CHAPTER- V

RESULTS AND DISSCUSSIONS

5.1 Results and Discussions

The VECM model of inflation rate in India measured by WPI Price inflation is being illustrated in following manner**.**

Model -1: INFL= β_1 M1 + β_2 R + β_3 YG +ε ……….. (1)

TABLE 5.1 – Descriptive Statistics

	INFL	M1	M3	R	V1	V3	YG
4 Mean	7.273913	12.06094	14.26130	8.235870	22.70865	11.03167	5.223950
Median	6.500000	11.96890	14.36992	8.500000	11.89917	4.104783	5.540870
Maximum	25.20000	21.57502	19.08139	12.00000	87.38663	58.47450	9.305246
Minimum	-2.500000	-11.37059	9.188179	3.000000	3.216914	0.762787	-5.527630
Std. Dev.	5.198694	5.206156	2.332289	1.928159	22.74536	14.56688	2.798301
Skewness	1.294952	-1.724849	-0.119998	-0.295475	1.198688	1.742997	-1.377007
Kurtosis	5.510459	10.19600	2.556104	3.105131	3.408408	5.182449	6.154124
Jarqu-Bera	24.93584	122.0588	0.488064	0.690528	11.33557	32.42088	33.60509
Probability	0.000004	0.000000	0.783463	0.708033	0.003456	0.000000	0.000000
Sum	334.6000	554.8033	656.0199	378.8500	1044.598	507.4567	240.3017
SumSq.De	1216.189	1219.683	244.7808	167.3008	23280.81	9548.731	352.3719
Obsern	46	46	46	46	46	46	46

Looking to this descriptive statistics table, it can be inferred that most of the variables considered for the analysis are normal as suggested by the Jarque-Bera test.

Table No. 5.2 Correlation Matrix

Covariance							
Prob	INFL	M1	M3	R	V1	V3	Y
INFL	26.43888						

M1	-10623.42**	49175434					
	0.0469	-----					
M3	-45653.45**	2.14E+08*	9.46E+08				
	0.0517	0.0000	-----				
R	0.775338	-1007.795	-4018.424	3.636974			
	0.6014	0.6187	0.6510	-----			
V1	23.80209	-86880.00*	-349715.8*	-11.50645	506.1045		
	0.1701	0.0001	0.0003	0.0715	-----		
V3	14.47946	-47447.95*	-190832.0*	-8.975085**	316.9340*	207.5811	
	0.1930	0.0010	0.0028	0.0267	0.0000	-----	
YG	-43804.48**	1.83E+08*	8.10E+08*	-2902.378	-333679.8*	-186068.5*	7.17E+08
	0.0312	0.0000	0.0000	0.7076	0.0001	0.0007	-----

***, ****Denotes 1% and 5% significant level respectively.

The above table deals with correlation matrix. Looking to the raw data, there is significant correlation among INFL, M1, M3 and YG while R is negatively correlated with V3. Growth rate of GDP is negatively correlated with INFL, V1 and V3 while positively correlated with M1 and M3. There isn't any significant correlation found between R and YG.

Table No. 5.3 Unit Root Test at Level

Variables	ADF Test at Level		PP Test at Level		KPSS Test at Level	
	C	C & T	C	C & T	C	C & T
INFL	-4.365840* (0.0011)	-5.349041* (0.0004)	-4.288609* (0.0014)	-4.568486* (0.0035)	0.370676* (3)	0.089474* (9)
M1	-7.724984* (0.0000)	-7.638131* (0.0000)	-7.663630* (0.0000)	-7.583549* (0.0000)	0.128245* (2)	0.122668* (2)
M3	-4.604086* (0.0005)	-4.828818* (0.0017)	-4.613702* (0.0005)	-4.802984* (0.0018)	0.222720* (2)	0.102685* (2)
R	-2.524809 (0.1165)	-2.473158 (0.3393)	-2.494553 (0.1235)	-2.400936 (0.3742)	0.129486* (5)	0.132308*(5)
V1	-3.505766** (0.0128)	-1.652321 (0.7545)	-8.109608* (0.0000)	-3.670073** (0.03491)	0.780953 (5)	0.232996 (5)
V3	-6.448097* (0.0000)	-5.591960* (0.0002)	-68.08073* (0.0001)	-39.31021* (0.0000)	0.701906*(5)	0.211954* (5)
YG	-5.908045* (0.0000)	-8.013172* (0.0000)	-6.016459* (0.0000)	-9.468926* (0.0000)	0.797212(4)	0.091049*(7)

Cointegration Analysis for first equation.

Following Engle and Granger (1987), the estimated co-integrating regression for the level series (growth rate of Wholesale Price Index) is given below. The following table provides results. The constant is significant at 5 % level. Only Growth rate of GDP –YG is significantly.

Table No. 5.4 Cointegration analysis

Dependent Variables	Independent Variables			
	CONSTANT	YG	R	M1
INFL	8.62593 ** (3.34185) (0.0134)	−0.870855* (0.259695) (0.0017)	0.487888 (0.392914) (0.2212)	−0.0680623 (−0.4741) (0.6379)
	R^2 = 0.216 Adj. R^2 = 0.160 D.W. = 1.341			

***, ****Denotes 1% and 5% significant level respectively.

The ADF test for the residuals is stationary

The following table provides the possible lag length to be appropriate for the above mention equation. As per the all of the criteria, one lag is appropriate to estimate VAR for this model.

Table No 5.5 ADF Test In First Equation for residuals

VAR Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-435.1841	NA	14215.02	20.91353	21.07902	20.97419
1	-397.4986	66.39820*	5084.313*	19.88089*	20.70835*	20.18418*
2	-383.9354	21.31354	5839.520	19.99693	21.48636	20.54286
3	-375.6137	11.49195	8910.689	20.36256	22.51396	21.15113
4	-363.4203	14.51596	11954.53	20.54382	23.35719	21.57503
* 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

Following Johansen (1988), the Johansen test of co-integration for the level series of the growth rate of WPI has been given in the below table.

Johansen test Cointegration for Growth rate of WPI (Level Series)

Table No 5.6 Johansen test Cointegration

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.590176	82.91535	63.87610	0.0006
At most 1 *	0.413829	43.66617	42.91525	0.0420
At most 2	0.264450	20.16385	25.87211	0.2177
At most 3	0.140266	6.649819	12.51798	0.3825
Trace test indicates 2 cointegration eqn (s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

The values of the trace test indicate that there are two cointegration vectors in this estimated VAR. While the below table provides information on λ Max Eigenvalue test for number of co-integration in the equation. It suggests only one co-integration equation. As there has been contradictory results been found for both of the tests, the thumb rule is applied and that is the test which suggests higher co-integration equation has to be considered.

Table No 5.7 Johansen test Co-integration for Growth rate of WPI (Level Series)

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.590176	39.24918	32.11832	0.0057
At most 1	0.413829	23.50231	25.82321	0.0983
At most 2	0.264450	13.51404	19.38704	0.2883
At most 3	0.140266	6.649819	12.51798	0.3825
Max-eigenvalue test indicates 1 cointegration eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Analysis of VECM for First Model Specification:

After having confirmed with the numbers of cointegration equation in the model, the estimates of VECM are discussed in the following four equations.

Table No 5.8 VECM for First equation Model

Dependent Variables	Independent Variables						
	ECT-1	ECT-2	Δ(INFL(-1))	Δ (M1(-1))	Δ (R(-1))	Δ(YG(-1))	CONSTANT
ΔINFL	-0.955229* (0.0000)	0.218624** (0.0212)	0.355247** (0.0240)	0.153979 (0.2113)	0.152382 (0.7918)	0.183148 (0.5247)	-0.172863 (0.7851)
	R^2 = 0.577989 Adj. R^2 = 0.509555 D.W. = 2.004537						
Dependent Variables	Independent Variables						
	ECT-1	ECT-2	Δ(INFL(-1))	Δ (M1(-1))	Δ (R(-1))	Δ(YG(-1))	CONSTANT

ΔM1	0.060415 (0.8443)	-0.066986 (0.6397)	-0.345832 (0.1464)	-0.561871** (0.0031)	-0.71175 (0.4180)	-0.155133 (0.7230)	0.002810 (0.9977)
	R^2 = 0.468640 Adj. R^2 = 0.382474 D.W. = 2.141063						
Dependent Variables	Independent Variables						
	ECT-1	ECT-2	Δ(INFL(-1))	Δ (M1(-1))	Δ (R(-1))	Δ(YG(-1))	CONSTANT
ΔR	0.056555 (0.3991)	-0.005994 (0.8475)	0.012431 (0.8100)	-0.005588 (0.8908)	-0.070682 (0.7117)	0.077556 (0.4164)	0.029723 (0.8874)
	R^2 = 0.099063 Adj. R^2 = -0.047035 D.W. = 2.003659						
Dependent Variables	Independent Variables						
	ECT-1	ECT-2	Δ(INFL(-1))	Δ (M1(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT
ΔYG	-0.005139 (0.9615)	0.200851* (0.0001)	0.004323 (0.9580)	-0.211783* (0.0013)	0.156571 (0.6066)	0.144109 (0.3423)	0.107383 (0.7477)
	R^2 = 0.709055 Adj. R^2 = 0.661875D.W. = 1.979418						

***, ****Denotes 1% and 5% significant level respectively.

The above table contains both of the co-integrated estimated equations. In first equation growth of the WPI in the current period is associated with its previous period that is its first lag. Along with the first period lag of other variables like M1, R and YG are also estimated. Both of the error terms in the equations are significant but only first error term with negative sign is considered for analysis. Thus it took 95 % adjustment within one year to adjust the error. Lag of the INFL is positively and significantly associated with the dependent variable. In equation two, current period of growth rate of M1 is negatively and significantly associated with its lagged value while other variables in the system are insignificant with no error correction mechanism in the equation.

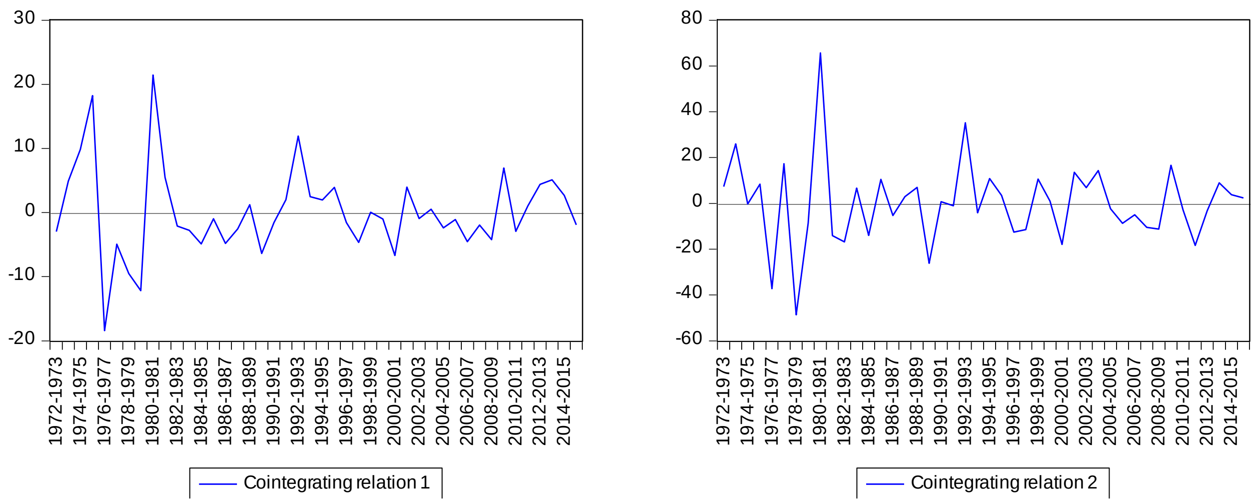
The third equation is with interest rate as the dependent variable and found no variable significantly associated in the system. The last equation shows the growth rate of GDP as dependent variable and having only negative and significant association with lagged value of M1 with no error correction mechanism.

Though, there have been two co-integrating equations, but only single equations shows appropriate error correction mechanism in the system.

Figure No- 5.1.1: First Equation VECM First Model

The above estimated residuals graph provide enough indication that most of the estimated residuals are approaching to zero except in the case of INFL.

Figure No 5.1.2 Cointegration



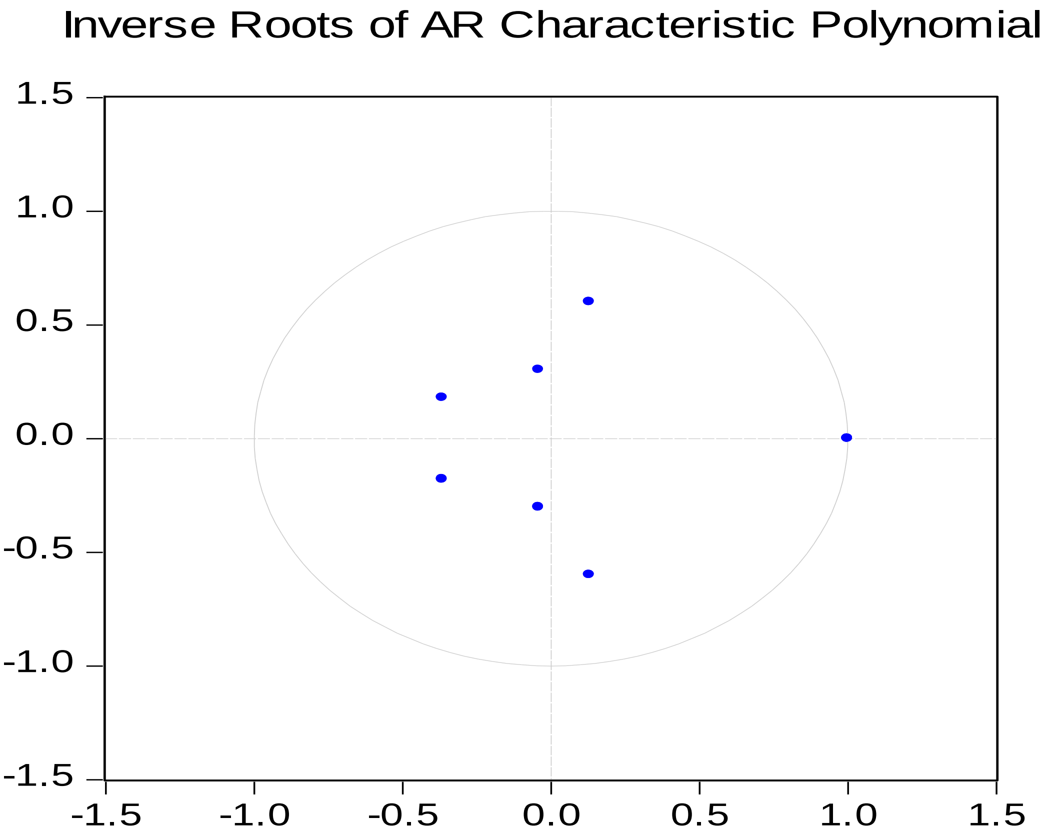
Both of the cointegration relationship showed equilibrium approach with quite stable relations.

Table No 5.9 First Equation Polynomial Test Model

Roots of Characteristic Polynomial	
Endogenous variables: INFL M1 R YG	
Root	Modulus
1.000000	1.000000
1.000000	1.000000
0.130314 - 0.599434i	0.613436
0.130314 + 0.599434i	0.613436
-0.364912 - 0.178621i	0.406284
-0.364912 + 0.178621i	0.406284
-0.040181 - 0.302191i	0.304850
-0.040181 + 0.302191i	0.304850
VEC specification imposes 2 unit root(s).	

The above table provides the roots of characteristic polynomial of the variables of the level series are given where it confirmed 2 cointegration relations and others are less than on and all lie inside the circle which is plotted in following figure.

Figure No -5.1.3: Inverse Roots of AR Characteristic polynomial



All the roots lay inside the circle and 2 roots are equal to 1 and others are less than one, therefore, variables are co-integrated in the order of CI (2,2).

Diagnostic Testing

Table no- 5.10 First Equation Autocorrelation Model (X^2 Distribution):

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
1	1.703965	NA*	1.743592	NA*	NA*
2	11.91422	0.9916	12.44005	0.9884	26

3	27.50871	0.9588	29.17560	0.9331	42
4	35.06408	0.9926	37.48650	0.9833	58
5	52.57836	0.9720	57.24621	0.9253	74
6	63.33085	0.9852	69.69646	0.9446	90
7	77.88937	0.9816	87.00930	0.9107	106
8	84.52277	0.9961	95.11678	0.9659	122
9	89.77535	0.9995	101.7200	0.9911	138
10	104.4913	0.9992	120.7643	0.9779	154

The above table provides diagnostic test –autocorrelation for the residual. It deals with Q statistics and Adjusted Q- statistics with their respective probabilities. And it shows that residuals are not suffering from the problem of the autocorrelation as the Ho = NO residual autocorrelation up to lag h cannot be rejected as per the VEC residual Portmanteau test.

Table No 5.11 First Equation VECM Residual Serial Correlation LM Test

Lags	LM-Stat	Prob
1	9.128473	0.9080
2	13.85990	0.6092
3	20.30596	0.2068
4	9.041435	0.9117
5	16.99197	0.3861
6	11.19127	0.7975
7	17.40909	0.3596
8	6.957486	0.9741
9	5.352296	0.9937

10	14.77641	0.5411

The table above is the serial correlation LM test showed the values of LM statistics for Lags 1 to 10 and all are insignificant. Thus the null hypothesis Ho= No serial Correlation cannot be rejected. Thus residuals are free from the serial correlation.

Table no 5.12 first Equation Normality Test of Skewness

Component	Skewness	Chi-sq	Df	Prob.
1	0.151735	0.213006	1	0.6444
2	-0.415215	1.525186	1	0.2168
3	-1.066252	8.086511	1	0.0045
4	0.005528	0.000285	1	0.9865
Joint		9.824989	4	0.0435

Table no 5.13 first Equation Normality of Kurtosis

Component	Kurtosis	Chi-sq	df	Prob.
1	3.840337	4.223126	1	0.0399
2	3.752802	2.075641	1	0.1497
3	4.212229	1.064290	1	0.3022
4	2.631003	0.008690	1	0.9257
Joint		7.371747	4	0.1175

Table No- 5.14 first Equation Jarque- Bera Test

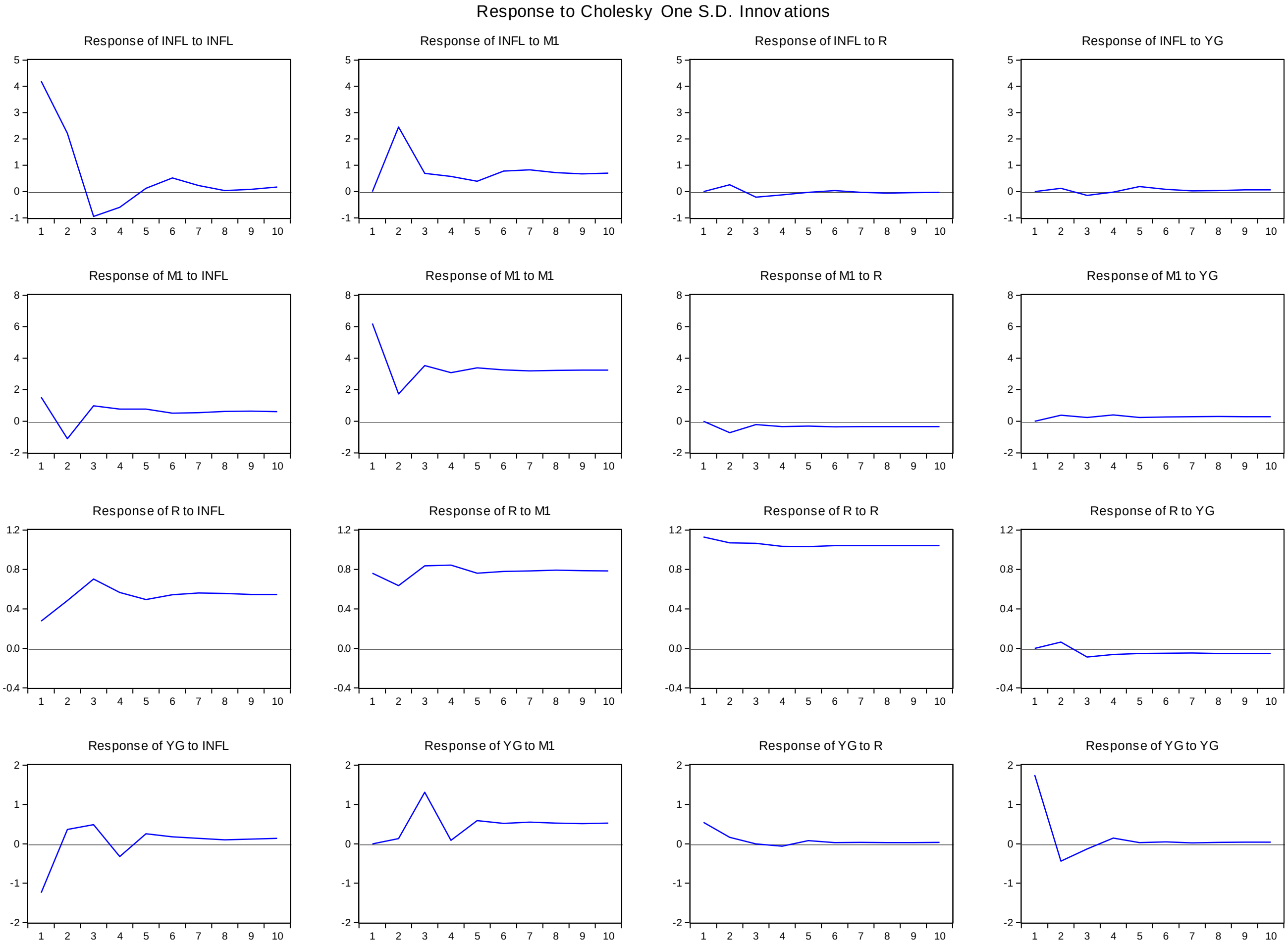
Component	Jarque-Bera	df	Prob.
1	4.436132	2	0.1088

2	3.600827	2	0.1652
3	9.150801	2	0.0103
4	0.008975	2	0.9955
Joint	17.19674	8	0.0281

The normality test has been performed using Orthogonalisation of Residual correlation (Doornik-Hansen). The orthohogonalised residuals are obtained by a principal component decomposition of the original residual correlation. The orthogonalised residuals are uncorrelated by construction and independent under the assumption of normality. The Skewness, Chi-square and Kurtosis with their joint probability have been tested. The null hypothesis H_o- Residuals are multivariate normal, cannot be rejected.

The impulse response functions are given in the below figure. There are stable as well as unstable functions can be seen in the figure. Those of the functions which are not coming to zero i.e. diverting from zero are termed as unstable. INFL to INFL, INFL to R, INFL to YG, M1 to INFL, M1 to R, M1 to YG, YG to INFL, YG to R and YG to YG are the stable impulse responses can be seen in the figure.

Figure No 5.1.4 The Impulse Response Function of first equation



5.2 Some Implications

Looking to the econometric techniques used and the results derived. It can be inferred based on that INFL in India is highly influenced by the growth rate of GDP along with Lagged value of inflation growth rate based on WPI.

Model 2: Second Equation Model

INFL= β_1 M3 + β_2 R + β_3 YG +ε …………………………………………….. (2)

Cointegration Analysis for Second equation.

Following Engle and Granger (1987), the estimated cointegration regression for the level series (growth rate of Wholesale Price Index) is given below.

Table No 5.15 Cointegration Analysis of second Equation

Dependent Variables	Independent Variables			
	CONSTANT	YG	R	M3
INFL	9.57056*** (1.814) (0.0769)	−0.863407* (−3.332) (0.0018)	0.443799 (1.178) (0.2453)	−0.101065 (−0.3288) (0.7439)
	R^2 = 0.214 Adj. R^2 = 0.157 D.W. = 1.386			

Lag Length Criteria.

The following table provides the possible lag length to be appropriate for the above mention equation. As per the all of the criteria, one lag is appropriate to estimate VAR for this model.

Table No 5.16 Equation of Second Lag length Selection in

VAR Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-403.3250	NA	3118.027	19.39643	19.56192	19.45709
1	-370.7056	57.47233*	1419.495*	18.60503*	19.43249*	18.90832*
2	-358.0987	19.81074	1706.303	18.76661	20.25604	19.31254
3	-347.0790	15.21774	2289.782	19.00376	21.15516	19.79233
4	-336.3281	12.79867	3290.392	19.25372	22.06709	20.28493
* 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

Johansen test Cointegration for Growth rate of WPI (Level Series) Trace Statistics

Table No 5.17 Model Second Equation

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.564320	78.30439	63.87610	0.0019
At most 1	0.432069	41.74706	42.91525	0.0652
At most 2	0.186614	16.85383	25.87211	0.4260
At most 3	0.161795	7.765654	12.51798	0.2714
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				

Johansen test Cointegration for Growth rate of WPI (Level Series) Maximum Eigenvalue

Table No.5.18 Statistics Second equation model

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**

None *	0.564320	36.55733	32.11832	0.0134
At most 1	0.432069	24.89323	25.82321	0.0660
At most 2	0.186614	9.088172	19.38704	0.7154
At most 3	0.161795	7.765654	12.51798	0.2714
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				

Analysis of VECM for Second Model Specification:

After having confirmed with the numbers of cointegration equation in the model, the estimates of VECM are discussed in the following four equations.

Table No 5.19 Second Equation Model Specification

Dependent Variables	Independent Variables					
	ECT-1	Δ(INFL(-1))	Δ (M3(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT
ΔINFL	- 0.204940*** (0.0806)	-0.248926 (0.1276)	0.478495 (0.1756)	0.428136 (0.5028)	0.331077 (0.3953)	-0.192146 (0.8184)
	R^2 = 0.245603 Adj. R^2 = 0.146341 D.W. = 2.086294					
Dependent Variables	Independent Variables					
	ECT-1	Δ(INFL(-1))	Δ (M3(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT
ΔM3	0.054127 (0.2498)	-0.236832* (0.0004)	-- 0.401373* (0.0051)	0.031960 (0.9009)	-0.293145*** (0.0624)	-0.116623 (0.7289)
	R^2 = 0.434765 Adj. R^2 = 0.360392 D.W. = 2.286489					
Dependent Variables	Independent Variables					
	ECT-1	Δ(INFL(-1))	Δ (M1(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT

ΔR	-0.017227 (0.5460)	0.037417 (0.3474)	-0.137257 (0.1122)	-0.021942 (0.8881)	0.113136 (0.2350)	0.019887 (0.9225)
	R^2 = 0.124133 Adj. R^2 = 0.008888 D.W. = 2.112057					
Dependent Variables	Independent Variables					
	ECT-1	Δ(INFL(-1))	Δ (M1(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT
ΔYG	-0.164078* (0.0067)	0.181525** (0.0307)	-0.297192 (0.1009)	0.091272 (0.7802)	0.049592 (0.8034)	0.109618 (0.7981)
	R^2 = 0.508098 Adj. R^2 = 0.443375 D.W. = 2.023646					

*, **Denotes 1% and 5% significant level respectively.

Figure No. 5.1.5 Graphs of Residuals

Figure No. 5.1.6 Cointegration Graph

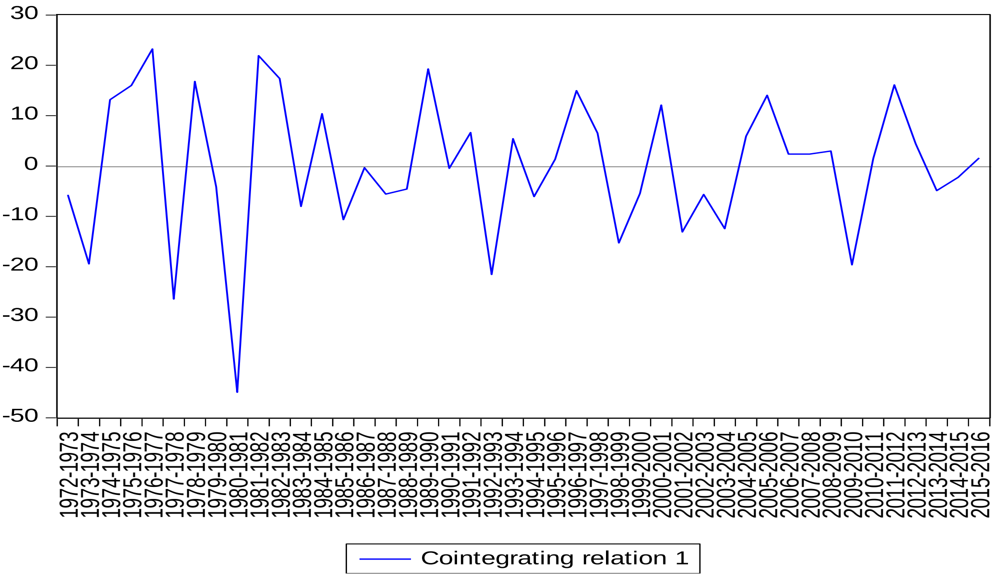
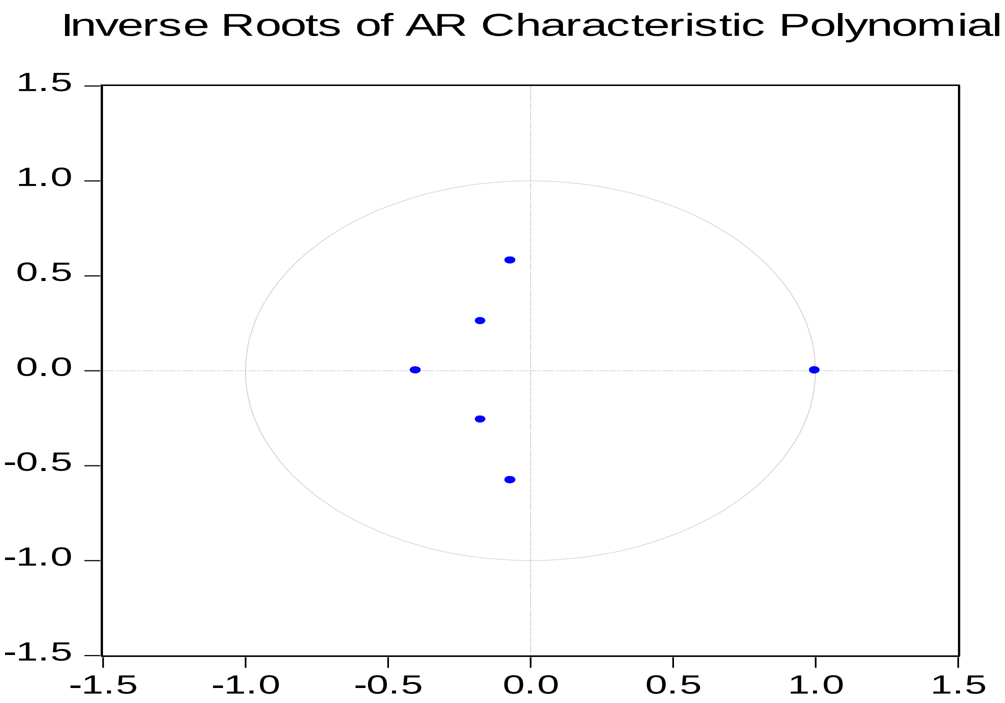


Table No. 5.20 Second Equation polynomial characteristics

Roots of Characteristic Polynomial	
Root	Modulus
1.000000	1.000000
1.000000	1.000000
1.000000	1.000000
-0.068643 - 0.578747i	0.582803
-0.068643 + 0.578747i	0.582803
-0.399743	0.399743
-0.172461 - 0.258937i	0.311112
-0.172461 + 0.258937i	0.311112
VEC specification imposes 3 unit root(s).	

Figure No .5.1.7



Diagnostic Testing

Table No. 5.21 Second Equation Autocorrelation (X^2 Distribution)

VEC Residual Portmanteau Tests for Autocorrelations					
Null Hypothesis: no residual autocorrelations up to lag h					
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
1	5.283087	NA*	5.405950	NA*	NA*
2	22.98032	0.7774	23.94591	0.7316	29
3	40.75742	0.6522	43.02377	0.5560	45
4	55.98323	0.6578	59.77216	0.5205	61
5	73.31397	0.5979	79.32480	0.4055	77
6	82.92405	0.7636	90.45226	0.5555	93
7	93.96586	0.8470	103.5831	0.6285	109
8	101.2883	0.9411	112.5327	0.7805	125
9	112.4836	0.9631	126.6067	0.8018	141
10	125.8277	0.9681	143.8756	0.7656	157
*The test is valid only for lags larger than the VAR lag order.					
df is degrees of freedom for (approximate) chi-square distribution					

Table NO. 5.22 Second Equation VECM Residual Serial Correlation LM Test

VEC Residual Serial Correlation LM Tests		
Null Hypothesis: no serial correlation at lag order h		
Lags	LM-Stat	Prob
1	22.02215	0.1425
2	18.35130	0.3037
3	19.48372	0.2444
4	17.08290	0.3803
5	16.79411	0.3990
6	10.40129	0.8448
7	11.54609	0.7746
8	7.120935	0.9709
9	10.97175	0.8112
10	13.27225	0.6528
Probs from chi-square with 16 df.		

Table No. 5.23 Second Equation Normality Test for Skewness

Component	Skewness	Chi-sq	Df	Prob.
1	-0.651159	3.508255	1	0.0611
2	0.091283	.077449	1	0.7808
3	-0.921455	6.385168	1	0.0115
4	-1.053308	7.931352	1	0.0049
Joint		17.90222	4	0.0013

Table No. 5.24 Second Equation Normality Test for Kurtosis

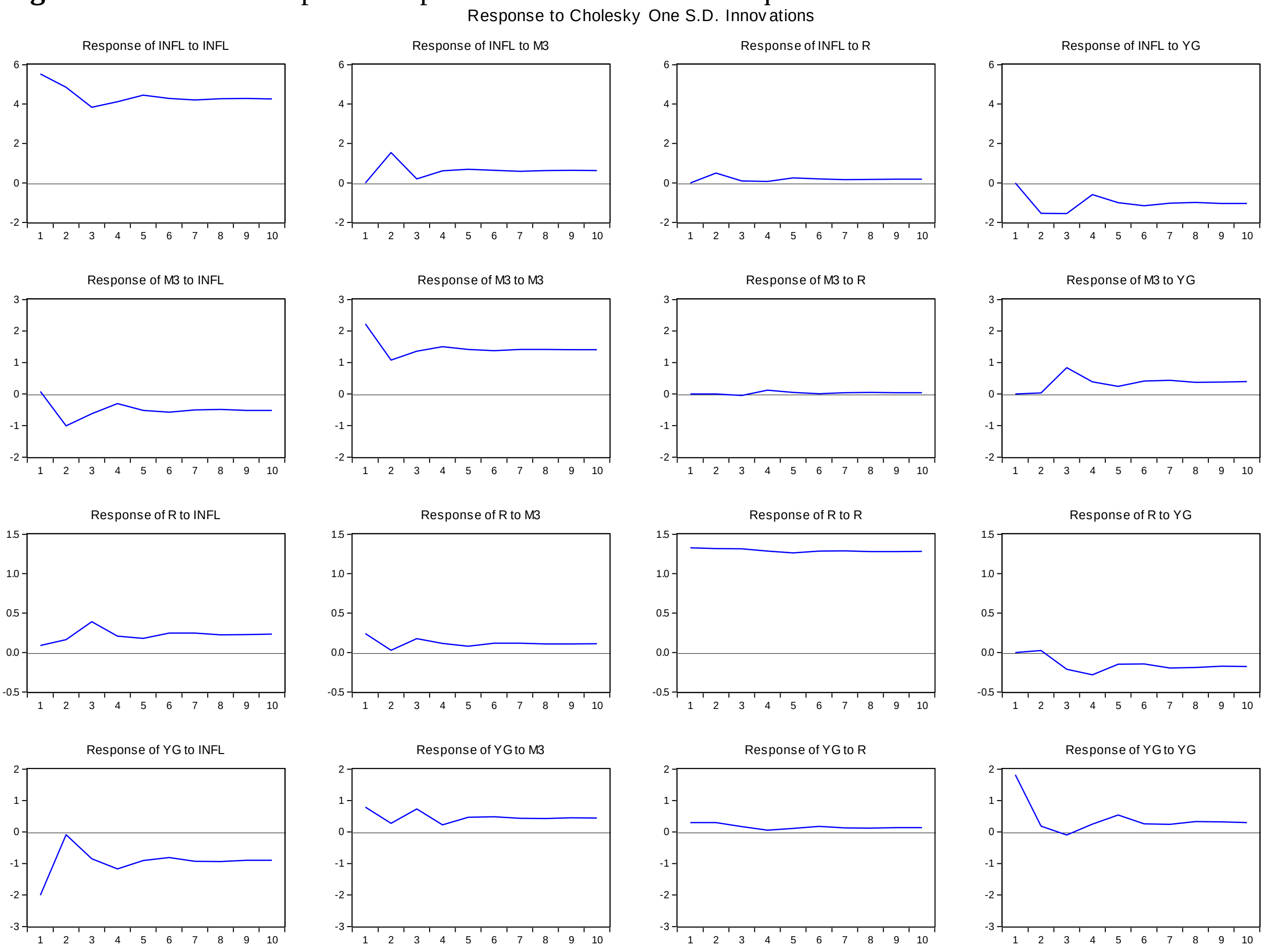
Component	Kurtosis	Chi-sq	Df	Prob.
1	4.774492	4.444069	1	0.0350
2	2.017859	1.974309	1	0.1600
3	4.368377	0.043780	1	0.8343
4	5.415725	0.986900	1	0.3205

Joint		7.449057	4	0.1140

Table No. 25 Second Equation Jarque-Bera Test

Component	Jarque-Bera	Df	Prob.
1	7.952324	2	0.0188
2	2.051757	2	0.3585
3	6.428947	2	0.0402
4	8.918252	2	0.0116
Joint	25.35128	8	0.0014

Figure No.5.1.7 The Impulse Response Function of second equation



Some Implications

Looking to the econometric techniques used and the results derived. It can be inferred based on that inflation in India is highly influenced by the growth rate of GDP along with Lagged value of inflation growth rate based on M3 and interest rate.

Model-3: Third Equation

INFL= β_1 V1 + β_2 R + β_3 YG +ε ………… (3)

Cointegration Analysis for third equation.

Following Engle and Granger (1987), the estimated cointegrating regression for the level series (growth rate of Wholesale Price Index) is given below.

Third equation Cointegration Analysis Table No.5.26

Dependent Variables	Independent Variables			
	CONSTANT	YG	R	V1
INFL	7.44665 *** (1.931) (0.0603)	−0.813430* (−2.856) (0.0066)	0.460129 (1.200) (0.2370)	0.0126389 (0.3529) (0.7259)
	R^2 = 0.214 Adj. R^2 = 0.158 D.W. = 1.395			

Lag Length Criteria

The following table provides the possible lag length to be appropriate for the above mention equation. As per the all of the criteria, one lag is appropriate to estimate VAR for this model.

Table No 5.27 Third Equation lag length Criteria

VAR Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-482.2985	NA	134000.9	23.15707	23.32257	23.21773
1	-350.9631	231.4006	554.4280	17.66491	18.49237*	17.96820
2	-329.3554	33.95491*	434.1342*	17.39788	18.88731	17.94381*

3	-313.1489	22.38038	455.0894	17.38804	19.53944	18.17662
4	-295.7230	20.74517	475.8886	17.32014*	20.13351	18.35135
* 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 No. 5.28 Johansen test Cointegration for Growth rate of WPI (Level Series) Trace Statistics Third Equation

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.668212	102.1900	63.87610	0.0000
At most 1 *	0.487465	53.64653	42.91525	0.0031
At most 2	0.313588	24.23755	25.87211	0.0788
At most 3	0.160187	7.681364	12.51798	0.2788
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Table No. 5.29 Johansen test Cointegration for Growth rate of WPI (Level Series) Maximum Eigenvalue Statistics Third Equation

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.668212	48.54344	32.11832	0.0002
At most 1 *	0.487465	29.40898	25.82321	0.0161
At most 2	0.313588	16.55619	19.38704	0.1230
At most 3	0.160187	7.681364	12.51798	0.2788
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Analysis of VECM for Third Model Specification:

After having confirmed with the numbers of cointegration equation in the model, the estimates of VECM are discussed in the following four equations

Table No. 5.30 Third Equation Model of Analysis of VECM

Dependent Variables	Independent Variables						
	ECT-1	ECT-2	Δ(INFL(-1))	Δ (V1(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT
ΔINFL	-0.741130* (0.0000)	-0.157271* (0.0000)	0.094399 (0.5086)	-1.500785* (0.0000)	-0.613487 (0.3098)	0.381873 (0.1999)	-3.003170* (0.0008)
	R^2 = 0. 0.561589 Adj. R^2 = 0.490495 D.W. = 1.976344						
Dependent Variables	Independent Variables						

	ECT-1	ECT-2	Δ(INFL(-1))	Δ (V1(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT
ΔV1	-0.125241 (0.2947)	- 0.041219** (0.0425)	0.228093** (0.0236)	0.163879 (0.4647)	0.350519 (0.4067)	-0.227680 (0.2744)	-1.368838** (0.0269)
	R^2 = 00.254661 Adj. R^2 = 0.133796 D.W. = 1.866926						
Dependent Variables	Independent Variables						
	ECT-1	ECT-2	Δ(INFL(-1))	Δ (V1(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT
ΔR	0.031007 (0.5508)	0.018485 ** (0.0367)	0.019798 (0.6490)	0.209757** (0.0328)	0.122522 (0.5052)	0.111286 (0.2202)	0.418550 (0.1186)
	R^2 = 0.208246 Adj. R^2 = 0.079854 D.W. = 1.978582						
Dependent Variables	Independent Variables						
	ECT-1	ECT-2	Δ(INFL(-1))	Δ (V1(-1))	Δ (R(-1))	Δ (YG(-1))	CONSTANT
ΔYG	-0.099364 (0.3277)	0.041190** (0.0173)	0.194294** (0.0232)	0.573543* (0.0030)	0.560203 (0.1197)	0.022917 (0.8968)	1.197031** (0.0228)
	R^2 = 0.614711 Adj. R^2 = 0.552232 D.W. = 1.872853						

***, ****Denotes 1% and 5% significant level respectively.

Figure No 5.1.8 Residual

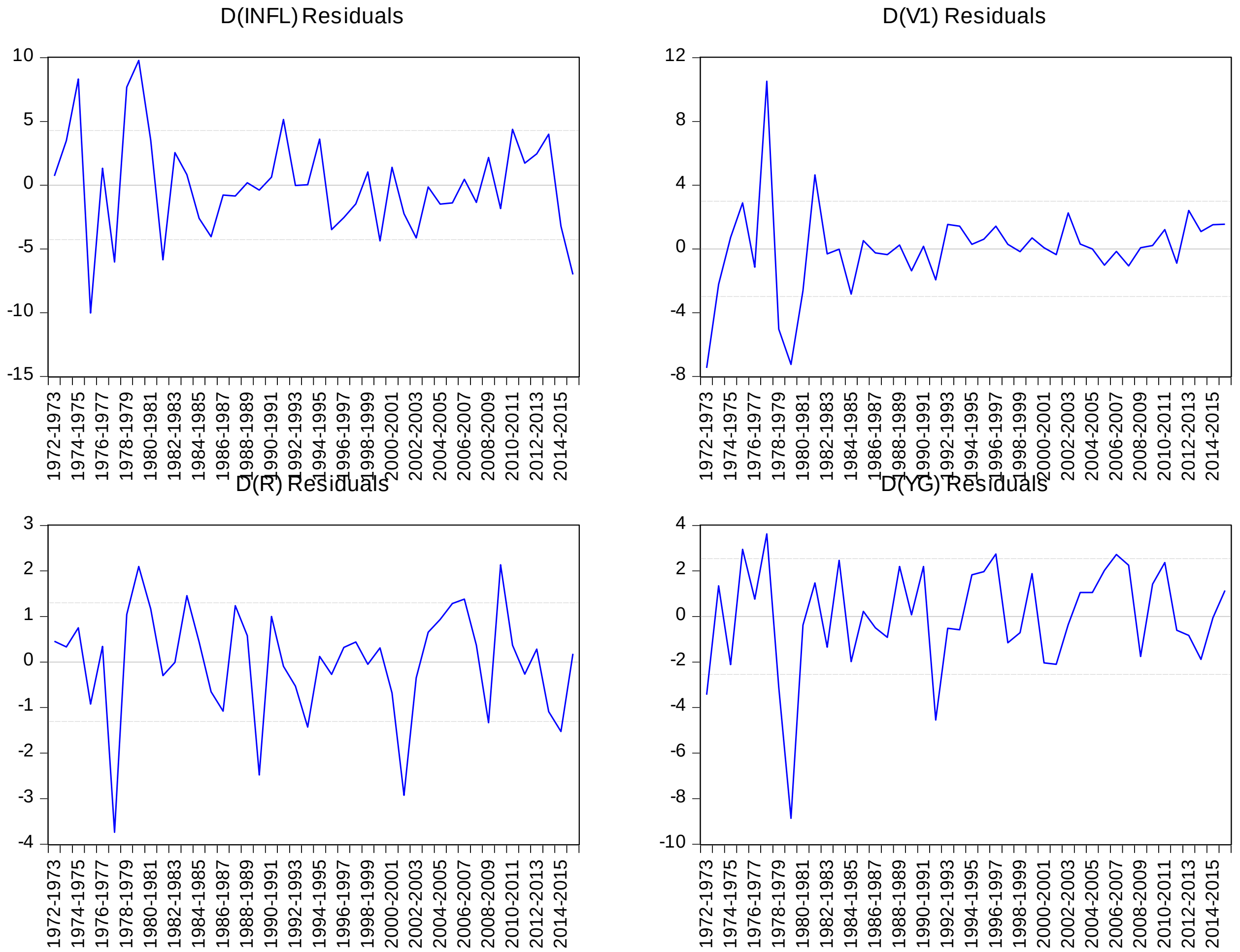


Figure No. 5.1.9 Cointegration Graph

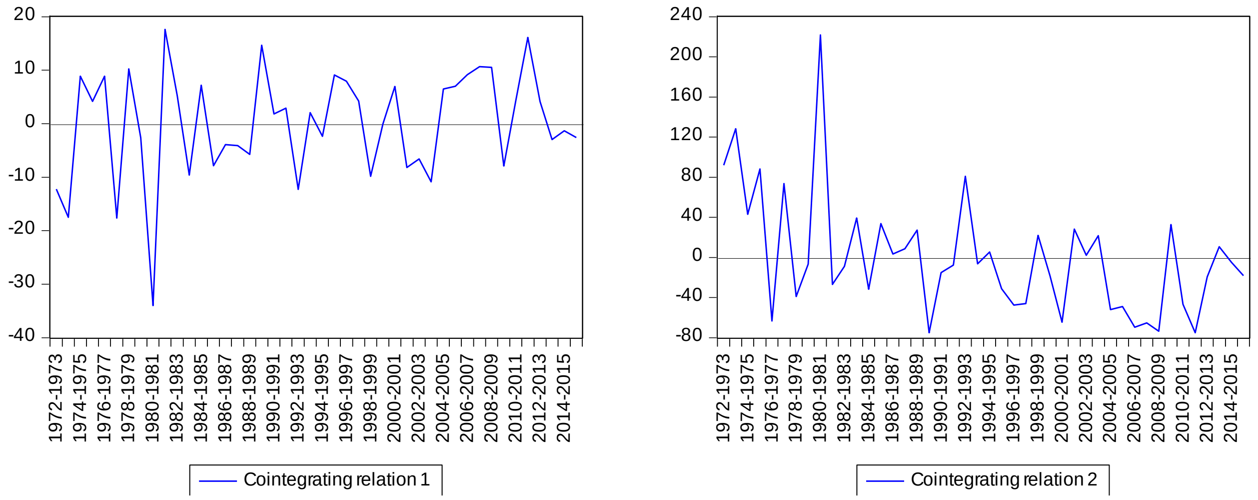


Table No. 5.31 Third Equation polynomial Test

Roots of Characteristic Polynomial	
Root	Modulus
1.000000	1.000000
1.000000	1.000000
0.791477	0.791477
0.112776 - 0.618669i	0.628864
0.112776 + 0.618669i	0.628864
-0.313386 - 0.416530i	0.521256
-0.313386 + 0.416530i	0.521256
-0.045076	0.045076
VEC specification imposes 2 unit root(s).	

Figure No .5.1.10

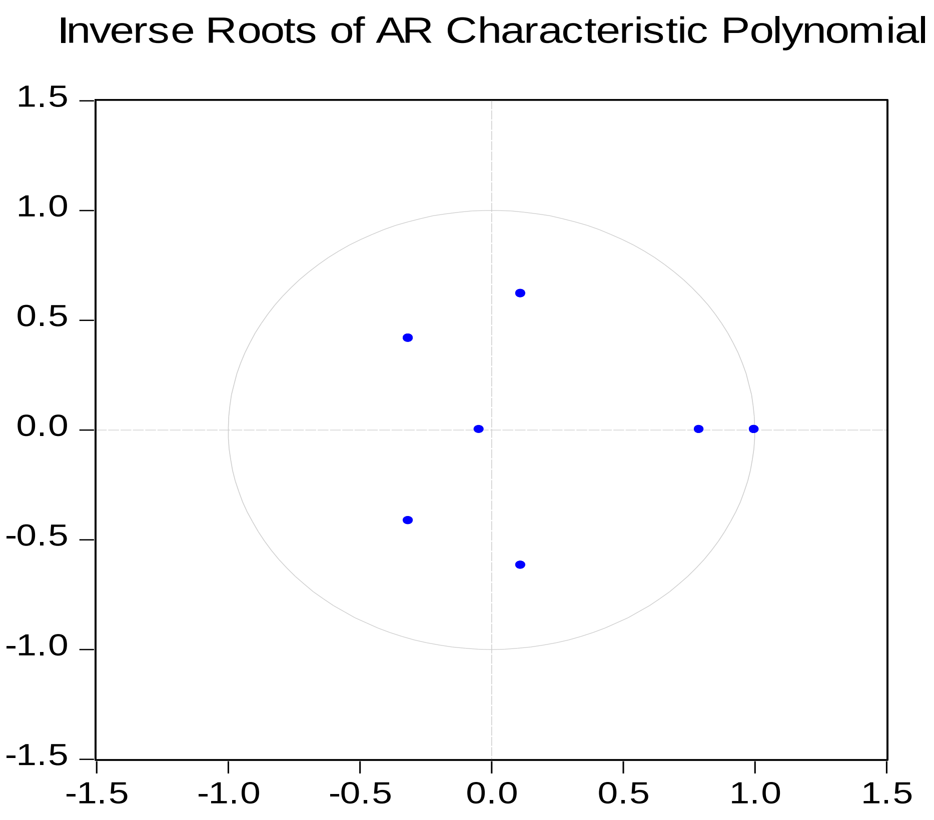


Table No. 5.32 Diagnostic Testing Third Equation Autocorrelation Test (X^2 Distribution)

VEC Residual Portmanteau Tests for Autocorrelations					
Null Hypothesis: no residual autocorrelations up to lag h					
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
1	3.944178	NA*	4.035903	NA*	NA*
2	14.64789	0.9634	15.24931	0.9526	26
3	27.21717	0.9624	28.73830	0.9407	42
4	38.89409	0.9746	41.58292	0.9489	58
5	58.78984	0.9018	64.02940	0.7893	74
6	68.39987	0.9563	75.15681	0.8694	90
7	82.18641	0.9582	91.55160	0.8401	106
8	93.84550	0.9726	105.8016	0.8517	122
9	99.61968	0.9942	113.0606	0.9408	138
10	117.5963	0.9870	136.3244	0.8438	154
*The test is valid only for lags larger than the VAR lag order.					
df is degrees of freedom for (approximate) chi-square distribution					

Table No 5.33 Third Equation VECM Residual Serial Correlation LM Test

VEC Residual Serial Correlation LM Tests		
Null Hypothesis: no serial correlation at lag order h		
Lags	LM-Stat	Prob
1	17.81921	0.3346
2	12.39279	0.7165
3	16.94934	0.3889

4	11.82335	0.7560
5	23.63558	0.0978
6	9.464195	0.8931
7	18.06864	0.3199
8	13.82602	0.6117
9	5.978878	0.9883
10	18.33178	0.3048
Probs from chi-square with 16 df.		

Table No. 5.34 Normality Test in third Equation for Skewness

Component	Skewness	Chi-sq	Df	Prob.
1	-0.105791	0.103929	1	0.7472
2	0.256829	0.602174	1	0.4377
3	-0.823835	5.291585	1	0.0214
4	-0.814017	5.184575	1	0.0228
Joint		11.18226	4	0.0246

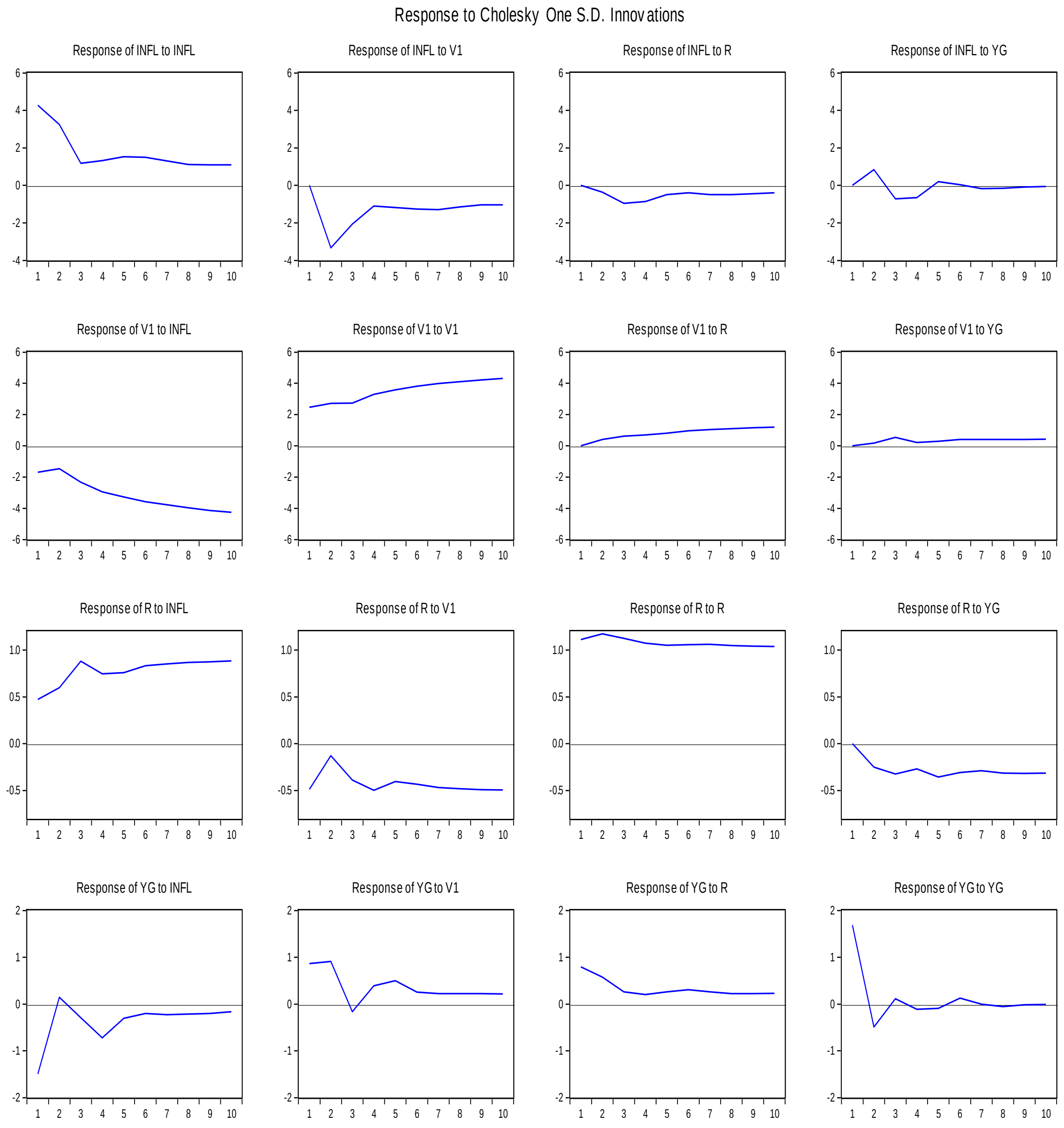
Table No. 5.35 Normality Test in third Equation for Kurtosis

Component	Kurtosis	Chi-sq	Df	Prob.
1	2.979648	0.518692	1	0.4714
2	6.087273	20.69735	1	0.0000
3	3.979545	0.014477	1	0.9042
4	4.692828	1.658498	1	0.1978
Joint		22.88902	4	0.0001

Table No.5.36 Third Equation for Jarque-Bera test

Component	Jarque-Bera	Df	Prob.
1	0.622621	2	0.7325
2	21.29952	2	0.0000
3	5.306062	2	0.0704
4	6.843073	2	0.0327
Joint	34.07128	8	0.0000

Figure No.5.1.11 Impulse response function Third equation



Some Implications

Looking to the econometric techniques used and the results derived. It can be inferred based on that inflation in India is highly influenced by the growth rate of GDP along with Lagged value of inflation growth rate based on the variation of money(V1) and with interest rate.

Model-4: Fourth Equation

INFL= β_1 V3 + β_2 R + β_3 YG +ε ………… (4)

Cointegration Analysis for Forth equation.

Following Engle and Granger (1987), the estimated cointegrating regression for the level series (growth rate of Wholesale Price Index) is given below.

Table No.5.37 Cointegration Analysis for Forth equation

Dependent Variables	Independent Variables			
	CONSTANT	YG	R	V3
INFL	7.28471*** (1.893) (0.0653)	−0.807839* (−2.875) (0.0063)	0.478595 (1.226) (0.2269)	0.0242632 (0.4316) (0.6683)
	R^2 = 0.2154 Adj. R^2 = 0.1594 D.W. = 1.400			

Lag Length Criteria

The following table provides the possible lag length to be appropriate for the above mention equation. As per the all of the criteria, one lag is appropriate to estimate VAR for this model.

Table No. 5.38 Lag Length Criteria Fourth Equation

VAR Lag Order Selection Criteria					
Lag	LogL	LR	FPE	AIC	SC
0	-456.3592	NA	38963.99	21.92187	22.08736

1	-287.5364	297.4496	27.04822	14.64459	15.47205*
2	-265.3770	34.82190	20.63040	14.35129	15.84072
3	-243.9615	29.57385*	16.87536	14.09340	16.24480
4	-223.1660	24.75651	15.03065*	13.86505*	16.67842
* 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 No. 5.39 Johansen test Cointegration for Growth rate of WPI (Level Series) Trace Statistics fourth Equation

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.658812	74.93788	63.87610	0.0044
At most 1	0.293411	30.84966	42.91525	0.4526
At most 2	0.234543	16.61009	25.87211	0.4446
At most 3	0.128764	5.651547	12.51798	0.5058
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				

Johansen test Cointegration for Growth rate of WPI (Level Series) Maximum Eigenvalue Statistics Fourth Equation Table No.5.40

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.658812	44.08822	32.11832	0.0011
At most 1	0.293411	14.23957	25.82321	0.7018
At most 2	0.234543	10.95855	19.38704	0.5176
At most 3	0.128764	5.651547	12.51798	0.5058
Max-eigenvalue test indicates 1 cointegration eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Analysis of VECM for fourth Model Specification:

After having confirmed with the numbers of cointegration equation in the model, the estimates of VECM are discussed in the following four equations.

Table No. 5.41 Analysis of VECM for fourth Equation Model Specification

Dependent Variables	Independent Variables					
	ECT-1	Δ(INFL(-1))	Δ(INFL(-2)	Δ(INFL(-3)	Δ(INFL(-4)	Δ (R(-1))
ΔINFL	-0.800456* (0.0000)	-0.375808 (0.0806)	0.119349 (0.6529)	0.211460 (0.3456)	0.074427 (0.7022)	0.113074 (0.8562)
	Δ (R(-2))	Δ (R(-3))	Δ (R(-4))	Δ (V3(-1))	Δ (V3(-2))	Δ (V3(-3))
	-1.638688* (0.0087)	-0.858297 (0.1396)	0.124530 (0.8178)	-6.306609* (0.0005)	-4.508401** (0.0398)	-0.775758 (0.6927)

	Δ (V3(-4))	Δ (YG(-1))	Δ (YG(-2))	Δ (YG(-3))	Δ (YG(-4))	CONSTANT
	-2.509114 (0.2000)	-0.546352 (0.1843)	0.054010 (0.8841)	0.238810 (0.4873)	0.256722 (0.2349)	-15.55199* (0.0000)
	R^2 = 0.835741 Adj. R^2 = 0.714331 D.W. = 1.396276					
Dependent Variables	Independent Variables					
	ECT-1	Δ(INFL(-1))	Δ(INFL(-2)	Δ(INFL(-3)	Δ(INFL(-4)	Δ (R(-1))
ΔR	-0.095966 (0.1566)	0.020189 (0.8099)	-0.009692 (0.9260)	-0.051750 (0.5567)	0.029758 (0.6976)	0.249791 (0.3100)
	Δ (R(-2))	Δ (R(-3))	Δ (R(-4))	Δ (V3(-1))	Δ (V3(-2))	Δ (V3(-3))
	- 0.457387*** (0.0601)	-0.066211 (0.7708)	-0.132961 (0.5321)	1.298508*** (0.0636)	-1.904970** (0.0275)	0.011180 (0.9884)
	Δ (V3(-4))	Δ (YG(-1))	Δ (YG(-2))	Δ (YG(-3))	Δ (YG(-4))	CONSTANT
	-0.860337 (0.2634)	-0.312688** (0.0546)	-0.007570 (0.9586)	-0.066643 (0.6219)	0.011538 (0.8916)	-1.912744 (0.1490)
	R^2 = 0.548306 Adj. R^2 = 0.214446 D.W. = 1.986003					

Dependent Variables	Independent Variables					
	ECT-1	Δ(INFL(-1))	Δ(INFL(-2)	Δ(INFL(-3)	Δ(INFL(-4)	Δ (R(-1))
ΔR	0.015199 (0.4851)	0.087922* (0.0016)	0.035521 (0.2929)	0.017510 (0.5378)	0.051176** (0.0405)	0.046791 (0.5549)
	Δ (R(-2))	Δ (R(-3))	Δ (R(-4))	Δ (V3(-1))	Δ (V3(-2))	Δ (V3(-3))
	0.061164 (0.4322)	0.118628 (0.1081)	-0.022104 (0.7474)	0.208721 (0.3520)	0.353638 (0.2006)	0.054537 (0.8267)
	Δ (V3(-4))	Δ (YG(-1))	Δ (YG(-2))	Δ (YG(-3))	Δ (YG(-4))	CONSTANT

	0.345056 (0.1653)	-0.020921 (0.6875)	-0.032203 (0.4939)	-0.060355 (0.1683)	-0.051689*** (0.0610)	0.320290 (0.4521)
	R^2 = 0.939382 Adj. R^2 = 0.894578 D.W. = 1.930895					
Dependent Variables	Independent Variables					
	ECT-1	Δ(INFL(-1))	Δ(INFL(-2)	Δ(INFL(-3)	Δ(INFL(-4)	Δ (R(-1))
ΔYG	0.223885 *** (0.0991)	0.105543 (0.5297)	-0.050495 (0.8088)	-0.019769 (0.9105)	0.131416 (0.3915)	0.593298 (0.2284)
	Δ (R(-2))	Δ (R(-3))	Δ (R(-4))	Δ (V3(-1))	Δ (V3(-2))	Δ (V3(-3))
	0.119945 (0.8034)	0.099129 (0.8273)	-0.216744 (0.6104)	1.267261 (0.3618)	0.517890 (0.7613)	1.845333 (0.2335)
	Δ (V3(-4))	Δ (YG(-1))	Δ (YG(-2))	Δ (YG(-3))	Δ (YG(-4))	CONSTANT
	0.102437 (0.9467)	-0.598375*** (0.0657)	-0.429919 (0.1423)	-0.511645*** (0.0606)	-0.291988*** (0.0872)	4.435399*** (0.0949)
	R^2 = 0.765878 Adj. R^2 = 0.592832 D.W. = 1.955204					

***, ****Denotes 1% and 5% significant level respectively.

FIGURE NO 5.1.12

Figure no 5.1.13 Cointegration Graph

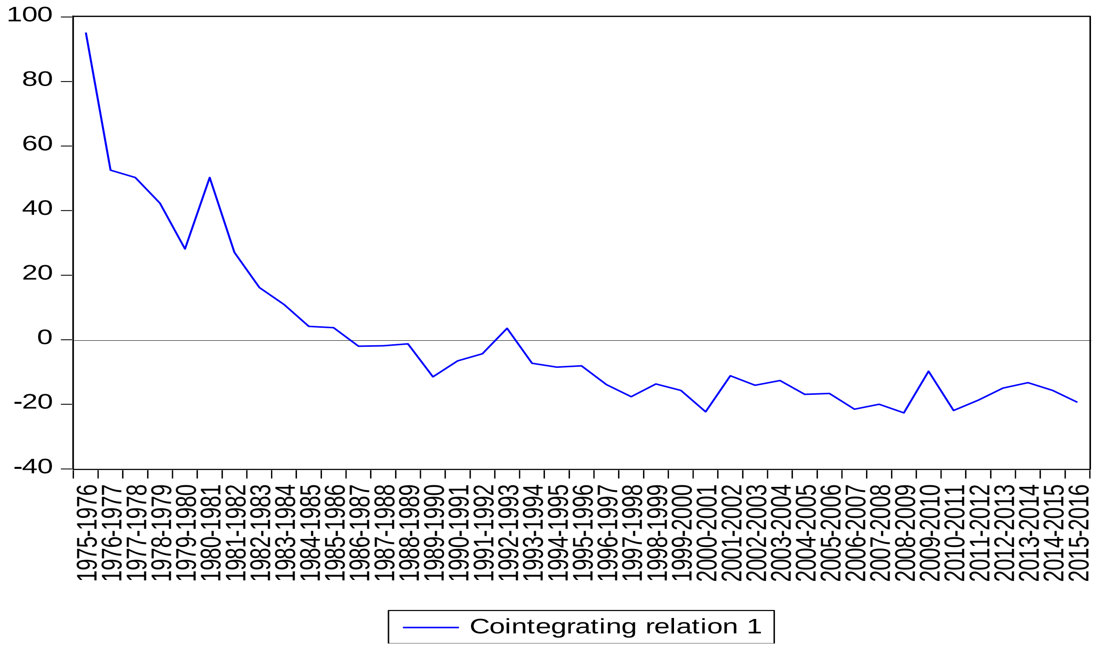


Table NO.5.42 Fourth Equation Polynomial Test

Roots of Characteristic Polynomial	
Root	Modulus
1.000000	1.000000
1.000000	1.000000
1.000000	1.000000
-0.896443	0.896443
0.869618	0.869618
0.546013 + 0.658081i	0.855103
0.546013 - 0.658081i	0.855103
0.024136 + 0.833019i	0.833368
0.024136 - 0.833019i	0.833368
-0.615277 - 0.466139i	0.771914
-0.615277 + 0.466139i	0.771914
0.315988 - 0.677770i	0.747810
0.315988 + 0.677770i	0.747810
-0.313709 - 0.650406i	0.722109
-0.313709 + 0.650406i	0.722109
-0.697260	0.697260
-0.262212 - 0.634664i	0.686697
-0.262212 + 0.634664i	0.686697
0.392114 + 0.191248i	0.436267
0.392114 - 0.191248i	0.436267

Figure No 5.1.14

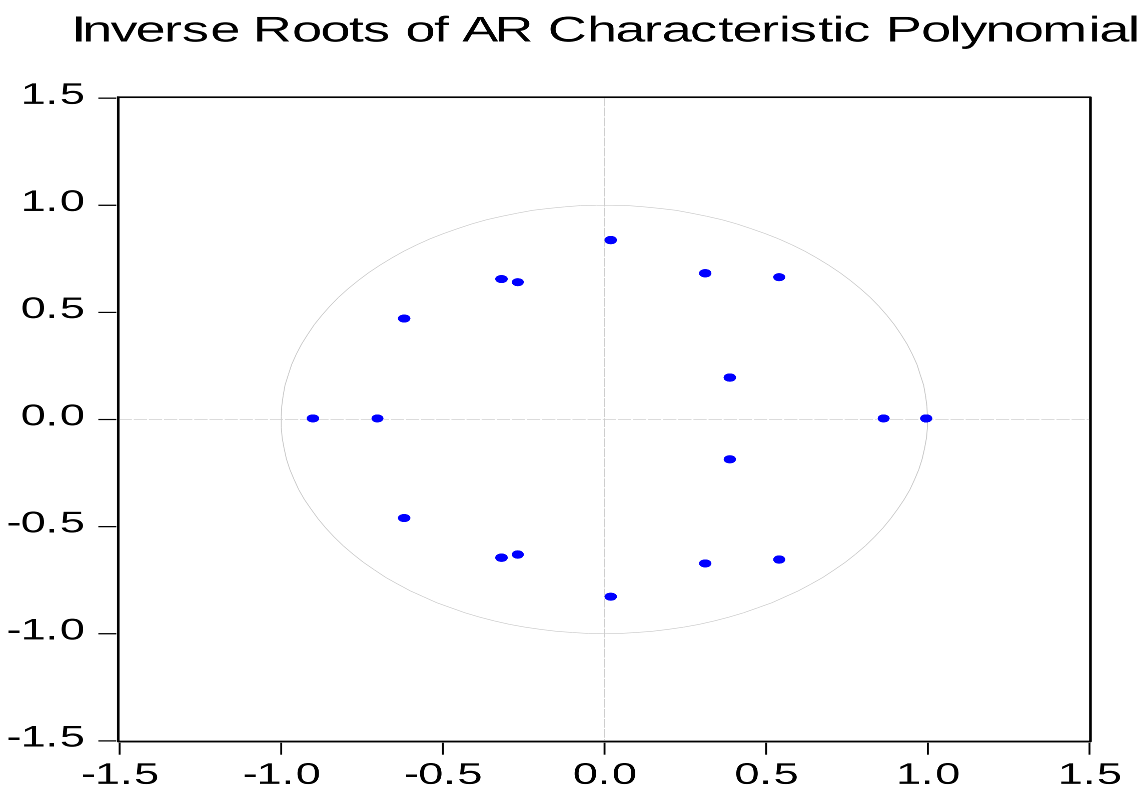


Table No. 5.43 Diagnostic Testing Fourth Equation Autocorrelation (X^2 Distribution)

VEC Residual Portmanteau Tests for Autocorrelations					
Null Hypothesis: no residual autocorrelations up to lag h					
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
1	10.19949	NA*	10.45448	NA*	NA*
2	18.14309	NA*	18.80544	NA*	NA*
3	28.59027	NA*	30.07740	NA*	NA*
4	38.94952	NA*	41.55657	NA*	NA*
5	58.20488	0.0010	63.48628	0.0002	29
6	73.70800	0.0044	81.64708	0.0007	45
7	90.52312	0.0084	101.9241	0.0008	61
8	105.0634	0.0185	119.9894	0.0012	77

9	115.3009	0.0584	133.1062	0.0041	93
10	133.5611	0.0551	157.2568	0.0017	109
*The test is valid only for lags larger than the VAR lag order.					
df is degrees of freedom for (approximate) chi-square distribution					

Table No. 5.44 Fourth Equation VECM Residual Serial Correlation LM Test

VEC Residual Serial Correlation LM Tests		
Null Hypothesis: no serial correlation at lag order h		
Lags	LM-Stat	Prob
1	14.88770	0.5329
2	14.35795	0.5721
3	12.54209	0.7059
4	11.07600	0.8048
5	23.39987	0.1035
6	14.53258	0.5591
7	17.10168	0.3790
8	15.55504	0.4844
9	13.63588	0.6258
10	22.66843	0.1229
Probs from chi-square with 16 df.		

Table No. 5.45 Normality Test of fourth for Skewness

Component	Skewness	Chi-sq	Df	Prob.
1	0.053407	0.025067	1	0.8742
2	-0.843291	5.219648	1	0.0223

3	-0.026815	0.006323	1	0.9366
4	-0.379237	1.212301	1	0.2709
Joint		6.463339	4	0.1671

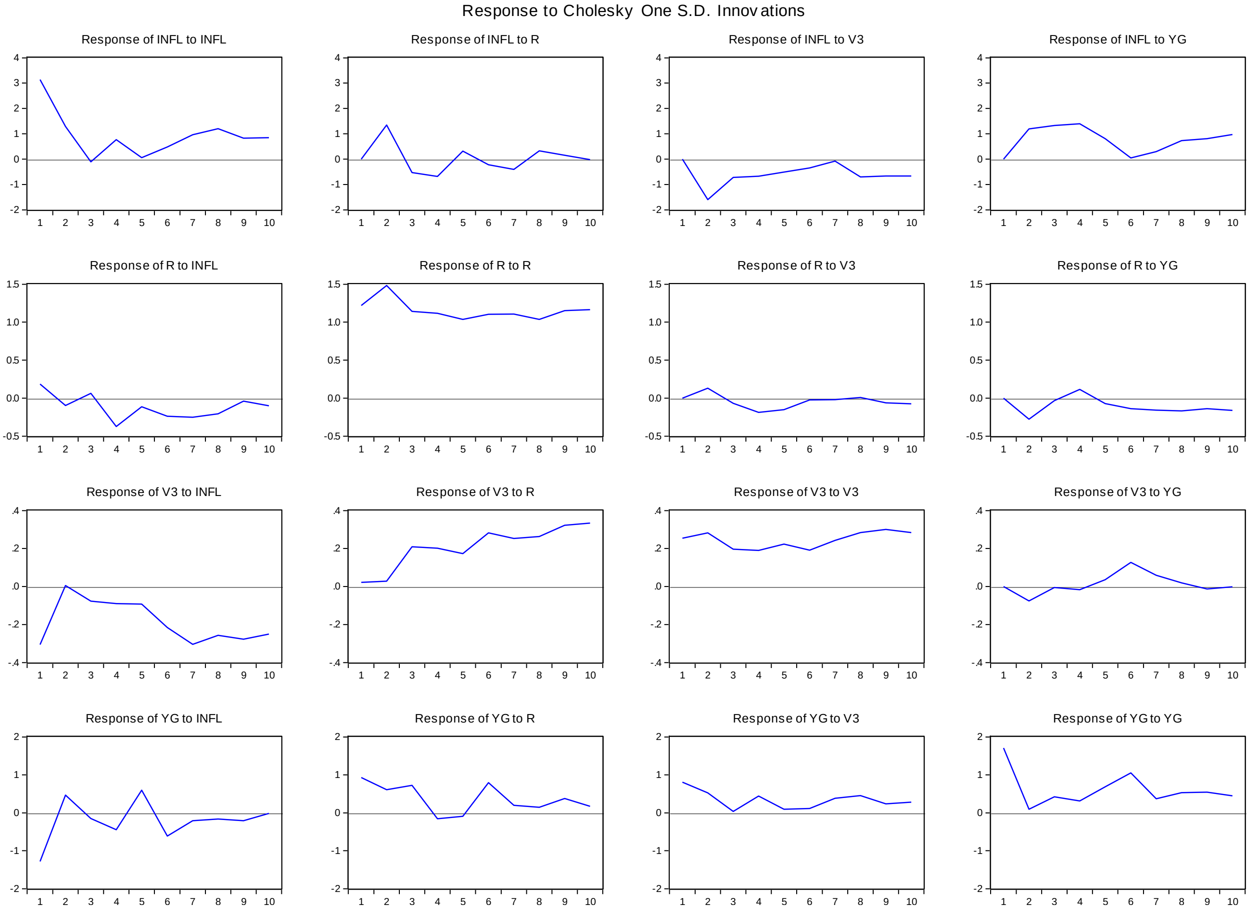
Table No.5.46 Normality Test of fourth for Kurtosis

Component	Kurtosis	Chi-sq	Df	Prob.
1	4.271564	7.249102	1	0.0071
2	4.952090	2.437636	1	0.1185
3	2.497985	0.020667	1	0.8857
4	2.511197	0.488867	1	0.4844
Joint		10.19627	4	0.0372

Table No. 5.47 Fourth Equation Jarque-Bera test

Component	Jarque-Bera	Df	Prob.
1	7.274169	2	0.0263
2	7.657283	2	0.0217
3	0.026991	2	0.9866
4	1.701168	2	0.4272
Joint	16.65961	8	0.0339

Figure No 5.1.15 Impulse response fourth equation function



Some Implications

Looking to the econometric techniques used and the results derived. It can be inferred based on that inflation in India is highly influenced by the growth rate of GDP along with Lagged value of inflation growth rate based on the interest rate with variation of money(V3).

Table No.5.48 Granger Causality Test for All equation

Pairwise Granger Causality Tests
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
M1 does not Granger Cause INFL	43	3.95581	0.0155**
INFL does not Granger Cause M1		2.21793	0.1028
M3 does not Granger Cause INFL	43	2.34643	0.0890
INFL does not Granger Cause M3		3.38655	0.0284**
R does not Granger Cause INFL	43	2.00035	0.1313
INFL does not Granger Cause R		2.99997	0.0432**
V1 does not Granger Cause INFL	43	8.80861	0.0002*
INFL does not Granger Cause V1		5.22639	0.0042*
V3 does not Granger Cause INFL	43	6.47821	0.0013*
INFL does not Granger Cause V3		15.3661	1.E-06*
YG does not Granger Cause INFL	43	1.32211	0.2823
INFL does not Granger Cause YG		2.05729	0.1232
M3 does not Granger Cause M1	43	0.47061	0.7046
M1 does not Granger Cause M3		1.44562	0.2457
R does not Granger Cause M1	43	0.41242	0.7451
M1 does not Granger Cause R		0.70464	0.5555
V1 does not Granger Cause M1	43	0.83093	0.4856
M1 does not Granger Cause V1		0.26017	0.8536
V3 does not Granger Cause M1	43	2.02152	0.1282
M1 does not Granger Cause V3		1.70402	0.1835
YG does not Granger Cause M1	43	0.22331	0.8796
M1 does not Granger Cause YG		3.62399	0.0220**
R does not Granger Cause M3	43	0.15309	0.9270

M3 does not Granger Cause R		1.54871	0.2187
V1 does not Granger Cause M3	43	1.74776	0.1746
M3 does not Granger Cause V1		1.19376	0.3259
V3 does not Granger Cause M3	43	2.75661	0.0564**
M3 does not Granger Cause V3		1.22389	0.3151
YG does not Granger Cause M3	43	0.24672	0.8631
M3 does not Granger Cause YG		1.38843	0.2620
V1 does not Granger Cause R	43	2.14991	0.1110
R does not Granger Cause V1		0.47617	0.7008
V3 does not Granger Cause R	43	5.14843	0.0046*
R does not Granger Cause V3		1.38879	0.2619
YG does not Granger Cause R	43	1.03373	0.3893
R does not Granger Cause YG		2.25779	0.0983
V3 does not Granger Cause V1	43	4.93686	0.0057*
V1 does not Granger Cause V3		4.76569	0.0067*
YG does not Granger Cause V1	43	1.21488	0.3183
V1 does not Granger Cause YG		7.18561	0.0007*
YG does not Granger Cause V3	43	2.36341	0.0873
V3 does not Granger Cause YG		1.68879	0.1867

The above table deals with the Granger causality test. The Null hypothesis of X doesn't cause to Y has been tested and respective probabilities are given. Accordingly there is unidirectional causality being found between M1 and WPI inflation. Unidirectional causalities have been found from WPI inflation to M3, WPI inflation and interest rate, M1 to GDP at MP, V3 to M3, V3 to Interest rate and V1 to GDP at MP. Bi-directional causalities have been found from V1 to WPI inflation and WPI inflation to V1 as well with V3 to WPI inflation and WPI inflation to V3. Moreover bi-directional causality has also been found from V1 to V3 and V3 to V1. These results are well in accordance with the monetary theoretical foundation.