CHAPTER-5

RELATIONSHIPS BETWEEN EXCHANGE RATE (RUPEE/DOLLAR) AND INTEREST RATE IN INDIAN ECONOMY: A STUDY OF COINTEGRATION AND VERIFICATION OF (UIRAP) DOCTRINE.

5.1 Introduction

The Uncovered Interest Rate Arbitrage Parity (UIRAP) doctrine, as explained in section 1.8.4 holds that domestic currency price of a unit of foreign currency (s_t) rises (falls) following rise (fall) in domestic interest rate (i_h). Thus following rise (fall) in domestic interest rate, domestic currency undergoes depreciation (appreciation).

Again since $s_t \infty i_h$, the percentage change in (s_t) equals the percentage change in i_h. This indicates that rate of depreciation (appreciation) of domestic currency, under UIRP doctrine, must in the long-run equal the percentage rise (falls) in domestic interest rate.

Figure 1.1 depicts the time plots of rate of change of rupee/dollar exchange rate and domestic interest rate over the period 22nd September, 2011-7th August, 2012. Figure 1.1 shows that both the series seem to share the common trend and coincide several times over the period concerned. This implies that the percentage change in exchange rate seems to be equal to that in interest rate. Consequently, the UIRAP doctrine seems to be holding good in the Indian economy over the period concerned.

We seek to examine in this chapter if rate of change of rupee/dollar exchange rate were really cointegrated with that in interest rate. In the event of its existence, long-run relationship between these two series would be established. In such case, it will be pertinent for us to estimate the cointegrating equation between these two variables and examine if there did exist a '*homogenous of degree one'* relation between the two.

It was observed in chapter - 4 that both (E_t)and (I_t) are I(1) variables. Consequently, there exists a scope for examining the 'cointegrating' relation between the two variables.

The study in this chapter is to assess this scope and estimate the cointegrating equation. We seek also to examine how short-run deviations of any of the variables from its equilibrium level get corrected over time. More specifically, the short-run dynamics of exchange rate variations will be enquired into in this chapter.

5.2 Study of Cointegration between rupee/dollar Exchange rate (E_t) Series and Interest Rate Series (I_t)

Both E_t and (I_t) are I(1) variables. This implies the possibility of existence of cointegration between E_t and (I_t). This possibility is being enquired into through the application of Johansen Cointegration Method. Results of such tests are being presented through the Table 5.1 below

Table: 5.1
Results of Johansen Cointegration Test for E_t and I_t at level [Period: 22nd September 2011 to 7th August 2012]
Trend Assumption: No constant and Linear Deterministic Trend
Lag Intervals (in first difference): 1-4

Unrestricted Cointegration Rank λ_{trace} Test Variables Involved: e_t and i_h at level					
Null Hypothesis	Alternative Hypothesis	Eigen Value	Trace Statistic (λ_{trace})	Critical Values 5%	1%
$r = 0$ $r \leq 1$	$r = 1$ $r = 2$	0.98689 0.00551	17.18196 0.868878	12.53 3.84	16.31 6.51
Unrestricted Cointegration Rank λ_{trace} Test Variables Involved E_t and I_t at Level					
Null Hypothesis	Alternative Hypothesis	Eigen Value	Trace Statistic (λ_{trace})	Critical Values 5%	1%
$r = 0$ $r \leq 1$	$r = 1$ $r = 2$	0.09868 0.00551	16.3131 0.86887	11.44 9.84	15.69 6.51

**MacKinnon (1996) one-side p-values. *Based on SIC, Max Lag = 1

5.2.1 Findings From the Table 5.1

It is observed from the Table 5.1 that

(i) for the null-hypothesis $r = 0$ against the alternative hypothesis $r > 0$, $\lambda_{trace}(0)$ =17.181 is greater than the corresponding 5% and 1% critical values. Therefore, the null-hypothesis of 'no cointegration' relation can be rejected even at 1% level.

(ii) for the null-hypothesis $r \leq 1$ against the alternative hypothesis $r > 1$, the value of $\lambda_{\text{trace}}\ (1)$ statistics is 0.868878 which is lower than 1% and 5% critical values. So the null-hypothesis of $r \leq 1$ is accepted and hypothesis of $r > 1$ is rejected at 5% level.

(iii) the null-hypothesis $r = 0$ against the alternative hypothesis $r = 1$ under λ_{trace} test, $\lambda_{\text{trace}}\ (1, 0)$ value is 16.31310. It exceeds the corresponding 5% and 1% critical values. It implies that the null-hypothesis of 'no cointegration' gets rejected at even 1% level.

(iv) for the null-hypothesis $r = 1$ against the alternative hypothesis $r = 2$ under λ_{trace} test, $\lambda_{\text{trace}}(1, 2) = 0.868878$ falls short of the corresponding critical values at 5% and 1% levels. Consequently, the null-hypothesis of 'one cointegrating equation' between the variables appears to be accepted at 5% level.

5.2.2 Overview of the Findings of Cointegration Study.

It is observed from the findings in section 5.2.1 that

(i) there exists 'cointegration' between exchange rate (e_t) and interest rate (i_t) at level over the period of study (22nd September 2011 to 7th August 2012).

(ii) $E_t \sim I(1)$ and $I_t \sim I(1)$ are CI(1, 0).

(iii) there exists one and only one cointegtrating relation between E_t and I_t.

5.2.3 Economic Implication of the Findings of Cointegration study

The existence of cointegration between E_t and I_t at level implies that there did exist a long-run relation between rupee/dollar exchange rate of the currency concerned with the domestic interest rate over the period (22nd September 2011 to 7th August 2012). Moreover, existence of one cointegrating relation between the variables establishes that exchange rates (rupee price per unit of dollar) were uniquely related to domestic interest rate.

5.3 Cointegrating Equation for Exchange Rate and Interest Rate.

Exchange Rate [$E_t \sim I(1)$] and Interest Rate [$I_t \sim I(1)$] are found to be cointegrated and these are $CI(1,0)$. The Cointegrating Equation which exhibits the long-run relationship between E_t and I_t needs to be estimated.

The estimated Cointegrating Equation between [$E_t \sim I(1)$] and [$I_t \sim I(1)$] is as follows:-

$$\widehat{E}_t = -0.158451 + 1.029044\, I_t \tag{5.1}$$

SE	(0.797677)	(0.040592)
t	[-0.198640]	[25.35118]
Prob	0.8428	0.0000

R^2 = 0.8006, $\overline{R}^2$ = 0.7994, Log likelihood = -375.2281 DW = 1.89852, AIC = 4.6571, SIC = 4.6952, F Statistics = 642.6822, Prob (F – Statistics) = 0.0000

Results of ADF Unit Root Test on residuals from the equation (5.1) are being presented below.

Table: 5.2
ADF Unit Root Test on Residuals (U_t) from the Equation (5.1)

Variable	Null Hypothesis	Lag Length*	ADF Test Statistics	Prob.	Mac-Kinnon Critical Value**		
					1%	5%	10%
U_t	U_t has unit root Exogenous: Constant	0	-2.885	0.049	-3.471	-2.879	-2.576
	U_t has unit root Exogenous: Constant, Linear Trend	0	-2.904	0.163	-4.016	-3.437	-3.143
	U_t has unit root Exogenous: None	0	-2.894	0.004	-2.579	-1.942	-1.615

**MacKinnon (1996) one-side p-values. *Based on SIC, Max Lag = 1

ADF Unit Root Tests testifies for the stationarity of the residuals from the equation (5.1). Thus the estimated equation (5.1) stands for the Cointegrating equation for [$E_t \sim I(1)$] and [$I_t \sim I(1)$].

5.3.1 Characteristics of the Cointegrating Equation (5.1)

The estimated cointegrations equation (5.1) exhibits several characteristics as stated below:

(i) The equation residuals are stationary.

(ii) The equation is good fit.

(iii) The estimated constant is not significant even at 10% level.

(iv) The estimated coefficient = 1.029044 is significant even at 1% level.

It may again be noted that the estimated coefficient is virtually not different from unity. Consequently, the equation (5.1) can be written as

$$\widehat{E}_t = I_t \tag{5.2}$$

since the estimated constant term is not significantly different (even at 10% level) from zero. This finding [as in the equation (5.1)] bears startling significance. The equation (5.2) implies *that the rate of change in exchange rate equals the rate of change in interest rate*. This finding is in conformity with the tenets of "the Uncovered Interest Rate Parity (UIRAP) Theory" of exchange rate. It shows that variations in exchange rate over the period of study were triggered by those in interest rate. Again variations in E_t were in '*Homogenous of Degree One*' relation with those in interest rate.

5.4 VEC Model for E_t and I_t: Study of the Short-run Dynamics of Relationship between E_t and I_t .

E_t and I_t are CI (1, 0) and there exists a long-run relationship between E_t and I_t. It becomes imperative to examine if such relationship were stable. The long-run relationship becomes stable if innovations or shocks transmitted through the channels of exchange rate (E_t) or interest rate (I_t) series converge and wither away within a short period of time. Results of VEC estimation of equations for E_t and I_t have been reported through Tables 5.3 and 5.4 below.

Table: 5.3
Results of VEC Model Estimation for E_t
Period: 22nd September 2011 to 7th August 2012
Included Observations: 160 (after adjusting end period)

Variable	$D(E_t)$		
	Coefficient	S.E	t-Statistics
$(Z_{t-i};\ i = 1,2)$	-0.1007	0.0273	-3.6875
$L^{-1}[\ D(E_t)]$	0.0571	0.0760	0.7513
$L^{-1}[\ D(I_t)]$	-0.2079	0.0971	-2.1409
C	0.0923	0.0665	1.3875
R^2=0.8925 $\bar{R}^2 = 0.0717$ F-Stat = 5.0959 Log likelihood = -195.7271 AIC = 2.4965 SIC = 2.5734			

5.4.1 Findings from the VECM Estimation for $\mathbf{D(E_t)}$

The Table 5.3 shows that

(i) $\hat{\rho}_1$, coefficient of the cointegrating term (Z_{t-1}) is significant even at 1% level. This indicates that the short-run shocks, transmitted through the interest rate channel, significantly affected the long-run relationship which exchange rate (rupee price per unit of dollar) maintained with interest rate level.

(ii) $\hat{\rho}_1 < 0$ indicates that interest rate falls in order to reduce exchange rate when it rises above the target rate. Thus the adjustment of short-run exchange rate to its long-run target value becomes possible because of the negative variation in interest rate.

(iii) $|\hat{\rho}_1| < 1$ indicates that exchange rate does not make over adjustment in order to ensure adjustment of observed exchange rate to its long-run target values. Thus the long-run equilibrium relationship between exchange rate and interest rate remains stable in the face of short-run variations in exchange rate.

(iv) coefficient of $L^{-1}[\ D(I_t)]$ in the $D(E_t)$ equation is significant at 5% level. Thus variation of exchange rate above its long-run target value appears to be responsive to rate of change in exchange rate. This confirms the Granger Causal Relation from interest rate to exchange rate.

(v) Coefficient of $L^{-1}[\,D(I_t)]$ in the $D(E_t)$ equation is negative and its absolute value is lower than one. This finding hints at the fact that variation of exchange rate above its target level is tamed by interest rate variations.

This particular phenomenon accounts for the absence of run-away rise or fall in exchange rate following variations in interest rate. This happens because exchange rate rises in response to an initial rise in interest rate. Interest rate remains constant for some time after an initial rise such that rate of change of exchange rate with respect to the reference period remains unchanged until rate of change of exchange rate equals that in interest rate. Exchange rate changes may exceed interest rate variations for a very short-period. However, unchanged past period interest rate triggers a decline in exchange rate until if touches back the previous period interest rate level. Figure 1.1 provides a testimony to this effect.

Table: 5.4
Results of VEC Model Estimation for I_t
Period: 22nd September 2011 to 7th August 2012
Included Observations: 160 (after adjusting end period)

Variable	$D(I_t)$		
	Coefficient	S.E	t-Statistics
$(Z_{t-i};\ i = 1,2)$	0.0089	0.0233	0.3843
$L^{-1}[\,D(E_t)]$	0.0366	0.0649	0.5640
$L^{-1}[\,D(I_t)]$	-0.0085	0.0829	-0.1027
C	0.0722	0.0567	1.2725
$R^2 = 0.0033$ $\bar{R}^2 = -0.0757$ F-Stat = 0.1771 Log likelihood = -170.4012 AIC = 2.1800 SIC = 2.2568			

5.4.2 Findings from the VECM Estimation for $D(I_t)$ in the Table 5.4.

It is observed from the Table 5.4 that

(i) $\hat{\rho}_2$, the coefficient of the error correction term in the equation for $D(I_t)$, is not significant even at 10% level. This indicates that short-run shocks, transmitted through the channel of exchange rate, fail to affect the long-run relationship which exchange rate maintained with interest rate.

(ii) Coefficients of $L^{-1}[\,D(E_t)]$ and $L^{-1}[\,D(I_t)]$ in the equation for $D(I_t)$ are not significant even at 10% level. Thus the equation for $D(I_t)$ in the VECM hints at block exogenity in it. Variation in interest rate appears to be autonomous and such variation is independent of variations in the current and previous period exchange rates. Moreover, variation in interest rate remains irresponsive to variation in previous period interest rate.

5.4.3 Overview of Findings from the Estimated VEC Model

Following inferences may be drawn on the basis of the findings from the study with the estimated VEC Model regarding the relationship between exchange rate (E_t) and interest rate (I_t) over the period 22nd September 2011 to 7th August 2012.

(i) The long-run relationship that exchange rate maintained with interest rate was stable.

(ii) Interest rate level exhibited significant adjustment in order to induce appropriate variations in exchange rate so that short-run deviations of exchange rate from its target (long-run) level may wither away.

(iii) Shocks, transmitted through the interest rate level channel, thus had significant impact on the maintenance of long-run relationship between E_t and I_t. Thus the short-run dynamics of exchange rate variations defined a *'Stable Equilibrium Process'*

(iv) There did exist *'unidirectional Short-run Granger Causality'* running from interest level to exchange rate

(v) Exchange rate failed to *'Granger Cause'* interest rate level in the short-run.

5.5 Summary of the Chapter 5

It is observed in Chapter 5 that

(i) E_t and I_t are cointegrated such that these are CI(1, 0). This implies that there exists a long run relationship between exchange rate and interest rate over the period of study.

(ii) there exists one and only one cointegrating equation relating E_t to I_t. The estimated cointegrating equation is given by the equation (5.1)

(iii) in the estimated equation, the constant term is not significantly different from zero even at 10% level while the regression coefficient for I_t is not significantly different from unity.

This means that the cointegration equation (5.1) virtually reduces to

$$\widehat{E}_t = I_h \tag{5.2}$$

This implies that percentage change in exchange rate equals or tends in the long run to be equal to percentage change in interest rate. This finding is in conformity with the doctrine of UIRAP and, therefore, UIRAP doctrine is found to hold good in Indian foreign exchange (Rupee/Dollar) market over the period of study.

(iv) VECM study confirms the existence of one and only one cointegration relation between exchange rate and interest rate. In this relation exchange rate varies in response to interest rate variations while interest rate variations are found to be independent of exchange rate variations. Thus, autonomous variations in interest rate are found to generate ‘induced variations’ in exchange rate in Indian economy over the period of study.