THE MONETARY POLICY TRANSMISSION FROM OFFICIAL RATE TO UNOFFICIAL RATE UNDER LIQUIDITY ADJUSTMENT FACILITY IN INDIA

PURNA CHANDRA PADHAN*

Abstract

This paper empirically examines the dynamic relationship between two short-term interest rates namely, repo rate (official) and call money rate (unofficial) during the full-fledged working of the liquidity adjustment facility in India. Using daily data, the study finds a strong relationship between the two rates in the long run and short-run, through cointegration tests and Error Correction Mechanism (ECM) respectively. The ECM and Granger causality test results reveal the bi-directional causality between the two rates in the short run and unidirectional causality from official to unofficial rate in the long run. The paper also examines the transmission of monetary policy impulses from official rates to unofficial rates and vice-versa. The Impulse Response Functions result shows that, in the short run, the interest rates responds to shocks to itself and other variables in the system, suggesting that monetary policy impulse can be efficiently transmitted to other financial markets.

1. INTRODUCTION

The increasing globalization and growing integration of various financial markets has significantly changed the operating framework of monetary policy in terms of instruments, procedure and institutional architecture (RBI Annual Report 2003-2004). Continuous innovations in financial markets and increasing international capital flows have switched up transmission channels from quantum to rates and thereby complicated the task of monetary transmission mechanism. Though the basic objectives of monetary policy, namely price stability and growth remains unchanged, financial stability emerged as an important concern of monetary authority in recent times. Such regime

* Assistant Professor, Economics, Xavier Labour Relations Institute (XLRI), *School of Business an Human Resources,* P. Box. 222, C H Area(East), Jamshedpur-831001, Jharkhanad, INDIA, E-mail: pcpadhan@xlri.ac.in, pcpadhan@yahoo.com, padhanpc@yahoo.com.

shifts have urged the monetary authority to shift existing monetary targeting framework to a multiple indicator approach to achieve desired goals. As a result, short-term operational targets and instruments have become more popular to steer financial markets rates and maintain liquidity consistent with policy goals. In view of the shift in operating procedure of monetary policy from direct instruments to indirect instruments, short-term interest rates have become key instruments through which the central bank can transmit monetary policy impulses (signal) to financial markets. Thereby controlling these short-term interest rates, monetary authority can send signals across markets, and thereby affect investment and real economic activity.

The theoretical relationships between monetary policy and interest rates and between interest rate and economic activity have been well established in the literature (Monnet and Warren, 2001; Stock and Watson 1989; Friedman and Kuttner, 1992; Bernanke and Blinder 1992). However, there is lack of empirical studies examining the relationship between various interest rates and the role of monetary authority in influencing interest rates[1]. The dynamic relationship among interest rates and the transmission of monetary policy impulses to the various markets is substantially yet to be explored in the context of India and needs utmost attention. An empirical exercise has been carried out here to examine the linkages between two short-term interest rates i.e. repo rate and call money rate and also to examine the transmission of monetary impulses from one market to another, under liquidity adjustment facility.

The paper is divided into six sections, including the introduction. Section II discusses the monetary policy operating procedure and interest rates under liquidity adjustment facility (LAF). Section III describes the empirical methodology. Section IV deals with the data used. The empirical analysis and results are discussed in section V. The paper concludes in the final section.

2. MONETARY POLICY OPERATING PROCEDURES AND INTEREST RATES UNDER LIQUIDITY ADJUSTMENT FACILITY (LAF)

Economists offer two seemingly contradictory views to explain the relationship between money supply and interest rates. According to *the liquidity view*, which follows from the interaction between demand and supply of money, money supply and interest rates are negatively related (Bernanke

[1] Elliot and Bewley (1994) have examined in the context of Australia.

and Mihov (1998), Christiano, Eicheanbaum and Evans (1997). In contrast to this, the *Fisher equation* view suggests that money supply and interest rates are positively related (Lucas, 1980). Since the monetary policy is being measured in terms of the changes in the money supply, the theoretical relationship between monetary policy and interest rate can be established in both directions. The increasing globalization and changing economic policies across globe resulted in a continuous change in the operating procedure of monetary policy in terms of instruments and targets. In fact, in most countries the intermediate monetary target of monetary policy has been shifted to interest rate targeting, inflation targeting, exchange rate targeting. This may be due to various reasons, such as instability of money demand, external oil price shocks and so on. All these factors have complicated the task of formulation, operation and the role of monetary policy to achieve the desired objectives of price stability, output growth and financial stability.

In the context of India, the monetary policy operating procedure has undergone a significant transformation since independence at various capacities. A remarkable change has taken place after the economic reforms of nineties. The objectives of monetary policy namely price stability and growth remains more or less the same, but maintaining stability in financial markets has emerged as an important task before monetary policy in recent years. To achieve the primary goals, the monetary authority adopted, formally or informally, various intermediate targets over the years. Although the Reserve Bank of India (RBI) did not have a formal intermediate target till the 1980, bank credit and, from 1980 to 1997-98, monetary (M3) target served as a private target of monetary policy (RBI Annual report 2003-2004). However, due to further deregulation of financial sectors in general, and interest rates in particular, RBI finally adopted a multiple indicator approach in April 1998. In this scenario, although broad money remained important information variable, other macro economic indicators such as interest rates, fiscal position, capital flows, inflation rate, exchange rates etc were also important in the process of monetary formulation.

In view of the regime shift from a uniform target framework towards a multiple indicator approach, the monetary policy instrument changed from a direct to indirect (market based) instrument in various steps, such as through the introduction of the auctioning process of government securities in April 1992-93 and repos in Dec 1992. The deregulation of lending rate since October 1994 and deposits rate in October 1997, allowed banks to determine their own rates. Ways and Means Advance (WMA) replaced the automatic monetisation of government security in April 1997, which has short-term liquidity impact on a daily basis. Direct instruments such as Bank Rate, CRR, SLR, etc have been replaced by indirect instruments such as repo, reverse repo supported by OMO.

The policy reforms led to the integration of financial markets and improved efficacy of monetary policy transmission across markets. However, due to growing complexities and increasing volatilities in financial markets maintaining financial stability and enforcing economic growth has become a challenging task for monetary authority. All these factors led the RBI to model short-term liquidity in the market, and hence short term interest rate become principal operating instrument of monetary policy. Following the recommendations of the Narasimham Committee Report on Banking sector reforms, 1998, an interim *Liquidity Adjustment Facility* (LAF) was introduced in April 1999[2] to further develop the money market. LAF is a mechanism to manage short term liquidity in the market through a combination of repo transactions, export credit, refinance facility, and collateralized lending facility supported by Open Market Operation (OMO) at a set rate of interest. Liquidity absorption was done through fixed repo announced on a daily basis, supported by OMO in government-dated securities and treasury bills and injected at various interest rates. In the process, an informal corridor of the call rate emerged with the bank rate (refinance rate) as the ceiling and the repo rate as the floor rate. This will help in minimizing the volatility in the money market. Since June 5, 2000, it was upgraded into a full-fledged LAF allowing the RBI to manage market liquidity on a daily basis and transmit interest rate signals to the market. In the process of liquidity adjustment facility the collateralized lending facility was replaced by variable in repo/reverse repo rate auctions, and LAF started operating at different times on the same day, with flexible quantity and rates depending upon the need. The ultimate goal of LAF is to confine inter bank call money market to banks only and non-banks to repo market.

Thus the Reserve Bank of India influences liquidity by modeling the liquidity in the system through repo/reverse repo operation under the LAF

[2] LAF operates through daily repo and reverse repo auctions. The main objective of LAF is to maintain day-to-day liquidity mismatches in the system but not funding requirements. It also aims at reducing the volatility in the short-term money markets rates and steering these rates consistent with monetary policy objectives. Since May 8, 2002 the action of formation of LAF was changed from the uniform price auction method to the multiple price auction method to ensure more responsible bidding. The time for LAF auctions was advanced by 30 minutes to provide additional time for unsuccessful bidders in LAF auctions to cover up their positions in the short-term money market. A system of balances is maintained by scheduled commercial banks, with Reserve Bank on a cumulative basis, to stabilize market expenditure and dampening volatility in call rates (RBI Annual Report, 2001-2002).

(RBI Annual Report 2000; Sen Gupta, *et. al.* 2000; Dua, *et. al.* 2003). RBI manipulates the interest rate corridor defined by the reverse repo rate, the price at which, it injects liquidity and the repo rate/bank rate, the price at which it absorbs liquidity. For example, if the RBI intends to tighten the money market through LAF, then it can do by increasing the repo rate and vice versa. In the process, interest rates emerge out of repo/reverse repo auctions and provide a corridor for the call money rate and other short-term interest rates. The LAF is gradually emerging as the principal operating instrument of monetary policy and is quite successful in controlling liquidity in the market and influencing the other short-term interest rates[3].

In this context the paper analyses empirically the relationship between repo rate (official) and call money rate (unofficial) and the transmission of monetary policy influence from one market to the other.

3. EMPIRICAL METHODOLOGY

Most of the macroeconomic time series variables are generally non-stationary and time dependent. Modeling such times series variable often provides inconclusive and spurious results. However, any transformation of such variables could give a meaningful explanation to the underlying behavioral relationship. Modeling cointegration of such non-stationary variables could explain the long run relationship between them. In fact if the linear combination between (among) a set of non-stationary variables is stationary, then such variables are cointegrated and they therefore follow an equilibrium relationship in the long run. For example, if the linear combination between two time series variables Xt ~ I (1), and Y_t ~ I (1), can be expressed as, $Y_t = \alpha + \beta X_t + \varepsilon_t$, then the two series are said to be cointegrated, if εt is I (0), where I (0) is integrated of order zero or stationary in level.

However, if the variables are cointegrated, it doesn't necessarily mean that they are always in equilibrium during short run. In fact, the existence of cointegration makes it possible to investigate the short-run relationship among the cointegrated variables. The Error Correction Mechanism (ECM) provides statistical information on the short run relationship between vari-

[3] RBI is using the LAF as an effective flexible instrument for smoothening interest rates. The operations of non-bank participants including financial institutions, mutual funds and insurance companies that were participating in the call/notice money markets have been gradually reduced. Such a ultimate goal of making a pure-inter-bank call money market is linked to the operationalisation of the Clearing Corporation of India Limited and is also attracting non-bank into an active repo market (Y.V. Reddy, 2002).

ables. Engel and Granger (1987) define ECM as a mean of reconciling the short run behavior of the economic variables with its long run behavior. The estimation of ECM determines whether the system under consideration is in equilibrium or not in the short run and it can determine if a part of disequilibrium from one estimation period is corrected in the period that follows it.

If the variables are cointegrated they are necessarily causally related (Granger, 1969). The ECM and also Granger Causality tests provide empirical evidence regarding the causality between variables. One can examine the long run and short run causality between variables from EC Mechanism and Granger causality tests respectively. If some restriction is put in the Error Correction Mechanism then Granger causality test will be a special case of ECM.

Once the long run, short run and the casual relationship between variables is established, it is of interest to know further how the variable responses over a period of time to any external shock given to itself and other variables in a VAR model[4]. This can be estimated through the impulse response function of the VAR model. In fact, impulse response functions trace out the responsiveness of the dependent variable to shocks of each of the variables in the system.

The estimation procedure is as follows: The first step is to examine the stationary of the series, through unit root tests. To test unit root we have applied Augmented Dickey-Fuller Tests, Phillips- Perron Tests and KPSS tests. The second step is to find out the cointegration between repo rates and call money rate applying Engel-Granger tests and Johansen-Juselius tests. The third and fourth step estimates the error correction model and the Granger Causality tests respectively and in the final steps the Impulse Response Functions of the VAR model.

4. DATA

The daily data of repo rate and the corresponding day call money rate from June 5,2000 to May 31, 2005 has been collected from the Hand Book of Statistics on Indian Economy 2003-04 and subsequent data is collected from various issues of the Reserve Bank of India (RBI) Bulletin. Call money rate

[4] Since the empirical exercise is carried out using daily data, we confined our definition of short-run as less one month, medium-run as greater than one month and up to one year, and long run as more than one year. However, this definition is different from the usual definition (i.e. Marshallian' definition of the term with respect to market demand analysis).

(lending rate) is a very short-term interest rate determined by the equilibrium between demand and supply of short-term fund in the market and hence represents unofficial rates[5]. On the other hand, repo rate (repurchase rate) though determined by bidding, is an official rate used for policy purposes to even out the mismatches between demand and supply of short-term funds in the market. The starting date is due to the beginning of operation of the liquidity adjustment facility in full-fledged. The end period is based on availability of data. It is mentioning here some of the changes in LAF. The revised LAF scheme was operationalised with effect from March 29, 2004 through (1) Seven day fixed repo conducted daily, (ii) overnight fixed rate reverse repo conducted daily on weekdays and, (iii) fixed rate overnight repo introduced since August 16, 2004. Here only one-day repo conducted daily and call money rate of the corresponding day is considered.

5. EMPIRICAL ANALYSIS AND RESULTS

This section discusses the empirical analysis carried out for the present study and the results. Prior to the application of the cointegration test it is essential to check whether the variables are stationary or not. The stationarity of the series has been tested applying unit root test of Augmented Dickey-Fuller (Dickey-Fuller, 1981), PP (Phillips-Perron, 1987) and KPSS (Kwiatkowsk, Phillips, Schmidt and Shin, 1992). The ADF and PP unit root tests formulate the null hypothesis of non-stationary against the alternative of stationary, whereas KPSS test is a confirmatory test, which formulates the null hypothesis of stationary against the alternative of non-stationary. In contrast to the ADF test, the PP test has an added advantage as it gives robust estimates when the series has serial correlation and time dependent hetroscedasticity. Each interest rate is tested for stationary including a constant term but not trend. The trend is excluded since the data do not follow any systematic trend. The lag length for ADF test is selected based on minimum of AIC (Akaike, 1974) and SBC (Schwarz, 1978) starting with a higher lag length[6]. For PP and KPSS tests, it is decided according to Newey–West (Newey–West,

[5] The weighted average of call money rate (lending) Mumbai is used here.

[6] AIC (Akaike Information Criteria) = $\ln(\hat{\sigma}^2) + \frac{2k}{T}$

SBC (Schwarz Bayesian Criteria) = $\ln(\hat{\sigma}^2) + \frac{2k}{T}(\ln T)$, where $\hat{\sigma}^2$ is the estimator of the variance of regression disturbances, k is the number of parameter and T is the sample size.

1994) bandwidth using Bartlett kernel. These tests have been carried out both at levels and first difference data. The regression equation of these tests includes a constant term but no trend.

Through out the study abbreviations, 'cmr' stands for call money rate and 'repo' for repo rate. The prefix 'd' stands for the variable at first difference. The results reported in table 1 show that both series are I (1), i.e. non-stationary at level but stationary at first difference.

Table 1. Unit Root Tests

Variables	ADF	PP	KPSS
cmr	-2.330(3) (0.1628)	-2.549(9) (0.104)	2.279(22)
repo	-3.022(4) (0.033)	-2.760(12) (0.0645)	2.163(22)
dcmr	-12.725(15)* (0.000)	-27.011(8)* (0.0000)	0.029(8)*
drepo	-12.002(13)* (0.0000)	-22.766(8)* (0.000)	0.395(11)*

* Implies 1% significance levels. The critical values for ADF and PP test with constant and no trend are –3.4386, –2.856, and –2.568 for 1%, 5%, and 10% significance level respectively. Whereas for KPSS Test (drawn from KPSS, 1992 Table 1) the critical values are 0.739, 0.463 and 0.347 at 1%, 5%, and 10% significance level respectively. Figures in the parenthesis show the McKinnon (1996) one sided p value for ADF and PP test. Figures in the brackets show the maximum lag length.

Since both the series are I (1), we can apply cointegration tests of Engel-Granger (1987), and also Johansen (1988), and Johansen-Juselius (1990) tests at the level data[7]. The two-step estimation procedure of Engel-Granger residual based cointegration test is analysed below. In the first step, apply ordinary least square (OLS) method to estimate the coefficient of the cointegrating equation and obtain the estimated residuals. In the second step, apply unit root tests (DF and/or ADF) to test the stationary of the estimated residuals. Here the variable 'residcmr' stands for estimated residuals of call money rate equation, where 'cmr' is the dependent variable and 'repo' is the independent variable. Similarly, 'residrepo' stands for estimated residuals of repo rate equation, where 'repo' is a dependent variable and 'cmr' is an independent variable.

[7] Gonzalo (1994) analyzed the statistical performance of three cointegration tests such as, Engel-Granger, the Stock and Watson tests, and Johansen's test and found that Johansen's is superior to the other tests under consideration.

Table 2. Engel Granger Cointegration Test

Variables	DF Test With constant no trend	ADF Test With constant no trend
residcmr ($\Delta\varepsilon_{yt}$)	-0.2355 (-10.654)*	-0.12389 (-5.0521)*
residrepo($\Delta\varepsilon_{xt}$)	-0.2257 (-10.459)*	-0.1219 (-5.094)*

* Denotes 1% significance level. The ADF critical values at 1%, 5% and 10% are –4.07, –3.37 and –3.03 respectively as provided by Engel and Yaoo (1987) for n=2 i.e. number of variables is equal to 2. The figures denote the estimated coefficients of the test equation and in the parenthesis are associated τ statistics.

The Engel-Granger results are given in table no 2. In the table, the variables denoted as 'residcmr' and 'residrepo' are residuals of regression equation of call money rate and repo rate respectively. Lag length of 5 is selected, based on minimum of AIC and SBC for ADF test. The result shows that, the residuals of both the cointegrating equations are stationary at level data as revealed by the Dickey-Fuller and Augmented Dickey Fuller tests. Both the DF and ADF test statistics suggest the rejection of null hypothesis of non-stationary at 1% significance level. So we can conclude that the repo rate and call money rate are cointegrated. The respective cointegrating equations are $Y_t = \alpha_1 + \beta_1 X_t + \varepsilon_{yt}$ and $X_t = \alpha_2 + \beta_2 Y_t + \varepsilon_{xt}$, Where Y_t and X_t denotes call money rate and repo rate respectively[8].

The limitation of the Engel Granger cointegration test is that, a priori, it does not specify the nature of a dependent and independent variable. Johansen (1988) and Johansen and Juselius (1990) cointegration tests solve this problem. The JJ cointegration tests give better results for more than two variables and test the cointegration by applying maximum likelihood estimation procedure. The estimation procedure is based on the VAR model. Prior to the application of the VAR model, the selection of lag length is important. The AIC, SC, HQ, FPE and LR Statistics determine the VAR order (lag length k)[9].

[8] The results of the estimated equation are given below. $Y_t = - 0.10025 + 1.025 X_t$ —— (1)
t values (-1.98554) (119.801)
P values (0.0474) (0.0000)*
$X_t = 0.382 + 0.925 Y_t$ —— (2)
't' values (8.277) (119.80)
p values (0.0000) (0.0000)*

[9] All these estimations have been carried out with Eviews 5.0 software.

Table 3. Lag Length Selection for the VAR Model

VAR lag order	Log LR	LR	FPE	AIC	SC	HQ
30	1441	11.752	0.000097	-3.560	-2.8015	-3.267
25	1365.496	11.591	0.00011	-3.387	-2.756	-3.144
14	1038.797	66.302	0.0002	-2.599	-2.237	-2.455
7	319.399	5.487	0.0017	-0.757	-0.575	-0.687
5	310.058*	10.155*	0.0016*	-0.752*	-0.618*	-0.6007*

Here, 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.
* Implies the selected lag length based on the respective criteria.

The results are reported in table 3. We have started the upper bound for k = 30 and successively tested the coefficient of the largest lag. Using individual significance level, a lag length of 5 is suggested, based on these criteria.

Table 4 reports some misspecification tests of error process of the VAR Model. The results provide mixed evidence. The cmr equation accepts the existence of auto correlation by LM (1) And ARCH (1) at 5% significance level. There is no auto correlation at lag 5, but there is hetroscedasticity. Similarly, the repo equation accepts the existence of auto correlation at lag 5 but not at lag 1. The error is hetroscedasticity. In addition, both call money rate and repo rate seem to be non-normal due to existence of excess kurtosis. This problem is not severe though, and according to Gonzalo (1994), Johansen's cointegration method is robust even when the errors are non-normal. As the VAR model specifies well, the data, we can estimate the Johansen Juselius cointegration based on the VAR model with 5 lag.

The number of cointegrating vectors among the variables expressed linearly, is estimated and identified through λ trace and λ max statistics of Johansen-Juselius maximum likelihood tests. The λ trace statistics assumes null hypothesis (H_0) of r=0 cointegrating vector against the alternative (H1) of r>0 cointegrating vector. On the other hand, λ max assumes the H_0 of r=0 cointegrating vectors against the H1 of r=1 cointegrating vector. Table 5 reports the results of the λ trace and λ max statistics of JJ test. According to the results, λ trace statistics rejects the null hypothesis of no cointegrating vector at 1% significance level and accept the alternative hypothesis of more than zero cointegrating vector. Again it accepts the null hypothesis of r≤1 cointegrating vector and rejects the alternative of r>1 cointegrating vector. Similarly, λ max statistics rejects the null hypothesis of r=0 cointegrating vector at 1% significance level and accepts the alternative hypothesis of 1 cointegrating vector. It also rejects the alternative hypothesis of r=2 cointegrating vector. So both the tests statistics suggest the presence of one cointegrating vector and hence the variables are cointegrated and follow a long run equilibrium relationship.

Table 4. Misspecification tests for VAR Model (Univariate and Multivariate)

VAR (5)	LM(1) χ^2	LM(5) χ^2	ARCH(1)	Skewness	Kurtosis	Hetroscedasticity (White's tests)
cmr	5.776** (0.016)	12.374 (0.300)	3.9438** (0.047)	-1.1619	76.085	107.0752* (0.000)
repo	0.524 (0.469)	15.234* (0.0094)	0.026 (0.871)	12.82	364.469	22.162 (0.334)
dcmr	0.038 (0.844)	10.831 (0.054)**	4.641 (0.031)**	-1.186	76.085	31.108 (0.053)*
drepo	0.0325 (0.568)	3.818 (0.564)	0.024 (0.877)	12.085	362.832	10.357 (0.961)
System (Joint tests) χ^2	15.819 (0.003)	18.158 (0.0000)		111114.84 (0.0000)	144592 (0.0000)	336.172 (0.0000)

Notes: LM (1) is the Lagrange multiplier test for residual serial auto correlation of Order 1. LM (5) is with order 5. ARCH (1) is the first order Autoregressive conditional hetroscedasticity of order 1. Normality is tested based on Skewness and Kurtosis. Hetroscedasticity is tested based on whites' test. All test statistics are asymptotically distributed as χ^2.
* and ** denotes statistically significant at the 1% and 5% level.

Table 5. Results of Johansen- Juselius Cointegration Test

Eigen values	Hypothesis		Trace values	Critical Value		Hypothesis		Max values	Critical Value	
	H0	H1		5%	1%	H0	H1		5%	1%
0.324	r=0	r>0	32.804*	19.96	24.60	r=0	r=1	25.168*	15.67	20.20
0.0099	r1	r>1	7.635*	9.24	12.97	r=1	r=2	7.653*	9.24	12.97

* (**) denotes the rejection of the hypothesis at the 5% (1% level). The critical values are from Oster-Lenum (1992: Table, 1). The cointegrating equation contains intercept but no linear deterministic trend.

Once it is found that the variables are cointegrated, the next step is to estimate the error correction model (ECM) to examine the short run relationship between the variables. As defined by Engel and Granger (1987), the Vector Error Correction Model is used to determine whether a part of the disequilibrium from one estimation period is corrected in the period that follows. If the disequilibrium exists in the short run, VECM tests provide an indication of the direction and size of the short run impact between the test variable. The VECM may be specified as,

$$\Delta Y_t = \gamma_{i0} + \sum_{j=1}^{n} \Delta Y_{t-i} + \lambda z_{t-i} + u_t. \qquad \text{.... (1)}$$

Where Y_t =[cmr, repo]′ and u_t is a 2 × 1 vector of disturbance term. The constant term is denoted by γ_{i0}. In the Vector Error Correction model the interesting part is lagged term z_{t-i}, which gives an indication of the short run deviations from the long run equilibrium for both cointegrating equations. The lagged term implies that the disturbance of the last period has impact on the current period. If the coefficient λ is statistically significant, then the system is in short run disequilibrium and if not, then equilibrium exists in the short run. Also, the coefficient λ describes the speed of adjustment back to equilibrium and it measures the proportion of last period's equilibrium error that is corrected for.

Table 6. Results of Error Correction Test

Independent Variables	Dependent Variables	
	dcmr	drepo
dcmr(1)	-0.253 (-5.066)**	-0.122(-3.608)**
dcmr(2)	-0.253(-5.066)**	-0.072(-3.607)**
dcmr(3)	-0.149(-2.981)*	0.0096(0.283)
dcmr(4)	-0.067(-1.416)	0.023(0.715)
dcmr(5)	0.0132(303)	0.019(0.658)
drepo(1)	0.5299(7.499)*	0.443(9.22)**
drepo(2)	0.285(3.839)*	-0.023(-0.451)
drepo(3)	0.1586(2.195)***	0.103(2.1009)**
drepo(4)	0.197(2.753)***	0.0901(1.848)**
drepo(5)	-0.012(-0.192)	-0.084(-1.979)***
dresidcmr (1) (or l)	-0.105(-3.403)**	0.016(0.786)

*, **, and *** denotes 1%, 5%, and 10% significance level respectively. Figures in the parenthesis are estimated 't' statistics.

The result of error correction mechanism (ECM) is given in table 6. Since the cointegrating equation contains intercept but no linear deterministic trend, in the vector error correction model, the constant does not appear again. The ECM results reveal that call money rate responds to a deviation from the long run equilibrium, as the coefficient of lagged term is statistically significant and negative, whereas repo rate does not. This provokes the active role of liquidity adjustment facility and the repo rate as an adjustment mechanism to even out the mismatches between short-term demand and supply of funds. In the present case ECM is estimated at a lag length of 5.

Table 7 represents the misspecification or diagnostics check under the restriction of one cointegrating vector. The result shows that error terms are non-normal and hetroscedasticity. However, they are not serially correlated. According to Gonzalo (1994) non-normality is not a serious problem in Johansen's cointegration method.

Table 7. Multivariate Miss specification tests of the VECM Models

Residual auto correlation	LM(1) LM Statistics 5.703 (p=0.223)	LM(5) LM Statistics = 8.931 (p=0.0628)
Hetroscedasticity	$\chi^2_{(66)}$ 323.803 Joint test (P=0.0000)	
Normality	Skewness Joint test χ^2 =11250.51 P=0.0000	Kurtosis Joint test χ^2 =1421288, P=0.0000

The presence of cointegration necessarily implies causality, which can be examined through Error Correction Mechanism and Granger Causality tests. The former gives the long run causality, whereas the latter the short run. In the above-mentioned ECM the lagged error correction term z_{t-1} represents the long run relationship. A negative and significant coefficient λ associated with z_{t-1} indicates the presence of a long run causal relationship. If l in both the equations are significant, then it suggests that there is bi-directional causality. In this case λ is significant only in the first equation i.e. call money rate (cmr), suggesting that there is unidirectional causality from repo rate to call money rate. In other words, repo rate drives call money rate toward long run equilibrium but not the other way round.

On the other hand, the coefficient δ_i represents the short run cause and effect relationship between the two series. So, the lagged coefficient ΔY_t determines the direction of short run causality. If we omit the error correction term z_{t-1}, from the equations we get the conventional Granger causality model, which is widely used to investigate causal relations. Since the cointegrated VAR model approximate the data well, the Granger Causality test is estimated with 5 lag length. The results of the Granger Causality test is given in table no 8. The result suggests that, at 1% significance level of F statistics, we reject null hypothesis in both ways and accept the alternative hypothesis. This supports the existence of bi-directional causality between call money rate and repo rate.

Table 8. Granger Causality Test

Null Hypothesis	F Statistics	P Value	Causal Direction
repo does not GC cmr	27.322*	0.0000	repo→cmr
cmr does not GC repo	4.494*	0.00048	cmr→repo

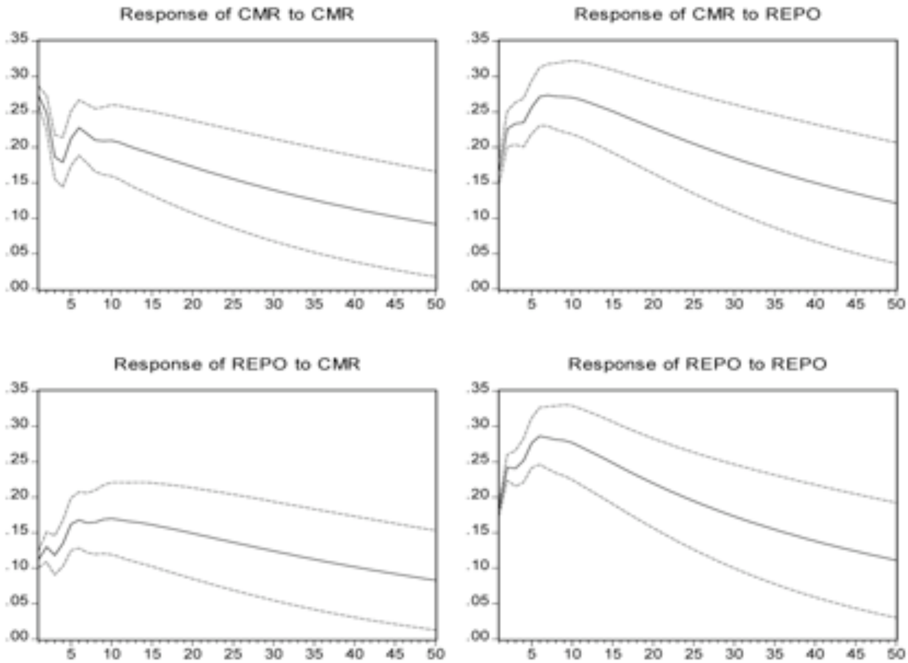
*, Denotes 1% significance level.

Also, the relationship between repo rate and call money rate can be explained through Impulse response functions of VAR model. As there is one cointegrating vector and VAR correctly specifies the data with 5 lag length, the VAR model can be estimated at level[10]. The impulse response functions trace out the responsiveness of the dependent variables to shocks to each of the variables. Therefore, for each variable from each equation separately, a unit shock is applied to the error term and the effects upon the VAR system over time are noted. The impulse response functions of the call money rate to shock in repo rate and vice versa have been estimated using generalized impulse response functions under the maintained hypothesis of one cointegrating vector.

The graphs of impulse response functions depicted in Figure 1 have been plotted for 50 periods ahead. It is evident from the figure that a shock to call money rate has a significant impact on the repo rate and vice versa in the short run. Initially, each variable responds positively to shocks in itself and to the other variable and there is a contemporaneous effect. The response of call money rate to shocks in repo rate lasts for at least one week and then starts decaying. Similarly, response of repo rate to shocks in call money rate also lasts for one to two week and then start decaying slowly. The response of call money rate to shocks on repo rate is higher than the response to repo rate to shocks in call money rate. Thus, the result suggests that monetary policy impulse can be transmitted effectively to other markets and quickly under LAF. From this analysis it can be concluded that repo rate is an active instrument of monetary policy under LAF to control the liquidity in the market and can send signals to call money rate in the short run.

[10] If there is zero cointegrating vector, then we do in fact have a VAR process in first difference. If there is 'n' cointegrating vector for 'n' number of vaiables, then the level data are already stationary, there is no need of cointegration and error correction tests and we can estimate the VAR at level. However if there is less n-1 cointegrating vector and data specifies the VAR model, then the VAR model can be estimated at level.

Figure 1: The Impulse Response Functions



6. CONCLUSION

The empirical relationship between repo rates and call money rates (official and unofficial interest rate) has been examined applying cointegration tests, error correction mechanism, Granger causality test and Impulse Response Functions of VAR model. The study finds the long run equilibrium relationship between both the interest rates and the short run call money rate adjusts to the repo rate in the deviation from the equilibrium relationship. In the short run, there is sufficient empirical evidence of bi-directional Granger Causality between the two interest rates, and repo rate to call money rate in the long run. The unofficial rate immediately responds to a unit shocks in the official rate and could last for a couple of days, suggesting that monetary policy could affect the interest rates of other financial markets effectively. The official rate also responds immediately to a unit shocks in the unofficial rate and could last for more than a week, which suggest that the monetary authority always has a vigil eye on the mismatch between the short-term demand and supply of money and therefore could manage it effectively through repo rate. For what concerns policy implications, the study suggests that, repo rate is an effective instrument of monetary policy to control the short-term liquidity in the market and supports the active role of LAF in this context.

References

Akaike H., 1973, "Information Theory and the Extension of the Maximum Likelihood Principle", *In* B.N. Petrov and F. Vsaki (ed), *Proceedings of the Second Intentional Symposium on Information Theory*, Budapest, pp. 267-181.

Bernanke B.S and I. Mihov, 1998, "The Liquidity Effect and Long-Run Neutrality", *Carnegie-Rochester Conference Series on Public Policy*, Vol. 49, Dec. pp. 149-194.

Bernanke B.S. and A.S. Blinder, 1992, "The Federal Funds Rates and the Channels of Monetary Transmission Mechanism", *American Economic Review,* Vol. 82, pp. 901-21.

Christiano L., M. Eicheanbaum and C.L. Evans, 1999, "Monetary Policy Shocks: What have we learned and to What End?", In John. B. Taylor and Michael Woodford, (eds.), *Handbook of Macroeconomics*, Amsterdam: Elsevier / North-Holland. Vol. 1 (A), Chap. 2, pp. 65-148.

Dickey D.A. and W.A. Fuller, 1981, "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica*, Vol. 49, pp. 1057-1072.

Dua P., N. Raje and S. Sahoo, 2003, "Interest Rate Modeling and Forecasting in India", DRG Study No 24, Reserve Bank of India, Mumbai, pp. 1-118.

Elliott G. and R. Bewley, 1994, "The Transmission of Monetary Policy: The Relationship between Overnight Cash Rates", *The Economic Record*, Vol. 70, No. 208, pp.-19-25.

Engel R.F. and B. Yaoo, 1987, "Forecasting and Testing in Cointegrated System", *Journal of Econometrics,* Vol. 35, pp.143-159.

Engel R.F. and C.W.J. Granger, 1987, "Co-integration and Error-Correction: Representation, Estimation, and Testing", *Econometrica*, Vol. 55, pp. 1-87.

Friedman M. and K.N. Kuttner, 1992, "Money, Income, Prices and Interest Rates", *American Economic Review*, Vol. 82, No. 3, pp. 472- 492.

Gonzalo J., 1994, "Five Alternative Methods of Estimating Long Run Equilibrium Relationships", *Journal of Econometrics*, Vol.60, pp. 203-233.

Granger C.W.J, 1969, "Investigating Causal Relationship By Econometrics Models And Cross-Spectral Methods", *Econometrica,* Vol. 37, pp. 424-438.

Johansen, S. (1988), "Statistical Analysis of Cointegrating Vectors", *Journal of Economic Dynamics and Control,* Vol. 12, pp. 231-254.

Johansen S. and K. Juselius, 1990, "Maximum Likelihood Estimation and Inferences on Cointegration – With Applications to the Demand for Money", *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169-210.

Kwiatkowsk, D., Phillips, P.C.B., Schmidt P., and Shin Y. (1992), "Testing the Null Hypothesis of a Stationary against the Alternative of A Unit Root: How sure are We that Economic Time Series have a Unit Root?", *Journal of Econometrics*, Vol. 54, pp. 159-178.

Lucas R.E. Jr., 1980, "Two Illustration of the Quantity Theory of Money", *American Economic Review*, Vol. 70, Dec, pp. 1005-1014.

Monnet C. and W.E. Weber, 2001, "Money and Interest Rates", *Federal Reserve Bank of Minneapolis Quarterly Review,* Fall, pp. 2-13.

Narasimham Committee Report on Banking Sector Reforms 1998, Reserve Bank of India, Mumbai.

Newey W.K. and K.D. West, 1987, "A Simple, Positive Semi-Definite, and Auto Correlation Covariance Matrix", *Econometrica*, Vol. 55, pp. 703-708.

Phillips P.C.B. and P. Perron, 1988, "Testing for a Unit Root in Time Series Regression," *Biometrica,* Vol. 75, pp. 335–346.

RBI Annual Report 1999-2000,2001-2002, 2003-2004, Reserve Bank of India, Mumbai.

RBI Report on Currency and Finance 2003-2004, Reserve Bank of India, Mumbai.

Schwarz G., 1978, "Estimating the Dimension of a Model". *Annals of Statistics*, Vol. 6, pp. 461-464.

Sen Gupta I., I. Bhattacharya, S. Sahoo and S. Sanyal, 2000, "Anatomy of Liquidity Management", *Reserve Bank of India Occasional Papers*, June, Vol. 39, No. 4. pp. 933-941.

Stock J. and Watson M.W., 1989, "New Index of Coincident and Leading Indicators", *In NBER Macro Economics Annual*, (ed) Blanchard, O. and Fischer S., Cambridge, Mass, MIT Press, pp. 351-393.

Résumé

L'article analyse les relations dynamiques entre deux taux intérêt de court terme, l'un officiel et l'autre non officiel quand les mesures d'ajustement de liquidité en Inde étaient en cours. En utilisant des donnés journaliers, l'étude démontre une relation forte entre le deux taux, une relation bidirectionnelle entre le deux dans le court terme et une relation unidirectionnelle de l'officiel au non officiel dans le long terme. L'article analyse aussi la transmission des impulses de la politique monétaire des taux officiels aux taux non officiels et démontre que dans le court terme les impulses peuvent être efficacement transmis aux autres marchés financiers.