Chapter Four

EMPIRICAL RESULTS AND DISCUSSION

This chapter presents the empirical findings of the study. To start with regime wise growth rates of all key variables are presented. The results of structural breaks are then presented in tabular form. The data is detrended first and then break points are tested for. Unit root tests both with and without structural breaks are then presented. The appropriate VAR models are then constructed and estimated as per the objectives of the study. Routine wise Modified Granger causality tests are conducted and the results are presented and suitably interpreted. The necessary diagnostic tests are conducted in order to verify the robustness of the estimates. All results are finally reported and logically analysed.

4.1 Analysis of Growth and Structural Breaks

The time-series behaviour of all variables can be understood from an analysis of growth and structural breaks. This is vital to observe from the point of view of long run annual time series.

Table 4.1.1. Average Annual Growth Rates (%) of Real GDP, Narrow Money and Broad Money in India during 1961-2013 (original series or non-detrended series)

Period	Real GDP		Narrow Money		Broad Money	
	Average Annual	Exp	Average Annual	Exp	Average Annual	Exp
1961-70	4.03	3.65	9.92	9.55	10.79	10.51
1971-80	3.08	3.52	12.61	10.47	17.65	16.50
1981-90	5.57	5.39	14.83	14.49	16.92	16.14
1991-00	5.60	6.09	15.27	13.68	17.35	15.92
2001-10	7.54	7.71	15.89	15.75	17.39	16.84
2011-13	5.46	4.76	7.85	8.39	13.45	12.58

Source: Computed on the basis of secondary annual time series data for the period 1961-2013 compiled from *RBI: Handbook of Statistics on the Indian Economy, 2014.*
Notes: "Exp" implies "exponential". It is estimated by slope coefficient of the linear regression of natural log of a variable on a constant and time.

Table 4.1.2. Average Annual Growth Rates (%) of Nominal GDP, WPIAC And CPIIW in India during 1961-2013 (original series or non-detrended series)						
Period	**NGDP**		**WPI**		**CPI**	
	Average Annual	Exp	Average Annual	Exp	Average Annual	Exp
1961-70	10.34	10.66	6.25	7.25	6.51	6.73
1971-80	12.25	11.39	10.26	8.50	8.28	7.23
1981-90	14.66	13.23	7.18	6.53	9.04	8.10
1991-00	14.06	13.44	7.81	6.67	8.74	8.26
2001-10	13.64	13.44	5.61	5.62	6.54	6.36
2011-13	13.42	11.57	7.42	6.45	9.45	9.54

Source: Computed on the basis of secondary time series data taken from *RBI: Handbook of Statistics on the Indian Economy, 2014.*.

Notes: "Exp" implies "exponential". It is estimated by slope coefficient of the linear regression of natural log of a variable on a constant and time.

Table 4.1.3. Average Annual Growth Rates (%) of Revenue Deficit, Revenue Expenditure and Capital Expenditure in India during 1961-2013 (for the original or non-detrended series)						
Period	**Revenue Deficit**		**Revenue Expenditure**		**Capital Expenditure**	
	Average Annual	Exp	Average Annual	Exp	Average Annual	Exp.
1961-70	NC	NC	12.76	11.38	17.10	5.99
1971-80	-204.96	NC	16.11	14.27	13.19	12.07
1981-90	48.66	36.29	17.80	17.48	14.45	12.68
1991-00	19.19	17.48	14.25	13.52	5.05	7.27
2001-10	35.67	11.96	14.34	14.23	17.47	6.42
2011-13	16.78	-3.15	10.39	10.00	6.96	9.27

Source: Computed on the basis of secondary time series data taken from *RBI: Handbook of Statistics on the Indian Economy, 2014.*.

Notes: (1) Average Annual Growth rates of Revenue Deficit are computed on the basis of 1972 – 2013 data series. (2) "NC" implies not computed. (3) Exponential growth rate of Revenue Deficit could not be estimated for 1971-80 on account of negative values of revenue deficit (natural logarithm of a negative quantity is not defined). (4) "Exp" implies "exponential" as estimated by the slope coefficient from semi-log regression of each time series variable on a constant and time.

Table 4.1.4. Average Annual Growth Rates (%) of Government Expenditure and Gross Fiscal Deficit in India during 1961-2013 (for the original or non-detrended series)				
Period	**Govt. Expenditure**		**Gross Fiscal Deficit**	
	Average Annual	Exponential	Average Annual	Exponential
1961-70	13.35	9.33	NC	NC
1971-80	14.82	13.39	16.78	15.93
1981-90	16.64	15.82	18.68	17.61
1991-2000	12.02	12.26	11.95	13.29
2001-10	14.09	13.01	19.03	12.86
2011-13	9.94	9.91	13.37	0.82

Source: Computed on the basis of secondary annual time series data for the period 1961-2013 compiled from *RBI: Handbook of Statistics on the Indian Economy, 2014.*
Notes: "NC" implies not computed as data for the relevant period was not available.

The time period for selected variables along with the number of time points are shown in table 4.1.1. In table 4.1.1.average annual growth rates of real GDP or constant price GDP, narrow money supply (M1) and broad money supply (M3) are analysed in terms of their decadal growth performances during 1961-2013. For each variable average annual growth rates are compared with the exponential growth rates.

The growth rate of real GDP was more than 4 percent during the first two decades. However there was a decline in GDP growth to 3 percent during 1971-80. There was a sharp recovery during the next decade as real GDP continued to grow at 5.5 percent or more during the 1980s and 90s (1981-2000). Interestingly no significant improvement in the growth rate of real GDP is observed during the first decade after 1991, i.e., during the first ten years of strong liberalization. However, real GDP grew at more than 7.5 percent over the first decade of the new millennium, i.e., during 2001-10. However during 2011-13, the average annual growth rate dropped sharply to 5.4 percent per annum. On the whole post liberalization real GDP growth rates are higher compared to the same during pre 1991 years.

Both narrow money supply (M1) and broad money supply (M3) are found to grow at brisk pace since the 1960s. In particular narrow money supply (M1) grew at a rate of almost 10 percent on an average per annum during 1961-70. During subsequent decades the rate of growth of narrow money supply (M1) increased continuously almost touching 16 percent per annum during 2001-10. However 2011-13, narrow money supply (M1) growth seems to have reduced significantly (below 8 percent per annum). Broad money supply (M3) exhibits very similar growth behaviour since 1951, but growth rate of broad money supply (M3) has been continuously higher than that of narrow money supply (M1) throughout all decades. In fact during the post liberalization era broad money supply (M3) has grown at a rate of more than 17 percent per annum.

Table 4.1.2 presents the decadal average growth rates of nominal GDP, wholesale price index and consumer price index for industrial workers. A comparison with the first column of table 4.1.1, reveals that nominal GDP growth rates across decades have been consistently higher than that of real GDP. In fact during post liberalization years, real GDP growth rate has been closed to 6.5 percent while nominal GDP growth rate has been closed to 13.5 percent. The difference between real and nominal GDP growth rates can be accounted for due to inflation i.e., captured by the growth in WPI, CPI as well as the GDP deflator. Growth rate of WPI per annum is perhaps the best indicator of the overall inflationary situation in the economy. However the average annual growth rate of WPI shot up to 6.25 percent during 1961-70. This rate further increased to 10.26 percent during the next decade. In other words the Indian economy experienced a phase of high inflation during 1971-80. During 1981-90 and during 1991-2000 WPI grew at more than 7 percent which also indicates a poor phase as far as inflation is concerned. During 2001-10, WPI grew at less than 6 percent indicating that inflation was checked to a certain extent. However during 2011-13, WPI inflation is found to be very close to 7.5 percent.

In terms of CPI the inflation rate was closed to 9 percent throughout the period 1971-2000. However, as indicated by WPI, CPI inflation dropped sharply to 6.54 percent during 2001-10 but picked up again during 2011-13. In sum, CPI inflation during 1991-2010 has been closed to 8 percent on an average per annum.

Table 4.1.3 presents the average annual growth rates of revenue deficit, revenue expenditure and capital expenditure. Revenue deficit figures are available from 1971. Revenue deficit grew negatively during 1970s. However revenue deficit grew on an average at almost 49 percent per annum during 1981-1990. However this growth rate dropped to around 19 percent during the first decade of the period of strong liberalization. However in the subsequent decade 2001-10, revenue deficit grew at more than 35 percent on an average but dropped to 16.8 percent during 2011-13. In other words, during 1981-2010 average annual growth rate of revenue deficit has been alarmingly high. The growth pattern of revenue expenditure has been different compared to the growth behaviour of revenue deficit. The growth of revenue expenditure increased from 10.6 percent during the first decade after independence and increased upto 17.8 percent during 1981-90. However the growth rate of revenue expenditure seems to have been checked since 1991 to around 14 percent per annum. During 2011-13 this growth rate has dropped further to almost 10 percent.

High growth rates of capital expenditure was expected and anticipated during the first two plan periods, where massive public investments were necessary to build social overhead capital in the form of new roads, bridges, dams, power generation units, steel plants, set up of basic and heavy industries among many others. During 1961-70 and subsequent decades growth rate of capital expenditure started declining gradually and reached just 5 percent during 1991-2000. During 2001-10, there was a revival in capital expenditure growth which again fell during 2011-13.

Table 4.1.4 presents the average annual growth rates of government expenditure and fiscal deficit during 1961-2013. Government expenditure has grown at a steady rate during 1961-1990 and the growth rate has fluctuated around 15 percent on an average per annum. The growth rate in government expenditure has continued to be around 13 percent during post 1991 years. During 2011-13, government expenditure has grown at around 10 percent which is lower compared to that of the previous decade. Gross fiscal deficit is defined as the sum of revenue deficit and capital expenditure and thus reflects the overall indebtedness of the central government. Fiscal deficit grew at almost 17 percent per annum during 1971-90. However the growth rate fell below 12 percent during 1991-2000. However fiscal deficit grew at more than 19 percent on an average per annum during 2001-10.

4.2 Detrending and Identifying Structural Breaks

Table 4.2.1. Comparing Goodness of Fit Statistics of Parabolic Trend Fitting vis-s-vis Exponential Trend Fitting for each Time Series Variable for the period 1961-2010

Variables	Parabolic Trend		Exponential Trend	
	R^2;Adj.R^2	AIC;SIC;HQ	R^2;Adj.R^2	AIC;SIC;HQ
Real GDP (**RGDP**)	0.961; 0.956	28.19; 28.28; 28.23	0.983; 0.974	-1.35; -1.28; -1.32
Real GDP Growth Rate (**RGDPGR**)	NA	NA	NA	NA
Broad Money (**BM**)	0.973; 0.968	32.13; 32.37; 32.28	0.979; 0.962	-1.87; -1.71; -1.84
Broad Money Growth Rate (**BMGR**)	NA	NA	NA	NA
Narrow Money (**NM**)	0.952; 0.941	34.36; 34.12; 34.29	0.988; 0.979	-2.11; -2.09; -2.17
Narrow Money Growth Rate (**NMGR**)	NA	NA	NA	NA
Revenue Expenditure (**REVEXP**)	0.941; 0.926	47.66; 47.42; 47.51	0.975; 0.959	-1.99; -2.06; -2.01
Capital Expenditure (**CAPEXP**)	0.911; 0.889	53.23; 53.65; 53.40	0.946; 0.932	-2.36; -2.23; -2.17
Govt. Expenditure (**G**)	0.864; 0.849	63.29; 62.99; 63.11	0.922; 0.901	-2.91; -2.88; -2.79
Revenue Deficit (**REVDEF**)	0.824; 0.801	59.97; 60.25; 60.16	0.959; 0.946	-2.33; -2.27; -2.29
Fiscal Deficit (**GFD**)	0.853; 0.839	56.88; 57.01; 56.97	0.973; 0.966	-1.99; -1.82; -1.89
Whole-sale Price Index (**WPI**)	0.912; 0.899	44.08; 44.63; 44.39	0.982; 0.979	-1.39; -1.29; -1.33
WPI Inflation (**INFLA**)	NA	NA	NA	NA
Consumer Price Index (**CPI**)	NA	NA	NA	NA
Bank Rate (**BR**)	NA	NA	NA	NA
Cash Reserve Ratio (**CRR**)	NA	NA	NA	NA
Statutory Liquidity Ratio (**SLR**)	NA	NA	NA	NA

Source: Computed on the basis of secondary time series data taken from *RBI: Handbook of Statistics on the Indian Economy, 2010.*

Notes: (1) NA implies not applicable as these variables do not have any non-linear trend observed in the other time series variables. No linear or non-linear trend equation is fitted to RGDPGR, BMGR, NMGR, INFLA, BR, CRR and SLR as no clear trends are observed in these cases. (2) Parabolic trend line fitting is done by linearly regressing the variable in level on a constant, time and time – squared. The exponential trend is obtained by the linear regression of natural log of a variable in level on a constant and time. The two model fit statistics are not directly comparable in a strictly statistical sense as exponential and polynomial functional forms of regression are non-nested and incompatible.

Table 4.2.2. Bai-Perron Test for Unknown Multiple Structural Break Points of Original *vis-a-vis* De-trended Annual Time Series of Selected Variables		
Variables	**Break dates in Original Series**	**Break Dates in De-trended Series**
Real GDP (RGDP)	**1969, 1985, 1993, 2003**	**2002**
F-Statistic	21.76, 35.22, 49.97, 39.55	(46.28)
Real GDP Growth Rate (RGDPGR)	**1985, 2002**	**NA**
F-Statistic	67.97, 33.21	34.27
Broad Money (BM)	**1994, 2004**	**2001**
F-Statistic	43.66, 29.31	21.95
Broad Money Growth Rate (BMGR)	**1969**	**NA**
F-Statistic	74.31	72.11
Narrow Money (NM)	**1995, 2004**	**2000**
F-Statistic	95.29, 34.78	76.42
Narrow Money Growth Rate (NMGR)	**1978**	**NA**
F-Statistic	14.01	21.98
Govt. Expenditure (G)	**1992, 2002**	**1994, 2002**
F-Statistic	71.63, 10.29	32.76, 87.34
Revenue Deficit (REVDEF)	**1997, 2006**	**2002**
F-Statistic	86.66, 13.79	63.23
Revenue Expenditure (Revexp)	**1999, 2004**	**1984, 1999, 2009**
F-Statistic	87.25, 56.23	75.46, 28.44, 98.60
Capital Expenditure (Capexp)	**1982, 1999, 2008**	**1980, 2002, 2006**
F-Statistic	34.79, 58.86, 47.27	20.26, 36.72, 77.25
Gross Fiscal Deficit (GFD)	**1994, 2008**	**2004**
F-Statistic	56.87, 47.22	39.87
Whole-sale Price Index (WPI)	**1990, 1996, 2008,**	**2004**
F-Statistic	71.09, 38.33, 81.69	54.92
Consumer Price Index (CPI)	**1991, 1997, 2008**	**1995, 2005**
F-Statistic	19.89, 37.72, 65.38	19.25, 93.40
WPI Inflation (INFLA)	**1990, 2001, 2006**	**NA**
F-Statistic	76.66, 20.87, 66.32	40.29
Bank Rate (BR)	**1978, 1990, 1998, 2006**	**NA**
F-Statistic	(33.34, 85.03, 28.83, 21.67)	**NA**
Cash Reserve Ratio (CRR)	**1990, 1998, 2006**	**NA**
F-Statistic	29.77, 97.42, 19.37	**NA**
Statutory Liquidity Ratio (SLR)	**1991, 1999, 2008**	**NA**
F-Statistic	32.21, 59.39, 63.85	**NA**

Source: Computed on the basis of original and exponentially detrended time series data for major macroeconomic indicators of India (1961-2010) taken from *RBI: Handbook of Statistics on the Indian Economy,* 2010.

Notes: (1) F-statistic values corresponding to each repatriation date are presented below the break date series. (2) No detrending has been done for RGDPGR, BMGR, NMGR, INFLA, BR, CRR and SLR. Thus break dates for these variables are not applicable for the detrended series. (3) Bai-Perron tests are carried out using EVIEWS 9 for Windows. Trimming factor used is 15 and maximum breaks selected are 4. (4) No statistically significant breaks were found in case of RGDPGR, BMGR, NMGR, INFLA, BR, CRR and SLR.

4.3 Stationarity Testing of all Variables

Table 4.3.1 Stationarity Tests of Detrended Time Series Data Ignoring any Structural Break in the Series

Variable	ADF		PP		KPSS	
	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.
NM	-3.996 (<0.01,4)	NC	-1.217 (0.662)	-5.517 (<0.01)	0.491	0.101
NMGR	-5.701 (<0.01, 6)	NC	-6.018 (<0.01)	NC	0.499	0.240
BM	1.591 (0.999, 5)	-3.526 (0.011, 4)	1.089 (0.997)	-2.830 (0.060)	0.541	0.345
BMGR	-3.658 (<0.01,5)	NC	-3.461 (0.013)	-16.827 (<0.01)	0.577	0.293
RGDP	1.828 (0.999, 6)	-3.892 (<0.01,6)	3.375 (0.999)	-3.771 (< 0.01)	0.355	0.319
RGDPGR	-7.472 (<0.01,2)	NC	-7.530 (<0.01)	NC	0.852	0.066
G	-3.348 (0.017, 6)	-6.435 (<0.01, 6)	-1.998 (0.287)	-5.738 (<0.01)	0.446	0.112
Revexp	-3.245 (0.023, 6)	-7.386 (<0.01,5)	-2.198 (0.209)	-4.981 (<0.01)	0.229	NC
Capexp	3.396 (0.999,6)	-9.307 (0.999,6)	0.178 (0.969)	-8.390 (<0.01)	0.542	0.317
Revdef	-3.389 (0.017,4)	-3.469 (0.015,6)	-3.461 (0.014)	-8.461 (<0.01)	0.088	NC
GFD	-4.343 (<0.01,5)	NC	-2.354 (0.161)	-3.514 (0.013)	0.052	NC
CPI	-4.161 (<0.01,4)	NC	-2.13 (0.233)	-3.393 (0.016)	0.133	NC
WPI	1.278 (0.998,5)	-5.333 (<0.01,6)	0.202 (0.971)	-5.467 (<0.01)	0.193	NC
INFLA	-5.633 (<0.01,2)	NC	-5.425 (<0.01)	NC	0.172	NC
BR	-1.689 (0.431,6)	-5.738 (<0.01,5)	-1.857 (0.350)	-5.785 (<0.01)	0.236	NC
CRR	-0.844 (0.796,5)	-4.981 (<0.01,6)	-1.131 (0.694)	-4.979 (<0.01)	0.193	NC
SLR	-1.026 (0.737,5)	-4.085 (<0.01,6)	-1.071 (0.721)	-4.053 (<0.01)	0.274	NC

Source: Computed on the basis of exponentially detrended time series data for major macroeconomic indicators of India (1961-2010) taken from *RBI: Handbook of Statistics on the Indian Economy,* 2010.

Notes: **(1)** Asymptotic critical values of KPSS Test Statistic for time series with intercept but without trend: 1% = 0.739; 5% = 0.463; 10%=0.347. **(2)** **'**Null hypothesis' for KPSS test is that the concerned time series variable is stationary (or absence of any Unit Root), whereas the 'null hypothesis' in other tests is that the concerned time series variable has a Unit Root (or is non-stationary). **(3)** For very small p values the expression < 0.001 is written. (4) No detrending has been done for RGDPGR, NMGR, BMGR, BR (bank rate), CRR (cash reserve ratio) and SLR (statutory liquidity ratio). (5) NC indicated 'not computed' wherever stationarity is attained at level. (6) For all tables the abbreviations ADF, PP and KPSS respectively stand for Augmented Dickey-Fuller, Philips-Perron and Kwiatkowski-Phillips-Schmidt-Shin tests.

Table 4.3.2 Structural Break Point Unit Root Test of De-trended Time Series				
Variables	**ADF**		**Zivot-Andrews**	
	Level	1st Diff.	Level	1st Diff.
Real GDP (**RGDP**)	-4.05 (0.142, 4)	-7.99 (<0.01, 4)	-3.36 (<0.81, 4)	-6.49 (<0.01, 4)
Break Date (year)	1999	2002	2002	2001
Real GDP Growth Rate (**RGDPGR**)	-7.36 (<0.01, 5)	NA	-4.93 ((<0.01, 4)	NA
Break Date (year)	2002	NA	2002	NA
Broad Money (**BM**)	-14.88 (<0.01, 5)	NA	-6.85 (<0.01,4)	NA
Break Date (year)	2001	NA	2001	NA
Broad Money Growth Rate (**BMGR**)	-8.13 (<0.01,6)	NA	-7.87 (<0.01,4)	NA
Break Date (year)	2000	NA	2000	NA
Narrow Money (**NM**)	-10.43 (<0.01,6)	NA	-9.91 (<0.01,4)	NA
Break Date (year)	2001	NA	2001	NA
Narrow Money Growth Rate (**NMGR**)	-11.66 (<0.01, 6)	NA	-8.89 (<0.01, 4)	NA
Break Date (year)	2001	NA	2001	NA
Govt. Expenditure (**G**)	-11.43 (<0.01,6)	NA	-6.86 (<0.01,4)	NA
Break Date (year)	2001	NA	2002	NA
Revenue Deficit (**REVDEF**)	-6.273 (<0.01, 5)	NA	➢	NA
Break Date	2002	NA	NA	NA
Fiscal Deficit (**GFD**)	-6.747 (<0.01, 5)	NA	➢	NA
Break Date	2004	NA	NA	NA
Whole-sale Price Index (**WPI**)	-2.760 (0.81, 6)	-7.649 (<0.01, 8)	-5.095 (<0.05, 6)	-9.765 (<0.01, 7)
Break Date	2004	1994	1991	1995
WPI Inflation (**INFLA**)	-7.988 (<0.01, 4)	NA	-6.861 (<0.01, 4)	NA
Break Date (year)	2004		2003	
Consumer Price Index (**CPI**)	-1.879 (0.91,6)	-7.235 (<0.01, 7)	-5.867 (<0.05, 6)	-8.898 (<0.01, 8)
Break Date	2004	1995	1991	1995
Bank Rate (**BR**)	-2.086 (0.96, 6)	-6.440 (<0.01, 6)	➢	NA
Break Date	1990	1996	NA	NA
Cash Reserve Ratio (**CRR**)	-1.875 (0.99, 6)	-7.446 (<0.01, 8)	➢	NA
Break Date	1989	1988	NA	NA
Statutory Liquidity Ratio (**SLR**)	-2.123 (0.97, 6)	-5.234 (<0.01, 8)	➢	NA
Break Date	1989	1991	NA	NA

Source: Estimated on the basis of secondary time series data on relevant variables (RBI: Handbook of Statistics on the Indian Economy, 2010) using EVIEWS 9 for Windows.

Notes: (i) Figures free of parenthesis in each cell are computed **test statistic** values. The first figure in parenthesis indicates p-value. For very small p-values (0.001, etc, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Information Criteria (automatic selection by the EVIEWS 9). (iii) NA implies not applicable wherever stationarity is attained at level. (iv) A single unknown break date is selected by minimising the Dickey-Fuller t-Statistic automatically set in EVIEWS 9. (iv) No detrending has been done for RGDPGR, NMGR, BMGR, BR (bank rate), CRR (cash reserve ratio) and SLR (statutory liquidity ratio). (5) NC indicated 'not computed' wherever stationarity is attained at previous level.

➢ In these cases Zivot-Andrews test statistic could not be computed as independent variable columns are near perfectly collinear resulting in near singular design matrix.

Table 4.3.3 Stationarity Tests of all Detrended Variables till Break Date

Variable	ADF		PP		KPSS	
	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.
NM	-1.682 (0.434,6)	-5.871 (<0.01,6)	-1.914 (0.323)	-5.873 (<0.01)	0.158	NC
NMGR	-4.913 (<0.01,2)	NC	-5.031 (<0.01)	NC	0.612	0.283
BM	0.302 (0.976,6)	-6.464 (<0.01,6)	0.226 (0.972)	-6.511 (<0.01)	0.346	NC
BMGR	-3.282 (0.021,5)	-7.378 (<0.01,4)	-3.070 (0.036)	-17.90 (<0.01)	0.589	0.242
RGDP	-1.419 (0.566,6)	-7.307 (<0.001,6)	-1.419 (0.566)	-7.307 (<0.01)	0.731	0.180
RGDPGR	-8.113 (<0.01,2)	NC	-8.113 (<0.01)	NC	0.334	NC
G	-1.412 (0.569,6)	-5.274 (<0.01,4)	-0.832 (0.801)	-4.720 (<0.01)	0.430	0.214
Revexp	-0.194 (0.932,6)	-5.551 (<0.01,4)	-1.504 (0.524)	-3.627 (<0.01)	0.630	0.105
Capexp	-0.886 (0.784,4)	-0.148 (0.938,6)	-2.171 (0.219)	-6.702 (<0.01)	0.155	NC
Revdef	-2.720 (0.082,5)	-4.081 (<0.01,5)	-2.537 (0.117)	-4.067 (<0.01)	0.197	NC
GFD	2.063 (0.999,6)	-4.780 (<0.01,6)	1.865 (0.999)	-4.964 (<0.01)	0.699	0.388
CPI	-1.748 (0.400,6)	-4.118 (<0.01,6)	-1.573 (0.487)	-4.133 (<0.01)	0.470	0.091
WPI	-1.965 (0.301,6)	-3.505 (0.012,6)	-1.717 (0.417)	-3.551 (0.011)	0.543	0.099
INFLA	-5.022 (<0.01,2)	NC	-4.913	NC	0.223	NC
BR	-1.940 (0.311,6)	-4.216 (<0.01,6)	-1.618 (0.465)	-4.144 (<0.01)	0.451	0.423
CRR	-1.462 (0.538,6)	-3.865 (<0.01,6)	-1.088 (0.707)	-3.862 (<0.01)	0.290	NC
SLR	-1.374 (0.585,6)	-3.502 (0.013,6)	-1.258 (0.640)	-3.392 (0.017)	0.234	NC

Source: Estimated on the basis of secondary time series data on relevant variables (RBI: Handbook of Statistics on the Indian Economy, 2010) using EVIEWS 9 for Windows.

Notes: (i) First figures in each cell are computed **test statistic** values. The first figures in parenthesis in each cell indicate p-value. For very small p-values (smaller than 0.001, etc, exact p-values are not presented, instead "<0.001" is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Information Criteria (automatic selection by the EVIEWS 9). (iii) NA implies not applicable wherever stationarity is attained at level. (iv) Break dates (single) are the same as in table 4.2.3 for each variable. **(**iv**)** Asymptotic critical values of KPSS Test Statistic with intercept and without trend: 1% = 0.739; 5% = 0.463; 10%=0.347. **'**Null hypothesis' for KPSS test is that the time series variable is stationary (or does not have any Unit Root), whereas the 'null hypothesis' in other tests is that the concerned time series variable has a Unit Root (or is non-stationary). No detrending has been done for RGDPGR, NMGR, BMGR, BR (bank rate), CRR (cash reserve ratio) and SLR (statutory liquidity ratio) as no significant trends are observable. (5) NC indicated 'not computed' wherever stationarity is attained at previous level.

Table 4.3.4. Stationarity Test Results of all De-trended Variables for Post Break Period

Variable	ADF			PP			KPSS		
	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.
NM	-1.786 (0.367,3)	-1.966 (0.294,3)	-5.622 (<0.01,2)	-1.766 (0.376)	-1.912 (0.314)	-6.087 (<0.01)	0.351	0.348	0.263
NMGR	-0.586 (0.832,3)	-8.929 (<0.01,2)	NC	-2.814 (0.088)	-16.75 (<0.01)	NC	0.348	0.176	NC
BM	-6.794 (0.01,2)	NC	NC	-0.728 (0.799)	-1.090 (0.674)	-2.776 (0.099)	0.466	0.146	NC
BMGR	-1.662 (0.422,2)	-3.970 (0.016,2)	-6.573 (<0.01,2)	-1.652 (0.426)	-3.970 (0.016)	-7.286 (<0.01)	0.171	NC	NC
RGDP	-0.202 (0.912,2)	-3.540 (0.034,1)	-243.883 (<0.01,3)	0.065 (0.946)	-3.589 (0.029)	-4.852 (<0.01)	0.504	0.500	0.450
RGDPGR	-2.973 (0.069,2)	-3.972 (0.016,2)	-3.600 (0.035,2)	-2.983 (0.068)	-6.147 (<0.01)	NC	0.187	NC	NC
G	-0.890 (0.751,3)	-2.228 (0.209,3)	-4.063 (0.016,3)	-1.024 (0.704)	-2.228 (0.209)	-4.063 (0.016)	0.353	0.136	NC
Revexp	-3.445 (0.042,3)	-1.946 (0.302,3)	-3.981 (0.018,3)	-1.334 (0.574)	-1.932 (0.307)	-3.981 (0.018)	0.103	NC	NC
Capexp	-1.800 (0.357,3)	-5.773 (<0.01,3)	NC	-0.436 (0.870)	-6.367 (<0.01)	NC	0.482	0.442	0.412
Revdef	-1.672 (0.417,3)	-3.795 (0.021,1)	-4.479 (0.011,1)	-1.672 (0.417)	-5.437 (<0.01)	NC	0.317	NC	NC
GFD	-2.045 (0.266,3)	-1.546 (0.471,3)	-2.933 (0.079,3)	-1.200 (0.633)	-1.546 (0.471)	-2.933 (0.079,3)	0.224	NC	NC
CPI	-10.156 (<0.01,4)	NC	NC	-1.604 (0.448)	-0.702 (0.802)	-5.160 (<0.01)	0.149	NC	NC
WPI	-3.075 (0.075,4)	-3.829 (0.020,0)	-5.585 (0.002,0)	-0.948 (0.731)	-3.877 (0.019)	-10.323 (<0.001)	0.497	0.115	NC
INFLA	-3.900 (0.016,2)	-6.335 (<0.01,2)	NC	-3.940 (0.015)	- 12.413 (<0.01)	NC	0.381	0.178	NC
BR	-0.578 (0.838,2)	-3.336 (0.042,2)	-4.769 (<0.01,0)	-0.578 (0.838)	-3.367 (0.040)	-8.576 (<0.01)	0.370	0.246	NC
CRR	-1.636 (0.433,3)	-3.374 (0.039,3)	-4.596 (<0.01,1)	-1.622 (0.439)	-3.609 (0.028)	-7.333 (<0.01)	0.180	NC	NC
SLR	1.776 (0.999,3)	-3.952 (0.017,0)	-7.107 (0.01,0)	0.589 (0.981)	-3.945 (0.017)	-17.855 (<0.01)	0.456	0.421	0.205

Source: Estimated on the basis of secondary time series data on relevant variables compiled from RBI: Handbook of Statistics on the Indian Economy, 2010 and RBI Occasional Publications.

Notes: (i) First figures in each cell are computed **test statistic** values. The first figures in parenthesis in each cell indicate p-value. For very small p-values (smaller than 0.001, exact p-values are not presented, instead <0.001 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Information Criteria (automatic selection by the EVIEWS 9). (iii) Break dates for each variable are the same as in table 4.2.3. (iv) Asymptotic critical values of KPSS Test Statistic for series with intercept and without trend: 1% = 0.739; 5% = 0.463; 10%=0.347. **'**Null hypothesis' for KPSS test is that the time series variable is stationary (or does not have any Unit Root), whereas the 'null hypothesis' in other tests is that the concerned time series variable has a Unit Root (or is non-stationary). NC implies not calculated wherever stationarity is attained at the previous level.

Table 4.3.5. Stationarity Tests of Original Time Series (non-detrended) Ignoring Structural Breaks in the Series

Variable	ADF			PP			KPSS		
	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.
NM	6.460 (0.999,6)	1.331 (0.999,6)	-3.989 (<0.01,8)	9.938 (0.999)	-0.843 (0.799)	-17.302 (<0.01)	0.457	0.671	0.457
NMGR	-5.701 (<0.01,6)	NC	NC	-6.018 (<0.01)	NC	NC	0.499	0.240	NC
BM	6.759 (0.999)	4.999 (0.999,6)	-2.195 (0.210,6)	24.162 (0.999)	5.108 (0.999)	-6.058 (<0.01)	0.635	0.635	0.694
BMGR	-3.658 (<0.01,5)	NC	NC	-3.461 (0.013)	-16.827 (<0.01)	NC	0.577	0.293	NC
RGDP	16.202 (0.999,5)	0.639 (0.990,5)	-7.01 (<0.01,8)	17.288 (0.999)	-1.284 (0.632)	-16.392 (<0.01)	0.850	0.771	0.500
RGDPGR	-7.472 (<0.01,2)	NC	NC	-7.530 (<0.01)	NC	NC	0.852	0.066	NC
G	6.504 (0.999,6)	4.874 (0.999,6)	-0.579 (<0.96,8)	19.621 (0.999)	0.827 (0.994)	-6.589 (<0.01)	0.713	0.667	0.378
Revexp	6.223 (0.999,6)	6.363 (0.999,6)	-0.197 (<0.99,8)	15.843 (0.999)	-0.008 (0.952)	-11.323 (<0.01)	0.281	NC	NC
Capexp	4.380 (0.999,6)	-3.473 (0.012,6)	-2.096 (<0.55,7)	3.607 (0.999)	-8.074 (<0.01)	NC	0.840	0.655	0.054
Revdef	5.063 (0.999,6)	0.271 (0.973,5)	-4.377 (<0.01,6)	0.676 (0.990)	-7.546 (<0.01)	NC	0.623	0.325	NC
GFD	4.899 (0.999,6)	-2.008 (0.282,5)	-5.012 (<0.01,7)	2.064 (0.999)	-6.875 (<0.01)	NC	0.661	0.432	0.270
CPI	3.256 (0.999,6)	0.465 (0.984,6)	-2.581 (<0.29,6)	8.894 (0.999)	0.963 (0.996)	-8.715 (<0.01)	0.903	0.761	0.418
WPI	2.15 (0.99,8)	-0.571 (0.98,8)	-3.023 (0.136,7)	4.82 (0.999)	-4.14 (<0.01)	NC	0.255	0.379	0.444
INFLA	-5.633 (<0.01,3)	NC	NC	-5.425 (<0.01)	NC	NC	0.157	0.128	0.080
BR	-1.689 (0.431,6)	-5.738 (<0.01,5)	NC	-1.857 (0.350)	-5.785 (<0.01)	NC	0.202	0.098	NC
CRR	-0.844 (0.796,5)	-4.981 (<0.01,6)	NC	-1.131 (0.694)	-4.979 (<0.01)	NC	0.193	0.034	NC
SLR	-1.026 (0.737,5)	-4.085 (<0.01,6)	NC	-1.071 (0.721)	-4.053 (<0.01)	NC	0.189	0.076	NC

Source: Estimated on the basis of secondary time series data on relevant variables taken from RBI: Handbook of Statistics on the Indian Economy, 2010.

Notes: (i) First figures in each cell are computed **test statistic** values. The first figures in parenthesis in each cell indicate p-value. For very small p-values (smaller than 0.001, exact p-values are not presented, instead <0.001 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Information Criteria (automatic selection by the EVIEWS-9). (iii) Asymptotic critical values of KPSS Test Statistic with trend and intercept: 1% = 0.216; 5% = 0.146; 10%=0.119. **'**Null hypothesis' for KPSS test is that the time series variable is stationary (or does not have any Unit Root), whereas the 'null hypothesis' in other tests is that the concerned time series variable has a Unit Root (or is non-stationary). NC implies not calculated wherever stationarity is attained at the previous level.

4.4 Causality between Money Supply and Inflation

This section presents the modified Granger causality results using the Toda-Yamamoto (1995) approach under a VAR environment. For the purpose of choosing the appropriate detrended series for each time series variable both exponential and parabolic curves are first fitted to the data and the goodness of fit statistics of both are presented. The EVIEWS reported values of R-square, adjusted R-square, AIC, SIC and HQ are presented for both models. It is evident that the exponential trend fit is a statistically better compared to the parabolic fit for each variable –WPI and broad money supply. This is by virtue of obtaining higher R-square and lower AIC, SIC and HQ values in case of exponential trend fit. Thus the results in table (4.4.A1) suggest that exponential detrending should be preferred over quadratic or parabolic detrending. Hence the present study makes use of exponentially detrended data on each of the variables.

Identification of structural breaks is of utmost importance. Table 1 presents the results of Bai-Perron test for unknown multiple structural break points of original *vis-a-vis* de-trended annual time series of selected variables. Interestingly, the detrended series exhibit single break points only.

Table 4.4.1. Bai-Perron Test for Unknown Multiple Structural Break Points of Original *vis-a-vis* De-trended Annual Time Series

Variables	Break dates in Original Series	Break Dates in De-trended Series
WPI	**1990, 1996, 2008**	**2004**
F-Statistic	71.09, 38.33, 81.69	54.92
M3	**1994, 2004**	**2002**
F-Statistic	43.66, 29.31	21.95

Source: Computed on the basis of original and exponentially detrended time series data for major macroeconomic indicators of India (1961-2010) taken from *RBI: Handbook of Statistics on the Indian Economy,* 2010. **Notes**: F-statistic values corresponding to each repatriation are presented below the break date series.

For detrended variables the break points are single – at 2004 and 2002 respectively for WPI and M3. In other words there is a consistency in the time series behaviour of the detrended series of both real WPI and broad money supply. The original or non-detrended series on the other hand exhibits different as well as multiple break dates. The WPI exhibits significant breaks in 1990, 1996 and 2008. Interestingly no breaks in the original WPI series are observed during the plan holidays of the 1960s or just after nationalisation of banks. The first statistically significant break is found to occur at 1990, just before the onset of the period of liberalisation in India. The second break date in the original WPI series is 1996. Finally the third break date in real WPI is found at 2008. Broad money supply exhibits two points of break, one at 1994 and the other at 2004.

Table 4.4.2. Structural Break Point Unit Root Test of De-trended Series

Variables	**ADF**		**Zivot-Andrews**	
	Level	1st Diff.	Level	1st Diff.
WPI	-2.760	-7.649	-4.015	-9.765
	(0.81, 6)	(<0.01, 6)	(0.125, 6)	(<0.01, 7)
Break Date	2004	1994	1991	1995
M3	-14.88	NA	-6.85	NA
	(<0.01,5)		(<0.01,4)	
Break Date	2001	NA	2001	NA

Source: Estimated on the basis of secondary time series data on relevant variables (RBI: Handbook of Statistics on the Indian Economy, 2010) using EVIEWS 9 for Windows.
Notes: (i) Figures free of parenthesis in each cell are computed test statistic values. The first figure in parenthesis indicates p-value. For very small p-values (0.001, etc, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Criterion (automatic selection by the EVIEWS 9). (iii) A single unknown break date is selected by minimising the Dickey-Fuller t-Statistic automatically set in EVIEWS 9. (iv) M3 denotes broad money supply.

Stationarity testing is important from the point of view of knowing the order of integration of each time series variable. For example, if a time series is stationary not at level but at first difference then it follows an *I(1)* process. If a time series has a structural break the usual unit root test results (without incorporation of a break dummy) would be not only different, but would be misleading. Structural break point unit root tests are most appropriate under such circumstances. The structural break point unit root test results for detrended variables are shown in table 2. WPI is found to be non-stationary at level but stationary at first difference according to both the ADF and Zivot-Andrews tests. However the break dates are unidentical but close (1994 or 1995) at first difference. Detrended broad money supply is found to be stationary at level according to both tests. Both tests suggest a structural break point at 2001in case of broad money supply. EVIEWS 9 automatic optimum lag length selection option on the basis of Schwartz's Information Criterion is chosen while conducting these tests. The results in table 2 reveals that detrended WPI and M3 are not integrated of the same order. Here the maximum order of integration is thus 1.

Table 4.4.3. Stationarity Tests of Original Time Series (non-detrended) Ignoring Structural Breaks in the Series

Variable	ADF			PP			KPSS		
	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.
M3	6.759 (0.999,6)	4.999 (0.999,6)	-2.195 (0.210,6)	24.162 (0.999)	5.108 (0.999)	-6.058 (<0.01)	0.635	0.635	0.694
WPI	2.15 (0.99,8)	-0.571 (0.98,8)	-3.023 (0.136,7)	4.82 (0.999)	-4.14 (<0.01)	NC	0.255	0.379	0.444

Source: Estimated on the basis of secondary time series data on relevant variables taken from RBI: Handbook of Statistics on the Indian Economy, 2010.

Notes: (i) First figures in each cell are computed test statistic values. The first figures in parenthesis in each cell indicate p-value. For very small p-values (smaller than 0.001, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Information Criteria (automatic selection by the EVIEWS-9). (iii) Asymptotic critical values of KPSS Test Statistic with trend and intercept: 1% = 0.216; 5% = 0.146; 10%=0.119. 'Null hypothesis' for KPSS test is that the time series variable is stationary (or does not have unit root).

The picture however is very different in table 3 which presents the stationarity test results of original time series (non-detrended) ignoring structural breaks in each series. The ADF, PP and the KPSS test results are presented at level, first difference and second difference for each variable. In sharp contrast to the results in table 2, none of the time series variables are stationary at level, at first difference or even at second difference (in case of M3). The KPSS test shows no stationarity at level, first difference, or second difference in case of M3 and WPI. In sum, the contrasting results observed in tables 2 and 3 justifies the 'detrending of long run time series data' on the one hand and 'inclusion of structural break while testing for unit root' on the other.

After testing the structural break points and stationarity (i.e. unit roots), the vector auto regression (VAR) between broad money supply and WPI and consequently the modified Granger–Causality test results are presented and discussed. But first the optimum lag length for the VAR (i.e., the number of lagged regressors to be incorporated in the VAR – both WPI and broad money supply terms) needs to be found. The EVIEWS 9 reported optimum lag length selection criteria results are presented in table A2 of the appendix. Most criteria suggest that 4 endogenous lags must be chosen in the VAR model. According to Toda-Yamamoto (1995) approach however (p+m) lags have to be incorporated in the VAR model where m is the maximum order of integration of variables in the group. The m additional lagged terms cannot be restricted to zero while testing for Granger–Causality for the Wald statistic to asymptotically follow a chi-square distribution. Apart from the intercept or constant, a structural break dummy variable is also included, the break date being taken as 2001 which is the break date for the detrended M3 series (the structural break dummy D_2001 assumes 0 for pre 2001 observations and assumes 1 for observations pertaining to 2001 and after). Since maximum order of integration in the group is 1, an additional 5th period lagged terms of both variables are introduced in the VAR as exogenous variables as per Toda-Yamamoto (1995) requirements.

The estimated results of the VAR between real WPI and broad money supply are presented in table A3. The terms year and period are synonymous here. When WPI is the dependent variable, the 1 year lagged WPI significantly explains current year WPI. Rest of the lagged WPI coefficients are insignificant. More importantly, 1, 2 and 4 years lagged broad money supply terms are statistically significant in explaining current year WPI. When broad money supply is the dependent variable only the 1 year lagged WPI term is significant. R-square and adjusted R-square are both close to 99 percent implying that the VAR in table A3 is in fact very well fit. The constant is insignificant in both models but the structural break dummy is statistically significant.

Before conducting Wald test for Granger Causality the statistical robustness of the VAR must be ensured. First, serial correlation if any must be eliminated from the VAR residuals. That is, VAR residuals must not be serially correlated and to this end the number of lagged endogenous regressors may have to be adjusted. Second, it is desirable that the VAR residuals be normal. Statistical testing and estimation based on non-normal disturbances may be problematic. The residual serial correlation LM tests for the WPI – M3 VAR were conducted in EVIEWS and the results are presented in table 4. Results in table 4 reveal that at lags 1 and 2 respectively the LM statistic is significant at 5.8 percent but not at 5 percent. Otherwise it may safely inferred that serial correlation is absent in the VAR residuals till lag 10. The results of White's heteroscedasticity tests (table not presented) imply that the null hypothesis that VAR residuals are jointly heteroscedastic can be rejected only at 6.2 percent level of significance as the computed Chi-square value of 81.09 for 63 degrees of freedom has a *P*-value of 0.062. In other words the homoscedasticity hypothesis may be accepted. The normality test results for the VAR residuals are shown in table 5. The joint hypothesis of zero skewness is accepted. Similarly the joint hypothesis of a kurtosis of 3 is also accepted. Finally the p-value corresponding to the Jarque-Bera test statistic is high implying that the joint null hypothesis of normality of residuals is accepted.

Table 4.4.4. The Residual Serial Correlation LM Tests
For the WPI – Broad money supply VAR

Lags	LM-Stat	Prob
1	9.127	0.058
2	9.147	0.058
3	2.642	0.619
4	1.521	0.823
5	8.707	0.069
6	6.914	0.141
7	4.492	0.344
8	8.200	0.085
9	8.086	0.088
10	9.020	0.061

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. The results as generated under the post VAR option of Residual Tests in EVIEWS 9.

The Wald tests for Granger non-causality, tests for zero parameter restrictions on the coefficients of the lagged endogenous variables of the VAR model. However the exogenous variables are not dropped. The Wald test results of Granger non-causality between WPI and M3 are presented in table 6. The first null hypothesis that M3 does not Granger-cause WPI is rejected at less than 0.1 percent. Thus the alternative that M3 causes WPI is accepted. The second null hypothesis that WPI does not Granger-cause G is accepted at 16.89 percent. Hence M3 Granger causes WPI but the converse is not true. In other words there is uni-directional causality between M3 and WPI and runs from M3 to WPI. So monetary expansion in India is found to have a positive influence on WPI, but whether this expansionary policy is independent or triggered due to fiscal factors is beyond the scope of the present study.

Table 4.4.5. The WPI–Broad Money Supply VAR Model: Normality Test of Residuals				
Method of Orthogonalization: Cholesky (Lutkepohl)				
Null Hypothesis: Residuals Are Multivariate Normal				
Component	**Skewness**	**Chi-sq**	**df**	**P-value**
1	-0.3349542	1.009749	1	0.315
2	0.4184673	1.576034	1	0.209
Joint		2.585783	2	0.274
Component	**Kurtosis**	**Chi-sq**	**df**	**P-value**
1	2.436645	0.714079	1	0.398
2	1.837485	3.040743	1	0.081
Joint		3.754822	2	0.153
Component	**Jarque-Bera Stat**		**df**	**P-value**
1	1.723828		2	0.422
2	4.616777		2	0.099
Joint	7.579983		4	0.108

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Residual Tests. The figures as reported in EVIEWS output sheet are exactly reproduced.

Table 4.4.6. Wald Tests for Granger Causality between M3 and WPI (Included observations: 44)

Null Hypothesis	**Chi-sq**	**df**	**P-value**	**Inference**
(i) M3 does not Granger Cause WPI	16.335	4	0.003	Reject Null Hypothesis
(ii) WPI does not Granger Cause M3	8.068	4	0.089	Accept Null Hypothesis

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Lag Structure. G represents broad money supply. The 2nd null hypothesis implies absence of Wagner's Law.

The Johansen Co-integration test between WPI and broad money supply are presented in table 7. Clearly the trace test and maximum eigen value test indicates 1 co-integrating vector each between real WPI and M3 implying thereby that there is a long run equilibrium relationship between real WPI and broad money supply in India over the period 1961-2010. This is somewhat unexpected in view of the fact that exponentially detrended M3 and WPI were not found to be integrated of the same order. Both structural break point ADF and Zivot-Andrews tests suggest that M3 is *I(0)* (stationary at level) while WPI is *I(1)* (stationary at first difference), both having different break dates.

It may finally be argued however that the long–run co-integrating or equilibrium relationship between broad money supply and whole-sale price index justifies the causality results obtained earlier.

Table 4.4.7. Johansen Co-integration Test between M3 and WPI

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	P-value **
None *	0.629547	57.393010	17.99296	0
At most 1	0.006437	0.368148	3.756954	0.5501

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	P-value **
None *	0.635768	57.588341	16.77044	0
At most 1	0.006501	0.371786	3.756954	0.5383

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated and are not rounded off.

Key Findings

The findings are suggestive of a uni-directional causality from broad money supply to WPI. Further both real WPI and broad money supply have a long-run co-integrating relationship. Hence short run causal relations may exist. But to a certain extent monetary expansion in India is not independent of fiscal expansion. **Thus the first null hypothesis is rejected.**

Table 4.4.A1. Comparing Goodness of Fit Statistics of Parabolic Trend Fitting vis-s-vis Exponential Trend Fitting for each Time Series Variable for the period 1961-2010

Variables	Parabolic Trend Fitting		Exponential Trend Fitting	
	R^2;Adj.R^2	AIC;SIC;HQ	R^2;Adj.R^2	AIC;SIC;HQ
WPI	0.955; 0.936	27.19; 27.28; 27.23	0.978; 0.954	-1.32; -1.25; -1.29
M3	0.969; 0.945	36.21; 36.29; 36.24	0.988; 0.979	-2.22; -2.13; -2.17

Source: Computed on the basis of secondary time series data compiled from *RBI: Handbook of Statistics on the Indian Economy,* 2010.

Table 4.4.A2. Optimum Lag Length Selection in the M3–WPI VAR Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1487.52	NA	5.37E+20	55.24689	55.39947	55.30574
1	-1361.47	233.4434	6.85E+18	50.73146	51.03642	50.84906
2	-1333.71	49.35273	2.95E+18	49.85658	50.31403	50.03304
3	-1324.88	15.02708	2.51E+18	49.68321	50.29325	49.91852
4	-1315.37	12.82616*	1.8E+18*	49.33205*	50.24664*	49.77818
5	-1307.12*	15.50923	2.07E+18	49.48412	50.24705	49.68496*

Source: Estimated on the basis of Secondary Data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. Results are EVIEWS 9 generated.

Notes: * indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Table 4.4.A3. Estimated VAR between M3 and WPI		
	M3	**WPI**
M3 (-1)	1.31188	0.39175
	0.20108	0.12072
	[6.52420]	[3.24521]
M3 (-2)	-0.42797	0.01177
	0.24861	0.14925
	[-1.72148]	[0.07886]
M3 (-3)	0.34847	0.09090
	0.25416	0.15257
	[1.37109]	[0.59573]
M3 (-4)	-0.02373	-0.20346
	0.28042	0.16835
	[-0.08462]	[-1.20858]
WPI (-1)	0.59349	1.31506
	0.24134	0.21263
	[2.45916]	[6.18474]
WPI (-2)	1.77065	-0.03419
	0.48406	0.29060
	[3.65794]	[-0.11767]
WPI (-3)	-0.49203	-0.35157
	0.52496	0.31515
	[-0.93727]	[-1.11554]
WPI (-4)	1.41886	-0.19121
	0.53821	0.32311
	[2.63625]	[-0.59177]
Exogenous Variables		
c	-5.93778	8.87366
	10.092	6.058
	[-0.58836]	[1.46471]
d_2001	7.712	2.478
	2.396	1.339
	[3.21873]	[1.85132]
M3 (-5)	-0.04639	-0.18993
	0.20952	0.12578
	[-0.22143]	[-1.50995]
WPI (-5)	-0.84891	0.03395
	0.36927	0.22169
	[-2.29890]	[0.15315]
R-squared	0.94422	0.94937
Adj. R-quared	0.94145	0.94792
F-Statistic	325.64687	625.02831
Log-likelihood	-633.09312	-606.29032
Akaike AIC	23.43832	22.46367
Schwarz SC	23.85659	22.88194

Source: Estimated on the basis of Secondary data on relevant variables compiled from RBI: Handbook of Statistics of the Indian Economy, 2010. Estimations are done using EVIEWS 9 for Windows.
Notes: The figures as reported in EVIEWS output sheet are exactly reproduced in table 6 without rounding off. The structural break dummy (for 2004) and the two 5^{th} period lagged terms of both variables are exogenous to the VAR system. The Granger Causality or Block Exogeneity Wald Tests imply zero parameter restrictions only the endogenous lagged terms i.e., on lag 1 to 4 only.

4.5 Causality between Real GDP and Money Supply

For the purpose of choosing the appropriate detrended series for each time series variable both exponential and parabolic curves are first fitted to the data. For the sake of comparing the exponential and parabolic fits, the goodness of fit statistics of both are presented .(see table A1). In particular the EVIEWS reported values of R-square, adjusted R-square, AIC, SIC and HQ are presented for both models. Clearly from the results of table A1, it is evident that the exponential trend fit is a statistically better compared to the parabolic fit for each variable – real GDP, broad money supply (M3) and narrow money supply (M1). This is by virtue of obtaining higher R-square and lower AIC, SIC and HQ values in case of exponential trend fit. Thus the results in table A1 justify exponential detrending rather than quadratic or parabolic detrending. Hence the present study makes use of exponentially detrended data on each of the three variables.

Identification of structural breaks is of utmost importance. Table 1 presents the results of Bai-Perron test for unknown multiple structural break points of original *vis-a-vis* de-trended annual time series of selected variables. Interestingly, the detrended series exhibit single break points only.

Table 4.5.1. Bai-Perron Test for Unknown Multiple Structural Break Points of Original *vis-a-vis* De-trended Annual Time Series of Selected Variables

Variables	Break dates in Original Series	Break Dates in De-trended Series
GDP	**1985, 1993, 2004**	**2002**
F-Statistic	35.22, 49.97, 39.55	46.28
M3	**1994, 2004**	**2002**
F-Statistic	43.66, 29.31	21.95
M1	**1995, 2004**	**2001**
F-Statistic	95.29, 34.78	76.42

Source: Computed on the basis of original and exponentially detrended time series data for major macroeconomic indicators of India (1961-2010) taken from *RBI: Handbook of Statistics on the Indian Economy,* 2010. **Notes**: F-statistic values corresponding to each repatriation are presented below the break date series.

For all detrended variables the break points are either in 2002 or in 2001. In other words there is a consistency in the time series behaviour of the detrended series of both real GDP and money supply. The original or non-detrended series on the other hand exhibits a different behaviour in terms of break dates. Real GDP exhibits significant breaks in 1985, 1993 and 2004. Interestingly no breaks in the original real GDP series are observed during the plan holidays of the 1960s or just after nationalisation of banks. Incidentally the first statistically significant break is found to occur at 1985, the first year of the period of weak liberalisation in India. The second break date in the original GDP series is 1993, two years after the first wave of major economic reforms of 1991. Finally the third break date in real GDP is found at 2004. Money supply exhibits two points of break, one at around 1994-95 and the other at 2004.

Table 4.5.2. Structural Break Point Unit Root Test of De-trended Time Series

Variables	ADF		Zivot-Andrews	
	Level	1st Diff.	Level	1st Diff.
GDP	-4.05	-7.99	-3.36	-6.49
	(0.142, 4)	(<0.01, 4)	(<0.81, 4)	(<0.01, 4)
Break Date	1999	2002	2002	2001
M3	-14.88	NA	-6.85	NA
	(<0.01, 5)		(<0.01,4)	
Break Date	2001	NA	2001	NA
M1	-10.43	NA	-9.91	NA
	(<0.01,6)		(<0.01,4)	
Break Date	2001	NA	2001	NA

Source: Estimated on the basis of secondary time series data on relevant variables (RBI: Handbook of Statistics on the Indian Economy, 2010) using EVIEWS 9 for Windows.
Notes: (i) Figures free of parenthesis in each cell are computed test statistic values. The first figure in parenthesis indicates p-value. For very small p-values (0.001, etc, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Criterion (automatic selection by the EVIEWS 9). (iii) A single unknown break date is selected by minimising the Dickey-Fuller t-Statistic automatically set in EVIEWS 9.

Stationarity testing is important from the point of view of knowing the order of integration of each time series variable. For example, if a time series is stationary not at level but at first difference then it follows an *I(1)* process. If a time series has a structural break the usual unit root test results (without incorporation of a break dummy) would be not only different, but would be misleading. Structural break point unit root tests are most appropriate under such circumstances. The structural break point unit root test results for all detrended variables are shown in table 2. GDP is found to be stationary at level according to both the ADF and Zivot-Andrews tests and the break dates vary slightly across 2001 and 2002, with software determined optimum lag length at 4. EVIEWS 9 automatic optimum lag length selection option on the basis of Schwartz's Information Criterion was chosen. Detrended GDP is found to be non-stationary at level. However, both the detrended narrow and broad money supply series are found to be stationary at level according to both tests. Surprisingly both tests suggest a structural break date of 2001 for both narrow and broad money. The first difference option is not tried as stationarity is obtained at level.

Table 4.5.3. Stationarity Tests of Original Time Series (non-detrended) Ignoring Structural Breaks in the Series

Variable	ADF			PP			KPSS		
	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.
M1	6.460 (0.999,6)	1.331 (0.999,6)	-3.989 (<0.01,8)	9.938 (0.999)	-0.843 (0.799)	-17.302 (<0.01)	0.257	0.271	0.217
M3	6.759 (0.999,6)	4.999 (0.999,6)	-2.195 (0.210,6)	24.162 (0.999)	5.108 (0.999)	-6.058 (<0.01)	0.325	0.335	0.394
GDP	16.202 (0.999,5)	0.639 (0.990,5)	-7.01 (<0.01,8)	17.288 (0.999)	-1.284 (0.632)	-16.392 (<0.01)	0.350	0.371	0.268

Source: Estimated on the basis of secondary time series data on relevant variables taken from RBI: Handbook of Statistics on the Indian Economy, 2010.
Notes: (i) First figures in each cell are computed test statistic values. The first figures in parenthesis in each cell indicate p-value. For very small p-values (smaller than 0.001, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Information Criteria (automatic selection by the EVIEWS-9). (iii) Asymptotic critical values of KPSS Test Statistic with trend and intercept: 1% = 0.216; 5% = 0.146; 10%=0.119. 'Null hypothesis' for KPSS test is that the time series variable is stationary (or does not have unit root).

The picture however is very different in table 3 which presents the stationarity test results of original time series (non-detrended) ignoring structural breaks in each series. The ADF, PP and the KPSS test results are presented at level, first difference and second difference for each variable. In sharp contrast to the results in table 2, none of the time series variables are stationary at level or at first difference. In fact M3 is non-stationary even at second difference as per ADF test. The KPSS test shows no stationarity at level, first difference, or second difference in case of all three variables. Thus contrasting outcomes seen in tables 2 and 3 justifies 'detrending the long run time series data' on the one hand and 'incorporation of structural breaks while testing for unit root' on the other.

After testing the structural break points and stationarity (i.e. unit roots), the vector auto regression (VAR) between real GDP and broad money supply (M3) and consequently the modified Granger – Causality results are presented and discussed. But first the optimum lag length for the VAR (i.e., the number of lagged regressors to be incorporated in the VAR – both GDP and money supply terms) needs to be determined with the help of alternative criteria. The EVIEWS 9 reported optimum lag length selection criteria results are presented in table A2 of the appendix. Most criteria suggest that 4 endogenous lags must be chosen in the VAR system. According to Toda-Yamamoto (1995) however (*m*+*d*) lags have to be incorporated in the VAR model where *d* is the order of integration of each variable. The *d* additional lagged terms cannot be restricted to zero while testing for Granger –Causality.

Table 4.5.4. The Residual Serial Correlation LM Tests For the GDP-Broad Money VAR

Null Hypothesis: No serial correlation at lag order h (=10)

Lags	LM-Stat	P-value
1	2.249454	0.6900
2	3.275096	0.5129
3	3.953462	0.5491
4	5.624178	0.2290
5	6.255866	0.1808
6	9.231212	0.0556
7	1.931306	0.7484
8	5.573649	0.2333
9	5.547362	0.2216
10	8.222846	0.0837

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. The results are EVIEWS 9 generated under the post VAR option of Residual Tests and are exactly reproduced without rounding off.

The estimated results of the VAR between real GDP and broad money supply are presented in table A3. The terms year and period are synonymous here. When GDP is the dependent variable, the 1 year lagged GDP significantly explains current year GDP. Rest of the lagged GDP coefficients are insignificant. More importantly, 1, 2 and 4 years lagged broad money terms are statistically significant in explaining current year GDP. When broad money supply is the dependent variable only the 1 year lagged GDP term is significant. R-square and adjusted R-square are both close to 99 percent implying that the VAR in table A3 is in fact very well fit. Since both M3 and GDP are integrated of order 1, additional 5^{th} period lagged terms of both variables are introduced in the VAR as exogenous variables. Apart from the intercept or constant, a structural break dummy variable is also included, the break date being taken as 2002 (the structural break dummy D_2002 assumes score 0 for pre 2002 observations and assumes score 1 for observations pertaining to 2002 onwards). The constant is insignificant in both models but the structural break dummy is statistically significant.

Before conducting Wald test for Granger Causality the statistical robustness of the VAR must be ensured. First, serial correlation if any must be eliminated from the VAR residuals. That is, VAR residuals must not be serially correlated and to this end the number of lagged endogenous regressors may have to be adjusted. Second, it is desirable that the VAR residuals be normal. Statistical testing and estimation based on non-normal disturbances may be problematic. The residual serial correlation LM tests for the GDP-Broad Money VAR were conducted in EVIEWS and the results are presented in table 4 above. The LM statistic is significant at 5.56 percent (so insignificant at 5 percent) only for the 6^{th} period lagged residual and the rest are statistically insignificant. The results of White's heteroscedasticity tests (not presented in tabulated form) reveal that the VAR residuals are jointly heteroscedastic at 6.2 percent level of significance as the computed Chi-square value of 81.09 for 63 degrees of freedom has a p-value of 0.062. Thus the homoscedasticity hypothesis may be accepted at 5 percent level but not at 10 percent level. The normality test results for the VAR residuals are shown in table 5. The joint hypothesis of zero skewness is accepted. Similarly the joint hypothesis of a kurtosis of 3 is also accepted. Finally the p-value corresponding to the Jarque-Bera test statistic is high implying that the joint null hypothesis of normality of residuals is accepted at 34.13 percent.

Table 4.5.5. The Real GDP – Broad Money VAR Model: Normality Tests of Residuals

Method of Orthogonalization: Cholesky (Lutkepohl)

Null Hypothesis: Residuals Are Multivariate Normal

Component	Skewness	Chi-sq	df	P-value
1	-0.066791	0.040893	1	0.8397
2	-0.641913	3.777152	1	0.0520
Joint		3.818045	2	0.1482
Component	**Kurtosis**	**Chi-sq**	**df**	**P-value**
1	3.193490	0.085796	1	0.7696
2	3.514637	0.606952	1	0.4359
Joint		0.692748	2	0.7072
Component	**Jarque-Bera Test Statistic**		**df**	**P-value**
1	0.126689		2	0.9386
2	4.384104		2	0.1117
Joint	4.510793		4	0.3413

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Residual Tests. The figures as reported in EVIEWS output sheet are exactly reproduced without rounding off.

The Wald tests for Granger Non-Causality, tests for zero parameter restrictions on the coefficients of the lagged endogenous variables of the VAR model. However the exogenous variables are not dropped. The Wald test results of Granger non-causality between real GDP and broad money are presented in table 6.

Table 4.5.6. Wald Tests for Granger Causality between GDP and M3 (Included obs: 45)

Null Hypothesis	Chi-sq	df	P-value	Inference
(i) M3 does not Granger Cause GDP	11.20	4	0.0244	Reject Null Hypothesis
(ii) GDP does not Granger Cause M3	15.53	4	0.0037	Reject Null Hypothesis

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Lag Structure.

The first null hypothesis that broad money M3 does not Granger-cause real GDP is rejected at 2.44 percent or conventionally at 5 percent. Thus the alternative that M3 causes GDP is accepted. The second null hypothesis that GDP does not Granger-cause M3 is rejected at 1 percent. Thus real GDP Granger causes M3. Hence there is bi-directional causality between real GDP and broad money supply. Broad money expansion in India is found to have a positive influence on real GDP, but whether this expansionary monetary policy is independent or triggered due to fiscal factors is beyond the scope of this paper.

The VAR estimates between narrow money supply M1 and real GDP are shown in table A5.

Table 4.5.7. The Residual Serial Correlation LM Tests For the GDP-Narrow Money VAR

Lags	LM-Stat	Prob
1	9.063214	0.0596
2	9.024152	0.0605
3	2.606522	0.6257
4	1.500959	0.8265
5	8.590112	0.0722
6	6.820343	0.1457
7	4.431025	0.3508
8	8.089513	0.0883
9	7.976495	0.0924
10	8.898527	0.0637

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. The results are EVIEWS 9 generated under the post VAR option of Residual Tests.

The optimal lag length as per SIC is 5. Since both variables are integrated of order 1 an additional exogenous lag is incorporated in the VAR which would not be set to zero for the Wald test as per Toda-Yamamoto (1995) requirements. Goodness of fit measures are extremely satisfactory. Just the 1 year lagged M1 term is statistically significant. Similar to the previous VAR, the structural break dummies are also significant. As seen in table 7 the hypothesis of no serial correlation in VAR residuals up to lag 10 is accepted at 5 percent. Results in table 8 also verify that the residuals are in fact normal.

Table 4.5.8. The Real GDP–M1 VAR Model: Normality Test of Residuals				
Method of Orthogonalization: Cholesky (Lutkepohl)				
Null Hypothesis: Residuals Are Multivariate Normal				
Component	**Skewness**	**Chi-sq**	**df**	**P-value**
1	-0.349781	1.101123	1	0.2940
2	0.431140	1.672938	1	0.1959
Joint		2.774061	2	0.2498
Component	**Kurtosis**	**Chi-sq**	**df**	**P-value**
1	2.118114	1.749759	1	0.1859
2	1.966485	2.403347	1	0.1211
Joint		4.153106	2	0.1254
Component	**Jarque-Bera Test Statistic**		**df**	**P-value**
1	2.850882		2	0.2404
2	4.076285		2	0.1303
Joint	6.927167		4	0.1398

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Residual Tests. The figures as reported in EVIEWS output sheet are exactly reproduced without rounding off.

Finally the Granger non-causality between real GDP and M1 is tested by means of the Wald test. The first hypothesis that M1 does not cause GDP is rejected at less than 1 percent implying that narrow money supply causes real GDP. However the second null hypothesis that real GDP does not cause M1 is accepted. Thus the present finding is indicative of one way causality between M1 and GDP (M1 causes GDP).

Table 4.5.9. Wald Tests for Granger Causality between GDP and M1 (Included obs: 45)

Null Hypothesis	**Chi-sq**	**df**	**P-value**	**Inference**
(i) M1 does not Granger Cause GDP	32.36	5	<0.001	Reject Null Hypothesis
(ii) GDP does not Granger Cause M1	4.09	5	0.5364	Accept Null Hypothesis

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Lag Structure.

The Johansen Co-integration test between GDP and broad money supply and the same between GDP and narrow money supply are presented in tables 10 and 11 respectively. Clearly the trace test and maximum eigen value test indicates 1 co-integrating vector each between real GDP and M3 and between real GDP and M1 implying thereby that there is a long run equilibrium relationship between real GDP and broad money supply and further between real GDP and narrow money supply in India over the period 1961-2010. The long – run co-integrating or equilibrium relationship justifies the causality results obtained earlier.

Table 4.5.10. Johansen Co-integration Test between GDP and Broad Money

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	P-value **
None *	0.636076	57.98820	18.39771	0.0000
At most 1	0.006504	0.371966	3.841466	0.5419

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	P-value **
None *	0.636076	57.61623	17.14769	0.0000
At most 1	0.006504	0.371966	3.841466	0.5419

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated and are not rounded off.

Table 4.5.11. Johansen Co-integration Test between GDP and Narrow Money				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	P-value **
None *	0.465116	36.09614	18.39771	0.0001
At most 1	0.007532	0.430936	3.841466	0.5115
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	P-value **
None *	0.465116	35.66521	17.14769	0.0000
At most 1	0.007532	0.430936	3.841466	0.5115
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated.

Key Findings

The findings are suggestive of a bi-directional causality between broad money and GDP. However the study suggests uni-directional causality from narrow money to GDP. Further, both narrow and broad money have a long-run co-integrating relationship with real GDP and short run causal relations may be anticipated. But to a certain extent monetary expansion in India may be fiscal expansion triggered and may not be independent. **Thus the first part of the second null hypothesis is rejected.**

Table 4.5.A1. Comparing Goodness of Fit Statistics of Parabolic Trend Fitting vis-s-vis Exponential Trend Fitting for each Time Series Variable for the period 1961-2010

Variables	Parabolic Trend Fitting		Exponential Trend Fitting	
	R^2;Adj.R^2	AIC;SIC;HQ	R^2;Adj.R^2	AIC;SIC;HQ
GDP	0.961; 0.956	28.19; 28.28; 28.23	0.983; 0.974	-1.35; -1.28; -1.32
M3	0.973; 0.968	32.13; 32.37; 32.28	0.979; 0.962	-1.87; -1.71; -1.84
M1	0.952; 0.941	34.36; 34.12; 34.29	0.988; 0.979	-2.11; -2.09; -2.17

Source: Computed on the basis of secondary time series data compiled from *RBI: Handbook of Statistics on the Indian Economy,* 2010.
Notes: Parabolic trend is fitted by estimating the model $y_t = \beta_0 + \beta_1.t + \beta_2.t^2$.

Table 4.5.A2. Optimum Lag Length Selection in VAR for the GDP and M3 Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1437.122	NA	5.19e+20	53.37490	53.52223	53.43172
1	-1315.334	225.5332	6.62e+18	49.01239	49.30705	49.12603
2	-1288.514	47.68038	2.85e+18	48.16719	48.60919	48.33765
3	-1279.993	14.51789	2.42e+18	47.99973	48.58906	48.22702
4	-1270.798	12.39157*	1.74e+18*	47.66045*	48.54401*	48.09145
5	-1262.832	14.98368	2.00e+18	47.80734	48.54445	48.00138*

Source: Estimated on the basis of Secondary Data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. Results are EVIEWS 9 generated.
Notes: * indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 4.5.A3. VAR Model Estimates between GDP and Broad Money Supply (detrended) for India during 1961-2010

Endogenous Variables	Dependent Variables	
	GDP	**M3**
GDP(-1)	1.104453	0.329806
	(0.16929)	(0.10163)
	[6.52420]	[3.24521]
GDP(-2)	-0.360305	0.009909
	(0.20930)	(0.12565)
	[-1.72148]	[0.07886]
GDP(-3)	0.293372	0.076524
	(0.21397)	(0.12845)
	[1.37109]	[0.59573]
GDP(-4)	-0.019978	-0.171290
	(0.23608)	(0.14173)
	[-0.08462]	[-1.20858]
M3(-1)	0.499652	1.107125
	(0.20318)	(0.17901)
	[2.45916]	[6.18474]
M3(-2)	1.490683	-0.028788
	(0.40752)	(0.24465)
	[3.65794]	[-0.11767]
M3(-3)	-0.414230	-0.295979
	(0.44196)	(0.26532)
	[-0.93727]	[-1.11554]
M3(-4)	1.194519	-0.160975
	(0.45311)	(0.27202)
	[2.63625]	[-0.59177]
Exogenous Variables		
C	-5943.726	8882.544
	(10101.6)	(6064.36)
	[-0.58840]	[1.46471]
D_2002	77199.17	24804.26
	(23984.3)	(13398.7)
	[3.21873]	[1.85132]
GDP(-5)	-0.046441	-0.190116
	(0.20973)	(0.12591)
	[-0.22143]	[-1.50995]
M3(-5)	-0.849760	0.033985
	(0.36964)	(0.22191)
	[-2.29890]	[0.15315]
R-squared	0.988666	0.994062
Adj. R-squared	0.985766	0.992543
F-statistic	340.9758	654.4497
Log likelihood	-662.8942	-634.8297
Akaike AIC	24.54161	23.52108
Schwarz SC	24.97957	23.95904

Source: Estimated on the basis of Secondary data on relevant variables compiled from RBI: Handbook of Statistics of the Indian Economy, 2010. Estimations are done using EVIEWS 9 for Windows.

Notes: The figures as reported in EVIEWS output sheet are exactly reproduced in table 6 without rounding off. The structural break dummy (for 2004) and the two 5^{th} period lagged terms of both variables are exogenous to the VAR system. The Granger Causality or Block Exogeneity Wald Tests imply zero parameter restrictions only the endogenous lagged terms i.e., on lag 1 till 4 only.

VAR Results between GDP and M1

Table 4.5.A4. Optimum Lag Length Selection in VAR for the GDP and M1 Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1407.150	NA	1.71e+20	52.26481	52.41214	52.32163
1	-1266.632	260.2183	1.09e+18	47.20859	47.50325	47.32223
2	-1264.861	3.147843	1.19e+18	47.29116	47.73315	47.46162
3	-1247.116	30.23218	7.15e+17	46.78209	47.37141	47.00937
4	-1233.979	21.40848	5.12e+17	46.44368	47.18034	46.72778
5	-1222.186	18.34515*	3.86e+17	46.15504	47.03903*	46.49596
6	-1216.293	8.729677	3.63e+17*	46.08494*	47.11627	46.48268*

Source: Estimated on the basis of Secondary Data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. Results are EVIEWS 9 generated.
Notes: * indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 4.5.A5. VAR Model Estimates between GDP and Narrow Money Supply in India during 1961-2010

Endogenous Variables	Dependent Variables	
	GDP	**M1**
GDP(-1)	0.399158	-0.165367
	(0.24224)	(0.10690)
	[1.64780]	[-1.54693]
GDP(-2)	0.096712	0.039675
	(0.28928)	(0.12766)
	[0.33432]	[0.31079]
GDP(-3)	0.055579	0.022007
	(0.27718)	(0.12232)
	[0.20051]	[0.17991]
GDP(-4)	-0.283536	-0.038806
	(0.26397)	(0.11649)
	[-1.07412]	[-0.33312]
GDP(-5)	0.203297	-0.041465
	(0.26320)	(0.11615)
	[0.77240]	[-0.35698]
M1(-1)	1.904034	1.018095
	(0.52498)	(0.23167)
	[3.62690]	[4.39450]
M1(-2)	0.004934	0.658024
	(0.58160)	(0.25666)
	[0.00848]	[2.56376]
M1(-3)	-0.921034	0.211801
	(0.80695	(0.35611)
	[-1.14138]	[0.59476]
M1(-4)	0.968424	-0.574120
	(0.81063)	(0.35773)
	[1.19466]	[-1.60488]
M1(-5)	0.075435	-0.835709
	(0.87400)	(0.38570)
	[0.08631]	[-2.16674]
Exogenous Variables		
C	-17912.19	-2306.040
	(9604.08)	(4238.33)
	[-1.86506]	[-0.54409]
D_2002	80635.20	43690.93
	(24137.4)	(10652.0)
	[3.34068]	[4.10168]
GDP(-6)	0.473424	0.232379
	(0.23849)	(0.10524)
	[1.98513]	[2.20798]
M1(-6)	-0.226621	0.392824
	(0.87012)	(0.38399)
	[-0.26045]	[1.02300]
R-squared	0.991869	0.973551
Adj. R-squared	0.989227	0.964955
F-statistic	375.3558	113.2586
Log likelihood	-642.3626	-598.1897
Akaike AIC	24.30973	22.67369
Schwarz SC	24.82539	23.18935

Source: Estimated on the basis of Secondary data on relevant variables compiled from RBI: Handbook of Statistics of the Indian Economy, 2010. Estimations are done using EVIEWS 9 for Windows. **Notes**: The figures as reported in EVIEWS output sheet are exactly reproduced in table 11 without rounding off. The structural break dummy (for 2004) and the two 6th period lagged terms of both variables are exogenous to the VAR system. The Granger Causality or Block Exogeneity Wald Tests imply zero parameter restrictions only the endogenous lagged terms i.e., on lag 1 till 5 only.

4.6 Causality between Real GDP and Government Expenditure

For the purpose of choosing the appropriate detrended series for each time series variable both exponential and parabolic curves are first fitted to the data and the goodness of fit statistics of both are presented (see table A1). The EVIEWS reported values of R-square, adjusted R-square, AIC, SIC and HQ are presented for both models. It is evident that the exponential trend fit is a statistically better compared to the parabolic fit for each variable – real GDP and government expenditure. This is by virtue of obtaining higher R-square and lower AIC, SIC and HQ values in case of exponential trend fit. Thus the results in table A1 justify exponential detrending rather than quadratic or parabolic detrending. Hence the present study makes use of exponentially detrended data on each of the three variables.

Identification of structural breaks is of utmost importance. Table 1 presents the results of Bai-Perron test for unknown multiple structural break points of original *vis-a-vis* de-trended annual time series of selected variables. Interestingly, the detrended series exhibit single break points only.

Table 4.6.1. Bai-Perron Test for Unknown Multiple Structural Break Points of Original *vis-a-vis* De-trended Annual Time Series

Variables	Break dates in Original Series	Break Dates in De-trended Series
GDP	**1985, 1993, 2004**	**1999**
F-Statistic	35.22, 49.97, 39.55	46.28
G	**1996, 2005**	**1998**
F-Statistic	86.09, 29.88	66.53

Source: Computed on the basis of original and exponentially detrended time series data for major macroeconomic indicators of India (1961-2010) taken from *RBI: Handbook of Statistics on the Indian Economy,* 2010. **Notes**: F-statistic values corresponding to each repatriation are presented below the break date series.

For detrended variables the break points are either in 1998 or in 1999. In other words there is a consistency in the time series behaviour of the detrended series of both real GDP and government expenditure. The original or non-detrended series on the other hand exhibits different break dates. Real GDP exhibits significant breaks in 1985, 1993 and 2004. Interestingly no breaks in the original real GDP series are observed during the plan holidays of the 1960s or just after nationalisation of banks. The first statistically significant break is found to occur at 1985, the first year of the period of weak liberalisation in India. The second break date in the original GDP series is 1993, two years after the first wave of major economic reforms of 1991. Finally the third break date in real GDP is found at 2004. Government expenditure exhibits two points of break, one at around 1996 and the other at 2005.

Table 4.6.2. Structural Break Point Unit Root Test of De-trended Series

Variables	**ADF**		**Zivot-Andrews**	
	Level	1st Diff.	Level	1st Diff.
GDP	-4.02 (0.144, 4)	-7.98 (<0.01, 4)	-3.29 (<0.84, 4)	-6.53 (<0.01, 4)
Break Date	1999	2001	2000	2001
G	-9.67 (<0.01,5)	NA	-9.32 (<0.01,4)	NA
Break Date	1999	NA	1999	NA

Source: Estimated on the basis of secondary time series data on relevant variables (RBI: Handbook of Statistics on the Indian Economy, 2010) using EVIEWS 9 for Windows.

Notes: (i) Figures free of parenthesis in each cell are computed test statistic values. The first figure in parenthesis indicates p-value. For very small p-values (0.001, etc, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Criterion (automatic selection by the EVIEWS 9). (iii) A single unknown break date is selected by minimising the Dickey-Fuller t-Statistic automatically set in EVIEWS 9.

Stationarity testing is important from the point of view of knowing the order of integration of each time series variable. For example, if a time series is stationary not at level but at first difference then it follows an *I(1)* process. If a time series has a structural break the usual unit root test results (without incorporation of a break dummy) would be not only different, but would be misleading. Structural break point unit root tests are most appropriate under such circumstances. The structural break point unit root test results for all detrended variables are shown in table 2. GDP is found to be non-stationary at level but stationary at first difference according to both the ADF and Zivot-Andrews tests and the break dates are identical (at 2001), with software determined optimum lag length at 4. EVIEWS 9 automatic optimum lag length selection option on the basis of Schwartz's Information Criterion was chosen. However, the detrended government expenditure is found to be stationary at level according to both tests. Both tests suggest a structural break date of 1999 for government expenditure.

Table 4.6.3. Stationarity Tests of Original Time Series (non-detrended) Ignoring Structural Breaks in the Series

Variable	ADF			PP			KPSS		
	Level	1^{st} Dif.	2^{nd} Dif.	Level	1^{st} Dif.	2^{nd} Dif.	Level	1^{st} Dif.	2^{nd} Dif.
G	6.911 (0.999,6)	1.424 (0.999,6)	-4.268 (<0.01,7)	10.634 (0.999)	-0.902 (0.799)	-18.513 (<0.01)	0.263	0.278	0.223
GDP	16.202 (0.999,5)	0.639 (0.990,5)	-7.01 (<0.01,8)	17.288 (0.999)	-1.284 (0.632)	-16.392 (<0.01)	0.350	0.371	0.268

Source: Estimated on the basis of secondary time series data on relevant variables taken from RBI: Handbook of Statistics on the Indian Economy, 2010.

Notes: (i) First figures in each cell are computed test statistic values. The first figures in parenthesis in each cell indicate p-value. For very small p-values (smaller than 0.001, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Information Criteria (automatic selection by the EVIEWS-9). (iii) Asymptotic critical values of KPSS Test Statistic with trend and intercept: 1% = 0.216; 5% = 0.146; 10%=0.119. 'Null hypothesis' for KPSS test is that the time series variable is stationary (or does not have unit root).

The picture however is very different in table 3 which presents the stationarity test results of original time series (non-detrended) ignoring structural breaks in each series. The ADF, PP and the KPSS test results are presented at level, first difference and second difference for each variable. In sharp contrast to the results in table 2, none of the time series variables are stationary at level or at first difference. The KPSS test shows no stationarity at level, first difference, or second difference in case of all three variables. Thus contrasting outcomes observed in tables 2 and 3 justifies 'detrending the long run time series data' on the one hand and 'incorporation of structural breaks while testing for unit root' on the other.

After testing the structural break points and stationarity (i.e. unit roots), the vector auto regression (VAR) between real GDP and government expenditure and consequently the modified Granger–Causality results are presented and discussed. But first the optimum lag length for the VAR (i.e., the number of lagged regressors to be incorporated in the VAR – both GDP and government expenditure terms) needs to be determined. The EVIEWS 9 reported optimum lag length selection criteria results are presented in table A2. Most criteria suggest that 4 endogenous lags must be chosen in the VAR system. According to Toda-Yamamoto (1995) however (m+d) lags have to be incorporated in the VAR model where d is the order of integration of each variable. The d additional lagged terms cannot be restricted to zero while testing for Granger –Causality.

The estimated results of the VAR between real GDP and government expenditure are presented in table A3. The terms year and period are synonymous here. When GDP is the dependent variable, the 1 year lagged GDP significantly explains current year GDP. Rest of the lagged GDP coefficients are insignificant. More importantly, 1, 2 and 4 years lagged government expenditure terms are statistically significant in explaining current year GDP. When government expenditure is the dependent variable only the 1 year lagged GDP term is significant. R-square and adjusted R-square are both close to 99 percent implying that the VAR in table A3 is in fact very well fit. Since both G and GDP are integrated of order 1, additional 5th period lagged terms of both variables are introduced in the VAR as exogenous variables as per Toda-Yamamoto requirement. Apart from the intercept or constant, a structural break dummy variable is also included, the break date being taken as 1999 (the structural break dummy D_1999 assumes score 0 for pre 1999 observations and assumes score 1 for observations pertaining to 1999 onwards). The constant is insignificant in both models but the structural break dummy is statistically significant.

Before conducting Wald test for Granger Causality the statistical robustness of the VAR must be ensured. First, serial correlation if any must be eliminated from the VAR residuals. That is, VAR residuals must not be serially correlated and to this end the number of lagged endogenous regressors may have to be adjusted. Second, it is desirable that the VAR residuals be normal. Statistical testing and estimation based on non-normal disturbances may be problematic. The residual serial correlation LM tests for the GDP-G VAR were conducted in EVIEWS and the results are presented in table 4. The LM statistic is significant at 5.56 percent (so insignificant at 5 percent) only for the 6^{th} period lagged residual and the rest are statistically insignificant. The results of White's heteroscedasticity tests (not presented in tabulated form) reveal that the VAR residuals are jointly heteroscedastic at 6.2 percent level of significance as the computed Chi-square value of 81.09 for 63 degrees of freedom has a p-value of 0.062. Thus the homoscedasticity hypothesis may be accepted at 5 percent level but not at 10 percent level. The normality test results for the VAR residuals are shown in table 5. The joint hypothesis of zero skewness is accepted. Similarly the joint hypothesis of a kurtosis of 3 is also accepted. Finally the p-value corresponding to the Jarque-Bera test statistic is high implying that the joint null hypothesis of normality of residuals is accepted.

Table 4.6.4. The Residual Serial Correlation LM Tests For the GDP – Government Expenditure VAR

Lags	LM-Stat	Prob
1	8.428	0.0774
2	8.392	0.0605
3	2.424	0.6257
4	1.395	0.8265
5	7.988	0.0722
6	6.343	0.1457
7	4.121	0.3508
8	7.523	0.0883
9	7.418	0.0924
10	8.275	0.0637

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. The results as generated under the post VAR option of Residual Tests in EVIEWS 9 are exactly presented without rounding-off.

The Wald tests for Granger Non-Causality, tests for zero parameter restrictions on the coefficients of the lagged endogenous variables of the VAR model. However the exogenous variables are not dropped. The Wald test results of Granger non-causality between real GDP and G are presented in table 6. The first null hypothesis that G does not Granger-cause real GDP is rejected at less than 0.1 percent. Thus the alternative that G causes GDP is accepted. The second null hypothesis that GDP does not Granger-cause G is accepted at 17.11 percent. Thus Wagner's Law is found to be invalid for the Indian economy during the study period. Hence real GDP Granger causes G but the converse is not true. In other words there is uni-directional causality between real GDP and government expenditure and runs from G to GDP. So fiscal expansion in India is found to have a positive influence on real GDP, but whether this expansionary fiscal policy is independent or triggered due to monetary factors is beyond the scope of the present paper.

Table 4.6.5. The Real GDP–Government Expenditure VAR Model: Normality Test of Residuals

Method of Orthogonalization: Cholesky (Lutkepohl)				
Null Hypothesis: Residuals Are Multivariate Normal				
Component	**Skewness**	**Chi-sq**	**df**	**P-value**
1	-0.338781	1.091123	1	0.2962
2	0.420100	1.652338	1	0.1986
Joint		2.743461	2	0.2537
Component	**Kurtosis**	**Chi-sq**	**df**	**P-value**
1	2.108114	1.988652	1	0.1585
2	1.964485	2.680702	1	0.1212
Joint		4.669354	2	0.0968
Component	**Jarque-Bera Test Statistic**		**df**	**P-value**
1	3.136601		2	0.2084
2	4.443382		2	0.1084
Joint	7.579983		4	0.1082

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Residual Tests. The figures as reported in EVIEWS output sheet are exactly reproduced without rounding off.

Table 4.6.6. Wald Tests for Granger Causality between GDP and G (Included observations: 45)

Null Hypothesis	Chi-sq	df	P-value	Inference
(i) G does not Granger Cause GDP (absence of Keynesian mechanism)	28.53	5	<0.001	Reject Null Hypothesis
(ii) GDP does not Granger Cause G (absence of Wagner's Law)	7.74	5	0.1711	Accept Null Hypothesis

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Lag Structure. G represents government expenditure. The 2nd null hypothesis implies absence of Wagner's Law.

The Johansen Co-integration test between GDP and government expenditure are presented in table 7. Clearly the trace test and maximum eigen value test indicates 1 co-integrating vector each between real GDP and G implying thereby that there is a long run equilibrium relationship between real GDP and government expenditure in India over the period 1961-2010. The long – run co-integrating or equilibrium relationship justifies the causality results obtained earlier.

Table 4.6.7. Johansen Co-integration Test between GDP and G				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	P-value **
None *	0.622082	56.71246	17.99296	0
At most 1	0.006361	0.363783	3.756954	0.5503
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	P-value **
None *	0.622082	56.34867	16.77044	0
At most 1	0.006361	0.363783	3.756954	0.5503
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated and are not rounded off. G implies government expenditure.

Key Findings

The findings are suggestive of a uni-directional causality from government expenditure to GDP which supports the Keynesian prescription and Wagner's law is found to be invalid. Further both real GDP and government expenditure have a long-run co-integrating relationship. Hence short run causal relations may be expected. But to a certain extent fiscal expansion in India may not be economically independent of monetary expansion. Thus the second part of the second null hypothesis is rejected.

Table 4.6.A1. Comparing Goodness of Fit Statistics of Parabolic Trend Fitting vis-s-vis Exponential Trend Fitting for each Time Series Variable for the period 1961-2010

Variables	**Parabolic Trend Fitting**		**Exponential Trend Fitting**	
	R^2;Adj.R^2	AIC;SIC;HQ	R^2;Adj.R^2	AIC;SIC;HQ
GDP	0.961; 0.956	28.19; 28.28; 28.23	0.983; 0.974	-1.35; -1.28; -1.32
G	0.949; 0.939	34.21; 34.29; 34.24	0.989; 0.981	-2.18; -2.09; -2.13

Source: Computed on the basis of secondary time series data compiled from *RBI: Handbook of Statistics on the Indian Economy,* 2010.
Notes: Parabolic trend is fitted by estimating the model $y_t = \beta_0 + \beta_1.t + \beta_2.t^2$.

Table 4.6.A2. Optimum Lag Length Selection in VAR for the GDP and G Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1445.74	NA	5.221E+20	53.6951	53.8434	53.7523
1	-1323.23	226.8864	6.660E+18	49.3065	49.6029	49.4208
2	-1296.25	47.9665	2.867E+18	48.4562	48.9008	48.6277
3	-1287.67	14.6050	2.435E+18	48.2877	48.8806	48.5164
4	-1278.42	12.4659*	1.750E+18*	47.9464*	48.8353*	48.3800
5	-1270.41	15.0736	2.012E+18	48.0942	48.8357	48.2894*

Source: Estimated on the basis of Secondary Data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. Results are EVIEWS 9 generated.

Notes: * indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Table 4.6.A3. VAR Model Estimates between GDP and Government Expenditure (detrended) for India during 1961-2010

Endogenous Variables	Dependent Variables	
	GDP	G
GDP(-1)	1.103349	0.329476
	(0.169121)	(0.101528)
	[6.52420]	[3.24521]
GDP(-2)	-0.359945	0.009899
	(0.209091)	(0.125524)
	[-1.72148]	[0.07886]
GDP(-3)	0.293079	0.076447
	(0.213756)	(0.128322)
	[1.37109]	[0.59573]
GDP(-4)	-0.019958	-0.171119
	(0.235844)	(0.141588)
	[-0.08462]	[-1.20858]
G(-1)	0.499152	1.106018
	(0.202977)	(0.178831)
	[2.45916]	[6.18474]
G(-2)	1.489192	-0.028759
	(0.407112)	(0.244405)
	[3.65794]	[-0.11767]
G(-3)	-0.413816	-0.295683
	(0.441518)	(0.265055)
	[-0.93727]	[-1.11554]
G(-4)	1.193324	-0.160814
	(0.452657)	(0.271748)
	[2.63625]	[-0.59177]
Exogenous Variables		
C	-5937.78	8873.661
	(10091.5)	(6058.3)
	[-0.58840]	[1.46471]
D_1999	77121.97	24779.46
	(23960.3)	(13385.3)
	[3.21873]	[1.85132]
GDP(-5)	-0.04639	-0.18993
	(0.20952)	(0.12578)
	[-0.22143]	[-1.50995]
G(-5)	-0.84891	0.033951
	(0.36927)	(0.22169)
	[-2.29890]	[0.15315]
R-squared	0.987677	0.993068
Adj. R-squared	0.984780	0.991550
F-statistic	340.6348	653.7953
Log likelihood	-662.2313	-634.1949
Akaike AIC	24.51707	23.49756
Schwarz SC	24.95459	23.93508

Source: Estimated on the basis of Secondary data on relevant variables compiled from RBI: Handbook of Statistics of the Indian Economy, 2010. Estimations are done using EVIEWS 9 for Windows.

Notes: The figures as reported in EVIEWS output sheet are exactly reproduced in table 6 without rounding off. The structural break dummy (for 2004) and the two 5th period lagged terms of both variables are exogenous to the VAR system. The Granger Causality or Block Exogeneity Wald Tests imply zero parameter restrictions only the endogenous lagged terms i.e., on lag 1 to 4 only.

4.7 Causality between Fiscal Deficit and Money Supply

For the purpose of choosing the appropriate detrended series for each time series variable both exponential and parabolic curves are first fitted to the data and the goodness of fit statistics of both are presented (see table 4.7.A1). The EVIEWS reported values of R-square, adjusted R-square, AIC, SIC and HQ are presented for both models. It is evident that the exponential trend fit is a statistically better compared to the parabolic fit for each variable – fiscal deficit (FD) and broad money supply (M3). This is by virtue of obtaining higher R-square and lower AIC, SIC and HQ values in case of exponential trend fit. Thus the results in table A1 suggest that exponential detrending should be preferred over quadratic or parabolic detrending.

Identification of structural breaks in long run time series is important. Table 1 presents the results of Bai-Perron test for unknown multiple structural break points of original *vis-a-vis* de-trended annual time series of selected variables. Interestingly, the detrended series exhibit single break points only.

Table 4.7.1. Bai-Perron Test for Unknown Multiple Structural Break Points of Original *vis-a-vis* De-trended Annual Time Series

Variables	Break dates in Original Series	Break Dates in De-trended Series
FD	**1994, 2008**	**2004**
F-Statistic	56.87, 47.22	54.92
M3	**1994, 2004**	**2001**
F-Statistic	43.66, 29.31	21.95

Source: Computed on the basis of original and exponentially detrended time series data for major macroeconomic indicators of India (1970-2010) taken from *RBI: Handbook of Statistics on the Indian Economy,* 2010.
Notes: F-statistic values corresponding to each repatriation are presented below the break dates.

For detrended variables the break points are single – at 2004 and 2001 respectively for FD and M3. In other words there is some consistency in the time series behaviour of the detrended series of both fiscal deficit and broad money supply. The original or non-detrended series exhibits almost similar multiple break dates, 1994 and 2008 for FD and 1994 and 2004 for M3.

Table 4.7.2. Structural Break Point Unit Root Test of De-trended Time Series

Variables	ADF		Zivot-Andrews	
	Level	1st Diff.	Level	1st Diff.
FD	-6.747 (<0.01, 5)	NA	ŧ	ŧ
Break Date	2004	NA	NA	NA
M3	-14.88 (<0.01,5)	NA	-6.85 (<0.01,4)	NA
Break Date	2001	NA	2001	NA

Source: Estimated on the basis of secondary time series data on relevant variables (RBI: Handbook of Statistics on the Indian Economy, 2010) using EVIEWS 9 for Windows.

Notes: (i) Figures free of parenthesis in each cell are computed test statistic values. The first figure in parenthesis indicates p-value. For very small p-values (0.001, etc, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Criterion (automatic selection by the EVIEWS 9). (iii) A single unknown break date is selected by minimising the Dickey-Fuller t-Statistic automatically set in EVIEWS 9. (iv) FD denotes fiscal deficit.

ŧ In these cases Zivot-Andrews test statistic could not be computed as independent variable columns are near perfectly collinear resulting in near singular design matrix.

If a time series has a structural break the usual unit root test results (without incorporation of a break dummy) would be not only different, but would be misleading. Structural break point unit root tests are most appropriate under such circumstances. The structural break point unit root test results for detrended variables are shown in table 2. FD is found to be stationary at level according to the ADF test with a statistically significant break at 2004. Detrended broad money supply is found to be stationary at level according to both tests. Both tests suggest a structural break point at 2001 in case of broad money supply. EVIEWS 9 automatic optimum lag length selection option on the basis of Schwartz's Information Criterion is chosen while conducting these tests. The results in table 2 reveals that detrended FD and M3 are integrated of the same order in the sense that both are stationary at level.

Table 4.7.3. Stationarity Tests of Original Time Series (non-detrended) Ignoring Structural Breaks in the Series

Variable	ADF			PP			KPSS		
	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.	Level	1st Dif.	2nd Dif.
FD	4.899 (0.999,6)	-2.008 (0.282,5)	-5.012 (<0.01,7)	2.064 (0.999)	-6.875 (<0.01)	NA	0.661	0.432	0.270
M3	6.759 (0.999,6)	4.999 (0.999,6)	-2.195 (0.210,6)	24.162 (0.999)	5.108 (0.999)	-6.058 (<0.01)	0.635	0.635	0.694

Source: Estimated on the basis of secondary time series data on relevant variables taken from RBI: Handbook of Statistics on the Indian Economy, 2010.

Notes: (i) First figures in each cell are computed test statistic values. The first figures in parenthesis in each cell indicate p-value. For very small p-values (smaller than 0.001, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Information Criteria (automatic selection by the EVIEWS-9). (iii) Asymptotic critical values of KPSS Test Statistic with trend and intercept: 1% = 0.216; 5% = 0.146; 10%=0.119. 'Null hypothesis' for KPSS test is that the time series variable is stationary (or does not have unit root, which is contrary to ADF and PP tests).

The picture however is very different in table 3 which presents the stationarity test results of original time series (non-detrended) ignoring structural breaks. The ADF, PP and the KPSS test results are presented at level, first difference and second difference for each variable. In sharp contrast to the results in table 2, FD is non-stationary at level, or at first difference as per ADF statistic. FD is found stationary only at 2nd difference according to ADF statistic. According to PP test however, FD is stationary at first difference. M3 is not found to stationary even at 2nd difference according to ADF test but found to be stationary at 2nd difference according to PP test. The KPSS test shows no stationarity at level, first difference, or second difference in case of FD and M3. In sum, the contrasting results observed in tables 2 and 3 justifies the 'detrending of long run time series data' on the one hand and 'inclusion of structural break while testing for unit root' on the other.

After testing the structural break points and stationarity (i.e. unit roots), the vector auto regression (VAR) between and fiscal deficit and broad money supply and consequently the modified Granger–Causality test results are presented and discussed. But first the optimum lag length for the VAR (i.e., the number of lagged regressors to be incorporated) needs to be found. The EVIEWS 9 reported optimum lag length selection criteria results are presented in table A2 of the appendix. Most criteria suggest that 3 endogenous lags must be chosen in the VAR model. According to Toda-Yamamoto (1995) approach however (*p*+*m*) lags have to be incorporated in the VAR model where *m* is the maximum order of integration of variables in the group. The *m* additional lagged terms cannot be restricted to zero while testing for Granger–Causality for the Wald statistic to asymptotically follow a chi-square distribution. Apart from the intercept or constant, a structural break dummy variable is also included, the break date being taken as 2001 which is the break date for the detrended fiscal deficit series (the structural break dummy D_2001 assumes 0 for pre 2001 observations and assumes 1 for observations pertaining to 2001 and after). Since both detrended variables are stationary at level maximum order of integration in the group is 0, but for present an additional 4^{th} period lagged terms of both variables are introduced in the VAR as exogenous variables as per Toda-Yamamoto (1995) requirements which would not be restricted to zero while testing for Granger causality.

The estimated results of the VAR between fiscal deficit and broad money supply are presented in table A3 of the appendix. For the first equation where FD is the dependent variable it is found that the 1 period lagged FD term is statistically significant while the same for 2 and 3 period lags are found to be insignificant. The lagged money supply terms are also found to be statistically insignificant. In case of the second equation where M3 is the dependent variable, 1 and 2 period lagged FD terms positively influence M3 and both these terms are significant. Among the lagged money supply terms only the 1 period lagged term is found significant. The constant or intercept is statistically significant in both the models. This is also true for the structural break dummy terms imposed in the VAR at 2001. The estimated VAR result justifies the use of the structural break dummy terms. Both R-square, adjusted R-square and F-statistic values are very high for both models implying that the VAR presented in Table A3 is a well fit.

Before conducting Wald test for Granger Causality the statistical robustness of the VAR must be ensured. First, serial correlation if any must be eliminated from the VAR residuals. That is, VAR residuals must not be serially correlated and to this end the number of lagged endogenous regressors may have to be adjusted. Second, it is desirable that the VAR residuals be normal. Statistical inference based on non-normal disturbances would be problematic. The residual serial correlation LM tests for the FD – M3 VAR were conducted in EVIEWS 9 and the results are presented in table 4. Results in table 4 reveal that at none of the lags, the LM statistic is significant and hence it may safely be inferred that serial correlation is absent in the VAR residuals till lag 10. The results of White's heteroscedasticity tests (table not presented) imply that the null hypothesis that VAR residuals are jointly heteroscedastic can be rejected only at 11.30 percent level of significance as the computed Chi-square value of 48.78 for 38 degrees of freedom has a *P*-value of 0.1130. In other words the homoscedasticity hypothesis is accepted. The normality test results for the VAR residuals are shown in table 5. The joint hypothesis of zero skewness is accepted. Similarly the joint hypothesis of a kurtosis of 3 is also accepted. Finally the p-value corresponding to the Jarque-Bera test statistic is high implying that the joint null hypothesis of normality of residuals is accepted.

Table 4.7.4. The Residual Serial Correlation LM Tests For the Broad Money Supply – Fiscal Deficit VAR

Lags	LM-Stat	Prob
1	8.944	0.063
2	8.964	0.062
3	2.589	0.629
4	1.491	0.828
5	8.533	0.074
6	6.776	0.148
7	4.402	0.354
8	8.036	0.090
9	7.924	0.094
10	8.840	0.065

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. The results as generated under the post VAR option of Residual Tests in EVIEWS 9.

The Wald tests for Granger non-causality tests for zero parameter restrictions on the coefficients of the lagged endogenous variables of the VAR model. However the exogenous variables are not dropped (1 in the present VAR). The Wald test results of Granger non-causality between FD and M3 are presented in table 6. The first null hypothesis that FD does not Granger-cause M3 is rejected at less than 3.9 percent but not at 1 percent. Thus the alternative that FD causes M3 is accepted. The second null hypothesis that M3 does not Granger-cause FD is rejected at 9.6 percent, or in other words is accepted at 5 percent. Thus under the Toda-Yamamoto (1995) modified Granger causality approach, the present study finds that fiscal deficit Granger causes broad money supply, while the converse is not true, implying uni-directional causality from fiscal deficit to broad money supply but not the other way round. Thus to sum up, monetary expansion in India is found to have a fiscal cause or a fiscal stimulus over the study period which indicates that expansionary fiscal and monetary policies are most likely to be interdependent.

Table 4.7.5. The Fiscal Deficit – Broad Money Supply VAR Model: Normality Test of Residuals

Method of Orthogonalization: Cholesky (Lutkepohl)				
Null Hypothesis: Residuals Are Multivariate Normal				
Component	**Skewness**	**Chi-sq**	**df**	**P-value**
1	-0.4349	1.292702	1	0.256
2	-0.6185	2.613634	1	0.106
Joint		3.906336	2	0.142
Component	**Kurtosis**	**Chi-sq**	**df**	**P-value**
1	2.23664	0.99542	1	0.318
2	1.93749	1.92851	1	0.165
Joint		2.92393	2	0.232
Component	**Jarque-Bera Stat**		**df**	**P-value**
1	2.288122		2	0.319
2	4.542144		2	0.103
Joint	6.830266		4	0.145

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010.
Notes: The results are EVIEWS 9 generated under the post VAR option of Residual Tests. The figures as reported in EVIEWS output sheet are exactly reproduced.

Table 4.7.6. Wald Tests for Granger Causality between Fiscal Deficit and Broad Money Supply (Included observations: 38)

Null Hypothesis	**Computed Chi-sq**	**Degrees of freedom**	**P-value**	**Inference**
(i) FD does not Cause M3	8.367	3	0.039	Reject Null Hypothesis
(ii) M3 does not Cause FD	6.342	3	0.096	Accept Null Hypothesis

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010.
Notes: The results are EVIEWS 9 generated under the post VAR option of Granger causality.

The Johansen Co-integration test between fiscal deficit and broad money supply are presented in table 7. Clearly the trace test and maximum eigen value test indicates one co-integrating vector between fiscal deficit and broad money supply implying thereby that there is a long run equilibrium relationship between FD and M3 in India over the period 1970-2010. It may be argued however that the long–run co-integrating or equilibrium relationship between fiscal deficit and broad money supply justifies the uni-directional causality results obtained earlier.

Table 4.7.7. Johansen Co-integration Test between Fiscal Deficit and M3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	P-value **
None *	0.64214	58.54087	17.99296	0.000
At most 1	0.00657	0.37551	3.756954	0.550

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	P-value **
None *	0.64848	58.74011	16.77044	0.000
At most 1	0.00663	0.37922	3.756954	0.538

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated and are not rounded off.

Key Findings

The findings are suggestive of a unidirectional causality from fiscal deficit to broad money supply. Further both fiscal deficit and broad money supply are found to have a long-run co-integrating relationship. Hence short run causal relations could be expected. In sum monetary expansion in India is not independent of fiscal expansion but is rather triggered by the latter.

Table 4.7.A1. Comparing Goodness of Fit Statistics of Parabolic Trend Fitting vis-s-vis Exponential Trend Fitting for each Time Series Variable for the period 1970-2010				
Variables	**Parabolic Trend Fitting**		**Exponential Trend Fitting**	
	R^2;Adj.R^2	AIC;SIC;HQ	R^2;Adj.R^2	AIC;SIC;HQ
Fiscal Deficit	0.853; 0.839	56.88; 57.01; 56.97	0.973; 0.966	-1.99; -1.82; -1.89
M3	0.969; 0.945	36.21; 36.29; 36.24	0.988; 0.979	-2.22; -2.13; -2.17

Source: Estimated on the basis of secondary time series data compiled from *RBI: Handbook of Statistics on the Indian Economy,* 2010.

Table 4.7.A2. Optimum Lag Length Selection in the Fiscal Deficit–Broad Money VAR Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1313.8186	225.272881	6.61E+18	48.9558	49.25015	49.06934
1	-1287.0302	47.6253845	2.847E+18	48.1116	48.55304	48.28188
2	-1278.5092	14.5011322	2.422E+18	47.9443	48.53299	48.17137
3	-1269.3321	12.377244*	1.737E+18*	47.6543*	48.4831*	48.03594
4	-1261.3708*	14.966407	1.998E+18	47.7521	48.4884	47.9459*

Source: Estimated on the basis of Secondary Data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. Results are EVIEWS 9 generated.

Notes: * indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Table 4.7.A3. Estimated VAR Model between Fiscal Deficit and Broad Money Supply in India

	FD	M3
FD (-1)	1.23973	0.37020
	0.27507	0.11408
	(4.50694)	(3.24511)
FD (-2)	-0.40443	0.01112
	0.23494	0.00474
	(-1.72145)	(2.34599)
FD (-3)	0.32930	0.08590
	0.24018	0.14418
	(1.37107)	(0.59579)
M3 (-1)	0.56085	1.24273
	0.32807	0.20094
	(1.7087)	(6.18473)
M3 (-2)	1.67326	-0.03231
	1.25744	0.27462
	(1.33068)	(-0.11765)
M3 (-3)	-0.46497	-0.33223
	0.49609	0.29782
	(-0.93727)	(-1.11556)
Exogenous Variables		
C	-21.73218	31.47229
	10.99977	6.60358
	(-1.97569)	(4.76594)
d_2001	8.40629	4.88096
	2.61167	1.45900
	(3.21874)	(3.34542)
FD (-4)	-0.05057	-0.20702
	0.22838	0.13710
	(-0.22141)	(-1.51002)
M3 (-4)	-0.92531	0.03701
	0.94750	0.24164
	(-0.97658)	(0.15315)
R-squared	0.94422	0.959678
Adj. R-quared	0.94145	0.940484
F-stat	354.9551	681.2809
Log-likelihood	-633.0931	-690.072
Akaike AIC	23.43832	25.54777
Schwarz SC	23.85659	26.00368

Source: Estimated on the basis of Secondary data on relevant variables compiled from RBI: Handbook of Statistics of the Indian Economy, 2010. Estimations are done using EVIEWS 9 for Windows.

Notes: The figures as reported in EVIEWS output sheet are exactly reproduced in table A3 without rounding off. The structural break dummy (for 2004) and the two 4th period lagged terms of both variables are exogenous to the VAR system. The Granger Causality or Block Exogeneity Wald Tests imply zero parameter restrictions only the endogenous lagged terms i.e., on lag 1 to 3 only.

4.8 Causality between Money Supply and Index of Industrial Production

Table 4.8.1. Bai-Perron Test for Unknown Multiple Structural Break Points of Original *vis-a-vis* De-trended Annual Time Series

Variables	Break dates in Original Series	Break Dates in De-trended Series
IIP	**1968, 1985, 1993,2002**	**2003**
F-Statistic	71.09, 38.33, 81.69	54.92
M3	**1994, 2004**	**2002**
F-Statistic	43.66, 29.31	21.95
BR	**1978, 1990,1998,2006**	NA
F-Statistic	76.85, 49.66, 56.35, 82.42	NA

Source: Computed on the basis of original and exponentially detrended time series data for major macroeconomic indicators of India (1961-2010) taken from *RBI: Handbook of Statistics on the Indian Economy,* 2010.
Notes: F-statistic values corresponding to each repatriation are presented below the break date series. Bank Rate (BR) was not detrended as trend coefficient is found insignificant.

Table 4.8.2. Structural Break Point Unit Root Test of De-trended Time Series

Variables	**ADF**		**Zivot-Andrews**	
	Level	1^{st} Diff.	Level	1^{st} Diff.
IIP	-6.747 (<0.01, 5)	NA	-6.429 (<0.01, 4)	NA
Break Date	2003	NA	2003	NA
M3	-14.884 (<0.01,5)	NA	-8.853 (<0.01,4)	NA
Break Date	2001	NA	2001	NA
BR	-11.003 (<0.01,4)	NA	-9.872 (<0.01,4)	NA
Break Date	1998	NA	1998	NA

Source: Estimated on the basis of secondary time series data on relevant variables (RBI: Handbook of Statistics on the Indian Economy, 2010) using EVIEWS 9 for Windows.
Notes: (i) Figures free of parenthesis in each cell are computed test statistic values. The first figure in parenthesis indicates p-value. For very small p-values (0.001, etc, exact p-values are not presented, instead <0.01 is used. (ii) The second figures in parenthesis indicate optimum lag length as selected by Schwartz's Criterion (automatic selection by the EVIEWS 9). (iii) A single unknown break date is selected by minimising the Dickey-Fuller t-Statistic automatically set in EVIEWS 9. (iv) IIP denotes Index of Industrial Production.
@ In case of BR the tests are done on original series or non-detrended data.

Table 4.8.3 The Residual Serial Correlation LM Tests
For the IIP-Broad Money-Bank Rate VAR

Null Hypothesis: No serial correlation at lag order *h* (=10)

Lags	LM-Stat	P-value
1	2.90179	0.57439
2	4.22487	0.37643
3	5.09996	0.27719
4	7.25518	0.12300
5	8.07006	0.08905
6	8.78676	0.06666
7	2.49138	0.64618
8	7.19000	0.12618
9	7.15609	0.12787
10	8.89766	0.06371

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes**: The results are EVIEWS 9 generated under the post VAR option of Residual Tests and are exactly reproduced without rounding off.

Table 4.8.4. IIP – M3 – BR VAR Model: Normality Tests of Residuals

Method of Orthogonalization: Cholesky (Lutkepohl)

Null Hypothesis: Residuals Are Multivariate Normal

Component	Skewness	Chi-sq	df	P-value
1	0.0656682	0.040893	1	0.8481
2	0.6508813	3.547152	1	0.0630
Joint		3.818045	2	0.1482
Component	**Kurtosis**	**Chi-sq**	**df**	**P-value**
1	3.201090	0.085796	1	0.7696
2	3.514637	0.606952	1	0.4359
Joint		0.692748	2	0.7072
Component	**Jarque-Bera Test Statistic**		**df**	**P-value**
1	0.126689		2	0.9386
2	4.384104		2	0.1117
Joint	4.510793		4	0.3413

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR option of Residual Tests. The figures as reported in EVIEWS output sheet are exactly reproduced without rounding off.

Table 4.8.5. Pair-wise Granger Causality Tests between IIP, M3 and BR (Obs = 49, lag = 3)

Null Hypothesis	F-statistic	P-value	Inference
M3 does not Granger Cause IIP	2.89	0.048	Reject Null Hypothesis
IIP does not Granger Cause M3	2.08	0.119	Accept Null Hypothesis
M3 does not Granger cause BR	1.32	0.282	Accept Null Hypothesis
BR does not Granger cause M3	2.41	0.082	Accept Null Hypothesis
IIP does not Granger cause BR	0.74	0.535	Accept Null Hypothesis
BR does not Granger cause IIP	2.94	0.045	Reject Null Hypothesis

Source: Estimated from secondary data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. **Notes:** The results are EVIEWS 9 generated under the post VAR options of Paired Granger Causality.

Table 4.8.A1. Comparing Goodness of Fit Statistics of Parabolic Trend Fitting vis-s-vis Exponential Trend Fitting for each Time Series Variable for the period 1961-2010

Variables	Parabolic Trend Fitting		Exponential Trend Fitting	
	R^2;Adj.R^2	AIC;SIC;HQ	R^2;Adj.R^2	AIC;SIC;HQ
IIP	0.972; 0.963	28.19; 28.28; 28.23	0.989; 0.979	-1.35; -1.28; -1.32
M3	0.973; 0.968	32.13; 32.37; 32.28	0.979; 0.962	-1.87; -1.71; -1.84
BR	NA	NA	NA	NA

Source: Computed on the basis of secondary time series data compiled from *RBI: Handbook of Statistics on the Indian Economy,* 2010.
Notes: Parabolic trend is fitted by estimating the model $y_t = \beta_0 + \beta_1 . t + \beta_2 . t^2$.

Table 4.8.A2. Optimum Lag Length Selection in VAR between IIP – BR – M3

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1437.122	NA	5.19e+20	53.37490	53.52223	53.43172
1	-1315.334	225.5332	6.62e+18	49.01239	49.30705	49.12603
2	-1288.514	47.68038	2.85e+18	48.16719	48.60919	48.33765
3	-1270.798	12.39157*	1.74e+18*	47.66045*	48.34401*	48.09145
4	-1262.832*	14.98368	2.00e+18	47.80734	48.54445	48.00138*

Source: Estimated on the basis of Secondary Data compiled from RBI: Handbook of Statistics on the Indian Economy, 2010. Results are EVIEWS 9 generated.
Notes: * indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 4.8.A3. Estimates of VAR Model between IIP, M3 and BR for India (1960-2010)			
Endogenous Variables	**Dependent Variables**		
	IIP	**M3**	**BR**
IIP(-1)	1.104453 (0.16929) [6.52420]	0.329806 (0.10163) [3.24521]	0.39175 (-0.12072) [3.24521]
IIP(-2)	-0.360305 (0.20930) [-1.72148]	0.009909 (0.12565) [0.07886]	0.01177 (-0.14925) [0.07886]
IIP(-3)	0.293372 (0.21397) [1.37109]	0.076524 (0.12845) [0.59573]	0.09090 (-0.15257) [0.59573]
M3(-1)	-0.019978 (0.23608) [-0.08462]	-0.171290 (0.14173) [-1.20858]	-0.20346 (-0.16835) [-1.20858]
M3(-2)	0.499652 (0.20318) [2.45916]	1.107125 (0.17901) [6.18474]	1.31506 (-0.21263) [6.18474]
M3(-3)	1.490683 (0.40752) [3.65794]	-0.028788 (0.24465) [-0.11767]	-0.03419 (-0.29060) [-0.11767]
BR(-1)	-0.414230 (0.44196) [-0.93727]	-0.295979 (0.26532) [-1.11554]	-0.35157 (-0.31515) [-1.11554]
BR(-2)	-1.194519 (0.45311) [2.63625]	-0.160975 (0.27202) [-0.59177]	-0.19121 (-0.32311) [-0.59177]
BR(-3)	-0.079823 (0.113542) [-0.703026]	-1.207698 (1.647834) [-0.732900]	-0.33223 (0.29782) [-1.11556]
Exogenous Variables			
C	-5.94372 (10.1016) [-0.5884]	8.88264 (6.0646) [1.4647]	-13.87344 (6.45322) [-2.14992]
D_2003	77.19917 (23.8463) [3.21873]	24.80426 (13.3987) [1.85132]	16.56667 (38.3399) [0.43209]
IIP (-4)	-0.046441 (0.20973) [-0.22143]	-0.19011 (0.12591) [-1.50995]	-2.39923 (2.41536) [-0.9932]
M3(-4)	-0.849760 (0.36964) [-2.29890]	0.033985 (0.22191) [0.15315]	0.39175 (0.52072) (0.75376)
BR (-4)	-0.647391 (1.345951) [-0.48094]	-0.647391 (1.345951) [-0.48094]	0.0909 0.15257 [0.59573]
R-squared	0.946533	0.973755	0.958677
Adj. R-squared	0.933264	0.959875	0.947211
F-statistic	337.8221	454.4497	631.1536
Log likelihood	-682.5942	-614.8791	-612.232
Akaike AIC	24.54161	23.52108	22.68381
Schwarz SC	24.97957	23.95904	23.10618

Source: Estimated on the basis of Secondary data on relevant variables compiled from RBI: Handbook of Statistics of the Indian Economy, 2010. Estimations are done using EVIEWS 9 for Windows.

Notes: The figures as reported in EVIEWS output sheet are exactly reproduced in table 6 without rounding off. The structural break dummy (for 2004) and the two 5th period lagged terms of both variables are exogenous to the VAR system. The Granger Causality/Block Exogeneity/Wald Tests imply zero parameter restrictions only the endogenous lagged terms i.e., on lag 1 till 3 only.

This empirically demonstrates that broad money influences (Granger causes) Index of Industrial Production (IIP). Bank rate, which can be taken as a proxy for key lending rates, is also found to influence (Granger causes) IIP. However bank rate does not influence or is not influenced by broad money supply. Usually lending rates influence industrial production in the medium to short run but that is not supported by the present results.