A statistical analysis on causality test in India’s foreign market

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Abstract
The gargantuan current account deficit was a much discussed issue in Indian economy during 2012-13. It was USD 87.8 billion, 4.8% of GDP in the financial year 2013. Accordingly the price of Rupees against Dollar has been continuously falling in the recent past. Foreign trade market has been characterized by some common scenarios. Firstly, there is a change in the composition of trade. Whereas the combined share of import of Petroleum, Electronic goods and Gold is rising, the same for Machinery, Iron and Steel is falling and Gold is rising. Secondly, major changes have been observed in the trading partners for the exportable and importable items in the past two decades. Thirdly, GDP trend has been heavily dependent on the foreign investment and external assistance.

This paper examines the trend of export and import and some other parameters related with India’s foreign trade with the help of usual statistical tools. There is also an effort to find out the dependency of the India’s GDP on these parameters using causality test and multiple regression analysis.

Keywords
Causality test, GDP, Export, Import, Trade.

AMS Subject Classification
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1. Introduction
India has been experiencing ballooning Current Account Deficit (CAD) since the first five year plan. CAD touched a record high of USD 87.8 billion in Financial Year 2013 which is 4.2% of GDP. During the period of first plan it was only Rs. 42 Crores.

India’s trade policy is characterized by both import restrictions and import liberalization (after 1991) along with export promotion. The policies recommended by Mudaliar Committee (1962), Alexander Committee (1978), Abid Hussain Committee (1985) are among the major ones. Trade policy 1991 was in favour of free flow of export and import. Petroleum has been always considered a major importable item in India. The situation was worsened in August 1990 because of the Iraq’s invasion of Kuwait. India experienced a double digit inflation resulting from the mammoth price rise of Petroleum. In the post reform era import of mineral oil is augmented at an average growth rate 7.8% despite of International price rise at an average rate 12.1%. At present about 70% of total import is for oil and non-essential items and the rest 30% includes Gold (12%), Capital Goods (6%), Chemical (5%) and Electronics (7%). In the last decade at different points of time India has experienced Current Account surpluses due to buoyant invisible inflows through private transfers (remittances) and software service exports. So it is clearly understandable foreign trade parameters and their trends mean a lot for the growth of any economy. Here is the reason enough for which the main theme of this paper can claim a great attention from us. For more details see [3–6, 8].
2. Objective of the Study

No country in this era of globalisation can exist without the influence of foreign countries. The direction of growth of domestic economy can be changed at any moment under the guidance of foreign trade market. FDI has a direct impact on the income and employment perspectives through its multiplier effect. The trends of export, import, external assistance also have serious links with the trends of GDP of any economy. Under these circumstances the main objective of this paper is to find out the extent of dependency of GDP on the foreign trade parameters so that the domestic economy can be modified accordingly for the growth and welfare of domestic people.

3. Methodology

Apart from the analysis of different dimensions of India’s foreign trade market in brief, the following methodologies have been used in this paper:

(a) Testing of hypothesis of simple linear type of trend equation i.e. $Y = A + Bt$ of different foreign trade parameters. In this case the null hypothesis ($H_0$) is there is no change of respective parameter over time.

(b) Multiple regression analysis to find out the impacts of FDI, External assistance and Export on the India’s GDP. In this case the equation will be

$$GDP = \text{constant} + a \ (\text{Export}) + b \ (\text{External Assistance}) + c \ (\text{FDI})$$

(c) Correlation Matrix which gives the strengths of relationships among the different foreign trade parameters.

(d) **Causality Test**: Let us consider in a bivariate framework we are trying to forecast for any particular variable. Under Granger test if that forecast is improved after taking lagged values of another variable then second variable has a Granger cause to the first variable. More generally “if variable X (Granger) cause variable Y then changes in X should precede changes in Y. Therefore, in a regression of Y on other variables (including its own past values) if we include past or lagged values of X and it significantly improves the prediction of Y, then we can say that X (Granger) cause Y”.

Relationship and causality between two variables are not the same things. There may be relationship between two variables. It does not necessarily mean causation. Let us consider that we are trying to have prediction on the time series data of a variable Y. If the error of current Y is reduced after taking into consideration the past values of another variable X along with the past values of Y, then time series X is said to be Granger cause to another time series Y. When the linear combination of two non-stationary variables is non-stationary the Granger’s causality test can take place.

$$\Delta X_t = \alpha_1 + \sum_{i=1}^{n_1} \beta_{1i} \Delta X_{t-i} + \epsilon_{1t} \quad (3.1)$$

$$\Delta X_t = \alpha_2 + \sum_{i=1}^{n_2} \beta_{2i} \Delta X_{t-i} + \sum_{j=1}^{n_2} \beta_{2j} \Delta X_{t-j} + \epsilon_{2t} \quad (3.2)$$

Equations (3.1) and (3.2) are useful to examine whether the coefficients of past lags of Y are zero or not. If in equation (3.2) the above-said co-efficient is not zero (i.e. computed F statistic is significant) then Y Granger causes X. By the same way, we can examine whether X Granger causes Y or not [2]. To test the hypothesis the relevant F statistic is given by

$$\frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/n-k}$$

where $m$ denote the number of lagged terms. To test the stationarity, graphical analysis on autocorrelation function (ACF) may be given. The ACF at lag k is given by,

$$N_k = S/a_0 = \text{(Covariance at lag k)}/\text{variance}$$

We have also taken help at first of unit root test to find out order of integration of the variables. Let us assume

$$Y_t = \rho Y_{t-1} + u_t, \quad -1 \leq \rho \leq 1,$$

where, $u_t$ is a white noise error term, also

- $\Delta Y_t = \delta Y_{t-1} + u_t$
- $\Delta Y_t = Y_t - Y_{t-1}, \quad \rho - 1.$

Thus in case of unit root test null hypothesis becomes $\delta = 0.$ If it is zero or if the null hypothesis is not rejected we conclude that $Y_t$ is non-stationary.

Cointegration test can be applied if the variables are of same order of integration. Dicky-Fuller (DF) and Augmented Dicky Fuller (ADF) are two popular tests which are useful to examine the unit roots and stationary property of the variables. The rule of thumb is, to run standard Granger causality test in a bivariate framework the linear combination of two series has to be non-stationary. If it is stationary then simple regression analysis is acceptable.

To get optimal lag length of independent variable we have followed Akike’s final prediction error (FPE) criterion as suggested by Hsiao [9].

Following this approach any optimum lag length will minimise the Final Prediction Error (FPE). Let us consider that $m$ and $n$ are the optimum

$$FPE(m,0) = [(R + m + 1)/(R-m-1)] \times [RSS(m,0)/R] \quad (3.3)$$

$$FPE(m,n) = [(R + m + n + 1)/(R-m-n-1)] \times [RSS(m,n)/R] \quad (3.4)$$

Lag Lengths of the independent variables estimated from the equations (3.1) and (3.2). In the equation (3.3) FPE ($m,0$)
will be obtained from equation (3.1) and in the equation (3.4) above FPE \((m,n)\) will be obtained from equation (3.2) where, RSS \((m,0)\) is the residual sum of square and \(R\) denotes the number of observation. If the FPE value in equation (3.4) is smaller than the FPE value in equation (3.3) then we can conclude \(Y\) Granger cause \(X\).

### 4. Hypotheses of the Study

Regarding testing of hypotheses, the analysis in this paper has taken place against following null hypotheses \((H_0)\)

(a) GDP is not dependent on FDI

(b) GDP is not dependent on External Assistance

(c) GDP is not dependent on Export

(d) There is no Causality between the trends of GDP and FDI

### 5. Brief Review of Literature

Shawa and Shen [14] have studied the existence of causality among FDI, G DP and export in Tanzania during 1980-2012 considering time series annual data over 33 years. The study found no causation between FDI and GDP. As per study of Miankhel, Thangvelu and Kalirajan [13] economic growth is responsible for the growth of FDI in India whereas, in Thailand there is bilateral causality between two. The study of Dritsaki M, Dritsakic and A. Adamopolous [7] shows the causality among the variables FDI, export and economic growth in Greece during 1960-2002. In his study they found the dependency of FDI on economic growth and unilateral causality from economic growth towards FDI in Bangladesh during 1973-2008. Athukorala [1] also received the same result in Sri Lanka. For more details see [10–12, 15].

### Statistical Results and their Interpretations

(A) Simple Linear Trend Results

The results we received subject to the time series data (see appendix) of Foreign exchange (1950-2010), Export (1950-2010) and Import (1950-2010). External assistance data covers the period 1979-2010. The trends of all the parameters are statistically significant at the 5% level of significance.

### Table 1. Parameters

| Parameters                  | R-square | t values | Sig. |
|-----------------------------|----------|----------|------|
| Forex.(Gold+SDR +Foreign Currency) | 0.382    | 5.936    | 0.002 |
| Export                      | 0.464    | 7.027    | 0.001 |
| Import                      | 0.404    | 6.215    | 0.001 |
| External Assistance (Loan+Grants) | 0.857    | 12.46    | 0.001 |
| Oil Import                  | 0.472    | 5.764    | 0.001 |

(B) Multiple Regression Results

From the results of multiple regression analysis we get the following equation

\[
GDP = 317670.3 + 20.334(FDI) - 1.435(External Assistance) + 7.652(Export)
\]

The value of \(R^2\) is quite high and satisfactory. The constant term, FDI and Export have shown statistically significant results at the 5% level of significance. The values of Variance Inflation Factor for all the parameters are less than 5. So we can rule out the possibility of multi-collinearity among the variables.

### Table 2. Multiple Regression Results

| Coeff. | t Value | Sig. | VIF | R Square |
|--------|---------|------|-----|----------|
| Constant | 317670.3 | 4.224 | 0.002 | 0.990 |
| FDI | 20.334 | 3.749 | 0.005 | 3.600 |
| External Assistance | -1.435 | -0.212 | 0.837 | 2.296 |
| Export | 7.652 | 10.988 | 0.001 | 4.790 |

(C) Correlation Results

The table given below presents the values of correlation coefficients among GDP, FDI, External Assistance and Export over the period 1990-2010. All the values are statistically significant either at 5% level of significance or at the 10% level of significance.

### Table 3. Correlation Matrix

| GDP | FDI | External Assistance | Export |
|-----|-----|---------------------|--------|
| GDP | 1.000 | 0.904* | 0.739** | 0.987* |
| FDI | 1.000 | 0.648** | 0.751* | 1.000 |

*5% level of significance; **10% level of significance.

Below the histograms and normal probability plots of residuals are presented. Histogram Dependent Variable: GDP
Causality Test
Here we try to get the results on Granger Causality between GDP and FDI over the period 1990-2011. The basic methodology has been mentioned before.

Correlogram of FDI

| Autocorrelation | Partial Correlation | AC  | PAC  | Q-Stat  | Prob |
|-----------------|---------------------|-----|------|---------|------|
| "****"          | "****"              | 1.0648 | 0.648 | 10.139  | 0.001 |
| "****"          | "****"              | 2.526 | 0.183 | 17.168  | 0.000 |
| "****"          | "****"              | 3.452 | 0.099 | 22.653  | 0.000 |
| "****"          | "****"              | 4.215 | -0.269 | 23.962  | 0.000 |
| "****"          | "****"              | 5.080 | -0.117 | 24.155  | 0.000 |
| "****"          | "****"              | 6.034 | 0.041 | 24.192  | 0.000 |
| "****"          | "****"              | 7.038 | 0.037 | 24.224  | 0.001 |
| "****"          | "****"              | 8.101 | -0.061 | 24.621  | 0.002 |
| "****"          | "****"              | 9.130 | -0.086 | 25.298  | 0.003 |
| "****"          | "****"              | 10.151 | -0.039 | 26.297  | 0.003 |
| "****"          | "****"              | 11.186 | -0.042 | 27.968  | 0.003 |
| "****"          | "****"              | 12.204 | -0.045 | 30.194  | 0.003 |

Correlogram of GDP

| Autocorrelation | Partial Correlation | AC  | PAC  | Q-Stat  | Prob |
|-----------------|---------------------|-----|------|---------|------|
| "****"          | "****"              | 1.797 | 0.797 | 15.338  | 0.000 |
| "****"          | "****"              | 2.629 | -0.018 | 25.383  | 0.000 |
| "****"          | "****"              | 3.478 | -0.049 | 31.513  | 0.000 |
| "****"          | "****"              | 4.338 | -0.067 | 34.754  | 0.000 |
| "****"          | "****"              | 5.217 | -0.045 | 36.182  | 0.000 |
| "****"          | "****"              | 6.117 | -0.038 | 36.623  | 0.000 |
| "****"          | "****"              | 7.031 | -0.046 | 36.656  | 0.000 |
| "****"          | "****"              | 8.042 | -0.046 | 36.720  | 0.000 |
| "****"          | "****"              | 9.102 | -0.047 | 37.141  | 0.000 |
| "****"          | "****"              | 10.159 | -0.064 | 38.244  | 0.000 |
| "****"          | "****"              | 11.211 | -0.072 | 40.403  | 0.000 |
| "****"          | "****"              | 12.262 | -0.080 | 44.081  | 0.000 |

To test the stationarity graphical analysis on autocorrelation function (ACF) may be presented. The ACF at lag k is given by

\[ N_k = S / \sigma_0 = (\text{Covariance at lag } k) / \text{variance} \]

The Correlograms of GDP and FDI indicate that the values of autocorrelation coefficients decline towards zero with the rising number of lag length. Here we run the causality test considering lag length one and get the following results. There is unilateral Granger causality from GDP to FDI.

### Table 6. Unit Root Tests without Trend

| Variable | DF   | ADF(1) | DF   | ADF(1) |
|----------|------|--------|------|--------|
| GDP      | -2.036 | -2.258 | -5.168 | -3.654 |
| FDI      | -1.568 | -0.425 | -5.712 | -3.487 |

### Table 7. Unit root Test with Time Trend

| Variable | DF   | ADF(1) | DF   | ADF(1) |
|----------|------|--------|------|--------|
| GDP      | -2.236 | -2.548 | -5.148 | -4.314 |
| FDI      | -4.170 | -2.295 | -5.025 | -2.236 |

### Table 8. Cointegration Tests

| Regression Equation | DF   | ADF   |
|---------------------|------|-------|
| (c) Regress GDP on FDI | -3.131 | -2.570 |
| (d) Regress FDI on GDP | -1.282 | -1.259 |

Note: No DF and ADF values are significant subject to Critical values at 5% level of significance.

### Table 9. Granger Causality Test between GDP & FDI

| Regression | FPE† |
|------------|------|
| (a) GDP as a dependent variable | 0.01495 |
| i. Regress GDP on GDP (m = 1) | 0.01407 |
| and FDI (n = 1) | 0.00468 |
| (b) FDI as a dependent variable | 0.00530 |
| i. Regress FDI on FDI (m = 1) | 0.00530 |
| and GDP (n = 1) | 0.00530 |

Note: † FPE represents Akaike’s final prediction error.

### Table 10

| Null hypothesis | F Statistic | Probability |
|-----------------|-------------|-------------|
| GDP does not cause FDI | 0.1884 | 8E-05 |
| FDI does not cause GDP | 0.3551 | 0.14327 |

### 6. Conclusion

There are ample proofs of sector-wise and region-wise concentrations in FDI inflow in India. The main Vantage points of India are cheap and skilled workforce and size of the market, whereas the foreign firms must have zeal in their own firm specific factors creating domestic monopoly. Thus we must apply social cost benefit approach in the long run utilizing domestic resources what Korea did in the semi-conductor and telecom equipment manufacturing sector. Needless to say Indian economy or its trend of GDP is heavily dependent on FDI inflow, Exports and External Assistance. The causality test apparently shows unilateral causality from GDP to FDI.

### Appendix
Table 11

| Year     | Export | Import | GDP   | Other Internal Assistance | FDI  |
|----------|--------|--------|-------|----------------------------|------|
| 1950-51  | 606    | 608    | 10401 |                            |      |
| 51-52    | 716    | 890    | 11054 |                            |      |
| 52-53    | 378    | 702    | 10850 |                            |      |
| 53-54    | 531    | 610    | 11810 |                            |      |
| 54-55    | 593    | 700    | 11170 |                            |      |
| 55-56    | 609    | 774    | 11371 |                            |      |
| 56-57    | 605    | 841    | 13547 |                            |      |
| 57-58    | 561    | 1035   | 13951 |                            |      |
| 58-59    | 581    | 906    | 15551 |                            |      |
| 59-60    | 640    | 961    | 16384 |                            |      |
| 60-61    | 642    | 1122   | 17942 |                            |      |
| 61-62    | 660    | 1190   | 19010 |                            |      |
| 62-63    | 685    | 1131   | 20429 |                            |      |
| 63-64    | 793    | 1223   | 23462 |                            |      |
| 64-65    | 816    | 1349   | 27367 |                            |      |
| 65-66    | 810    | 1409   | 28857 |                            |      |
| 66-67    | 1157   | 2078   | 32669 |                            |      |
| 67-68    | 1199   | 2008   | 38261 |                            |      |
| 68-69    | 1358   | 1909   | 40512 |                            |      |
| 69-70    | 1413   | 1582   | 44605 |                            |      |
| 70-71    | 1555   | 1634   | 47638 |                            |      |
| 71-72    | 1608   | 1825   | 50999 |                            |      |
| 72-73    | 1971   | 1867   | 56214 |                            |      |
| 73-74    | 2523   | 2955   | 68420 |                            |      |
| 74-75    | 3329   | 4519   | 80770 |                            |      |
| 75-76    | 4036   | 5265   | 86707 |                            |      |
| 76-77    | 5142   | 5074   | 93422 |                            |      |
| 77-78    | 5408   | 6020   | 105848|                            |      |
| 78-79    | 5726   | 6811   | 114647|                            |      |
| 79-80    | 6418   | 9143   | 125729| 1859.5                     |      |
| 80-81    | 6711   | 12549  | 149642| 3847                        |      |
| 81-82    | 7806   | 13608  | 175805| 2973.9                     |      |
| 82-83    | 8803   | 14293  | 196644| 2972.7                     |      |
| 83-84    | 9771   | 15831  | 229021| 2087.7                     |      |
| 84-85    | 11744  | 17134  | 256611| 4880                       |      |
| 85-86    | 10895  | 19658  | 289524| 5650.4                     |      |
| 86-87    | 12452  | 20096  | 323949| 6159.5                     |      |
| 87-88    | 15674  | 22244  | 368211| 9263.5                     |      |
| 88-89    | 20232  | 28235  | 436893| 13069.8                    |      |
| 89-90    | 27658  | 35328  | 501928| 10826| 351 |
| 90-91    | 32553  | 43198  | 586212| 8123                       | 351 |
| 91-92    | 44041  | 47851  | 673875| 12707.6                    | 675 |
| 92-93    | 53688  | 63375  | 774545| 14093.8                    | 1787|
| 93-94    | 69751  | 73101  | 891355| 14033.9                    | 3289|
| 94-95    | 82674  | 89971  | 1054590| 13460.1                    | 6820|
| 95-96    | 106353 | 122678 | 1226725| 12163.2                    | 10389|
| 96-97    | 118817 | 138920 | 1419277| 17141.4                    | 16425|
| 97-98    | 130100 | 154176 | 1572394| 16966                       | 13340|
| 98-99    | 139752 | 178332 | 1803378| 8530.6                      | 16868|
| 99-2000 | 159561 | 215236 | 2012198| 20319                      | 19342|
| 2000-01  | 203571 |        |        |                            |      |
| 2001-02  | 209018 |        |        |                            |      |
| 2002-03  | 255137 |        |        |                            |      |
| 2003-04  | 293367 |        |        |                            |      |
| 2004-05  | 375340 |        |        |                            |      |
| 2005-06  | 456418 |        |        |                            |      |
| 2006-07  | 571779 |        |        |                            |      |
| 2007-08  | 655864 |        |        |                            |      |
| 2008-09  | 840755 |        |        |                            |      |
| 2009-10  | 845534 |        |        |                            |      |
| 2010-11  | 1142922|        |        |                            |      |

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