Econometric Models of Forecasting Money Supply in India

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Introduction

Monetary policy is a very important factor influencing the working of the financial sector of the economy. Forecasting money supply is a part and parcel of designing monetary policy. This paper reviews the econometric models of forecasting money supply in India for the entire post independence period, points out their gaps and tries to fill these gaps.

Literature Review

Soumya *et al*. (2005) in their review of the studies till the beginning of 2005 found that there was no mention of the treatment of the monetary sector in the models prior to 1970s and after 1970s modelling monetary sector and it's links with the fiscal and external sectors became a challenging task in India. They also noted that modelling money and monetary policy for the determination of real output and price level has increased considerably in India. These issues were highlighted in models built by Rangrajan *et al*. (1990) and Rangrajan *et al*. (1997) also. In these models money stock varies endogenously through feedback from reserve money, which changes to accommodate fiscal deficit and changes in foreign exchange reserves. Reserve money credit to finance public sector investments lead to monetary expansion and investment which together may lead to higher output with a lag. In addition, models by Rangarajan *et al*. (1990) and Krishnamurty *et al*.(1984) show links between real, monetary and fiscal sectors. Soumya *et al*. (2005) further found that there has been recently a shift from net domestic assets to net foreign assets on resources side of the monetary base because of financial liberalization and the ensuing changes in the monetary policy i.e. relying more on market based direct measures than on direct monetary controls. These issues have been addressed by modelling money supply process in India by Rath (1999). Nachane (2005) discussed the impact of liberalization on monetary policy and the link between monetary base and money supply for the post reform period.

Following is the picture of the modelling money supply in India at a glance:

Author(s) and Year of Publication	Sample period, frequency of data	Independent Variable(s)	Dependent Variable(s)	Forecasting Technique/Model Employed/Composed
1. The First Working Group (1961)	1951-52 to 1960-61 annual data	Government money or monetary liabilities of the RBI and the Government to the public as well as the banking	Money supply comprising currency with the public, bank deposits and other deposits with the RBI	Balance sheet approach

		system		
2. Bhattacharya (1972)	1949-50 to 1967-68, annual data	Narrow money, Autonomous expenditure consisting of investment, government expenditure and trade balance, one year lagged consumption, Time deposits	Consumption, Disposable income	Causal model[1]
3. Gupta (1972)	1948-49 to 1967-68, annual data	Un-borrowed reserve money, money multiplier	Narrow money	Tabular analysis and data interpretation
4. Marwah (1972)	1939-65, annual data	Government bond yield percent per annum, index of industrial share price, income velocity	Narrow money real along with changes in savings deposits real	Causal model

[1] Causal model means simple linear or log linear regression analysis followed by simulation.

5. Gupta (1973)	1948-49 to 1967-68, annual observations	Reserve money, Money multiplier	Narrow money	Causal model
6. Mammen (1973)	1948-49 to 1963-64, annual data	Non-agricultural income at current prices, Average annual three months time deposits rate at Bombay, Calcutta and Madras; Yield on central government conversion loan 1986 or later, National income at current prices, average annual twelve months time deposits rate at Bombay,	Demand deposits, Time deposits	Casual model

		Calcutta and Madras, Non-agricultural income at current prices; Average annual twelve months time deposits rate at Bombay, Calcutta and Madras		
7. Chona (1976)	1951-52 to 1975-76, annual data average of last Fridays	Fluctuations in money multiplier, Net foreign assets of the central bank, Net credit to the government	Changes in narrow money supply	Tabular analysis and data interpretation
8. Swami (1978)	1952-53 to 1975-76, annual data	Change in government securities geld by	Changes in high powered money	Tabular analysis and data interpretation

		RBI due to open market operations, Subscriptions to new loans of Central Government, Purchase of securities from the public (the banks), Sale of securities to the public (the banks), Net Purchase of foreign exchange from RBI, Borrowings of commercial and cooperative banks from RBI, Change in government		

		securities held by the RBI due to the government borrowings from RBI, Government's net purchase of foreign exchange (forex) from the RBI,		
9. Rao *et al.* (1981)	1970-71 to 1979-80 annual data for last Friday of March	Nominal income, Rate of change in prices of sensitive commodities, Foreign remittances inflow, Rate of return on time deposits, Incremental cash reserve ratio,	Currency, Deposits,	Causal model

		Call money rate, Share of non-agricultural income to total income, Food credit		
10. Singh *et al*. (1982)	1970-71 to 1981-82 quarterly averages	Real income, Inflation rate, Nominal interest rate, lagged value of Real M1	Real M1	Causal model
11. Sarma (1982)	1961-62 to 1979-80 annual data	Bank credit to commercial sector, The central government's budget deficit, Foreign exchange assets with the banking system	Narrow money	Causal model

12. Rangarajan *et al.* (1984)	1974-75 to 1981-82, quarterly data	High powered money – current and lagged values	M1	Autoregressive relationship within a causal frame
13. Nachane *et al.* (1985)	1960-61 to 1981-82, annual data	M1 – lagged values	M1	Causality frame[2]
14. Chitre (1986)	1970-71 to 1983-84, annual data	Real income, Interest rate, Anticipated inflation	Currency, Deposits	Causal model
15. Ramachandra (1987)	1951-71 to 1985-86, annual data	Nominal income at current prices – lagged values	M1	Causality frame
16. Chakrabarty (1987)	1962-63 to 1983-84, annual data	High powered money	M3	Causality frame
17. Nachane *et al*. (1989)	1973-74 to 1984-85 monthly data	Reserve money current as well as lagged values	M3	Time series model

[2] Causality frame means the frame of Granger and Engel.

18. Singh (1989)	Monthly data as on the last Friday from 1970-71 to 1986-87	M3 – lagged values	M3	Causality frame, Autoregressive frame
19. Rangarajan *et al*. (1990)	1961-62 to 1984-85 annual data	Reserve money	M3	Causal model
20. Sharma (1991)	1951 to 1985 quarterly data	Money supply, Price level – lagged values	Price level	Causality frame
21. Klein *et al*. (1999)	1970-71 to 1999-98, annual data	Money multiplier, Reserve Money	M3	Causal model
22. Rangarajan *et al*. (1997)	1971-72 to 1993-94 annual data	Reserve Money	M3	Causal model
23. Rath (1999)	1980-81 to 1997-98 annual data	Reserve Money	M3	Causality frame

24. Dash *et al.* (2001)	1960-61 to 1992-93 annual data	Gross domestic product in agriculture, gross domestic product in non-agriculture, WPI for manufacturing, WPI for food, Ration of WPI for food to WPI for manufacturing, Call money rate, Bombay stock exchange index	M3	Causal model
25. Jha *et al.* (2002)	1959-60 to 1996-97 annual data,	Lagged values of all of the following: Government deficit growth rate, Inflation rate,	M1	Time series model, VAR

		Agricultural output growth rate, M1 growth rate		
26. Jha *et al.* (2003)	1980-81 to 1999-2000, Monthly data	Money multiplier, Reserve Money	Narrow money	Time series econometrics (unit root test and cointegration as per Engel-Granger)
27. Soumya *et al.* (2005)	1972-73 to 2001-02, Annual data	Aggregate Deposits with Banks, Government Borrowings from Banks	Broad Money, Aggregate Deposits with Banks, Statutory Liquidity Ratio	Three Stage Least Square Method

Incompleteness of the Above Models

There are following cases regarding money supply as independent and dependent variable, which are not taken into account in any of the above studies:

After the start of economic liberalization, there is massive inflow of foreign exchange. They add to the foreign exchange assets of the banks. Net foreign exchange assets constitute a source of money stock. So liberalization might have an impact on money stock. But availability of data on such flow of foreign exchange is meagre. The RBI publishes such data in annual figures under three heads since 1990-91: (a) NRI deposits outstanding, (b) Inflows/outflows under various NRI deposit schemes, and (c) foreign investment flows. The volume of data is not compatible with any kind of model building process, because of scanty degrees of freedom. However this point is missing in above studies especially those which were conducted in the post liberalization period. Sarma (1982) is a study in this respect on the pre-liberalisation period.

Secondly bank credit to the commercial sector is a source of money stock. Commercial sector includes export firms. Flow of bank credit to them can boost exports and can fetch foreign currencies, thereby add to foreign exchange assets and hence of money stock. Thus there exists theorization of empirical experiences regarding the following missing link: Source of money stock → Commercial credit provided by banks to export oriented units and zones → Export Growth → Inflow of foreign exchange → Foreign exchange assets of the banks → Source of money stock. Again, good export potential or performance encourages banks to offer more credit at least in the short run, though not in the long run. A second theorization is available in Soumya *et al.* (2005) where foreign direct investment is found to affect positively foreign exchange assets of the banks and hence the base money which in turn affects positively the broad money. Sarma (1982) is a similar study in this respect on the pre-liberalisation period. Datta (1984) hinted it.

Thirdly in a floating exchange rate regime the RBI has often to intervene in the foreign exchange market in order to prevent any untoward movement in the value of rupee vis-à-vis dollar[3]. Dollar is the reserve currency of India[4]. An increase in the RBI's purchase of

[3] Das (2004) describes the reasons behind central bank intervention in exchange rate movement:

foreign currencies in exchange for rupee ceteris paribus depreciates rupee and vice versa. The RBI does not disclose the information on its foreign exchange market operation, as was the case when writing of this paper commenced. An increase in money supply in the country leads, other things remaining unchanged, to a decrease in the equilibrium interest rate in the money market and increase in liquid money in the hand of public. The term 'public' includes individuals as well as corporate entities save for government. A decrease in rate of interest, other things remaining unchanged, decreases cost of capital incurred by business and hence increases profits of business. Some of the increased profits are invested further in US dollar assets among other assets. This means people want to buy more of US dollars in exchange for rupees. So price of dollar vis-à-vis rupee increases, i.e. price of rupee vis-à-vis dollar falls. Thus an increase in money supply leads to a decline in the external value of the domestic currency. Further, the theory of floating exchange rate insists the central bank to prevent any unwanted movement of the home

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a. Current Practice: The present monetary system of the world is a mix of fixed and flexible exchange rate systems. A country following an unmixed fixed/flexible exchange rate system is a rare instance.

b. Regional Agreements: There are pacts/agreements among different countries, whereby they try to maintain a mutually agreed level of exchange rates amongst themselves, but allow exchange rates to fluctuate against outsider countries.

c. Countries in Transition: Nearly half of the countries of the world are going through economic transition towards a more capitalist system from a less capitalist system.

d. Experts Opinion: There is a debate among economists and policy makers regarding which of the fixed and the flexible exchange rate systems is better. So the governments cannot decide which system is more beneficial.

[4] In reserve currency system the central bank of a country singles out one foreign currency as reserve currency and holds the reserve currency in its international reserves. The central banks in this case are ready to sell/buy the reserve currency in exchange for the domestic currency in the foreign currency market, whenever required, with a view to maintaining the fixed exchange rate between reserve and home currencies. US dollar has been the reserve currency between 1939 and 1973 and by and large all countries of the world peg their currencies to US dollar.

The reserve currency system gives an advantage to that country (henceforth called the reserve currency's country RCC) whose currency is considered reserve currency. The RCC need not intervene in the foreign currency, because other countries maintain the exchange rate between RCC and their countries.

Secondly the reserve currency system puts the RCC in a privileged position because it can control other countries' monetary policies through it's own monetary policy by means of influencing the exchange rate between the reserve currency and other countries' currencies. If USA increases it's own money supply then ceteris paribus value of Indian rupee appreciates. This may cause a balance of payment problem for India, currency. Here the shift from net domestic assets to net foreign assets on resources side of the monetary base mentioned should be remembered. This is another instance of theorization of empirical evidences. Following this line of argument one can envisage in the context of India a strong possibility of presence of link between net foreign exchange assets of the banking sector including RBI (NFEA) and the rupee value of the currencies in the reference basket of currency. Because of the importance of US Dollar in international trade tracing back to the Breton Woods System, dollar is taken as the representative of the basket.

Payment of insurance premium might have a contemporaneous impact on the bank deposits. Liberalization of the insurance sector may cause an increase in the flow of deposits from the banking sector to the insurance sector thereby reducing a component of money in the same financial year. Purchase of life insurance policy entailing one for tax relief may be one of the reasons.

The Unaddressed Issues

In the aforementioned studies the following unaddressed issues are taken care of:

(i) Whether there is any causality between commercial credit from banks and exports performance in terms of unidirectional or bi-directional flows.

(ii) Whether exports performance affects the trade balance (TB) of the country

(iii) Whether TB affects net foreign exchange assets of the banking sector (NFEA), which is a source of money stock

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because imports become cheaper and exports become costlier. So India has to increase her money supply in order to devalue Indian rupee vis-à-vis US dollar..

(iv) Whether there is any causality between NFEA and value of US dollar in terms of rupee (D/R)

(v) Whether there is any causality from household purchase of life insurance policies (LI) on total bank deposits (TLD), sum of demand deposits and time deposits.

It is necessary to test whether export growth leads to addition to foreign exchange assets of the banking sector. But data on foreign exchange assets are not available or published by the RBI. Lumping foreign exchange liabilities together with foreign exchange assets, the RBI publishes a composite item called net foreign exchange assets of the banking sector (NFEA). Since NFEA includes official reserves by definition and trade balances contribute to official reserves positively or negatively one need test the flow of causality from commercial credit from banks to NFEA via the flow of causality from commercial credit from banks to exports growth, the flow of causality from exports to TB and finally the flow of causality from TB to NFEA.

The Proposed Models

In order to test whether there is any causality between commercial credit from banks and exports performance in terms of unidirectional or bi-directional flows two sets of regressions are run covering periods 1990-91 to 1999-2000 in terms monthly data followed by forecasting:

First set of regressions aim at test testing H_0: Commercial credit (B) from banks does not (Granger) cause exports (X). Here there are two subsets of regression equations:

The first subset contains four pairs of regression equations of X on B, two pairs of these equations are based on monthly data and another two pairs on annual data. Out of the two pairs of regression equations on monthly data, one pair takes 4 lags of each variable as regressors and other takes 8 lags of each variable as regressors. On the other hand, out of the two pairs of regression equations on annual data, one pair takes 4 lags of each variable as regressors and other takes 2 lags of each variable as regressors.

Following are the equations on monthly data:

$X_t = \alpha + \sum_{i = 1 \text{ to } 8} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 8} \gamma_i B_t + \varepsilon_t$, t = 1 to 112 (a)

$X_t = \alpha + \sum_{i = 1 \text{ to } 8} \beta_i X_{t-i} + \varepsilon_t$, t = 1 to 112 (b)

$X_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 4} \gamma_i B_t + \varepsilon_t$, t = 1 to 112 (c)

$X_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \varepsilon_t$, t = 1 to 112 (d)

Here (a) and (c) are called unrestricted equations and (b) and (d) are called restricted equations. The sums of squared residuals obtained from (a) and (c) are called unrestricted residual sums of squares (URSS) and the sum of squared residuals obtained from (b) and (d) are called restricted residual sums of squares (RSS). Then F test is performed involving (a) and (b), and (c) and (d) separately for H_0, where F = {(RSS – URSS)/8}/{URSS/(112 – 16 – 1)} at 95% level for (a) and (b) and F = {(RSS – URSS)/4}/{URSS/(112 – 8 – 1)} at 95% level for (c) and (d).

Following are the equations on annual data from 1970-71 to 1999-2000:

$X_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 4} \gamma_i B_{t-i} + \varepsilon_t$, t = 1 to 26, (e)

$X_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \varepsilon_t$, t = 1 to 26, (f)

$X_t = \alpha + \sum_{i = 1 \text{ to } 2} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 2} \gamma_i B_{t-i} + \varepsilon_t$, t = 1 to 26, (g)

$X_t = \alpha + \sum_{i = 1 \text{ to } 2} \beta_i X_{t-i} + \varepsilon_t$, t = 1 to 26, (h)

Here (e) and (g) are called unrestricted equations and (f) and (h) are called restricted equations. The sums of squared residuals obtained from (e) and (g) are called unrestricted residual sums of squares (URSS) and the sum of squared residuals obtained from (f) and (h) are called restricted residual sums of squares (RSS). Then F test is performed for H_0, where $F = \{(RSS - URSS)/4\} / \{URSS/(26 - 8 - 1)\}$ at 95% level involving (e) and (f), and separately for $F = \{(RSS - URSS)/2\} / \{URSS/(26 - 4 - 1)\}$ at 95% level involving (g) and (h).

In the same way taking X as regressor and B as regressand one gets the following regression equations on monthly data:

$B_t = \alpha + \sum_{i = 1 \text{ to } 8} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 8} \gamma_i B_t + \varepsilon_t$, t = 1 to 112 (i)

$B_t = \alpha + \sum_{i = 1 \text{ to } 8} \beta_i B_{t-i} + \varepsilon_t$, t = 1 to 112 (j)

$B_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 4} \gamma_i B_t + \varepsilon_t$, t = 1 to 112 (k)

$B_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i B_{t-i} + \varepsilon_t$, t = 1 to 112 (l)

Here (i) and (k) are called unrestricted equations and (j) and (l) are called restricted equations. The sums of squared residuals obtained from (i) and (k) are called unrestricted residual sums of squares (URSS) and the sum of squared residuals obtained from (j) and (l) are called restricted residual sums of squares (RSS). Then F test is performed involving (i) and (j), and (k) and (l) separately for H_0, where $F = \{(RSS - URSS)/8\}/\{URSS/(112 - 16 - 1)\}$ at 95% level for (i) and (j) and $F = \{(RSS - URSS)/4\}/\{URSS/(112 - 8 - 1)\}$ at 95% level for (k) and (l). Following are the regression equations on annual data with X as regressor and B as regressand:

$B_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 4} \gamma_i B_{t-i} + \varepsilon_t$, t = 1 to 26, (m)

$B_t = \alpha + \sum_{i = 1 \text{ to } 4} \gamma_i B_{t-i} + \varepsilon_t$, t = 1 to 26, (n)

$B_t = \alpha + \sum_{i = 1 \text{ to } 2} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 2} \gamma_i B_t + \varepsilon_t$, t = 1 to 26, (o)

$B_t = \alpha + \sum_{i = 1 \text{ to } 2} \gamma_i B_{t-i} + \varepsilon_t$, t = 1 to 26, (p)

Here (m) and (o) are called unrestricted equations and (n) and (p) are called restricted equations. The sums of squared residuals obtained from (m) and (o) are called unrestricted residual sums of squares (URSS) and the sum of squared residuals obtained from (n) and (p) are called restricted residual sums of squares (RSS). Then F test is performed for H_0, where F = {(RSS – URSS)/4} / {URSS/(26 – 8 – 1)} at 95% level involving (m) and (n), and separately for F = {(RSS – URSS)/2} / {URSS/(26 – 4 – 1)} at 95% level involving (o) and (p).

A vector autoregressions (VAR) frame is detected in the equations (c) and (k) of Granger causality:

$X_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \gamma \sum_{i = 1 \text{ to } 4} \gamma_i B_{t-i} + \varepsilon_{Xt}$, t = 1 to 112 (c)

$B_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 4} \gamma_i B_{t-i} + \varepsilon_{Bt}$, t = 1 to 112 (k)

Here endogenous variables are same. In matrix form it appears as

$$\begin{bmatrix} X_t \\ B \end{bmatrix}_{2x1} = \begin{bmatrix} \alpha & \beta & \gamma \end{bmatrix}_{2x9} \begin{bmatrix} 1 \\ X \\ B \end{bmatrix}_{9x1} + \begin{bmatrix} \varepsilon_{Xt} \\ \varepsilon_{Bt} \end{bmatrix}_{2x1}$$

Stability of VAR depends on whether the value of the determinant of $\boxed{\alpha \quad \beta \quad \gamma}$ is less than one. The value of the determinant is more than one then the system is unstable. On the other hand if it is less than one then it is a stable system.

$X_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \gamma \sum_{i = 1 \text{ to } 4} \gamma_i B_{t-i} + \varepsilon_{Xt}$, t = 1 to 112 (c)

$B_t = \alpha + \sum_{i = 1 \text{ to } 4} \beta_i X_{t-i} + \sum_{i = 1 \text{ to } 4} \gamma_i B_{t-i} + \varepsilon_{Bt}$, t = 1 to 112 (k)

In order to find the impulse response functions, a simple VAR, with one period lag is proposed:

$X_t = \beta_{11} X_{t-1} + \gamma_{11} B_{t-1} + \varepsilon_{Xt}$, t = 1 to 112 (c1)

$B_t = \beta_{21} X_{t-1} + \gamma_{21} B_{t-1} + \varepsilon_{Bt}$, t = 1 to 112 (k1)

The system can be written in terms of lag operator L as

$X_t - \beta_{11} LX_t - \gamma_{11} L B_t = \varepsilon_{Xt}$, t = 1 to 112 (c1)

$B_t - \beta_{21} LX_t - \gamma_{21} L B_t = \varepsilon_{Bt}$, t = 1 to 112 (k1)

Or

$(1- \beta_{11} L) X_t - \gamma_{11} L B_t = \varepsilon_{Xt}$, t = 1 to 112 (c2)

$- \beta_{21} L X_t + (1- \gamma_{21} L) B_t = \varepsilon_{Bt}$, t = 1 to 112 (k2)

Or

$$\begin{bmatrix} 1-\beta_{11} L & -\gamma_{11} L \\ -\beta_{21} L & 1-\gamma_{21} L \end{bmatrix} \begin{bmatrix} X \\ B \end{bmatrix} = \begin{bmatrix} \varepsilon_{Xt} \\ \varepsilon_{Bt} \end{bmatrix}$$

This gives the solution

$$\begin{bmatrix} X_t \\ B_t \end{bmatrix} = \begin{bmatrix} 1-\beta_{11} L & -\gamma_{11} L \\ -\beta_{21} L & 1-\gamma_{21} L \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_{Xt} \\ \varepsilon_{Bt} \end{bmatrix}$$

Or

$$\begin{bmatrix} X_t \\ B_t \end{bmatrix} = (1/\Delta) \begin{bmatrix} 1-\gamma_{21} L & \gamma_{11} L \\ \beta_{21} L & 1-\beta_{11} L \end{bmatrix} \begin{bmatrix} \varepsilon_{Xt} \\ \varepsilon_{Bt} \end{bmatrix}$$

$\Delta = (1-\beta_{11}L)(1- \gamma_{21}L) - (\gamma_{11}L\, \beta_{21}L) = 1 - (\beta_{11} + \gamma_{21}) L + (\beta_{11} \gamma_{21} - \gamma_{11} \beta_{21}) L^2$

$= (1 - \lambda_1 L) (1 - \lambda_2 L)$, where λ_1 and λ_2 are roots of the equation,

$\lambda^2 - (\beta_{11} + \gamma_{21}) \lambda + (\beta_{11} \gamma_{21} - \gamma_{11} \beta_{21}) = 0$

The estimated versions of (c1) and (k1) are

$X_t = 0.43 X_{t-1} + 0.02 B_{t-1}$, t = 1 to 112 (c1)

$B_t = -1.31 X_{t-1} + 1.13 B_{t-1}$, t = 1 to 112 (k1)

Thus $\beta_{11} = 0.43$, $\gamma_{11} = 0.02$, $\beta_{21} = -1.31$, $\gamma_{21} = 1.13$.

Using these values one gets,

$\Delta = \lambda^2 - (0.43 + 1.13)\,\lambda - (0.43 \text{ x } 1.13)(0.02 \text{ x } 1.31)$

$= \lambda^2 - 0.4859\,\lambda - (0.4859 \text{ x } 0.0262)$

$= (\lambda - 0.5108)\,(\lambda + 0.0249)$

Since the absolute values of both of the roots of λ are less than unity, the expansions of X_t and B_t in terms of ε_{Xt} and ε_{Bt} are convergent.

Now one can have the following impulse response functions:

$X_t = \Delta^{-1}\,[(1- \gamma_{21}L)\,\varepsilon_{xt} + \gamma_{11}\,L\varepsilon_{Bt}] = \Delta^{-1}\,[(1- 1.13\,L)\,\varepsilon_{xt} + 0.02\,L\varepsilon_{Bt}] = \Delta^{-1}\,(\varepsilon_{xt} - 1.13\,\varepsilon_{x.t-1} + 0.02\,\varepsilon_{B.t-1})$.

$B_t = \Delta^{-1}\,[\beta_{21}L\,\varepsilon_{xt} + (1-\beta_{11}L)\,\varepsilon_{Bt}] = \Delta^{-1}\,[\varepsilon_{Bt} - 1.31\,\varepsilon_{x.t-1} - 0.43\,\varepsilon_{B.t-1}]$.

The impulse response functions show that a credit shock in period t has no effect on export till period t + 1 and vice-versa.

Now one can test whether B and X are cointegrated. It is found that the order of integration is different for two variables. As per the Augmented Dicky Fuller unit root test monthly sequence {B} is I(0) and monthly sequence {X} is I(1). So they are not cointegrated.

In order to build up alternative regression models, ADF unit root tests are performed for all of logX, logB, ΔX and ΔB. One find that logB, ΔX and ΔB are stationary, whereas logX is stationary at 95% and 90% levels, but not at 99% level. From the viewpoint of statistics, test at 95% level is a good test.

The following alternative models of forecasting are proposed in connection with issue (i):

$\Delta X = \alpha_1 + \beta_1\,B + \varepsilon_1$ (1)

$\Delta X = \alpha_2 + \beta_2\,\Delta B + \varepsilon_2$ (2)

$$\log X = \alpha_3 + \beta_3 B + \varepsilon_3 \qquad (3)$$

$$\log X = \alpha_4 + \beta_4 \log B + \varepsilon_4 \qquad (4)$$

$$\log X = \alpha_5 + \beta_5 \log B + \gamma_5 \log X_{t-1} + \varepsilon_5 \qquad (5)$$

Because, all dependent and independent variables are stationary, standard regression with help of ordinary least square (OLS) is the prescribed technique for estimating these.

In the second step the impact of export growth on trade balance is tested in the following model proposed in connection with issue (ii):

$$\Delta TB = \alpha_6 + \beta_6 \Delta X + \varepsilon_6$$

In the third step one tests the impact of change in trade balance on change in NFEA proposed in connection with issue (iii):

$$\Delta NFEA = \alpha_7 + \beta_7 \Delta TB + \varepsilon_7$$

Here the sequence is {NFEA} is I(0) and the sequence {TB} is I(1). So these sequences are not cointegrated. One need take ΔTB in order to regress it as an independent variable to explain the ΔNFEA.

None of the above models perform well in terms of explaining the variations in the dependent variables. It gives a signal that there must be other explanatory variables affecting the dependent variables.

In connection with the issue (iv) following are the models:

Model A

$$(D/R)_t = \alpha_1 NFEA_{t-1} + \beta_1 (D/R)_{t-1} + u_{1t}$$

$$(D/R)_t = \alpha_2 (D/R)_{t-1} + u_{2t}$$

This model is run on both of annual and monthly data.

Model B

$NFEA_t = \alpha_3 NFEA_{t-1} + \beta_3 (D/R)_{t-1} + u_{3t}$

$NFEA_t = \alpha_4 NFEA_{t-1} + u_{4t}$

This model is also run on both of annual and monthly data.

Payment of insurance premium might have a contemporaneous impact on the bank deposits in India because purchase of life insurance policy entails one for tax relief. So a causality test is performed between household purchase of life insurance policies (LI) and bank deposits (TLD). TLD = Demand deposits (DD) + Time deposits (TD). Following is the model proposed in connection with issue (v):

$TLD_t = \alpha_5 TLD_{t-1} + \beta_5 LI_{t-1} + u_{5t}$

$TLD_t = \alpha_6 LI_{t-1} + u_{6t}$

This model is run on only annual data, because monthly data on LI was not available when writing of this paper commenced.

Next a forecasting model is developed for the exchange rate of dollar in terms of rupee (D/R) on the basis of annual data, because one finds that net foreign exchanger assets of the banking sector (NFEA) causes (D/R) with 12 months lag. With ADF test, it is found that annual data of D/R and NFEA are I (0). So the following the model is proposed:

$\log (D/R) = a_1 + b_1 \log NFEA + e_1$.

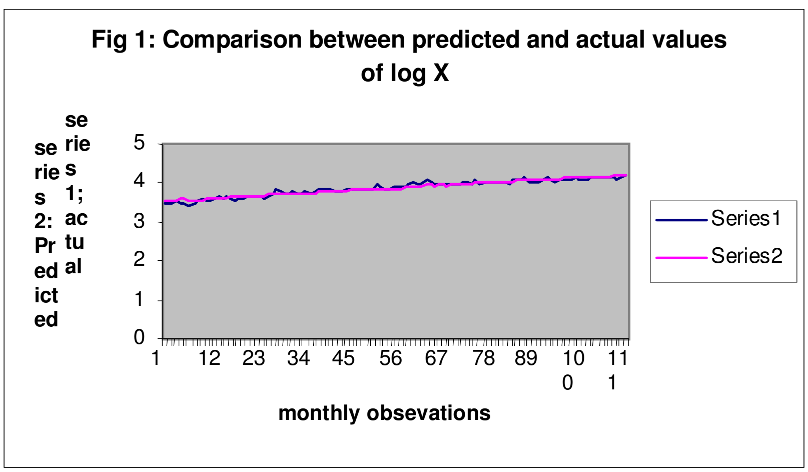
Data

For above models monthly data from April 1992 to March 2000 and annual data from 1970-71 to 1999-2000 are used. There are two purposes behind selecting these: (a) Actual data are available till March 2002 at the time when writing of this paper commenced. But data since April 2000 are provisional and hence may not have the desirable quality; (b)

Relatively recent data used are annual data till 1997-98 by Rath 1999, and monthly data till 1984-85 by Nachane and Ray (1989). In this respect this paper covers relatively more recent conclusive data.

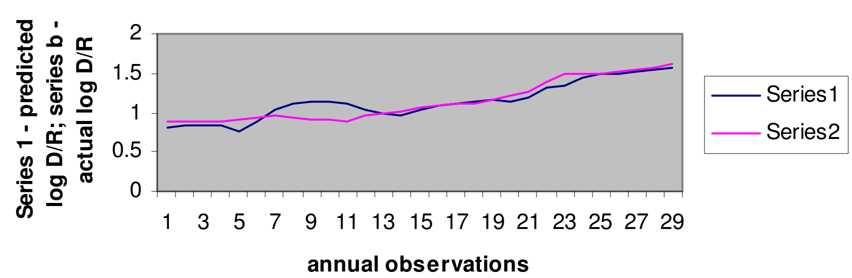
***Ex post* simulation**

In model (4), a permanent shock of increase by 10% is given to B and the results for the estimation period are examined. This is called *ex post* or historical simulation. The model then becomes log X = $\alpha_6 + \beta_6$ log (B+10% B) + ε_6. Figure 1 shows that the model is able to track the historical past with a root mean square simulation error (RMSE) = 0.05. The same exercise is performed for model 5: log X = $\alpha_5 + \beta_5$ log (B+10%B) + γ_5 log $X_{t-1} + \varepsilon_5$ and a lower RMSE = 0.04 is found.



After estimation the model log (D/R) = $a_1 + b_1$ log NFEA + e_1 is simulated over the estimation period for a 10% sustained increase in NFEA and RMSE = 0.09 is obtained. Figure 2 shows that the model has been able to track the historical past except for a minor deviation.

Figure 2: Historical simulation of log D/R by a 10% sustained rise in NFEA from 1970-71 to 1999-2000



The same exercise is performed with the model (D/R) = $a_2 + b_2$ NFEA + e_2 and RMSE = 4.3 is found. So the former model is better than the latter in terms of RMSE relative to graphical comparison.

An Autoregressive Distributed Lag (ADL) Model

As per standard literature of time series econometrics like Walters (1995), Pindyck *et al.* (1998) and Patterson (2000), a series that is I (d), the order of integration is d, is said to have d number unit roots for d being a positive number not less than one. Such a series generates random walk with drift and therefore needs to be differenced t times for becoming stationary. It is already found that monthly sequence {B} is I(0) and monthly sequence {X} is I(1). Thus sequence {X} has one unit root. The unit root can be removed by taking first difference or by taking logarithm of the variable. The both are done. In order to build up alternative regression models, ADF unit root tests are performed for all of log X, log B, ΔX and ΔB. It is found that log B, ΔX and ΔB are stationary at all levels, whereas log X is stationary at 95% and 90% levels, but not at 99% level. From the viewpoint of statistics, test at 95% level is a good test. Thus unit root problems are taken care of. Models such as partial adjustment model (PAM) written in standard form are known as ADL models. A model with p lags on the dependent variable and q lags on the independent variable is referred to as an ADL (p, q) model. Thus the model $\log X = \alpha_5 + \beta_5 \log B + \gamma_5 \log X_{t-1} + \varepsilon_5$ is an ADL (1, 0) model with the estimated form:

$$\log X = -1.0349 + 0.65402 \log B + 0.43316 \log X_{t-1}$$

$$(4.3782) \quad (9.486581) \qquad (4.92066) \qquad \overline{R}^2 = 0.96055$$

Absolute t values are in parentheses.

In order to check whether $\log B_{t-1}$ is also a significant independent variable in the model the following ADL (1, 1) model is proposed: $(\log X)_{t-1} = \alpha_8 + \beta_8 (\log X)_{t-1} + \gamma_8 (\log B)_{t-1} + \varepsilon_8$

The estimated form of the model is

$$(\log X)_{t-1} = 3.8 + 0.059 (\log X)_{t-1} + 6.34 (\log B)_{t-1}$$

$$(146.0) \quad (0.11) \qquad (1.8) \qquad \overline{R}^2 = 0.017$$

It shows that the independent variable coefficients have insignificant t values and the value of $\overline{R}^2$ is also very small.

Hence it is concluded that application of ADL model is not feasible here.

Projection

A series of future projections on X and D/R is made below:

In order to forecast X, the model $\log X = \alpha_5 + \beta_5 \log B + \gamma_5 \log X_{t-1} + \varepsilon_5$ is taken and worked upon with monthly data. Already it is noted that all the variables here along with the variable B are stationary at 95% level. Here there is the need of forecasting B for 2001 March and estimating the trend of B. So the monthly data of B is plotted in Figure

4. It gives the idea of a function log B = a + bt, where t is the number of the observation. Here 'a' is interpreted as the value of log X at the initial period t = 0, and b is the trend element. The estimated model is

log B = 5.158795 + 0.004836 t,

(2364.11) (154.499) $\overline{R}^2 = 0.995$

Estimation is based on the basis of the values of t from 1 for 1990 April to 120 for 2000 March. Now putting t = 121,…,132, the projected values of B are obtained and they plotted in Figure 3. Comparison between Figure 3 and figure 4 reveals close similarity between the in-sample movement of B and the projection.

Figure 3: Movement of Projected B from 2001 April to 2010 March

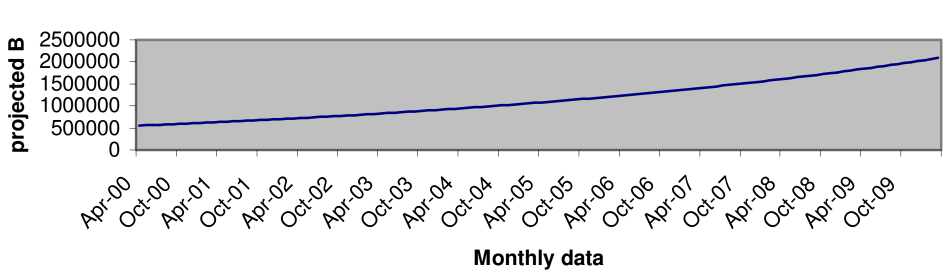
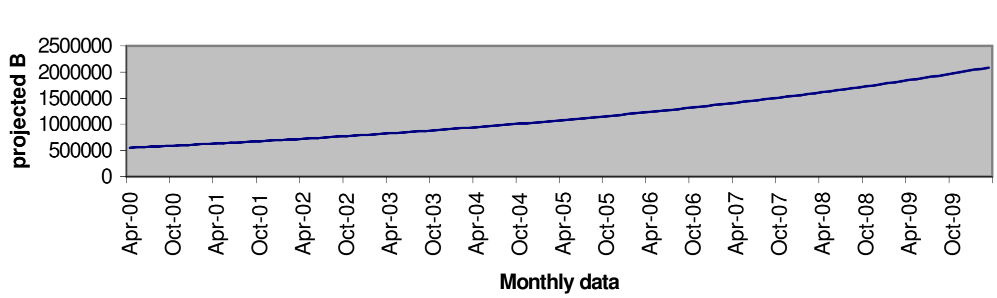


Figure 4: Movement of in-sample data of B from 2001 April to 2010 March



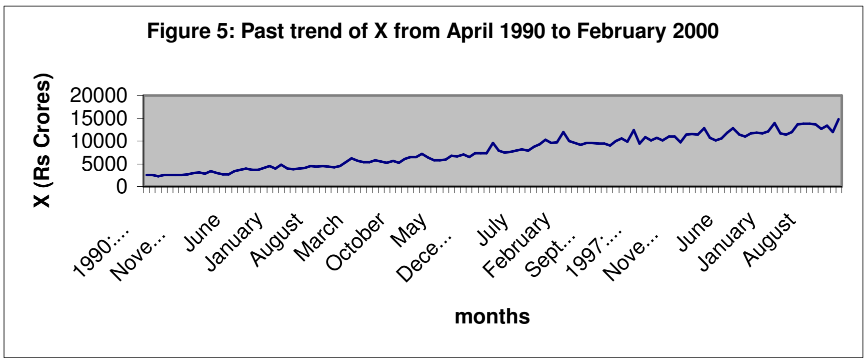
On the basis of projected values of B, the values of X from April 2000 to February 2010 is forecasted in the model $\log X = \alpha_5 + \beta_5 \log B + \gamma_5 \log X_{t-1} + \varepsilon_5$

The estimated model is

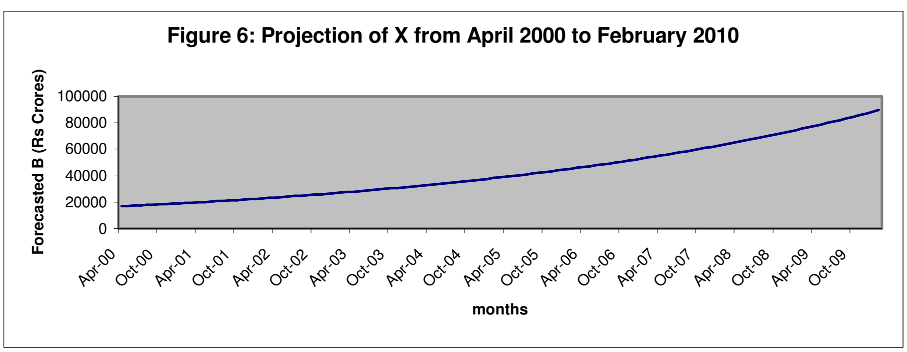
$$\log X = -\,0.751738 + 0.3098668 \log B + 0.75763148 \log X_{t-1}$$

$$(-3.055) \qquad (3.55) \qquad\qquad (11.76) \quad \overline{R}^2 = 0.96688584$$

The above data is plotted and is found to have captured almost exactly the previous trend



of X via comparison between Figure 5 and Figure 6.

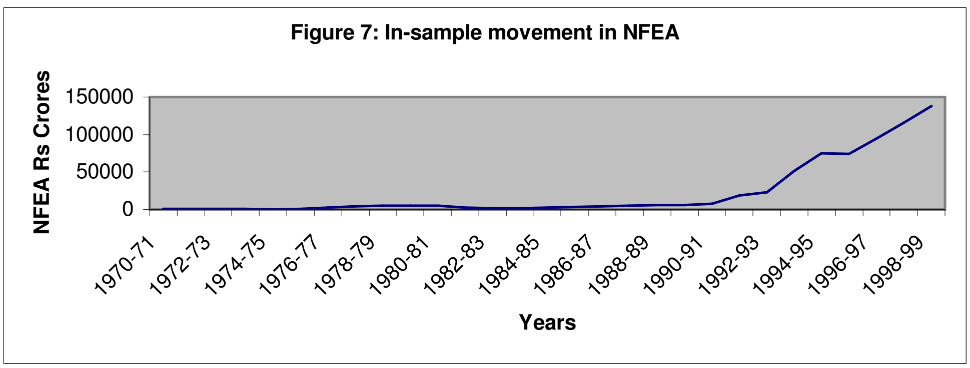


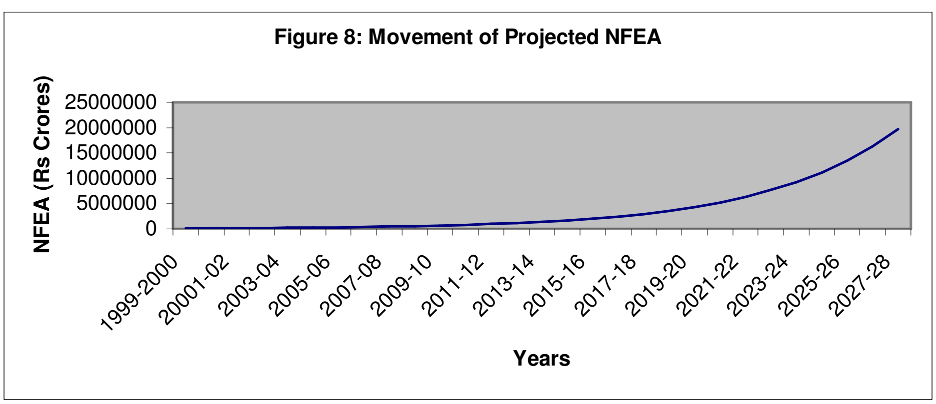
In order to forecast D/R on the basis of NFEA, the stationarity tests are run for both of the variables. Both of them are found I(0). It is necessary to forecast D/R annually from 2000-01 to 2010-11, because of the strong causality from NFEA to D/R in the annual data already found. First the trend of NFEA should be forecasted. So the annual data of NFEA is plotted. The plot gives the idea of a function *ln* NFEA = a + bt, where t is the number of the observation. a is interpreted as the value of log NFEA at the initial period t = 0. b is the trend element. The estimated model is

$$\ln \text{NFEA} = 5.80225 + 0.18957\, t,$$

$$(22.8) \qquad (12.8) \qquad \bar{R}^2 = 0.85$$

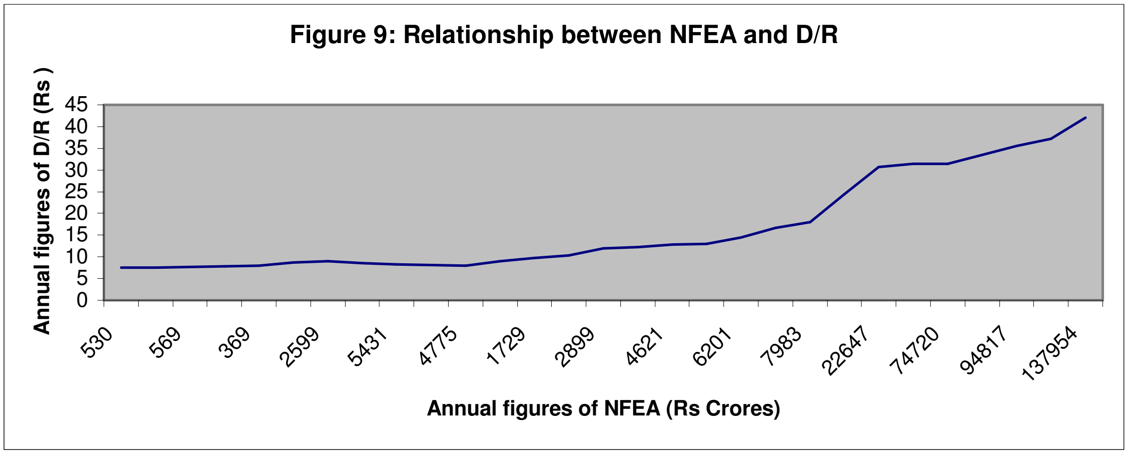
Estimation is based on the basis of the annual values of t from 1 for 1970-71 to 29 for 1998-99. Now t = 30, …, 58 is put and the projected values of NFEA are obtained. Then the diagram of projected NFEA is drawn. Again close similarity is found between in-sample and out-sample movements of the variate via comparison between Figure 7 and Figure 8.





On the basis of projected values of NFEA, the values of NFEA from 1999-2000 to 2027-28 are forecasted.

In order to understand the relationship between D/R and NFEA they are plotted in the following diagram.



From that plot, and from the results of the causality test one can conceive the model $(D/R)_t = a + b \log NFEA_{t-1} + e_t$. The estimated model is

$$D/R = -34.67 + 6.05 \log NFEA_{t-1}$$

$$(-7.07) \quad (10.7) \qquad \bar{R}^2 = 0.80$$

Now the above model is plotted and found not to have captured well the previous trend of D/R. An AR(1) model like the following could take care of projection of exchange rate: $(D/R)_{t+1} = a + b_1 \log NFEA + c_1(D/R)_{t+1} + e$. The estimation result gives a high $\bar{R}^2$, but a very low t value of the variable NFEA than that of $(D/R)_{t+1}$. So it is concluded that perhaps during the period of study the RBI's foreign exchange operation did not have close correspondence with exchange rate movement.

On the basis of Table 1 below one can strongly reject the hypothesis that credit does not cause exports.

Table 1				
F value, 95% / *Degrees of freedom* (Annual/monthly data)	*2, 21* (Annual data)	*4, 17* (Annual data)	*4, 103* (Monthly data)	*8, 95* (Monthly data)
Table value 5%, 10%	3.465, 2.575	2.96, 2.31	2.41, 2.004	2.0466, 1.74
Computed value	11.942869	11.75848	31.75372	17.4664

In all above tests, calculated F values are more than 95% table values irrespective of number of lags.

On the basis of Table 2 below one cannot strongly reject the null hypothesis in the case of annual data but can reject it in the case of monthly data.

Table 2				
F value, 95% / *Degrees of freedom* (Annual/monthly data)	*2, 21* (Annual data)	*4, 17* (Annual data)	*4, 103* (Monthly data)	*8, 95* (Monthly data)
Table value 5%, 10%	3.465, 2.575	2.96, 2.31	2.41, 2.004	2.0466, 1.74
Computed value	0.828132	0.482917	1.8469369	4.132217

For annual data calculated F value is below 95% table values, whereas for monthly data calculated F value is above 95% table value only for 8 lags, but not for 4 lags and so it is sensitive toward number of lags.

This means that in short run export performance may in some cases give incentives to banks to offer loans, but not in long run. This means exercising of discretionary power by bank managers in matter of extending credit facilities is a short-term and not much frequent phenomenon.

Quality of model in terms of goodness of fit is highest in (5) and lowest in (1). Then the in sample predicted data of log X is compared with the actual one. The models (4) and (5) are seen to have captured well the temporal behaviour of the dependent variable.

On the basis of Table 3 below, one can reject the null hypothesis H_0: NFEA does not affect D/R at 95% and 90% levels, for annual data, but not for the monthly data. This means that RBI operations in the foreign exchange market affect the exchange rate not immediately, but at 12 months lag.

Table 3

F value, 95% / *Degrees of freedom* (Annual/monthly data)	*1, 27* (Annual data)	*1,93* (Monthly data)
Table values at 5%, 10%	4.115, 2.9	3.96, 2.77
Computed value	19.2726	1.70973

On the basis of Table 4 below, one can not reject the null hypothesis H_0: D/R does not affect NFEA at 95% and 90% levels, for annual data, but for monthly data, one can reject it at 95% level and can not reject it at 95% level.

Table 4		
F value, 95% / *Degrees of freedom* (Annual/monthly data)	*1, 27* (Annual data)	*1,93* (Monthly data)
Table value 5%, 10%	4.115, 2.9	3.96, 2.77
Computed value	1.75421	3.31434

This means that the exchange rate movement may affect the RBI decision to interfere in the foreign exchange market in the immediate short run, but not in the long run.

One can not reject the null hypothesis H_0: LI does not affect TLD at 95% and 90% levels.

The model $\log (D/R) = a_1 + b_1 \log NFEA + e_1$ performs a better historical simulation in terms of RMSE than does the model $(D/R) = a_2 + b_2 NFEA + e_2$

The model $\log X = \alpha_5 + \beta_5 \log B + \gamma_5 \log X_{t-1} + \varepsilon_5$ performs better in historical simulation in terms of RMSE than does the model $\log X = \alpha_6 + \beta_6 \log B + \varepsilon_6$

Perhaps during the estimation period the RBI's foreign exchange operation does not have so close correspondence with exchange rate movement such as to enable one to make *ex ante* simulation of D/R on the basis of NFEA.

It is found that the sources of money supply like bank credit to export sector and net foreign exchange assets of the banking sector as policy variables can have strong effects on the economy in a unified exchange rate system. Money stock appears as an important determining factor of the economic variables like exchange rate and export volume, which in turn determine the external balance. Further the deficiency on part of RBI in publishing periodical data on inflow of foreign exchanges through direct investment, NRI deposits scheme etc and on its international transactions in individual currencies works as an obstacle on research in this field.

Same is true for the insurance regulation authority IRDA. It should publish monthly, quarterly and annual data on life and general insurances. Then only impact of this sector on money stock can be found out.

Finally for measure of accuracy of the above models Theil's inequality coefficient could be a useful measure. Theil's inequality coefficient is defined as

$$U = [\sqrt{\{(1/T)\Sigma_{t = 1 \text{ to } T} (Y^s_t - Y^a_t)^2\}}]/[\sqrt{\{(1/T)\Sigma_{t = 1 \text{ to } T} (Y^s_t)^2\}} + \sqrt{\{(1/T)\Sigma_{t = 1 \text{ to } T} (Y^a_t)^2\}}]$$

The numerator of U is just the RMSE, but the scaling of the denominator is such that U will always fall between 0 and 1. The model is a perfect fit if U = 0, i.e. $Y^s_t - Y^a_t = 0 \; \forall \; t$. The model is not at all a fit if U = 1. Theil's inequality coefficient measures RMSE in relative terms.

The estimated form of the model $\log X = \alpha_4 + \beta_4 \log B + \varepsilon_4$ for the monthly data from 1991-92 to 1999-2000 is

$\log X = -3.2983 + 1.30925 \log B$

$(18.879) \quad (40.8731) \qquad\qquad \bar{R}^2 = 0.93347$

Absolute t values are in parentheses. The negative intercept is interpreted in a way which means in absence of bank credit to commercial sector export would be negative or there will be net import.

From this model the following is available:

Predicted log B	4.15969	4.19678	4.18866	4.19839	4.22433	4.24695	4.23641	4.22678	4.23294	4.23208	4.23518	4.30297
Actual log B	4.25287	4.25457	4.27477	4.2685	4.27802	4.28529	4.29406	4.29797	4.31916	4.32226	4.3242	4.33726

On the basis of the above table, U = 0.00842, which is close to zero. Hence the model is a good fit.

Conclusion

Following are the findings of the paper:

- Money stock appears as an important determining factor of the economic variables like exchange rate and export volume, which in turn determine the external balance.

- RBI's operations in the foreign exchange market affect the exchange rate not immediately, but at 12 months lag.
- The exchange rate movement may affect the RBI decision to interfere in the foreign exchange market in the immediate short run, but not in the long run.
- In short run export performance may in some cases give incentives to banks to offer loans, but not in long run. Exercising of discretionary power by bank managers in matter of extending credit facilities is a short-term and not much frequent phenomenon.
- In absence of bank credit to commercial sector export would be negative or there will be net import.

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