1987). In order to employ error correction mechanism, equation 2.9 has been estimated and residual for the equation has been saved. Thus, the corresponding ECM model will be written as:

$$\Delta Y_t = \alpha + \beta \Delta X_t + \gamma \epsilon_{t-1} + v_{ti} \quad \dots \quad (2.16)$$

Where  $\Delta$  as usual denotes first difference;  $\epsilon_{t-1}$  is the one period lagged value of the residual from regression 2.9, the empirical estimates of the equilibrium error terms; and  $v_{ti}$  is the error term with the usual properties. Regression equation 2.16 relates the change in Y to change in X and the equilibrium error in the previous period. In this equation,  $\Delta Y$  captures the short run disturbances in X whereas the error correction term  $\epsilon_{t-1}$  captures the adjustment toward the long-run equilibrium. If  $\gamma$  is statistically significant, it tells us what proportion of the disequilibrium in Y in one period is corrected in the next period.

## III Stationarity tests of Export and GDP

### III.1 Unit Root Test for GDP and Export: Dickey Fuller Test

In our present study, we have data relating to eight forms of GDP at current prices, eight forms of GDP at constant prices and export for the period 1950-51 to 2001-02. In order to perform Dickey Fuller test regression equation of type

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \epsilon_t \quad \dots \quad (3.1)$$

has been estimated and are presented in Appendix 1-3. Based on regression coefficients as given in Appendix 1-3 calculated  $\tau$  values and tabulated  $\tau$  values relating to equation 3.1 for level, first difference and second difference are presented in Table 1. Table 1 reveals that in case of GDP at current prices calculated  $\tau$  values are found higher than tabulated  $\tau$  values at level and first difference. However, in this connection, calculated  $\tau$  is less than tabulated  $\tau$  at second difference. Thus, GDP at current prices for the period 1950-51 to 2001-02 contains unit root at level and at first difference. However, it is found stationary at second difference. So far as GDP at

constant prices is concerned, it is obvious from Table 1 that at level, calculated  $\tau$  is found higher than the tabulated  $\tau$  and thus having unit root in GDP at constant price at level. However, at first difference calculated  $\tau$  is found less than tabulated  $\tau$  for GDP at constant prices thus, stationary at first difference is found for the period under study. Similarly, in case of Indian exports, calculated  $\tau$  is greater than tabulated  $\tau$  at the level. Further, calculated  $\tau$  is found less than tabulated  $\tau$  in this connection at first difference. Thus, Indian export for the period 1951-2002 is found stationary at first difference.

Thus, Dickey-Fuller test results for unit roots in Indian exports, GDP at current prices and GDP at constant prices as given in Table 1 reveal that GDP at current prices is found stationary at second difference, while GDP at constant price as well as export are found stationary at first difference.

### **III.2 Unit Root Test for GDP and Export: Augmented Dickey Fuller Test**

For Augmented Dickey Fuller test regression equation of type

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \sum_{j=2}^q \delta_j \Delta Y_{t-j+1} + \epsilon_t \quad \dots \quad (3.2)$$

has been estimated for seventeen variables (GDP at current prices – eight components GDP at constant prices – eight components and exports) and regression result are presented in Appendix 4-6. The regression results as presented in Appendix 4-6 relate to level, first difference and second difference respectively. Based on these regression results, calculated value of  $\tau$  as well as critical values relating to seventeen variables at level, first difference and second difference are shown in Table 2.

Comparisons of calculated  $\tau$  value and tabulated  $\tau$  value at level and first difference for all seventeen variables (as given in Table 2) reveal that calculated  $\tau$  values are higher than tabulated critical values. It shows that at level and at first difference all the seventeen variables under study for the period 1950-51 to 2001-02 are found non-stationary as per ADF test. Table 2 also shows that at second difference calculated  $\tau$  values for all seventeen variables are found less than the tabulated  $\tau$  values. Thus, at second differences all seventeen variables under, present study for the period 1950-51 to 2001-02 are found stationary as per ADF test. Thus, in our present study all the seventeen variables are cointegrable of order two i.e. I(2).

### **IV Cointegration Tests: Indian Exports and GDP**

Tests for unit root are performed on univariate time series. In contrast, cointegration deals with the relationship among a group of variables (Dickey, Jansen and Thornton, 1991). A number of methods for testing of cointegration have been proposed by the scholars in the available literature. Details theoretical discussions regarding this cointegration test are given in section II Research Methodology. The cointegration test in Export and GDP for the period 1950-51 to 2001-02 in the present study is based on Engle Granger Test.

#### **IV.1 Cointegration Test for Indian Export and GDP (1950-51 to 2001-02) : Engle Granger Test**

In the present section, an attempt has been made to test cointegration in Indian export and GDP during the period 1950-51 to 2001-02 based on Engle Granger Methodology. As per Engle Granger cointegration test, residuals for the equation 4.1 and equation 4.2 have been saved.

$$Y_t = \beta_0 + \beta_1 X_t + e_t \quad \dots \quad (4.1)$$

$$X_t = \beta_0 + \beta_1 Y_t + \eta_t \quad \dots \quad (4.2)$$

Based on these residuals for equations 4.1 & 4.2 Dickey-Fuller test have been applied.

$$\Delta e_t = \delta_1 e_{t-1} + v_t \quad \dots \quad (4.3)$$

$$\Delta \eta_t = \delta_2 \eta_{t-1} + \kappa_t \quad \dots \quad (4.4)$$

The regression equations presented by equation 4.3 & 4.8 have been estimated through the technique of ordinary least square and the estimated regression results are shown in Appendix 7 & 8. Based on regression result as shown in Appendix 7 & 8, the calculated  $\tau$  value and tabulated  $\tau$  value for cointegration test are presented in Tables 3 and 4.

It is significant to mention here that cointegration of variables in the present study is governed on the basis of following hypothesis (Engle and Granger 1987).

$$H_0 : \quad \text{for non-cointegration, } \tau \text{ value related coefficient} \\ \text{of residuals in equations 4.3 \& 4.4} > \text{tabulated } \tau \text{ value.} \quad \dots \quad (4.5)$$

$$H_a : \quad \text{for cointegration, } \tau \text{ value related to coefficient} \\ \text{of residuals in equations 4.3 \& 4.4} < \text{tabulated } \tau \text{ value.}$$

Table 3 presents calculated  $\tau$  values as well as tabulated  $\tau$  values for Engle Granger Cointegration test relating to Export and GDP (at current and constant prices) treating

GDP as dependent variable. A comparison of calculated  $\tau$  values and tabulated  $\tau$  values as shown in Table 3 reveals that calculated  $\tau$  values have been found less than tabulated  $\tau$  values for export and GDP at constant prices for equation 4.3. This shows that export and GDP at current prices are cointegratable for the period 1950-51 to 2001-02. Similarly, it is clear from the table that calculated  $\tau$  values have been found higher than the tabulated  $\tau$  value for export and GDP at constant prices for equation 4.3. This reveals that export and GDP at constant prices are not cointegratable during the period under study.

Table 4 presents calculated  $\tau$  values as well as tabulated  $\tau$  values for Engle Granger cointegration test relating to Export and GDP (at current and constant prices) treating Export as dependent variable. A comparison of calculated  $\tau$  values and tabulated  $\tau$  values as shown in Table 4 reveals that calculated  $\tau$  values have been found less than tabulated  $\tau$  values for export and GDP at current prices for equation 4.4. This shows that export and GDP at current prices are cointegratable for the period 1950-51 to 2001-02. It is significant to observe that calculated  $\tau$  values have been found higher than the tabulated  $\tau$  values for export and GDP at constant prices for the equation 4.4. This reveals that export and GDP at constant prices are not cointegratable during the period under study.

The empirical results as contained in Table 3 and Table 4 shows that export and GDP (at constant price) are not cointegratable. However, it is significant to observe that Export and GDP at current prices are cointegratable as per Engle Granger methodology during the period 1950-51 to 2001-02.

## **V Export and GDP in Indian Economy (1950-51 to 2001-02): Engle Granger Causality Test**

In the present section, an attempt has been made to test the causality (Engle Granger) in between Indian export and GDP for the period 1950-51 to 2001-02. The causality between Export and GDP is divided in to two subsections.

### **V.1 Engle Granger Test: Exports Cause GDP (1950-51 to 2001-02)**

In order to detect causality from export to GDP (eight components at current prices) equation 5.1 has been estimated.

$$Y_t = a + \sum_{i=1}^M \alpha_1 Y_{t-1} + \sum_{i=1}^N \alpha_2 X_{t-1} + u_t \quad \dots \quad (5.1)$$

The optimum lag lengths for eight components of GDP i.e. m and export i.e. n have been calculated as per Equations 5.2 and 5.3.

$$FPE(m) = \frac{T + m + 1}{T - m - 1} \cdot \frac{S(m)}{T} \quad \dots \quad (5.2)$$

$$FPE(m^*, n) = \frac{T + m^* + n + 1}{T - m^* - n - 1} \cdot \frac{S(m^*, n)}{T} \quad \dots \quad (5.3)$$

These optimum values of m and n have been shown in Table 5 and Table 6. Based on optimum values of m and n as shown in Table 5 and Table 6, the regression results have been presented in Table 7. The minimum value of Akaike FPE for eight components of GDP as well as export for eight estimated regression equations as given in Table 7 are reported in Table 8. Here it is significant to mention that if optimal values of m and n taken together are found less than optimal values of n then export is taken to cause GDP. Thus, export causes GDP when  $FPE(m^*, n^*) < FPE(m^*)$ . It is obvious from Table 8 for all components of GDP values of  $FPE(m^*, n^*)$  are found less than  $FPE(m^*)$ . For example, if GDP at Factor Cost treated as dependent variable as shown in equation 5.1 the corresponding value of  $FPE(m^*, n^*)$  is found 0.1701 that is less than the value of  $FPE(m^*)$ , which is 0.1716 (Table 8).

Thus, a comparison of optimum values of  $FPE(m^*, n^*)$  with the optimum values of  $FPE(m^*)$  reveals that export cause eight components of GDP at current prices during the period 1950-51 to 2001-02.

The direction of causation from export of GDP is determined by sign of sum of coefficients of Export i.e.  $\alpha_2$ . Based on the regression results as shown in Table 7, the sum of coefficient of exports for all eight components of GDP at current prices are shown in Table 9. Table 9 reveals that the sums of coefficient of export in case of all eight components of GDP are found negative.

Thus empirical results of this section reveal that export has caused negatively to GDP and eight components in case of Indian economy during the period 1950-51 to 2001-02.

## V.2 Engle Granger Test: GDP Causes Export (1950-51 to 2001-02)

In the present section, an attempt has been made to find out the causality from GDP (eight components at current prices) to export for the period 1950-51 to 2001-02. For this purpose, equation 5.4 has been estimated.

$$X_t = b + \sum_{i=1}^j \beta_1 X_{t-1} + \sum_{i=1}^k \beta_2 Y_{t-1} + u_t \quad \dots \quad (5.4)$$

The optimum lag lengths for export i.e. m and eight components of GDP i.e. n have been calculated as per equation 5.2 and equation 5.3. The optimum values of m and n have been presented in Table 10 and Table 11 respectively. In the light of optimum values of m and n as shown in Table 10 and Table 11, the regression results have been presented in Table 12. The minimum values of Akaike FPE for export as well as eight component of GDP for eight estimated regression results as presented in Table 12 are reported in Table 13. Here it is significant to observe that optimal values of m and n taken together are found less than optimal values of n, and then GDP is taken to cause export. Thus GDP causes export when  $FPE(m^*n^*) < FPE(m^*)$ . It is obvious from Table 13 that values of  $FPE(m^*n^*)$  corresponding to export is found  $FPE(m^*)$ . For instance, export is treated as dependent variable as shown in equation 5.4 and the corresponding value of  $FPE(m^*)$  is 0.0202 which is less than value of  $FPE(m^*n^*)$  i.e. 0.0285 (Table 13).

The forgoing analysis relating to a comparison of optimum value of  $FPE(m^*n^*)$  with the optimum value of  $FPE(m^*)$  shows that eight components of GDP at current prices have caused to the exports during the period 1950-51 to 2001-02.

Also, it is significant to mention that direction of causation from GDP to export is determined by the sign of sum of coefficients of GDP i.e.  $\beta_2$ . As per regression results which are shown in Table 12 the sum of coefficient of GDP (eight components) are shown in Table 14. It is obvious from Table 14 that sum of coefficient of eight components of GDP are found positive.

Thus, forgoing analysis reveals that eight components of GDP have caused positively to Indian exports in the Indian economy for the period 1950-51 to 2001-02.

#### ***VI Export and GDP: Error Correction Mechanism***

In previous two sections, it has been observed that export and eight components of GDP (at current price) are cointegrated that is, there is a long term equilibrium relationship between the two. Of course, in the short run, there may be disequilibrium. Therefore, one can treat the error term in equation 4.1 and equation 4.2 as equilibrium

error (Griffiths, Carter and Judge 1993). One can use this error term to tie the short run behavior of GDP and export to their respective long run values.

Equation 6.1 has been estimated through the technique of OLS and estimated regression results are shown in Table 15. Similarly, equation 6.2 also has been estimated through the technique of OLS and estimated regression results have been shown in Table 16.

$$\Delta Y_t = \alpha + \beta \Delta X_t + \gamma \epsilon_{t-1} + v_{ti} \quad \dots \quad (6.1)$$

$$\Delta X_t = \chi + \lambda \Delta Y_t + \eta \epsilon_{t-1} + \mu_{ti} \quad \dots \quad (6.2)$$

Table 15 deals with error correction model with GDP as dependent variable and export as independent variables. It is obvious from the table that coefficients of export in eight equations are positive. This reveals that short run changes in export affect positively to GDP and its components. Also, it is worth mentioning that estimated coefficients of residual are found negative and insignificant.

Similarly, Table 16 deals with error correction model for export as a dependent variable and GDP and its eight components as independent variable. Table 16 reveals that the coefficients of GDP in eight equations are found positive. Thus, it shows that short run changes in GDP affect positively to the exports. Further, the coefficient of residual in eight equations is found negative and significant. This shows that a deviation of the exports from its long run equilibrium level is corrected each year.

## VII Causality in Export and GDP in India: Major Findings

In the present paper an attempt has been made to find out the causal relationship in export and eight components of GDP for the period 1950-51 to 2001-02. This has been done in four subsections of the present paper and major findings are listed below:

1. All seventeen variables (eight components of GDP at current prices, eight components of GDP at constant prices and export) under present study are found stationary at second difference as per ADF test. Thus, these seventeen variables are cointegrable at I(2).
2. The empirical findings related to CRDW cointegration test in between export and GDP reveal that export and GDP at constant prices are not cointegrable while export and GDP at current prices are cointegrable. The same inference has been drawn as per Engle Granger Cointegration test.

3. Engle Granger Causal relationship in between export and GDP for the period 1950-51 to 2001-02 reveals that export has caused negatively to GDP and its components (at current price).
4. Empirical results pertaining to Engle Granger causal relationship in between export and GDP for the period 1950-51 to 2001-02 reveal that GDP (eight components) at current prices has caused positively to the export in the Indian economy.
5. Empirical results relating to error correction model with GDP as dependent variable and export as an independent variable show that short run changes in export have affected positively to GDP and its components. Thus, it can be inferred that in short run enhancement in export has led enhancement in GDP.
6. And, finally empirical investigations relating to error correction model with export as dependent variable and GDP and its components as independent variable reveal that short run change in GDP has affected positively to the exports. Thus, it can be inferred that enhancement in GDP has resulted in enhancement in export.

Table 1: Dickey Fuller Test: GDP, its components (at current and constant prices) and export.

| GDP, its components and export | At level          |                  |                            | At first difference |                  |                            | At second difference |                  |                            |
|--------------------------------|-------------------|------------------|----------------------------|---------------------|------------------|----------------------------|----------------------|------------------|----------------------------|
|                                | $\tau$ calculated | $\tau$ tabulated | $H_0$ : accepted/ rejected | $\tau$ calculated   | $\tau$ tabulated | $H_0$ : accepted/ rejected | $\tau$ calculated    | $\tau$ tabulated | $H_0$ : accepted/ rejected |
| Current Price                  |                   |                  |                            |                     |                  |                            |                      |                  |                            |
| GDPFC                          | 12.5390           | -4.146           | Accepted                   | -1.2530             | -4.1490          | Accepted                   | -10.3200             | -4.1540          | Rejected                   |
| NDPFC                          | 12.4050           | -4.1460          | Accepted                   | -1.3720             | -4.1490          | Accepted                   | -10.6250             | -4.1540          | Rejected                   |
| GDPMP                          | 12.9250           | -4.1460          | Accepted                   | -1.1890             | -4.1490          | Accepted                   | -8.8730              | -4.1540          | Rejected                   |
| NDPMP                          | 12.8460           | -4.1460          | Accepted                   | -1.2850             | -4.1490          | Accepted                   | -9.0660              | -4.1540          | Rejected                   |
| GNPFC                          | 12.7930           | -4.1460          | Accepted                   | -1.1480             | -4.1490          | Accepted                   | -10.1420             | -4.1540          | Rejected                   |
| NNPFC                          | 12.6930           | -4.1460          | Accepted                   | -1.2620             | -4.1490          | Accepted                   | -10.4790             | -4.1540          | Rejected                   |
| GNPMP                          | 13.1770           | -4.1460          | Accepted                   | -1.0980             | -4.1490          | Accepted                   | -8.8940              | -4.1540          | Rejected                   |
| NNPMP                          | 13.1310           | -4.1460          | Accepted                   | -1.1910             | -4.1490          | Accepted                   | -9.1310              | -4.1540          | Rejected                   |
| Constant Price                 |                   |                  |                            |                     |                  |                            |                      |                  |                            |
| GDPFC                          | 4.2450            | -4.1460          | Accepted                   | -5.3780             | -4.1490          | Rejected                   | -                    | -                | -                          |

|        |        |         |          |         |         |          |   |   |   |
|--------|--------|---------|----------|---------|---------|----------|---|---|---|
| NDPFC  | 3.7870 | -4.1460 | Accepted | -5.8110 | -4.1490 | Rejected | - | - | - |
| GDPMP  | 4.0490 | -4.1460 | Accepted | -5.4640 | -4.1490 | Rejected | - | - | - |
| NDPMP  | 3.6310 | -4.1460 | Accepted | -5.8550 | -4.1490 | Rejected | - | - | - |
| GNPFC  | 4.4280 | -4.1460 | Accepted | -5.2860 | -4.1490 | Rejected | - | - | - |
| NNPFC  | 3.9700 | -4.1460 | Accepted | -5.7140 | -4.1490 | Rejected | - | - | - |
| GNPMP  | 4.2110 | -4.1460 | Accepted | -5.4190 | -4.1490 | Rejected | - | - | - |
| NNPMP  | 3.7920 | -4.1460 | Accepted | -5.8110 | -4.1490 | Rejected | - | - | - |
| Export | 4.3130 | -4.1460 | Accepted | -5.0420 | -4.1490 | Rejected | - | - | - |

Note : (i) Calculated  $\tau$  values for level, first difference and second difference have been taken from regression result as shown in Appendices 1-3.

Table 2: Augmented Dickey Fuller Test: GDP, its components (at current and constant prices) and export.

| GDP, its components and export | At level          |                  |                           | At first difference |                  |                           | At second difference |                  |                           |
|--------------------------------|-------------------|------------------|---------------------------|---------------------|------------------|---------------------------|----------------------|------------------|---------------------------|
|                                | $\tau$ calculated | $\tau$ tabulated | $H_0$ : accepted/rejected | $\tau$ calculated   | $\tau$ tabulated | $H_0$ : accepted/rejected | $\tau$ calculated    | $\tau$ tabulated | $H_0$ : accepted/rejected |
| Current Price                  |                   |                  |                           |                     |                  |                           |                      |                  |                           |
| GDPFC                          | 1.5280            | -4.1498          | Accepted                  | -0.7780             | -4.1540          | Accepted                  | -6.3680              | -4.1580          | Rejected                  |
| NDPFC                          | 1.7110            | -4.1498          | Accepted                  | -0.8350             | -4.1540          | Accepted                  | -6.4790              | -4.1580          | Rejected                  |
| GDPMP                          | 1.3450            | -4.1498          | Accepted                  | -0.8990             | -4.1540          | Accepted                  | -7.1030              | -4.1580          | Rejected                  |
| NDPMP                          | 1.4820            | -4.1498          | Accepted                  | -0.9570             | -4.1540          | Accepted                  | -7.1230              | -4.1580          | Rejected                  |
| GNPFC                          | 1.7440            | -4.1498          | Accepted                  | -0.6870             | -4.1540          | Accepted                  | -6.5520              | -4.1580          | Rejected                  |
| NNPFC                          | 1.9420            | -4.1498          | Accepted                  | -0.7380             | -4.1540          | Accepted                  | -6.7270              | -4.1580          | Rejected                  |
| GNPMP                          | 1.5930            | -4.1498          | Accepted                  | -0.8010             | -4.1540          | Accepted                  | -7.2980              | -4.1580          | Rejected                  |
| NNPMP                          | 1.7510            | -4.1498          | Accepted                  | -0.8510             | -4.1540          | Accepted                  | -7.3790              | -4.1580          | Rejected                  |
| Constant Price                 |                   |                  |                           |                     |                  |                           |                      |                  |                           |
| GDPFC                          | 3.7490            | -4.1498          | Accepted                  | -3.4230             | -4.1540          | Accepted                  | -8.5670              | -4.1580          | Rejected                  |
| NDPFC                          | 3.6320            | -4.1498          | Accepted                  | -3.7090             | -4.1540          | Accepted                  | -8.7620              | -4.1580          | Rejected                  |
| GDPMP                          | 3.5740            | -4.1498          | Accepted                  | -3.5090             | -4.1540          | Accepted                  | -8.2750              | -4.1580          | Rejected                  |
| NDPMP                          | 3.4450            | -4.1498          | Accepted                  | -3.7590             | -4.1540          | Accepted                  | -8.4280              | -4.1580          | Rejected                  |
| GNPFC                          | 3.9340            | -4.1498          | Accepted                  | -3.3430             | -4.1540          | Accepted                  | -8.6940              | -4.1580          | Rejected                  |
| NNPFC                          | 3.8290            | -4.1498          | Accepted                  | -3.6220             | -4.1540          | Accepted                  | -8.8990              | -4.1580          | Rejected                  |
| GNPMP                          | 3.7720            | -4.1498          | Accepted                  | -3.4330             | -4.1540          | Accepted                  | -8.4040              | -4.1580          | Rejected                  |
| NNPMP                          | 3.6530            | -4.1498          | Accepted                  | -3.6760             | -4.1540          | Accepted                  | -8.5660              | -4.1580          | Rejected                  |
| Export                         | 4.2070            | -4.1498          | Accepted                  | -2.0170             | -4.1540          | Accepted                  | -7.6810              | -4.1580          | Rejected                  |

Note : (i) Calculated  $\tau$  values for level, first difference and second difference have been taken from regression result as shown in Appendices 4-6

**Table 3: Cointegration test (Residual test): GDP (constant and current price) as dependent variable and Export as independent variable**

| Variables       |        | $\tau$ calculated | $\tau$ tabulated | $H_0$ : Accepted/rejected |
|-----------------|--------|-------------------|------------------|---------------------------|
| Current prices  |        |                   |                  |                           |
| GDPFC           | Export | -3.035            | -2.608           | Rejected                  |
| NDPFC           | Export | -3.101            | -2.608           | Rejected                  |
| GDPMP           | Export | -2.934            | -2.608           | Rejected                  |
| NDPMP           | Export | -2.980            | -2.608           | Rejected                  |
| GNPFC           | Export | -3.116            | -2.608           | Rejected                  |
| NNPFC           | Export | -3.189            | -2.608           | Rejected                  |
| GNPMP           | Export | -3.006            | -2.608           | Rejected                  |
| NNPMP           | Export | -3.059            | -2.608           | Rejected                  |
| Constant prices |        |                   |                  |                           |
| GDPFC           | Export | -1.114            | -2.608           | Accepted                  |
| NDPFC           | Export | -1.154            | -2.608           | Accepted                  |
| GDPMP           | Export | -1.111            | -2.608           | Accepted                  |
| NDPMP           | Export | -1.145            | -2.608           | Accepted                  |
| GNPFC           | Export | -1.157            | -2.608           | Accepted                  |
| NNPFC           | Export | -1.202            | -2.608           | Accepted                  |
| GNPMP           | Export | -1.148            | -2.608           | Accepted                  |
| NNPMP           | Export | -1.186            | -2.608           | Accepted                  |

Note : Calculated  $\tau$  values for residuals test have been taken from regression results as shown in Appendix 7.

**Table 4: Cointegration test (Residual test): Export as dependent variable and GDP (constant and current price) as independent variable**

| Variables       |       | CRDW statistics calculated | CRDW statistics tabulated* | $H_0$ : Accepted/rejected |
|-----------------|-------|----------------------------|----------------------------|---------------------------|
| Current prices  |       |                            |                            |                           |
| Export          | GDPFC | -2.977                     | -2.608                     | Rejected                  |
| Export          | NDPFC | -3.047                     | -2.608                     | Rejected                  |
| Export          | GDPMP | -2.869                     | -2.608                     | Rejected                  |
| Export          | NDPMP | -2.919                     | -2.608                     | Rejected                  |
| Export          | GNPFC | -3.064                     | -2.608                     | Rejected                  |
| Export          | NNPFC | -3.143                     | -2.608                     | Rejected                  |
| Export          | GNPMP | -2.948                     | -2.608                     | Rejected                  |
| Export          | NNPMP | -3.006                     | -2.608                     | Rejected                  |
| Constant prices |       |                            |                            |                           |
| Export          | GDPFC | -0.074                     | -2.608                     | Accepted                  |

|        |       |        |        |          |
|--------|-------|--------|--------|----------|
| Export | NDPFC | -0.126 | -2.608 | Accepted |
| Export | GDPMP | -0.028 | -2.608 | Accepted |
| Export | NDPMP | -0.067 | -2.608 | Accepted |
| Export | GNPFC | -0.139 | -2.608 | Accepted |
| Export | NNPFC | -0.199 | -2.608 | Accepted |
| Export | GNPMP | -0.085 | -2.608 | Accepted |
| Export | NNPMP | -0.131 | -2.608 | Accepted |

**Note :** Calculated  $\tau$  values for residuals test have been taken from regression results as shown in Appendix 8.

Table 5: Determining optimum lag length (m) for GDP and its components : Relevant statistics

| GDP   | Lag of GDP (m) | FPE (m) |
|-------|----------------|---------|
| GDPFC | 1              | 0.3415  |
| GDPFC | 2              | 0.1999  |
| GDPFC | 3              | 0.1854  |
| GDPFC | 4*             | 0.1716  |
| GDPFC | 5              | 0.1719  |
| NDPFC | 1              | 0.2821  |
| NDPFC | 2              | 0.1809  |
| NDPFC | 3              | 0.1668  |
| NDPFC | 4*             | 0.1516  |
| NDPFC | 5              | 0.1550  |
| GDPMP | 1              | 0.3839  |
| GDPMP | 2*             | 0.2149  |
| GDPMP | 3              | 0.2173  |
| NDPMP | 1              | 0.3202  |
| NDPMP | 2              | 0.1963  |
| NDPMP | 3              | 0.1962  |
| NDPMP | 4*             | 0.1714  |
| GNPFC | 1              | 0.3309  |
| GNPFC | 2              | 0.1968  |
| GNPFC | 3              | 0.1877  |
| GNPFC | 4              | 0.1769  |
| GNPFC | 5*             | 0.1699  |
| GNPFC | 6              | 0.1752  |
| NNPFC | 1              | 0.2715  |
| NNPFC | 2              | 0.1774  |
| NNPFC | 3              | 0.1684  |
| NNPFC | 4              | 0.1552  |
| NNPFC | 5*             | 0.1537  |

|       |    |        |
|-------|----|--------|
| NNPFC | 6  | 0.1556 |
| GNPMP | 1  | 0.3711 |
| GNPMP | 2* | 0.2142 |
| GNPMP | 3  | 0.2182 |
| NNPMP | 1  | 0.3075 |
| NNPMP | 2  | 0.197  |
| NNPMP | 3  | 0.1964 |
| NNPMP | 4* | 0.1728 |

Note : (i) \*-optimum lag of GDP; (ii) Relevant statistic and optimum value of FPE i.e. m have been calculated on the basis of equations 5.1 and 5.2.

Table 6: Determining optimum lag lengths (m and n) for GDP and Export: Relevant statistics

| GDP   | Lag of<br>GDP (m) | Export | Lag of<br>export (n) | FPE(m*,n)<br>x 10 <sup>8</sup> |
|-------|-------------------|--------|----------------------|--------------------------------|
| GDPFC | 4                 | Export | 1                    | 0.1776                         |
| GDPFC | 4                 | Export | 2*                   | 0.1388                         |
| GDPFC | 4                 | Export | 3                    | 0.1439                         |
| NDPFC | 4                 | Export | 1                    | 0.1560                         |
| NDPFC | 4                 | Export | 2*                   | 0.1360                         |
| NDPFC | 4                 | Export | 3                    | 0.1412                         |
| GDPMP | 2                 | Export | 1                    | 0.2228                         |
| GDPMP | 2                 | Export | 2*                   | 0.2089                         |
| GDPMP | 2                 | Export | 3                    | 0.2094                         |
| NDPMP | 4                 | Export | 1                    | 0.2015                         |
| NDPMP | 4                 | Export | 2                    | 0.1943                         |
| NDPMP | 4                 | Export | 3                    | 0.1940                         |
| NDPMP | 4                 | Export | 4                    | 0.0819                         |
| GNPFC | 5                 | Export | 1                    | 0.1739                         |
| GNPFC | 5                 | Export | 2*                   | 0.1386                         |
| GNPFC | 5                 | Export | 3                    | 0.1443                         |
| NNPFC | 5                 | Export | 1                    | 0.1582                         |
| NNPFC | 5                 | Export | 2*                   | 0.1359                         |
| NNPFC | 5                 | Export | 3                    | 0.1415                         |
| GNPMP | 2                 | Export | 1                    | 0.2228                         |
| GNPMP | 2                 | Export | 2*                   | 0.2043                         |
| GNPMP | 2                 | Export | 3                    | 0.2044                         |
| NNPMP | 4                 | Export | 1                    | 0.2008                         |

|       |   |        |   |        |
|-------|---|--------|---|--------|
| NNPMP | 4 | Export | 2 | 0.1900 |
| NNPMP | 4 | Export | 3 | 0.1895 |
| NNPMP | 4 | Export | 4 | 0.0843 |

**Note :** (i) \*-optimum lag of export; (ii) Relevant statistic and optimum value of FPE i.e. m and n have been calculated on the basis of equations 5.1 and 5.3.

**Table 7: Engle-Granger test for determining direction of causality (with GDP as dependent variable and Export as independent variable): Regression results.**

| Variables | Constant             | GDP(-1)            | GDP(-2)            | GDP(-3)          | GDP(-4)            | GDP(-5)            | X(-1)            | X(-2)              | X(-3)            | X(-4)              | X(-5)              | R2    | DW    | AIC    | SC     |
|-----------|----------------------|--------------------|--------------------|------------------|--------------------|--------------------|------------------|--------------------|------------------|--------------------|--------------------|-------|-------|--------|--------|
| GDPFC     | 1276.92<br>(0.522)   | 1.504<br>(11.038)  | 0.198<br>(0.706)   | 0.105<br>(0.376) | -0.87<br>(-3.169)  | -                  | 1.061<br>(2.287) | -1.968<br>(-3.689) | -                | -                  | -                  | 0.999 | 2.057 | 21.662 | 21.935 |
| NDPFC     | 1540.06<br>(0.630)   | 1.524<br>(10.761)  | 0.21<br>(0.717)    | 0.057<br>(0.198) | -0.866<br>(-2.905) | -                  | 0.747<br>(1.580) | -1.483<br>(-2.833) | -                | -                  | -                  | 0.999 | 2.066 | 21.64  | 21.913 |
| GDPMP     | 968.69<br>(0.341)    | 1.902<br>(15.476)  | -0.847<br>(-5.600) | -                | -                  | -                  | 0.801<br>(1.424) | -1.396<br>(-2.223) | -                | -                  | -                  | 0.999 | 2.234 | 22.018 | 22.209 |
| NDPMP     | -2155.12<br>(-1.295) | 1.234<br>(7.687)   | -0.732<br>(-2.741) | 0.367<br>(1.508) | 0.471<br>(1.659)   | -                  | 0.214<br>(0.498) | 0.226<br>(0.205)   | 4.082<br>(5.28)  | -5.145<br>(-3.987) | -1.631<br>(-1.345) | 0.999 | 2.117 | 20.791 | 21.185 |
| GNPFC     | 1801.98<br>(0.693)   | 1.489<br>(10.53)   | 0.157<br>(0.546)   | 0.194<br>(0.655) | -0.686<br>(-1.593) | -0.246<br>(-0.621) | 1.568<br>(2.472) | -2.525<br>(-3.465) | -                | -                  | -                  | 0.999 | 2.044 | 21.689 | 22.004 |
| NNPFC     | 1969.79<br>(0.762)   | 1.515<br>(10.404)  | 0.16<br>(0.531)    | 0.148<br>(0.481) | -0.699<br>(-1.526) | -0.223<br>(-0.540) | 1.186<br>(1.976) | -1.975<br>(-2.871) | -                | -                  | -                  | 0.999 | 2.058 | 21.67  | 21.985 |
| GNPMP     | 1138.58<br>(0.404)   | (1.896<br>(15.741) | -0.847<br>(-5.758) | -                | -                  | -                  | 0.998<br>(1.800) | -1.536<br>(-2.461) | -                | -                  | -                  | 0.999 | 2.223 | 21.995 | 22.187 |
| NNPMP     | -1756.27<br>(-1.063) | 1.243<br>(7.765)   | -0.764<br>(-2.806) | 0.428<br>(1.706) | 0.411<br>(1.458)   | -                  | 0.432<br>(1.004) | 0.049<br>(0.044)   | 4.082<br>(5.307) | -4.939<br>(-3.821) | -1.695<br>(-1.395) | 0.999 | 2.095 | 20.791 | 21.185 |

**Note :** (i) Regression results of type 5.1 have been obtained on the basis of optimum values of m and n as given in Table 6; (ii) Figures in the parenthesis are t-values.

**Table 8: Direction of causality from Export to GDP: Optimum lag length**

| Lag of GDP (m*) | Lag of export (n*) | Minimum FPE for GDP (x 10 <sup>8</sup> ) | Minimum FPE for GDP and export (x 10 <sup>8</sup> ) | Causation from export to GDP |
|-----------------|--------------------|------------------------------------------|-----------------------------------------------------|------------------------------|
| GDPFC (-4)      | Export (-2)        | 0.1716                                   | 0.1388                                              | Export Cause GDPFC           |
| NDPFC (-4)      | Export (-2)        | 0.1516                                   | 0.136                                               | Export Cause NDPFC           |
| GDPMP (-2)      | Export (-2)        | 0.2149                                   | 0.2089                                              | Export Cause GDPMP           |
| NDPMP (-2)      | Export (-5)        | 0.1943                                   | 0.056                                               | Export Cause NDPMP           |
| GNPFC (-5)      | Export (-2)        | 0.1699                                   | 0.1386                                              | Export Cause GNPFC           |
| NNPFC (-5)      | Export (-2)        | 0.1537                                   | 0.1359                                              | Export Cause NNPFC           |
| GNPMP (-2)      | Export (-2)        | 0.2142                                   | 0.2043                                              | Export Cause GNPMP           |
| NNPMP (-2)      | Export (-5)        | 0.193                                    | 0.056                                               | Export Cause NNPMP           |

Note : (i) Optimum lag lengths (i.e. m and n) and FPE are based on values of these parameters as given in Tables 5 and 6.

**Table 9: Direction of causality from Export to GDP**

| Direction       | Sum of coefficients of export | Positive or Negative |
|-----------------|-------------------------------|----------------------|
| Export to GDPFC | -0.906                        | (-) Negative         |
| Export to NDPFC | -0.735                        | (-) Negative         |
| Export to GDPMP | -0.594                        | (-) Negative         |
| Export to NDPMP | -2.253                        | (-) Negative         |
| Export to GNPFC | -0.956                        | (-) Negative         |
| Export to NNPFC | -0.789                        | (-) Negative         |
| Export to GNPMP | -0.537                        | (-) Negative         |
| Export to NNPMP | -0.071                        | (-) Negative         |

Note : The positive/negative values are sum of coefficients of exports as shown in Table 7

**Table 10: Determining optimum lag length (m) for Export: Relevant statistics**

| Export | Lag of export (m) | FPE (m)x10 <sup>8</sup> |
|--------|-------------------|-------------------------|
| Export | 1                 | 0.0297                  |
| Export | 2*                | 0.0285                  |

|        |   |        |
|--------|---|--------|
| Export | 3 | 0.0296 |
|--------|---|--------|

Note : (i) \*-optimum lag of export; (ii) Relevant statistic and optimum value of FPE i.e. m have been calculated on the basis of equations 5.2 and 5.4.

**Table 11: Determining optimum lag lengths (m and n) for GDP and Export: Relevant statistics**

| Export | Lag of export (m*) | GDP   | Lag of GDP (n) | FPE(m*,n) x 10 <sup>8</sup> |
|--------|--------------------|-------|----------------|-----------------------------|
| Export | 2                  | GDPFC | 1*             | 0.020215                    |
| Export | 2                  | GDPFC | 2              | 0.020958                    |
| Export | 2                  | NDPFC | 1*             | 0.020077                    |
| Export | 2                  | NDPFC | 2              | 0.020791                    |
| Export | 2                  | GDPMP | 1              | 0.019917                    |
| Export | 2                  | GDPMP | 2*             | 0.019645                    |
| Export | 2                  | GDPMP | 3              | 0.020068                    |
| Export | 2                  | NDPMP | 1              | 0.019756                    |
| Export | 2                  | NDPMP | 2*             | 0.019096                    |
| Export | 2                  | NDPMP | 3              | 0.019099                    |
| Export | 2                  | GNPFC | 1*             | 0.020444                    |
| Export | 2                  | GNPFC | 2              | 0.021125                    |
| Export | 2                  | NNPFC | 1*             | 0.020330                    |
| Export | 2                  | NNPFC | 2              | 0.020958                    |
| Export | 2                  | GNPMP | 1              | 0.020100                    |
| Export | 2                  | GNPMP | 2*             | 0.019669                    |
| Export | 2                  | GNPMP | 3              | 0.020192                    |
| Export | 2                  | NNPMP | 1              | 0.019962                    |
| Export | 2                  | NNPMP | 2*             | 0.019096                    |
| Export | 2                  | NNPMP | 3              | 0.019248                    |

Note : (i) \*-optimum lag of GDP; (ii) Relevant statistic and optimum value of FPE i.e. m and n have been calculated on the basis of equations 5.3 and 5.4.

Table 12: Engle-Granger test for determining direction of causality (with Export as dependent variable and GDP as independent variable): Regression results

| Variables | Constant             | Export (-1)      | Export (-2)      | GDP (-1)         | GDP (-2)           | R <sup>2</sup> | DW    | AIC    | SC     |
|-----------|----------------------|------------------|------------------|------------------|--------------------|----------------|-------|--------|--------|
| GDPFC     | -1649.11<br>(-1.854) | 0.533<br>(3.263) | 0.102<br>(0.511) | 0.049<br>(4.616) | -                  | 0.993          | 1.897 | 19.682 | 19.835 |
| NDPFC     | -1727.61<br>(-1.931) | 0.526<br>(3.226) | 0.101<br>(0.513) | 0.056<br>(4.665) | -                  | 0.993          | 1.885 | 19.676 | 19.829 |
| GDPMP     | -1475.85<br>(-1.694) | 0.618<br>(3.579) | 0.113<br>(0.589) | 0.101<br>(2.693) | -0.072<br>(-1.568) | 0.994          | 2.022 | 19.654 | 19.845 |
| NDPMP     | -1497.11<br>(-1.727) | 0.639<br>(3.685) | 0.095<br>(0.502) | 0.123<br>(2.977) | -0.094<br>(-1.841) | 0.994          | 2.055 | 19.626 | 19.817 |
| GNPFC     | -1645.11<br>(-1.833) | 0.54<br>(3.293)  | 0.095<br>(0.473) | 0.049<br>(4.540) | -                  | 0.993          | 1.884 | 19.693 | 19.846 |
| NNPFC     | 1721.04<br>(-1.904)  | 0.534<br>(3.261) | 0.094<br>(0.471) | 0.056<br>(4.575) | -                  | 0.993          | 1.871 | 19.688 | 19.841 |
| GNPMP     | 1480.27<br>(-1.696)  | 0.629<br>(3.658) | 0.100<br>(0.519) | 0.105<br>(2.827) | -0.077<br>(-1.689) | 0.994          | 2.015 | 19.654 | 19.846 |
| NNPMP     | -1504.18<br>(-1.733) | 0.652<br>(3.78)  | 0.079<br>(0.415) | 0.128<br>(3.129) | -0.099<br>(-1.978) | 0.994          | 2.047 | 19.626 | 19.817 |

Note : (i) Regression results of type 5.4 have been obtained on the basis of optimum values of m and n as given in Table 11; (ii) Figures in the parenthesis are t-values.

Table 13: Direction of causality from GDP to Export: Optimum lag length

| Lag of Export (m*) | Lag of GDP (n*) | Minimum FPE for GDP<br>(x 10 <sup>8</sup> ) | Minimum FPE for GDP and export<br>(x 10 <sup>8</sup> ) | Causation from export to GDP |
|--------------------|-----------------|---------------------------------------------|--------------------------------------------------------|------------------------------|
|--------------------|-----------------|---------------------------------------------|--------------------------------------------------------|------------------------------|

|             |            |        |        |                    |
|-------------|------------|--------|--------|--------------------|
| Export (-2) | GDPFC (-1) | 0.0285 | 0.0200 | GDPFC cause export |
| Export (-2) | NDPFC (-1) | 0.0285 | 0.0200 | NDPFC cause export |
| Export (-2) | GDPMP (-2) | 0.0285 | 0.0196 | GDPMP cause export |
| Export (-2) | NDPMP (-2) | 0.0285 | 0.0190 | NDPMP cause export |
| Export (-2) | GNPFC (-1) | 0.0285 | 0.0200 | GNPFC cause export |
| Export (-2) | NNPFC (-1) | 0.0285 | 0.0203 | NNPFC cause export |
| Export (-2) | GNPMP (-2) | 0.0285 | 0.0196 | GNPMP cause export |
| Export (-2) | NNPMP (-2) | 0.0285 | 0.0190 | NNPMP cause export |

Note : (i) Optimum lag lengths (i.e. m and n) and FPE are based on values of these parameters as given in Tables 10 and 11.

Table 14: Direction of causality from GDP to Export

| Direction       | Sum of coefficients of GDP | Positive or Negative |
|-----------------|----------------------------|----------------------|
| GDPFC to Export | 0.0376                     | (+) Positive         |
| NDPFC to Export | 0.0585                     | (+) Positive         |
| GDPMP to Export | 0.0336                     | (+) Positive         |
| NDPMP to Export | 0.0511                     | (+) Positive         |
| GNPFC to Export | 0.0382                     | (+) Positive         |
| NNPFC to Export | 0.0586                     | (+) Positive         |
| GNPMP to Export | 0.0332                     | (+) Positive         |
| NNPMP to Export | 0.0525                     | (+) Positive         |

**Note : The positive/negative values are sum of coefficients of exports as shown in Table 12**

Table 15: Error correction model for GDP as dependent variable: Regression results for equations 6.113-6.120

| Equations | Constant            | $\Delta$ Export  | Residuals (-1)     | $R^2$ | DW    | AIC    | SC     |
|-----------|---------------------|------------------|--------------------|-------|-------|--------|--------|
| GDPFC     | 16165.86<br>(2.648) | 6.073<br>(8.047) | -0.078<br>(-0.819) | 0.612 | 1.561 | 23.978 | 24.092 |

|       |                     |                  |                    |       |       |        |        |
|-------|---------------------|------------------|--------------------|-------|-------|--------|--------|
| NDPFC | 14322.97<br>(2.599) | 5.484<br>(8.054) | -0.090<br>(-0.929) | 0.609 | 1.565 | 23.774 | 23.887 |
| GDPMP | 18031.00<br>(2.718) | 6.581<br>(8.004) | -0.059<br>(-0.638) | 0.615 | 1.640 | 24.144 | 24.257 |
| NDPMP | 16190.51<br>(2.679) | 5.991<br>(8.003) | -0.067<br>(-0.717) | 0.612 | 1.650 | 23.957 | 24.070 |
| GNPFC | 15870.87<br>(2.593) | 6.088<br>(8.080) | -0.097<br>(-1.004) | 0.608 | 1.559 | 23.985 | 24.099 |
| NNPFC | 14033.7<br>(2.54)   | 5.496<br>(8.095) | -0.112<br>(-1.132) | 0.605 | 1.563 | 23.780 | 23.894 |
| GNPMP | 17730.21<br>(2.663) | 6.598<br>(8.029) | -0.076<br>(-0.806) | 0.610 | 1.638 | 24.152 | 24.265 |
| NNPMP | 15893.02<br>(2.621) | 6.006<br>(8.033) | -0.086<br>(-0.900) | 0.608 | 1.648 | 23.965 | 24.078 |

Note : (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in parenthesis are t-values

**Table 16: Error correction model for Export as dependent variable: Regression results for equations 6.121-6.128**

| Equations | Constant          | $\Delta$ GDP<br>(Components at<br>Current Prices) | Residuals (-<br>1) | R <sup>2</sup> | DW    | AIC    | SC     |
|-----------|-------------------|---------------------------------------------------|--------------------|----------------|-------|--------|--------|
| Export    | 8.927<br>(0.010)  | 0.098<br>(8.535)                                  | -0.318<br>(-2.837) | 0.663          | 1.985 | 19.827 | 19.940 |
| Export    | 35.517<br>(0.043) | 0.108<br>(8.532)                                  | -0.329<br>(-2.926) | 0.662          | 1.980 | 19.828 | 19.941 |
| Export    | 19.440<br>(0.020) | 0.090<br>(8.514)                                  | -0.298<br>(-2.706) | 0.663          | 2.056 | 19.827 | 19.941 |
| Export    | 2.824<br>(0.003)  | 0.099<br>(8.506)                                  | -0.307<br>(-2.773) | 0.662          | 2.057 | 19.828 | 19.942 |
| Export    | 29.964            | 0.098                                             | -0.331             | 0.661          | 1.987 | 19.833 | 19.946 |

|        |                   |                  |                    |       |       |        |        |
|--------|-------------------|------------------|--------------------|-------|-------|--------|--------|
|        | (0.036)           | (8.548)          | (-2.950)           |       |       |        |        |
| Export | 56.580<br>(0.069) | 0.109<br>(8.550) | -0.344<br>(-3.046) | 0.660 | 1.982 | 19.834 | 19.948 |
| Export | 2.568<br>(0.003)  | 0.090<br>(8.520) | -0.311<br>(-2.811) | 0.661 | 2.056 | 19.833 | 19.946 |
| Export | 25.468<br>(0.031) | 0.099<br>(8.515) | -0.320<br>(-2.886) | 0.660 | 2.057 | 19.834 | 19.948 |

Appendix 1: Regression results: Dickey Fuller test

| Equations                   | Constant              | Trend             | Independent variables | R <sup>2</sup> | DW    | AIC    | SC     |
|-----------------------------|-----------------------|-------------------|-----------------------|----------------|-------|--------|--------|
| GDPFC<br>(at current price) | -10398.96<br>(-1.897) | 806.55<br>(3.169) | 0.096<br>(12.539)     | 0.925          | 0.779 | 22.335 | 22.448 |
| NDPFC<br>(at current price) | -9252.70<br>(-1.849)  | 708.51<br>(3.049) | 0.097<br>(12.405)     | 0.922          | 0.859 | 22.155 | 22.268 |
| GDPMP<br>(at current price) | -11139.98<br>(-1.919) | 873.81<br>(3.234) | 0.095<br>(12.925)     | 0.929          | 0.743 | 22.446 | 22.560 |
| NDPMP<br>(at current price) | -9987.88<br>(-1.876)  | 775.39<br>(3.127) | 0.096<br>(12.845)     | 0.928          | 0.807 | 22.274 | 22.388 |
| GNPFC<br>(at current price) | -10060.32<br>(-1.858) | 774.98<br>(3.084) | 0.097<br>(12.793)     | 0.926          | 0.791 | 22.311 | 22.425 |
| NNPFC<br>(at current price) | -8915.49<br>(-1.807)  | 676.88<br>(2.955) | 0.099<br>(12.693)     | 0.924          | 0.874 | 22.127 | 22.241 |
| GNPMP<br>(at current price) | -10793.82<br>(-1.882) | 841.76<br>(3.153) | 0.097<br>(13.176)     | 0.930          | 0.763 | 22.423 | 22.536 |
| NNPMP<br>(at current price) | -9643.33<br>(-1.837)  | 743.27<br>(3.041) | 0.098<br>(13.131)     | 0.929          | 0.832 | 22.247 | 22.361 |

|                                 |                      |                       |                  |       |       |        |        |
|---------------------------------|----------------------|-----------------------|------------------|-------|-------|--------|--------|
| price)                          |                      |                       |                  |       |       |        |        |
| GDPFC<br>(at constant<br>price) | -6147.23<br>(-1.822) | -5.35<br>(0.018)      | 0.064<br>(4.244) | 0.719 | 2.220 | 21.640 | 21.750 |
| NDPFC<br>(at constant<br>price) | -6014.45<br>(-1.824) | -8.42<br>(-0.029)     | 0.064<br>(3.786) | 0.671 | 2.301 | 21.608 | 21.722 |
| GDPMP<br>(at constant<br>price) | -5905.10<br>(-1.573) | -9.55<br>(-0.028)     | 0.062<br>(4.049) | 2.200 | 2.200 | 21.852 | 21.965 |
| NDPMP<br>(at constant<br>price) | -5755.42<br>(-1.565) | -11.51<br>(-0.034)    | 0.062<br>(3.630) | 0.661 | 2.271 | 21.821 | 21.935 |
| GNPFC<br>(at constant<br>price) | -6297.79<br>(-1.871) | -61.57<br>(-0.208)    | 0.067<br>(4.428) | 0.722 | 2.244 | 21.641 | 21.755 |
| NNPFC<br>(at constant<br>price) | -6215.33<br>(-1.886) | -65.06<br>(-0.223)    | 0.068<br>(3.970) | 0.674 | 2.325 | 21.608 | 21.721 |
| GNPMP<br>(at constant<br>price) | -6035.11<br>(-1.610) | -67.16<br>(-0.200)    | 0.066<br>(4.211) | 0.709 | 2.238 | 21.851 | 21.965 |
| NNPMP<br>(at constant<br>price) | -5928.02<br>(-0.210) | -69.64<br>(-1.613)    | 0.066<br>(3.791) | 0.663 | 2.309 | 21.822 | 21.936 |
| Export                          | -1756.95<br>(-1.044) | 127.51<br>(1.759<br>) | 0.097<br>(4.313) | 0.590 | 2.155 | 20.020 | 20.130 |

Note: (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in the parenthesis are  $\tau$ -values  
Appendix 2: Regression results: Dickey Fuller test

| Equations               | Constant             | Trend             | Independent variables | R <sup>2</sup> | DW    | AIC   | SC    |
|-------------------------|----------------------|-------------------|-----------------------|----------------|-------|-------|-------|
| GDPFC<br>(at current pr | -6035.53<br>(-1.244) | 466.33<br>(2.034) | -0.073<br>(-1.253)    | 0.089          | 2.671 | 21.93 | 22.04 |

|                              |                      |                    |                    |       |       |       |       |
|------------------------------|----------------------|--------------------|--------------------|-------|-------|-------|-------|
| ice)                         |                      |                    |                    |       |       |       |       |
| NDPFC<br>(at current price)  | -5845.76<br>(-1.263) | 448.35<br>(2.059)  | -0.084<br>(-1.372) | 0.087 | 2.707 | 21.84 | 21.96 |
| GDPMP<br>(at current price)  | -6180.00<br>(-1.233) | 482.46<br>(2.026)  | -0.066<br>(-1.188) | 0.091 | 2.424 | 21.99 | 22.11 |
| NDPMP<br>(at current price)  | -5943.15<br>(-1.245) | 461.26<br>(2.042)  | -0.074<br>(-1.284) | 0.088 | 2.456 | 21.90 | 22.01 |
| GNPFC<br>(at current price)  | -5982.07<br>(-1.234) | 458.40<br>(2.005)  | -0.067<br>(-1.147) | 0.090 | 2.632 | 21.93 | 22.05 |
| NNPFC<br>(at current price)  | -5791.50<br>(-1.254) | 440.37<br>(2.031)  | -0.078<br>(-1.262) | 0.088 | 2.675 | 21.84 | 21.96 |
| GNPMP<br>(at current price)  | -6179.32<br>(-1.226) | 478.07<br>(2.001)  | -0.061<br>(-1.098) | 0.093 | 2.420 | 22.01 | 22.12 |
| NNPMP<br>(at current price)  | -5944.13<br>(-1.239) | 457.07<br>(2.018)  | -0.070<br>(-1.191) | 0.090 | 2.459 | 21.91 | 22.03 |
| GDPFC<br>(at constant price) | -6808.14<br>(-1.632) | 920.72<br>(4.442)  | -0.771<br>(-5.378) | 0.382 | 2.074 | 21.91 | 22.03 |
| NDPFC<br>(at constant price) | -6479.81<br>(-1.613) | 883.64<br>(4.621)  | -0.848<br>(-5.810) | 0.419 | 2.077 | 21.85 | 21.97 |
| GDPMP<br>(at constant price) | -7132.40<br>(-1.563) | 1011.07<br>(4.476) | -0.784<br>(-5.464) | 0.390 | 2.065 | 22.11 | 22.22 |
| NDPMP<br>(at constant price) | -6746.11<br>(-1.530) | 970.51<br>(4.628)  | -0.853<br>(-5.854) | 0.423 | 2.027 | 22.05 | 22.17 |
| GNPFC<br>(at constant price) | -6880.40<br>(-1.636) | 913.37<br>(4.401)  | -0.763<br>(-5.285) | 0.375 | 2.064 | 21.94 | 22.05 |

|                                  |                      |                    |                    |       |       |       |       |
|----------------------------------|----------------------|--------------------|--------------------|-------|-------|-------|-------|
| NNPFC<br>(at constant<br>pr ice) | -6560.64<br>(-1.619) | 877.44<br>(4.579)  | -0.841<br>(-5.713) | 0.412 | 2.014 | 21.88 | 21.99 |
| GNPMP<br>(at constant<br>pr ice) | -7260.97<br>(-1.577) | 1011.26<br>(4.467) | -0.783<br>(-5.418) | 0.386 | 2.055 | 22.13 | 22.24 |
| NNPMP<br>(at constant<br>pr ice) | -6878.26<br>(-1.546) | 971.40<br>(4.620)  | -0.854<br>(-5.810) | 0.420 | 2.015 | 22.07 | 22.19 |
| Export                           | -3864.13<br>(-1.993) | 258.88<br>(3.299)  | -0.711<br>(-5.041) | 0.351 | 1.916 | 20.27 | 20.38 |

Note: (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in the parenthesis are  $\tau$ -values

Appendix 3: Regression results: Dickey Fuller test

| Equations                       | Constant             | Trend             | Independent<br>variables | R <sup>2</sup> | DW    | AIC   | SC    |
|---------------------------------|----------------------|-------------------|--------------------------|----------------|-------|-------|-------|
| GDPFC<br>(at current pr<br>ice) | -3737.51<br>(-0.943) | 319.23<br>(2.410) | -1.404<br>(-10.320)      | 0.698          | 2.105 | 21.81 | 29.93 |
| NDPFC<br>(at current pr<br>ice) | -3361.26<br>(-0.894) | 288.35<br>(2.298) | -1.425<br>(-10.625)      | 0.710          | 2.122 | 21.71 | 21.83 |
| GDPMP<br>(at current pr<br>ice) | -3637.19<br>(-0.849) | 314.35<br>(2.191) | -1.274<br>(-8.872)       | 0.631          | 2.149 | 21.97 | 22.08 |
| NDPMP<br>(at current pr<br>ice) | -3279.01<br>(-0.804) | 285.29<br>(2.094) | -1.290<br>(-9.065)       | 0.641          | 2.160 | 21.87 | 21.98 |
| GNPFC<br>(at current pr<br>ice) | -3976.41<br>(-1.001) | 330.66<br>(2.491) | -1.400<br>(-10.142)      | 0.691          | 2.117 | 21.81 | 21.93 |
| NNPFC                           | -3603.70             | 300.11            | -1.424                   | 0.704          | 2.145 | 21.71 | 21.82 |

|                             |                      |                   |                    |       |       |       |       |
|-----------------------------|----------------------|-------------------|--------------------|-------|-------|-------|-------|
| (at current price)          | (-0.958)             | (2.392)           | (-10.478)          |       |       |       |       |
| GNPMP<br>(at current price) | -3925.89<br>(-0.915) | 330.10<br>(2.298) | -1.289<br>(-8.894) | 0.632 | 2.157 | 21.97 | 22.09 |
| NNPMP<br>(at current price) | -3570.53<br>(-0.876) | 301.32<br>(2.213) | -1.309<br>(-9.130) | 0.644 | 2.176 | 21.87 | 21.98 |

Note: (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in the parenthesis are  $\tau$ -values

#### Appendix 4: Regression results: Augmented Dickey Fuller test

| Equations                   | Constant             | Trend             | $Y_{t-1}$        | $\Delta Y_{t-1}$ | $R^2$ | DW    | AIC    | SC     |
|-----------------------------|----------------------|-------------------|------------------|------------------|-------|-------|--------|--------|
| GDPFC<br>(at current price) | -5964.41<br>(-1.247) | 463.20<br>(2.049) | 0.023<br>(1.528) | 0.731<br>(5.216) | 0.952 | 2.330 | 21.925 | 22.070 |
| NDPFC<br>(at current price) | -5720.00<br>(-1.261) | 438.95<br>(2.056) | 0.027<br>(1.710) | 0.685<br>(4.648) | 0.947 | 2.313 | 21.825 | 21.978 |
| GDPMP<br>(at current price) | -6186.20<br>(-1.244) | 485.78<br>(2.058) | 0.020<br>(1.345) | 0.762<br>(5.491) | 0.957 | 2.152 | 21.997 | 22.150 |
| NDPMP<br>(at current price) | -5916.12<br>(-1.255) | 460.38<br>(2.064) | 0.023<br>(1.481) | 0.727<br>(4.999) | 0.953 | 2.143 | 21.896 | 22.046 |
| GNPFC<br>(at current price) | -5846.28<br>(-1.232) | 450.29<br>(2.012) | 0.026<br>(1.743) | 0.712<br>(5.137) | 0.953 | 2.282 | 21.913 | 22.066 |
| NNPFC<br>(at current price) | -5587.79<br>(-1.244) | 424.57<br>(2.013) | 0.031<br>(1.942) | 0.664<br>(4.568) | 0.947 | 2.268 | 21.809 | 21.962 |
| GNPMP<br>(at current price) | -6132.58<br>(-1.236) | 477.64<br>(2.032) | 0.023<br>(1.593) | 0.736<br>(5.335) | 0.957 | 2.123 | 21.996 | 22.149 |

|                              |                       |                     |                  |                    |       |       |        |        |
|------------------------------|-----------------------|---------------------|------------------|--------------------|-------|-------|--------|--------|
| NNPMP<br>(at current price)  | -5852.62<br>(-1.246)  | 451.12<br>(2.035)   | 0.027<br>(1.750) | 0.698<br>(4.836)   | 0.953 | 2.119 | 21.892 | 22.045 |
| GDPFC<br>(at constant price) | -6840.99<br>(-1.854)  | 29.78<br>(-0.095)   | 0.072<br>(3.749) | -0.120<br>(-0.763) | 0.719 | 2.025 | 21.692 | 21.845 |
| NDPFC<br>(at constant price) | -6930.25<br>(3579.60) | -42.75<br>(306.71)  | 0.076<br>(0.020) | -0.163<br>(0.156)  | 0.674 | 2.046 | 21.647 | 21.800 |
| GDPMP<br>(at constant price) | -6569.20<br>(-1.609)  | -30.96<br>(-0.087)  | 0.070<br>(3.573) | -0.109<br>(-0.696) | 0.706 | 2.022 | 21.903 | 22.056 |
| NDPMP<br>(at constant price) | -6593.20<br>(-1.660)  | -42.99<br>(-0.122)  | 0.072<br>(3.444) | -0.146<br>(-0.934) | 0.663 | 2.038 | 21.864 | 22.017 |
| GNPFC<br>(at constant price) | -7048.21<br>(-1.916)  | -93.32<br>(-0.297)  | 0.077<br>(3.933) | -0.131<br>(-0.838) | 0.722 | 2.034 | 21.688 | 21.841 |
| NNPFC<br>(at constant price) | -7204.11<br>(-2.018)  | -108.59<br>(-0.352) | 0.082<br>(3.829) | -0.176<br>(-1.129) | 0.678 | 2.056 | 21.643 | 21.796 |
| GNPMP<br>(at constant price) | -6787.28<br>(-1.668)  | -98.50<br>(-0.276)  | 0.075<br>(3.772) | -0.128<br>(-0.818) | 0.709 | 2.032 | 21.899 | 22.052 |
| NNPMP<br>(at constant price) | -6866.51<br>(-1.734)  | -112.87<br>(-0.321) | 0.078<br>(3.653) | -0.167<br>(-1.068) | 0.667 | 2.049 | 21.859 | 22.012 |
| Export                       | -2014.67<br>(-1.169)  | 138.03<br>(1.884)   | 0.165<br>(4.207) | -0.460<br>(-2.138) | 0.626 | 1.875 | 19.989 | 20.142 |

Note: (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in the parenthesis are  $\tau$ -values  
Appendix 5: Regression results: Augmented Dickey Fuller test

| Equations                   | Constant             | Trend             | $Y_{t-1}$          | $\Delta Y_{t-1}$   | $R^2$ | DW    | AIC    | SC     |
|-----------------------------|----------------------|-------------------|--------------------|--------------------|-------|-------|--------|--------|
| GDPFC<br>(at current price) | -5907.31<br>(-1.216) | 461.65<br>(2.040) | -0.044<br>(-0.778) | -0.381<br>(-2.735) | 0.219 | 2.083 | 21.842 | 21.996 |

|                              |                      |                   |                    |                    |       |       |        |        |
|------------------------------|----------------------|-------------------|--------------------|--------------------|-------|-------|--------|--------|
| NDPFC<br>(at current price)  | -5552.36<br>(-1.208) | 432.01<br>(2.027) | -0.050<br>(-0.835) | -0.400<br>(-2.903) | 0.231 | 2.098 | 21.736 | 21.891 |
| GDPMP<br>(at current price)  | -6366.68<br>(-1.211) | 493.83<br>(2.008) | -0.051<br>(-0.899) | -0.249<br>(-1.701) | 0.146 | 2.121 | 21.994 | 22.148 |
| NDPMP<br>(at current price)  | -6021.26<br>(-1.207) | 465.46<br>(2.002) | -0.057<br>(-0.957) | -0.263<br>(-1.809) | 0.151 | 2.130 | 21.893 | 22.048 |
| GNPFC<br>(at current price)  | -5887.07<br>(-1.210) | 456.00<br>(2.017) | -0.039<br>(-2.687) | -0.381<br>(-0.687) | 0.217 | 2.093 | 21.849 | 22.004 |
| NNPFC<br>(at current price)  | -5529.33<br>(-1.204) | 426.29<br>(2.006) | -0.044<br>(-0.737) | 0.402<br>(-2.874)  | 0.230 | 2.119 | 21.740 | 21.895 |
| GNPMP<br>(at current price)  | -6349.87<br>(-1.206) | 489.41<br>(1.992) | -0.046<br>(-0.800) | -0.267<br>(-1.804) | 0.154 | 2.127 | 22.001 | 22.155 |
| NNPMP<br>(at current price)  | -5997.48<br>(-1.203) | 460.68<br>(1.987) | -0.050<br>(-0.850) | -0.284<br>(-1.941) | 0.160 | 2.144 | 21.897 | 22.051 |
| GDPFC<br>(at constant price) | -6193.01<br>(-1.381) | 782.58<br>(3.180) | -0.626<br>(-3.422) | -0.199<br>(-1.357) | 0.412 | 2.070 | 21.930 | 22.080 |
| NDPFC<br>(at constant price) | -6151.44<br>(-1.418) | 779.60<br>(3.365) | -0.718<br>(-3.709) | -0.163<br>(-1.099) | 0.439 | 2.048 | 21.887 | 22.042 |
| GDPMP<br>(at constant price) | -6481.60<br>(-1.319) | 866.41<br>(3.204) | -0.646<br>(-3.509) | -0.188<br>(-1.278) | 0.415 | 2.051 | 22.129 | 22.283 |
| NDPMP<br>(at constant price) | -6355.21<br>(-1.334) | 856.11<br>(3.357) | -0.727<br>(-3.758) | -0.158<br>(-1.070) | 0.441 | 2.035 | 22.085 | 22.240 |
| GNPFC                        | -6239.71             | 772.57            | -0.613             | -0.208             | 0.407 | 2.070 | 21.949 | 22.104 |

|                              |                      |                   |                    |                    |       |       |        |        |
|------------------------------|----------------------|-------------------|--------------------|--------------------|-------|-------|--------|--------|
| (at constant price)          | (-1.384)             | (3.146)           | (-3.342)           | (-1.408)           |       |       |        |        |
| NNPFC<br>(at constant price) | -6198.94<br>(-1.420) | 768.48<br>(3.326) | -0.705<br>(-3.621) | -0.173<br>(-1.157) | 0.434 | 2.045 | 21.905 | 22.059 |
| GNPMP<br>(at constant price) | -6529.62<br>(-1.322) | 855.53<br>(3.171) | -0.635<br>(-3.433) | -0.203<br>(-1.373) | 0.415 | 2.054 | 22.143 | 22.298 |
| NNPMP<br>(at constant price) | -6407.17<br>(-1.337) | 845.48<br>(3.320) | -0.715<br>(-3.676) | -0.174<br>(-1.168) | 0.441 | 2.035 | 22.101 | 22.255 |
| Export                       | -3219.11<br>(-1.545) | 207.08<br>(2.355) | -0.434<br>(-2.017) | 0.514<br>(-1.764)  | 0.397 | 1.981 | 20.264 | 20.418 |

Note: (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in the parenthesis are  $\tau$ -values

Appendix 6: Regression results: Augmented Dickey Fuller test

| Equations                    | Constant              | Trend             | $Y_{t-1}$          | $\Delta Y_{t-1}$ | $R^2$ | DW    | AIC    | SC     |
|------------------------------|-----------------------|-------------------|--------------------|------------------|-------|-------|--------|--------|
| GDPFC<br>(at current price)  | -4675.51<br>(-1.106)  | 374.37<br>(2.551) | -1.598<br>(-6.367) | 0.140<br>(0.922) | 0.704 | 1.958 | 21.858 | 22.014 |
| NDPFC<br>(at current price)  | -4283.41<br>(-1.069)  | 343.05<br>(2.475) | -1.638<br>(-6.478) | 0.150<br>(0.994) | 0.717 | 1.961 | 21.752 | 21.907 |
| GDPMP<br>(at current price)  | -5659.44<br>(-1.281)  | 443.19<br>(2.867) | -1.676<br>(-7.103) | 0.331<br>(2.113) | 0.665 | 1.971 | 21.938 | 22.094 |
| NDPMP<br>(at current price)  | -5232.42<br>(-1.244)  | 409.13<br>(2.785) | -1.706<br>(-7.123) | 0.336<br>(2.126) | 0.675 | 1.995 | 21.838 | 21.994 |
| GNPFC<br>(at current price)  | -5074.02<br>(-1.204)  | 396.68<br>(2.713) | -1.639<br>(-6.552) | 0.174<br>(1.142) | 0.700 | 1.939 | 21.852 | 22.008 |
| NNPFC<br>(at current price)  | -4701.25<br>(-1.181)  | 366.73<br>(2.665) | -1.689<br>(-6.726) | 0.191<br>(1.257) | 0.715 | 1.944 | 21.739 | 21.895 |
| GNPMP<br>(at current price)  | -6091.00<br>(-1.385)  | 467.51<br>(3.040) | -1.716<br>(-7.298) | 0.357<br>(2.261) | 0.671 | 1.948 | 21.927 | 22.083 |
| NNPMP<br>(at current price)  | -5686.17<br>(-1.364)  | 435.01<br>(2.987) | -1.757<br>(-7.379) | 0.367<br>(2.310) | 0.683 | 1.975 | 21.821 | 21.976 |
| GDPFC<br>(at constant price) | -1184.84<br>(-0.260)  | 129.35<br>(0.874) | -2.081<br>(-8.566) | 0.382<br>(2.707) | 0.787 | 2.076 | 22.032 | 22.188 |
| NDPFC<br>(at constant price) | -12.44.65<br>(-0.277) | 123.24<br>(0.844) | -2.119<br>(-8.761) | 0.399<br>(2.846) | 0.794 | 2.088 | 22.006 | 22.162 |
| GDPMP<br>(at constant price) | -1212.52<br>(-0.238)  | 137.36<br>(0.827) | -2.052<br>(-8.274) | 0.370<br>(2.523) | 0.781 | 2.095 | 22.257 | 22.413 |

|                              |                      |                   |                    |                  |       |       |        |        |
|------------------------------|----------------------|-------------------|--------------------|------------------|-------|-------|--------|--------|
| NDPMP<br>(at constant price) | -1272.63<br>(-0.253) | 131.36<br>(0.801) | -2.085<br>(-8.428) | 0.383<br>(2.623) | 0.787 | 2.104 | 22.237 | 22.390 |
| GNPFC<br>(at constant price) | -1463.21<br>(-0.323) | 143.06<br>(0.969) | -2.104<br>(-8.694) | 0.397<br>(2.818) | 0.789 | 2.066 | 22.026 | 22.182 |
| NNPFC<br>(at constant price) | -1524.22<br>(-0.341) | 136.94<br>(0.941) | -2.145<br>(-8.898) | 0.415<br>(2.966) | 0.796 | 2.078 | 21.999 | 22.155 |
| GNPMP<br>(at constant price) | -1491.81<br>(-0.293) | 151.36<br>(0.913) | -2.079<br>(-8.403) | 0.383<br>(2.610) | 0.784 | 2.086 | 22.254 | 22.409 |
| NNPMP<br>(at constant price) | -1553.04<br>(-0.309) | 145.34<br>(0.888) | -2.114<br>(-8.566) | 0.397<br>(2.717) | 0.791 | 2.094 | 22.229 | 22.385 |
| Export                       | -1662.37<br>(-0.870) | 106.69<br>(1.657) | -2.598<br>(-7.681) | 0.617<br>(2.272) | 0.722 | 2.103 | 20.263 | 20.419 |

Note: (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in the parenthesis are  $\tau$ -values

Appendix 7: Regression result: GDP (at current and constant prices) on export

| Equations                   | Residuals (-1)     | R <sup>2</sup> | DW    | AIC    | SC     |
|-----------------------------|--------------------|----------------|-------|--------|--------|
| GDPFC<br>(at current price) | -0.319<br>(-3.035) | 0.155          | 2.001 | 24.371 | 24.409 |
| NDPFC<br>(at current price) | -0.329<br>(-3.100) | 0.161          | 2.001 | 24.149 | 24.187 |
| GDPMP<br>(at current price) | -0.302<br>(-2.933) | 0.146          | 2.066 | 24.557 | 24.595 |
| NDPMP<br>(at current price) | -0.308<br>(-2.980) | 0.150          | 2.072 | 24.355 | 24.393 |
| GNPFC<br>(at current price) | -0.331<br>(-3.116) | 0.162          | 2.008 | 24.360 | 24.398 |
| NNPFC<br>(at current price) | -0.342<br>(-3.189) | 0.168          | 2.009 | 24.136 | 24.174 |
| GNPMP                       | -0.312             | 0.152          | 2.072 | 24.546 | 24.584 |

|                      |          |       |       |        |        |
|----------------------|----------|-------|-------|--------|--------|
| (at current pr ice)  | (-3.005) |       |       |        |        |
| NNPMP                | -0.320   | 0.157 | 2.079 | 24.344 | 24.382 |
| (at current pr ice)  | (-3.058) |       |       |        |        |
| GDPFC                | -0.046   | 0.024 | 1.797 | 23.660 | 23.690 |
| (at constant pr ice) | (-1.114) |       |       |        |        |
| NDPFC                | -0.048   | 0.025 | 1.840 | 23.442 | 23.480 |
| (at constant pr ice) | (-1.154) |       |       |        |        |
| GDPMP                | -0.045   | 0.024 | 1.827 | 23.879 | 23.917 |
| (at constant pr ice) | (-1.110) |       |       |        |        |
| NDPMP                | -0.047   | 0.025 | 1.867 | 23.683 | 23.721 |
| (at constant pr ice) | (-1.144) |       |       |        |        |
| GNPFC                | -0.048   | 0.025 | 1.837 | 23.639 | 23.677 |
| (at constant pr ice) | (-1.156) |       |       |        |        |
| NNPFC                | -0.050   | 0.027 | 1.884 | 23.417 | 23.455 |
| (at constant pr ice) | (-1.201) |       |       |        |        |
| GNPMP                | -0.047   | 0.025 | 1.865 | 23.859 | 23.897 |
| (at constant pr ice) | (-1.148) |       |       |        |        |
| NNPMP                | -0.049   | 0.027 | 1.909 | 23.662 | 23.699 |
| (at constant pr ice) | (-1.186) |       |       |        |        |

Note: (i) Figures in the parenthesis are  $\tau$ -values

Appendix 8: Regression results: Export on GDP (at current and constant prices)

| Equations           | Residuals (-1) | R <sup>2</sup> | DW    | AIC    | SC     |
|---------------------|----------------|----------------|-------|--------|--------|
| GDPFC               | -0.320         | 0.150          | 1.978 | 19.749 | 19.786 |
| (at current pr ice) | (-2.976)       |                |       |        |        |
| NDPFC               | -0.330         | 0.156          | 1.979 | 19.749 | 19.787 |
| (at current pr ice) | (-3.046)       |                |       |        |        |
| GDPMP               | -0.302         | 0.140          | 2.040 | 19.749 | 19.787 |
| (at current pr ice) | (-2.869)       |                |       |        |        |
| NDPMP               | -0.309         | 0.145          | 2.047 | 19.750 | 19.788 |
| (at current pr ice) | (-2.919)       |                |       |        |        |
| GNPFC               | -0.332         | 0.157          | 1.986 | 19.754 | 19.792 |
| (at current pr ice) | (-3.064)       |                |       |        |        |
| NNPFC               | -0.343         | 0.164          | 1.987 | 19.756 | 19.794 |
| (at current pr ice) | (-3.142)       |                |       |        |        |

|                               |                    |        |       |        |        |
|-------------------------------|--------------------|--------|-------|--------|--------|
| GNPMP<br>(at current pr ice)  | -0.313<br>(-2.948) | 0.147  | 2.047 | 19.755 | 19.792 |
| NNPMP<br>(at current pr ice)  | -0.321<br>(-3.005) | 0.152  | 2.055 | 19.756 | 19.794 |
| GDPFC<br>(at constant pr ice) | -0.003<br>(-0.074) | -0.006 | 1.654 | 20.374 | 20.412 |
| NDPFC<br>(at constant pr ice) | -0.006<br>(-0.125) | -0.006 | 1.691 | 20.406 | 20.444 |
| GDPMP<br>(at constant pr ice) | -0.001<br>(-0.028) | -0.007 | 1.676 | 20.400 | 20.438 |
| NDPMP<br>(at constant pr ice) | -0.003<br>(-0.067) | -0.006 | 1.709 | 20.432 | 20.469 |
| GNPFC<br>(at constant pr ice) | -0.006<br>(-0.138) | -0.005 | 1.687 | 20.375 | 20.413 |
| NNPFC<br>(at constant pr ice) | -0.009<br>(-0.198) | -0.005 | 1.726 | 20.408 | 20.446 |
| GNPMP<br>(at constant pr ice) | -0.004<br>(-0.085) | -0.006 | 1.706 | 20.401 | 20.439 |
| NNPMP<br>(at constant pr ice) | -0.006<br>(-0.131) | -0.005 | 1.743 | 20.434 | 20.471 |

Appendix 9: Regression results: GDP (at current and constant prices) as dependent variable and export as independent variable

| Equations                    | Constant            | Export             | R <sup>2</sup> | DW    | AIC    | SC     |
|------------------------------|---------------------|--------------------|----------------|-------|--------|--------|
| GDPFC<br>(at current pr ice) | 50672.40<br>(4.991) | 10.132<br>(60.705) | 0.986          | 0.637 | 25.009 | 25.084 |
| NDPFC<br>(at current pr ice) | 45982.29<br>(5.115) | 9.059<br>(61.298)  | 0.986          | 0.655 | 24.765 | 24.840 |
| GDPMP<br>(at current pr ice) | 56666.84<br>(4.978) | 11.120<br>(59.413) | 0.986          | 0.604 | 25.238 | 25.313 |
| NDPMP<br>(at current pr ice) | 51976.73<br>(5.087) | 10.046<br>(59.814) | 0.986          | 0.616 | 25.021 | 25.096 |

|                              |                       |                    |       |       |        |        |
|------------------------------|-----------------------|--------------------|-------|-------|--------|--------|
| GNPFC<br>(at current price)  | 50030.28<br>(5.017)   | 10.038<br>(61.235) | 0.986 | 0.658 | 24.973 | 25.048 |
| NNPFC<br>(at current price)  | 45240.17<br>(5.144)   | 8.965<br>(61.866)  | 0.987 | 0.679 | 24.726 | 24.801 |
| GNPMP<br>(at current price)  | 56024.47<br>(5.004)   | 11.026<br>(59.898) | 0.986 | 0.622 | 25.204 | 25.279 |
| NNPMP<br>(at current price)  | 51334.61<br>(5.116)   | 9.952<br>(60.335)  | 0.986 | 0.636 | 24.985 | 25.060 |
| GDPFC<br>(at constant price) | 300286.60<br>(16.570) | 5.358<br>(17.982)  | 0.866 | 0.085 | 26.168 | 26.243 |
| NDPFC<br>(at constant price) | 275036.6<br>(17.212)  | 4.702<br>(17.898)  | 0.864 | 0.088 | 25.916 | 25.991 |
| GDPMP<br>(at constant price) | 330156.40<br>(16.118) | 5.894<br>(17.501)  | 0.859 | 0.082 | 26.412 | 26.488 |
| NDPMP<br>(at constant price) | 304905.80<br>(16.624) | 5.238<br>(17.371)  | 0.857 | 0.085 | 26.192 | 26.267 |
| GNPFC<br>(at constant price) | 298343.50<br>(16.722) | 5.291<br>(18.038)  | 0.866 | 0.086 | 26.136 | 26.211 |
| NNPFC<br>(at constant price) | 273094.80<br>(17.397) | 4.635<br>(17.961)  | 0.865 | 0.089 | 25.880 | 25.955 |
| GNPMP<br>(at constant price) | 328215.30<br>(16.248) | 5.827<br>(17.546)  | 0.860 | 0.083 | 26.385 | 26.460 |
| NNPMP<br>(at constant price) | 302964.60<br>(16.778) | 5.171<br>(17.419)  | 0.858 | 0.086 | 26.160 | 26.235 |

Note: (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in the parenthesis are  $\tau$ -values

Appendix 10: Regression result: GDP (at current and constant prices) as dependent variable and export as independent variable

| Equations                    | Constant              | GDP               | R <sup>2</sup> | DW    | AIC    | SC     |
|------------------------------|-----------------------|-------------------|----------------|-------|--------|--------|
| GDPFC<br>(at current price)  | -4538.79<br>(-4.384)  | 0.097<br>(60.705) | 0.986          | 0.648 | 20.364 | 20.439 |
| NDPFC<br>(at current price)  | -4621.31<br>(-4.503)  | 0.108<br>(61.298) | 0.986          | 0.666 | 20.344 | 20.419 |
| GDPMP<br>(at current price)  | -4612.46<br>(-4.358)  | 0.088<br>(59.413) | 0.986          | 0.614 | 20.406 | 20.481 |
| NDPMP<br>(at current price)  | -4695.28<br>(-4.463)  | 0.098<br>(59.814) | 0.986          | 0.626 | 20.393 | 20.468 |
| GNPFC<br>(at current price)  | -4529.71<br>(-4.413)  | 0.098<br>(61.235) | 0.986          | 0.669 | 20.346 | 20.421 |
| NNPFC<br>(at current price)  | -4611.32<br>(-4.535)  | 0.110<br>(61.866) | 0.987          | 0.689 | 20.326 | 20.401 |
| GNPMP<br>(at current price)  | -4605.51<br>(-4.387)  | 0.089<br>(59.898) | 0.986          | 0.633 | 20.390 | 20.465 |
| NNPMP<br>(at current price)  | -4687.93<br>(-4.495)  | 0.099<br>(60.335) | 0.986          | 0.647 | 20.376 | 20.451 |
| GDPFC<br>(at constant price) | -44585.51<br>(-8.997) | 0.161<br>(17.982) | 0.866          | 0.102 | 22.667 | 22.742 |
| NDPFC<br>(at constant price) | -46607.34<br>(-9.189) | 0.183<br>(17.898) | 0.864          | 0.105 | 22.675 | 22.750 |
| GDPMP<br>(at constant price) | -44011.36<br>(-8.700) | 0.145<br>(17.501) | 0.859          | 0.100 | 22.713 | 22.788 |
| NDPMP                        | -45736.04             | 0.163             | 0.857          | 0.102 | 22.726 | 22.801 |

|                              |                       |                   |       |       |        |        |
|------------------------------|-----------------------|-------------------|-------|-------|--------|--------|
| (at constant price)          | (-8.833)              | (17.371)          |       |       |        |        |
| GNPFC<br>(at constant price) | -44941.13<br>(-9.066) | 0.163<br>(18.038) | 0.866 | 0.103 | 22.661 | 22.736 |
| NNPFC<br>(at constant price) | -47044.23<br>(-9.269) | 0.186<br>(17.961) | 0.865 | 0.106 | 22.669 | 22.744 |
| GNPMP<br>(at constant price) | -44328.56<br>(22.709) | 0.147<br>(22.784) | 0.860 | 0.101 | 22.709 | 22.784 |
| NNPMP<br>(at constant price) | -46117.15<br>(-8.899) | 0.166<br>(17.419) | 0.858 | 0.103 | 22.721 | 22.796 |

Note: (i) Raw data pertaining to regression results in this appendix have been taken from Handbook of Statistics on Indian Economy and Economic Survey; (ii) Figures in the parenthesis are  $\tau$ -values

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