CHAPTER 12

STUDY OF CAUSALITY BETWEEN EXCHANGE RATE AND MONEY SUPPLY IN THE BASKET PEG REGIME

12.1 Introduction

The relationship among macro-economic variables estimated by using the historical dataset may not represent the dynamic nature of the relationship. The relationships among the variables undergo changes following structural changes in the economy. The data used for econometric analysis embody the outcome of structural changes and, therefore, the consequent changes in the macroeconomic relationship. In the event of the presence of structural changes, the estimated econometric relationships among macro-economic variables fail to represent the true economic relationship.

The study covers the historical period 1975 (I) - 2006 (IV) when India has undergone two different exchange rate regimes, namely,

a. *The Regime of Basket Peg Exchange Rate System*, during 1974 to 1992 (I), and

b. *The Regime of Market Determined Exchange Rate System*, from September 1994[‡] to till date.

The policy and practices that *Reserve Bank of India* (**RBI**) followed for controlling and stabilizing the value of Indian Rupee in terms of major international currencies like Dollar were markedly different under these two exchange rate regimes. Therefore, it is very pertinent for us to enquire the role of money supply in India for stabilizing the value of Rupee/Dollar exchange rates. This is expected to enrich our knowledge about the theoretical and empirical mechanisms of the variation in Rupee/Dollar exchange and a better

[‡] Period covering from March, 1992 to August, 1994 may be termed as transition period for achieving fully Flexible Market Determined System of exchange rate.

understanding about the exchange rate policies and practices pursued by RBI. In this chapter we have addressed these issues in detail. With this end in view, first we have sought to enquire into the interrelationship between exchange rate and money supply in the Basket peg period of exchange rate covering period 1975(I) - 1992(I).

12.2 The Relationship Between Money Supply and Exchange Rate in the 'Basket-Peg Period' of Exchange Rate

For examining the relationship between the variables concerned in the Basket-Peg Period of Exchange Rates [1975(I) – 1992(I)], we have applied the *Vector Autoregression Model* where all variables are treated symmetrically without the reference of dependence versus independence. With this end in view, we have developed an appropriate **VAR** model for estimation in order to examine the effects of cross equation shocks on the endogenous variables concerned.

12.3 The VAR Model

The model of Vector Autoregression (VAR) for Rupee/Dollar Exchange Rate (E_t) and money supply (M_t) is as follows:

$$E_t = \alpha_1 + \sum_{i=1}^{k} \beta_{1i} E_{t-1} + \sum_{i=1}^{k} \gamma_{1i} M_{t-i} + u_{1t} \qquad (12.1)$$

$$M_t = \alpha_2 + \sum_{i=1}^{k} \beta_{2i} M_{t-i} + \sum_{i=1}^{k} \gamma_{2i} E_{t-i} + u_{2t} \qquad (12.2)$$

Here, E_t and M_t represent Rupee/Dollar exchange rate and money supply (M_1) in India at time t respectively. E_{t-i} and M_{t-i} represent exchange rate and money supply at time t-i, i = 1,2,3, ..., respectively. u_{1t}, u_{2t} are the stochastic error terms, called impulse or innovations or shocks in the VAR model.

These equations (12.1) and (12.2) do not represent any joint relationship among E_t and M_t. These equations, therefore, represent *"Seemingly Unrelated Regression"* (**SUR**) model. The

estimation of the model considers and uses the contemporaneous Var-Covariance matrix (Ω) of the error terms involved such that Ω = Var-Cov (u_{1t}, u_{2t}), where Ω is a positive definite matrix.

12.4 Selection of Lag Lengths

For selecting optimum lag length, we have followed Enders (1995) and started with eight lags and reduced lags one by one and carried out the test, given that estimated t-static for the coefficient of discarded lag is insignificant. With the 2nd, 3rd and 4th lag few coefficients have been found statistically significant. But corresponding to the 4th lag AIC and SC of model selection was minimum and, therefore, we have taken 4th lags in the VAR estimation.

12.5 Results of Estimation of the VAR Model

The results of estimation of the VAR model involving Equations 12.1 and 12.2 are being presented below through the Tables 12.1 and 12.2.

Table 12.1

Results of VAR Estimation (Equation 12.1)

Sample: 1975(IV) – 1992(1)

Included Observations: 64

Dependent Variable	Explanatory Variables	Coefficients	S.E.	't' statistic	Prob.
E_t	Constant	-0.1517	0.141	-1.069	0.28
	E_{t-1}	0.1539	0.139	1.104	0.27
	E_{t-2}	0.0568	0.145	0.390	0.69
	E_{t-3}	**-0.4221**	**0.223**	**-1.887**	**0.06**
	E_{t-4}	-0.1350	0.232	-0.581	0.56
	M_{t-1}	**1.3612**	**0.446**	**3.048**	**0.00**
	M_{t-2}	**1.5071**	**0.515**	**2.921**	**0.00**
	M_{t-3}	0.2762	0.521	0.529	0.59
	M_{t-4}	0.1961	0.498	0.393	0.69
$R^2 = 0.32$, Adjusted $R^2 = 0.27$, AIC = 1.91, SC = 2.21, F-statistic = 3.31, DW = 1.93.					

Table 12.2

Results of VAR Estimation (Equation 12.2)

Sample: 1975(IV) – 1992(1)

Included Observations: 64

Dependent Variable	Explanatory Variables	Coefficient	S.E.	't' statistic	Prob.
M_t	Constant	0.055	0.0311	1.777	0.08
	M_{t-1}	**-0.252**	0.0979	**-2.578**	**0.01**
	M_{t-2}	-0.016	0.1131	-0.143	0.88
	M_{t-3}	0.056	0.1143	0.494	0.62
	M_{t-4}	**0.727**	0.1094	**6.649**	**0.00**
	E_{t-1}	**0.085**	0.0305	**2.784**	**0.00**
	E_{t-2}	0.047	0.0319	1.495	0.14
	E_{t-3}	0.067	0.0490	1.376	0.17
	E_{t-4}	-0.043	0.0509	-0.845	0.40
$R^2 = 0.67$, Adjusted $R^2 = 0.62$, AIC = - 1.12, SC = - 0.82, F-statistic = 14.04, DW = 2.51.					

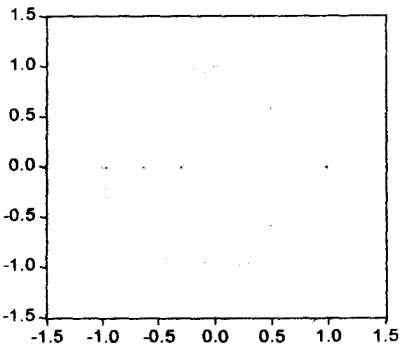
12.6 Stability of the VAR Model

The roots of the characteristic polynomials, A(L) and B(L) are given in the Table 12.3.

Table 12.3
VAR Stability Condition Check
Roots of the Characteristic Polynomial
Endogenous Variable: E_t and M_t
Exogenous Variable: C

Root	Modulus
0.974960	0.974960
-0.963039	0.963039
-0.087499 - 0.945131i	0.949173
-0.087499 + 0.945131i	0.949173
0.492523 - 0.579581i	0.760587
0.492523 + 0.579581i	0.760587
-0.628405	0.628405
-0.292086	0.292086

Figure 12.1
Inverse Roots of AR characteristic Polynomial



12.7 Findings From the Table 12.3 and Figure 12.1

The Table 12.3 shows that

(i) the absolute values of all the characteristic roots (eigen values) are less than unity,

(ii) four roots are not significantly different (at 1% level) from zero.

(iii) four roots are statistically different from zero.

Consequently, no root lies outside the unit circle. This is being shown by the Figure 12.1. These findings confirm the ***'Stability'*** of the VAR System.

12.8 Findings from the Table 12.1 (Equation 12.1)

It is observed from the estimated equation (12.1), as presented in the Table 12.1, that

(i) $\sum_{i=1}^{4} \hat{\beta}_{1i} < 1$. So the autoegressive lag structure is consistent.

(ii) D.W. = 1.93 indicates that the system is free from autocorrelation.

(iii) $\hat{\gamma}_{11}$ and $\hat{\gamma}_{12}$, i.e., the coefficient of M_{t-1}, and M_{t-2}, are significant at 1% level.

(iv) $\hat{\beta}_{13}$, the coefficient of E_{t-3}, is significant at 10% level.

12.9 Economic Interpretations

The economic significance of these findings is as follows:

(i) Since $\hat{\beta}_{13} < 0$ is significant, E_t followed AR(3) process in its univariate structure.

(ii) Significant coefficient $\hat{\beta}_{13} < 0$ indicates that current exchange rate was negatively related to three period lagged exchange rates. It shows that Rupee appreciates in the current period following depreciation in the previous (t-3) period.

(iii) Positive and the significant coefficients of M_{t-1} and M_{t-2} imply that a rise in money supply at (t-1) and (t-2) periods led to a rise in Rupee/Dollar exchange rate in the current period (quarter).

(iv) $\hat{\gamma}_{11} > 1$, $\hat{\gamma}_{12} > 1$ imply that change in one quarter lagged and two quarter back money supplies led to more than proportionate change in the current exchange rate. This testifies for the 'phenomenon' of ***'Overshooting'*** of exchange rate in the **'Basket-Peg regime'**.

(v) The significant coefficients of M_{t-1} and M_{t-2} (i.e., $\hat{\gamma}_{11}$ and $\hat{\gamma}_{12}$) in the presence of lagged exchange rate in the vector of regressors for the exchange rate equation indicate that *domestic of money supply Granger Caused Rupee/Dollar exchange rate* over the period 1975(I) to 1992(I).

12.10 Findings From the Table 12.2 (Equation 12.2)

It is observed from the Table 12.2 that

(i) $\sum_{i=1}^{4} \hat{\beta}_2 < 1$, $\sum_{i=1}^{4} \hat{\gamma}_{2i} < 1$. So the autoregressive and distributive lag structures are consistent.

(ii) D.W. = 2.51 indicates that the system is free from autocorrelation.

(iii) $\hat{\gamma}_{21}$, the coefficient of E_{t-1}, is significant at 1% level.

(iv) $\hat{\beta}_{21}$ and $\hat{\beta}_{24}$, the coefficient of M_{t-1} and M_{t-4} are statistically significant at 1% level.

12.11 Economic Interpretations of Findings in Section 12.9

The economic significance of these findings is as follows

1. Negative and significant coefficient of M_{t-1} (i.e., $\hat{\beta}_{21}$) indicates that current money supply was related to money supply in the previous period. Significant coefficient $\hat{\beta}_{24} > 0$ indicates current money supply was positively related to the four quarter lagged money supply. This seems to be a pointer to the practice of *'controlled expansion'* of money supply in order to conform to the 'K%' rule proposed by Friedman.

2. The coefficient of E_{t-1} being significant, even in the presence of lagged money in the vector of regressors, indicates that *exchange rate Granger caused money supply.*

3. Again $\hat{\gamma}_{21} > 0$ indicates that current money supply increased following depreciation of Rupee against Dollar in the previous period. Thus money supply appeared to be *'Accommodative'* of spot rate variation over the period concerned.

12.12 Overview of Findings of the VAR Model

The main findings of the VAR model are as follows:

(i) *Money supply was found to Granger cause exchange rate. Following a rise in money supply, exchange rate also registered a rise.*

(ii) *Exchange rate displayed 'Overshooting' following change in money supply in previous periods.*

(iii) *Money supply led to positive variation in spot exchange rate in the subsequent period and thereby caused depreciation of rupee. This is in conformity with the basic proposition of Monetary Approach of Exchange Rate* (MAER).

(iv) *Exchange rate was also found to Granger cause money supply. This finding indicates the 'Activist' nature of the monetary policy prevailed in India over the period 1975(I) – 1992(1).*

(v) *Consequently, the period is marked by the presence of* ***Bi-directional Causality*** *between Exchange Rate and Money Supply.*

12.13 Dynamic Adjustment Process: Intervention Analysis

In this section we seek to examine the responses of E_t and M_t to shocks transmitted through the channels of E_t and M_t and their relative importance. These may provide better insight about interrelations between these variables. With this end in view, 'Intervention Analysis has been carried on through the study of *Variance Decomposition* of exchange rate and money supply in India.

12.14 Intervention Analysis through the Variance Decomposition

Variance Decomposition separates the variation in an endogenous variable into some component shocks. Thus *Variance Decomposition* provides information about the relative importance of each random innovation in the matter of affecting the variables in the VAR. We seek to examine the relative importance of monetary and exchange rate shocks in the short-run variations of these two endogenous variables: Rupee/Dollar exchange rate and the domestic money supply.

12.15 Variance Decomposition of Rupee/Dollar Exchange Rate

The percentile decompositions of variances of exchange rate and money supply across different periods are given by the Tables 12.4 and 12.5. Figures 12.2 and 12.3 present graphical presentations of such decompositions.

Table 12.4
Variance Decomposition of E_t

Period	SE	E_t	M_t
1	0.588881	100.00	0.000
2	0.621263	91.997	8.002
3	0.656406	85.538	14.461
4	0.669078	85.464	14.535
5	0.669839	85.330	14.669
6	0.677386	83.609	16.390
7	0.685622	82.241	17.758
8	0.690962	82.461	17.538
9	0.698291	82.076	17.923
10	0.708374	79.992	20.007
11	0.713145	78.952	21.047
12	0.713962	78.951	21.048
13	0.717298	78.363	21.636
14	0.723633	77.141	22.858
15	0.726365	76.730	23.269
16	0.728268	76.773	23.226
17	0.732464	76.062	23.937
18	0.737062	75.213	24.786
19	0.738558	75.002	24.997
20	0.739928	74.978	25.021

Table 12.5

Variance Decomposition of M_t

Period	SE	E_t	M_t
1	0.129110	0.001	99.999
2	0.142242	12.361	87.638
3	0.145661	14.332	85.667
4	0.155338	21.878	78.121
5	0.193160	17.066	82.933
6	0.202000	19.952	80.047
7	0.204467	19.580	80.419
8	0.210640	22.208	77.791
9	0.226746	20.216	79.783
10	0.236115	23.350	76.649
11	0.240067	22.631	77.368
12	0.244450	23.679	76.320
13	0.252037	22.927	77.072
14	0.258489	24.781	75.218
15	0.263326	23.960	76.039
16	0.266268	24.587	75.412
17	0.269611	24.219	75.780
18	0.273991	25.646	74.353
19	0.279202	24.790	75.209
20	0.281016	25.231	74.768

Figure 12.6
Variance Decomposition of E_t

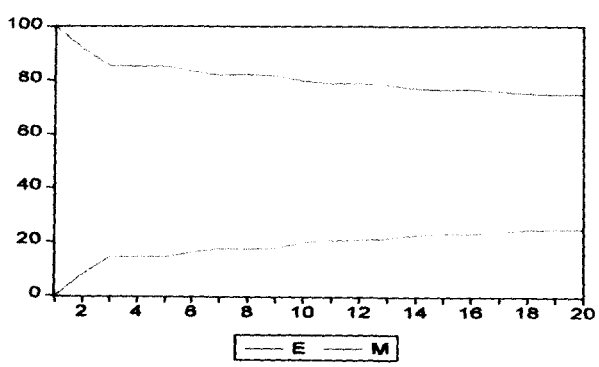
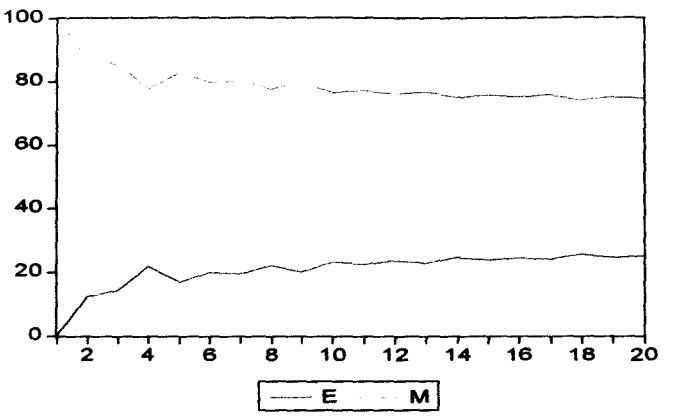


Figure 12.7
Variance Decomposition of M_t



12.16 Findings From the Table 12.4 and Figure 12.7

The Table 12.4 and Figure 12.7 show that

(i) The shocks, transmitted through the exchange rate channel, exerted immediate response by explaining 100% variations in exchange rate at the initial period t = 1.

(ii) At the period t = 20, the exchange rate shocks accounted for at least 75% of variations in exchange rate. Thus exchange rate shocks become weaker over time.

(iii) The shocks, transmitted through the domestic monetary channel, exerted delayed variations in Rupee/Dollar exchange rate. These shocks started to explain the variations in exchange rate from the period t = 2.

(iv) The contribution of the monetary shocks in exchange rate variation has increased over the periods and the shocks accounted for about 25% of variations in Rupee/Dollar exchange rate at t = 20 period.

12.17 Findings From the Table 12.5 and Figure 12.3

The Table 12.5 presents the percentile decomposition of domestic money supply variances into two components. One of the components is due to domestic monetary shocks while the other relates to exchange rate shocks. The graphical presentation is given by the Figure 12.3.

The Table 12.5 and Figure 12.3 show that

(i) the monetary shocks explained 100% of the variations in money supply at period (t = 1) while these explained 75% (approx) of the variations in money supply at period 20 (t = 20).

(ii) thus contributions of money shocks to money supply variation declined by 25% over a period of 20 quarter.

(iii) the exchange rate shocks explained 25% of total variations in money supply at t = 20 period. The contribution of such shocks increased over time from 0% (almost) at t = 1 to 25% at t = 20.

12.18 Overview of Findings From The Variance Decomposition Study

It, therefore, appears from Sections 12.15 – 12.16 that

(i) monetary shocks accounted for 25% of variations in exchange rate at t = 20.

(ii) exchange rate shocks accounted for 25% of variations in money supply at t = 20.

(iii) monetary shocks accounted for 75% of variations in money supply at t = 20.

(iv) exchange rate shocks accounted for 75% variations in exchange rate and consequently,

(v) monetary shocks, in accounting for exchange rate variation, were as important as exchange rate shocks in accounting for variations in money supply over the period concerned.

there did exist, therefore, a ***'Bi-directional Causality'*** between exchange rate and money supply over the ***'Basket-Peg Period'***.

12.19 Summary of Findings in Chapter 12

It is, therefore, observed in the chapter 12 that in the 'Basket-Peg regime'

(i) *money supply variations 'Granger Caused' exchange rate variations,*

(ii) *exchange rate variations also 'Granger Caused' money supply variations,*

(iii) *there did exists, therefore,* ***Bi-directional Granger Causality*** *between exchange rate and money supply,*

(iv) *'Variance Decomposition' analysis also testifies for the persistence of* ***'Bi-directional Granger Causality'*** *between exchange rate and money supply provided no structural shift occurred regarding practice of determining the Rupee/Dollar exchange rate in the economy.*

All these findings are in conformity with the findings observed in Chapter 10 when ***'Structural VAR'*** *Model was estimated in order to ascertain the nature and direction of 'Granger Causality' over the historical dataset covering the period 1975(I) – 2006(IV).*
