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Does India have a stable demand for money function after reforms?

A macroeconomic analysis

The present study analyzes the stability of the demand for money function in India over the period 1991:M4–2014:M9 using co-integration and Vector Error Correction Mechanism (VECM) framework. From analysis, it has been observed that there exists a stable demand for money function in India during the post-reforms period, i. e. a long-run relationship does exist between demand for real balances, national output (Y_t), rate of interest (R_t) and exchange rate (ER_t). Two variables Y_t and ER_t have been observed to be affecting demand for real balances positively, while the observed effect of M_t is negative. Thus, the signs and magnitudes of all three regressors have been observed according to a-priori information without any paradoxical situation.

Keywords: money demand function; stability of demand for money function; co-integration; vector error correction mechanism.

JEL classification: E41; C01; C13.

1. Introduction

The main purpose of theoretical and empirical studies on estimation of demand for money function is to find a stable money demand function because stability is one of the preconditions of effectiveness of monetary policy in each economy. The stability of money demand facilitates to evaluate the subjects related to the effectiveness of monetary policy; an issue vital for achieving stable economic growth. An effective and transparent monetary policy requires a strong relation between macroeconomic variables and output, income, interest rate, prices, etc. When it is observed that the demand for money is a stable function, an exact and suitable impact of change in money supply on the other macroeconomic variables such as prices and outputs becomes predictable. In such a case, the money supply will be a reliable way of attaining a constant inflation rate. In addition, Friedman believed that the demand for money is stable when it is possible to predict correctly the amount of money based on people's demand. In simple, if the demand for money is ascertained well before in time then the central bank may pump the same amount of money supply in economy to attain stable price level. In addition, it becomes possible to predict the velocity of money if demand for money is observed to be non-sensitive to interest rates.

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Thus, given the various advantages of estimating the demand for money function, a number of studies have been carried out around the world to analyze the stability of money demand function. Among others, following are some of the noteworthy contributions. Hamori and Hamori (1999) analyzed a stable relationship between money supply and real economic activity in Germany. Bahmani-Oskooee and Economidou (2005) observed M_1 as a stable while M_2 as unstable function of demand for money in Greece. However, both of these functions found to be co-integrated with income and interest rate in long-run. Further, Moghaddam and Bah (2008) found that the money demand is co-integrated with domestic income, interest rate and the real exchange rate in an open-economy of Gambia. Another study by Siliverstovs (2008) developed a stable demand for money function using Judd and Scadding (1982) model in Latvia. Another attempt by Kumar and Webber (2013) estimated the money demand function using M_1 for Australia and New Zealand. The observed demand for money function found to be unstable for the nations under evaluation.

In India too, many studies have taken empirical and theoretical perspectives to money demand function and a great deal of works have examined the stability of it using different methodologies. Rao and Shalabh (1995) have attempted to estimate the demand for money function in India using co-integration methodology. The study has examined the demand for narrow money (M_1) in India for the period 1951–52 to 1991–92. It has been noticed that there exists a long-run relationship between real money, income and interest rate. Krishna (1996) conducted an empirical analysis of demand for money in India for 21 year period spanning over the years 1969 to 1980; the period has further been subdivided into 2 sub periods 1969–70 to 1979–80 and 1980–81 to 1989–90. It has been observed that the national income was the main determinant of changes in demand for money. In addition, a negative relationship of demand for money has been observed with changes in interest rates, the price level, and agricultural output. In addition, Rao and Singh (2006) have attempted to describe the demand for Money in India over the period 1953–2003. Using Partial Adjustment Model (PAM) for a money demand function, unsatisfactory results had been observed. Therefore, the Vector Autoregressive (VAR) methodology has been used to prove that the demand for money in India is stable in the comparison of other countries. The significant income and interest rate elasticities have been observed; the income elasticity is 1.2 and the rate of interest is -0.18 . In same lines, Hamori and Inoue (2009) have attempted to conduct an empirical analysis of the money demand function in India. The study estimated two alternative models for monthly (over the period of 1980 to 2007) and annual data (over the period of 1976 to 2007) using the two alternative methods namely, Johansen co-integration approach and dynamic OLS (DOLS). The major finding of the study is that there exists a co-integration relation to the money demand function and it is statistically supported for M_1 and M_2 , but not for M_3 , for two sets of data.

In addition to aforementioned studies, many authors have analyzed the impact of economic reforms on demand for money function, e.g. Dasgupta and Gupta (2011) attempted to estimate the nature of demand for money function after macroeconomic reforms. The study is based on the monthly and quarterly data over the period April 1997 to March 2000. Different approaches like the Error Correction Model (ECM) and a Partial Adjustment Model (PAM) have been used to estimate the long-and short-run demand for money functions. It has been observed that income is significant source of demand for money. Further, Singh and Pandey (2009) conducted a study of the structural break and stability of demand for money in India. The study used annual data over the period 1952–53 to 2006–07. The main observation of study is that the demand for money is unstable during the period of 1975–1998 but it has become stable after few years of reforms. This stability indicates that the supply of money has been a key instrument

of the monetary policy. Another study by Bharadwaj and Pandit (2010) have re-examined policy reforms and stability of the money demand function in India. The study used annual data with the sample period extending from 1979–80 to 2005–06 (27 years). It has been noticed that the money supply is more stable and reliable behavior than other determinants. The rate of interest and the rate of inflation were significant variables for policy targeting. Also, the effect of the exchange rate on the demand of money measured by M_3 is more definite than measured by M_1 . Singh and Pandey (2010) have attempted to investigate financial innovation and stability of money demand function in the post reform period in India. Quarterly data have been obtained from Handbook of Statistics on Indian Economy published by RBI for the period from 1996–97:1 to 2009–10:3. Over the study period, income observed to be the insignificant source of demand for money, while, interest rate found to be having a positive and insignificant elasticity to the tune of 0.01. Another variable, the rate of exchange, observed with negative and insignificant elasticity to the tune of –0.01. Also, all findings based on different tests have led to an unstable money demand function in India during the post reforms. Sahadudheen (2012) has attempted to examine the demand for money with respect to exchange rate in India. The study used the logarithmic transformation of 46 quarterly observations. The data has been collected over a period of 1998:Q1 to 2009:Q2 from various secondary resources. The long-run income elasticity of demand for money has been observed to the tune of 1.327. So income observed to be the significant source of demand for money. The interest rate observed with a negative elasticity to the tune of –0.1664. Thus, the rate of interest has caused to decrease in money demand. A statistically significant exchange rate elasticity observed to the tune of 0.37204 that means the exchange rate has a significant influence on demand for money in India.

Thus, it is evident from the survey of literature that there exists ample literature on estimating demand for money function at both national and international levels. These studies have been either carried out for single economy or for a cross section of economies of the world. The major objective of all of these studies is to check the stability of demand for money function. In India too, many studies are available to test the stability of demand for money function. However, to the best of our knowledge, a few have used monthly data to estimate the demand for money function in India. Further, the latest period up to which the demand for money function in India has been estimated is 2009–10; Singh and Pandey (2010) used data up to 2009–10. Thus, the present study is an attempt to address the issue of stability in demand for money during the post reforms period using the monthly data over the period 1991:M4 to 2012:M9. To attain the objective, the study has been divided into five sections. Including present introductory one, the second section describes the sources of data, construction of variables and model used to estimate the demand for money function in India. The third section tests the time series properties of the variables under consideration so as an accurate model to estimate demand for money function may be specified. The fourth section provides long-run and short-run demand for money function estimates. The last section is concluding one and offers some policy implications of the study.

2. Data description and model specifications

The economic theory suggests that demand for real money balances positively depend on the scale of aggregate economic activity, which is measured by real output, and negatively depend upon the opportunity cost of holding a fraction of wealth in the form of money, which is nor-

mally measured by the nominal interest rate. However, in 1963, Nobel Laureate, Robert Mundell (1963) proposed the idea that the demand for money could also depend on the exchange rate, in addition to income and the interest rate. Following Arango and Nadiri (1981), Fielding (1994), and Bahmani-Oskooee and Wing Ng (2002), we use the real exchange rate as a proxy for expected currency depreciation. Changes in the real exchange rate have two effects on the demand for domestic currency — an income effect and a substitution effect. Assume that wealth holders evaluate their portfolio in terms of domestic currency. Exchange rate depreciation would increase the value of their foreign asset holdings expressed in terms of domestic currency and hence, be wealth enhancing. To maintain a fixed share of their wealth invested in domestic assets, they will repatriate part of their foreign assets to domestic assets, including domestic currency. Hence, exchange rate depreciation would increase the demand for domestic currency. On the other hand, exchange rate movements may generate a currency substitution effects in which investors' expectation plays a crucial role. If wealth holders develop an expectation that the exchange rate is likely to deteriorate further following an initial depreciation, they will respond by raising the share of their foreign assets in their portfolios. In this context, currency depreciation means higher opportunity cost of holding domestic money, so currency substitution can be used to hedge against such risk. In this logic, exchange rate depreciation would decrease the demand for domestic money. The actual effect of exchange rate depreciation is therefore, an empirical issue because it depends on which of the effects dominates (Baye, 2011). Thus, we have utilized specifications initially to estimate the money demand function in India as follow:

$$\ln(M^d/P) = f[\ln(ER_t), \ln(Y_t), \ln(CMR_t)]. \quad (1)$$

The empirical analysis is based upon the monthly data confined to the post-reform period 1991:M4 to 2014:M9. The wholesale price index (*WPI*) has been used as proxy variable of price level (*p*). The call money rate (*CMR*) has been utilized as the proxy of interest rate while, index of industrial production (*IIP*) has been taken as a proxy variable for real output (*Y*). The *IIP* has been used at the place of gross domestic product (*GDP*) as the monthly series of *GDP* for the period covered under the study is not available. Another independent variable in demand for money function is exchange rate (*ER*). The *ER* has been observed as Rupee per *US* dollar. In equilibrium $M^S = M^d$ thus, M_3 has been used as proxy variable for demand for money. The demand for real balances (M^d/P) has been used as dependent variable to estimate the demand for money function in India during the post-reforms period. Source of data for the variables namely, *WPI*, *IIP*, *ER*, and *CMR* is *Handbook of Statistics on Indian Economy*. Except the interest rates, all other variables are indexes with the base period 2004:M8 and transformed into logarithms.

The model (1) is a time series model and the stationarity is an important property of a time series variables because if one of the series in model is non-stationary, then all the typical results of the classical regression analysis are invalid; the regression with non-stationary series may have no meaning and therefore called spurious. In stationary time series, shocks will be temporary and over time, their effects will be eliminated as the series revert to their long-run mean values. Further, Monthly and quarterly time series are often characterized by considerable seasonal variations, which might complicate their interpretation. The most important method is for detecting the existence of seasonality is Hylleberg–Engle–Granger–Yoo (*HEGY*) test that checks for the existence of seasonal unit roots in quarterly and monthly time series.

To check for the presence of regular unit-root, variety of time series tests statistics like Dickey–Fuller (*DF*), Augmented Dickey–Fuller (*ADF*) and Phillips–Perron (*PP*), *ADF*–*GLS*,

and Kwiatkowski, Phillips, Schmidt and Shin (*KPSS*) have been used. The null hypothesis of earlier four test statistics is non-stationary time series while that of *KPSS* is stationary time series. As the existence of co-integration is the link between integrated process and steady state equilibrium, Johansen's co-integration approach has been used to test the existence of co-integration among the component variables of demand for money function. The Johansen's approach has been criticized for being sensitive to the selection of lag length. It is therefore, essential that the lag length for both the co-integration analysis and the error correction model has chosen according to a consistent procedure. Alternative criteria such as Akaike Information Criterion (*AIC*), Schwarz Bayesian Criterion (*SBC*), Final Prediction Error (*FPE*), etc. have been used to select the lag length for co-integration and Vector Error Correction Mechanism (*VECM*). The co-integration vector (*s*), and impulse response functions have been used to address the stability issue of demand for money function in India².

3. Preliminary analysis: Testing seasonal and regular unit-roots

Before the regression analysis, a preliminary analysis of testing seasonal and regular unit-roots is required. The use of *HEGY* test statistics has been preferred to analyze the existence of seasonal roots (i.e., problem of seasonality), while alternative tests statistics such as Augmented Dickey-Fuller (*ADF*), Phillips-Perron (*PP*), Kwiatkowski-Phillips-Schmidt-Shin (*KPSS*) and modified Dickey-Fuller *t* test (*ADF-GLS*) have been utilized to test the presence of regular unit root. The existence of structural breaks has also been tested using the Chao test statistics for the stability of parameters (see (Gujarati, Sangeetha, 2007, p. 836)).

Table 1 provides the estimated values of *HEGY* test statistics along with the tabulated values of each statistic in parenthesis. Following Charemza and Deadman (1997, p. 108), it can be concluded that there exists unit root in all the time series selected for the analysis purpose. In *HEGY* test $t(\pi_1)$ and $t(\pi_2)$ are less than tabulated value of *t* at 5 percent level of significance. Thus, the null hypothesis of unit root cannot be rejected among the time series under considerations. In addition to the testing regular unit-root, the use of *HEGY* test also refutes the existence of any type of seasonality in *LM*, *LY*, *LR* and *LER* series.

Further, all $F(\pi_i - \pi_{i+1})$ are statistically significant for each monthly series under evaluation; the null hypotheses of conjugate complex root can be rejected. It also substantiates the absence of periodicity in the data series. In sum, the application of *HEGY* test reveals the absence of seasonality and periodicity, and confirms the presence of regular unit-root in all the four variables to be used for analyzing the demand for money function.

The existence of unit-root in level series therefore, compels the need of testing accurate order of integration at which these series become stationary. As identified earlier in Table 1 that all the four series have regular unit-root, the alternative test statistics namely, *ADF*, *PP*, *KPSS* and *ADF-GLS* have been utilized to check the order of integration of all the four variables under evaluation. Table 2 provides the order of integration for all the series under consideration. The order has been determined using various unit-root test statistics obtained for three alternative models; namely with drift and trend, with drift only, and without drift and trend. These statistics have been obtained for level and first differenced series³.

² For detailed study of all these time series test statistics see Lutkepohl (2005).

³ Interested readers may contact authors for detailed *ADF*, *PP*, *KPSS* and *ADF-GLS* tables.

Table 1. Testing seasonality and unit root using Hylleberg–Engle–Granger–Yoo (HEGY) test

Test statistics	HEGY test			
	<i>LM</i>	<i>LY</i>	<i>LR</i>	<i>LER</i>
$t(\pi_1)$	1.7690 (-3.35)	1.8864 (-3.35)	3.5094 (-3.35)	2.5834 (-3.35)
$t(\pi_2)$	1.8226 (-2.81)	2.1237 (-2.81)	3.5308 (-2.81)	2.3668 (-2.81)
$F(\pi_3-\pi_4)$	12.3754*** (6.35)	6.1137*** (6.35)	3.2209*** (6.35)	20.6645*** (6.35)
$F(\pi_5-\pi_6)$	14.8586*** (6.48)	22.7691*** (6.48)	24.2072*** (6.48)	18.9075*** (6.48)
$F(\pi_7-\pi_8)$	14.9317*** (6.30)	16.7643*** (6.30)	28.2024*** (6.30)	31.0027*** (6.30)
$F(\pi_9-\pi_{10})$	13.6996*** (6.40)	14.6331*** (6.40)	37.6411*** (6.40)	24.7295*** (6.40)
$F(\pi_{11}-\pi_{12})$	10.9406*** (6.46)	16.7763*** (6.46)	28.3632*** (6.46)	18.0935*** (6.46)
$F(\pi_1-\pi_{12})$	14.2369*** (4.44)	17.9487*** (4.44)	25.5283*** (4.44)	29.1758*** (4.44)
$F(\pi_2-\pi_{12})$	14.8118*** (4.58)	18.8730*** (4.58)	25.8593*** (4.58)	30.9312*** (4.58)

Notes. The tabulated values for each statistics have been given in parenthesis of type () and see Franses and Hobbijn (1997) for detail on critical values. *** represents significance at 1%.

Table 2. Testing order of integration for component variables in demand for money function

Variables	<i>ADF</i>	<i>PP</i>	<i>DF-GLS</i>	<i>KPSS</i>
$\ln(M_t/P_t)$	<i>I</i> (1)	<i>I</i> (1)	<i>I</i> (1)	<i>I</i> (1)
$\ln(Y_t)$	<i>I</i> (1)	<i>I</i> (0)	<i>I</i> (1)	<i>I</i> (1)
$\ln(R_t)$	<i>I</i> (0)	<i>I</i> (0)	<i>I</i> (1)	<i>I</i> (1)
$\ln(ER_t)$	<i>I</i> (0)	<i>I</i> (0)	<i>I</i> (1)	<i>I</i> (1)

Notes. *I*(0) and *I*(1) represent series is level and first order stationary, respectively. Interested readers may ask authors for detailed results.

The majority of test statistics reveals that $\ln(M_t/P_t)$ and $\ln(Y_t)$ are first difference stationary whereas, for $\ln(R_t)$ and $\ln(ER_t)$ two tests (*ADF* and *PP*) favor level stationary and two (*ADF-GLS* and *KPSS*) favor first difference stationary. The *ADF-GLS* and *KPSS* test are more powerful than the traditional *ADF* and *PP* tests, therefore, the consensus that these series are first difference stationary is reached.

For cointegration analysis with $\ln(M_t/P_t)$ as dependent variable, the analysis of the existence of structural break in $\ln(M_t/P_t)$ is needed. However, the existence of structural breaks in other endogenous variables of the model may distort the short-run *VECM* results wherein all the first ordered differenced series are regressed upon differenced series of remaining endogenous and exogenous variables. The term «structural break» refers to a structural break in the moments of a respective time series, i.e., mean or variance. The changes are caused by certain

shifts in policy parameters governing Indian economy. The piecewise AR models process suggested by Adak (1998) has been used to identify the existence of structural breaks among the time-series variables under consideration. Thus, an analysis of the existence of structural break has been performed on all the model variables. Table 3 provides information on structural break observed in each time series under evaluation. From analysis, a single structural break has been observed in each variable and thus, the existence of multiple breaks in one series has been refuted. The dependent variable $\ln(M_t/P_t)$ has been observed with a significant break in March, 1995 and thus, entails the need of including structural dummy for the said period in analysis of the co-integration relationships having $\ln(M_t/P_t)$ as dependent variable. For the remaining three endogenous variables, observed structural breaks have been specified in the same table.

Table 3. Structural break analysis

Variable	Structural Break Date
$\ln(M_t/P_t)$	1995 March (M03)
$\ln(Y_t)$	1992 April (M04)
$\ln(R_t)$	1993 March (M03)
$\ln(ER_t)$	2007 June (M06)

After getting the structural breaks, the next step is to search the optimum lag-length. The optimum lag length may be observed using the *SBC* and *AIC* criterion; under this method *SBC* and *AIC* values of Vector Autoregressive (*VAR*) model estimated for various combinations of lag-length are used. In the light of observed results, i.e. absence of seasonality and presence of structural break, the *VAR* models with exogenous structural dummies have been estimated for various lag lengths.

Table 4 provides various criteria for selecting the optimum lag length. As quoted in the econometric literature that the lag-length corresponding to minimum *SBC* and *AIC* values is the optimum lag-length. However, if any clash emerges between the two criteria then one must go with alternative criterion and decide the lag length on the basis of the decision provid-

Table 4. Lag length selection for co-integration analyses using VAR

Lag	<i>LR</i>	<i>FPE</i>	<i>AIC</i>	<i>SBC</i>	<i>HQ</i>
0	—	1.88e-17	-4.138	-3.87	-4.03
1	26.09	9.25e-12	-14.06	-13.57*	-13.86
2	56.62	8.26e-12	-14.17	-13.47	-13.89*
3	24.49	8.45e-12	-14.15	-13.24	-13.78
4	38.53	8.15e-12	-14.18	-13.06	-13.73
5	25.40	8.28e-12	-14.17	-12.83	-13.63
6	19.25	8.62e-12	-14.13	-12.58	-13.51
7	43.01	8.10e-12	-14.19	-12.43	-13.48
8	27.84	8.11e-12	-14.19	-12.22	-13.40
9	35.19	7.85e-12	-14.23	-12.04	-13.35
10	59.27*	6.89e-12*	-14.36*	-11.96	-13.40
11	17.46	7.19e-12	-14.32	-11.70	-13.27

Notes. * represents optimum lag length.

ed by majority of test statistics. In our case, five alternative criteria have been used to decide the optimum lag length. The majority of test statistics settle on optimum 1–10 lag length. However, *SBC* provides 1–1 lag length, while *HQ* provides 1–2 lag length. On the basis of likelihood ratio (*LR*), *FPE* and *AIC* criterion, optimum lag length of 1–10 months has been selected for co-integration and *VECM* analysis purpose.

4. Demand for money function estimates: Existence and stability issues

In the light of above findings, it has been observed that all the endogenous variables are non-stationary and integrated of first order. Further, neither of the seasonality nor the periodicity problem has been observed in the time series under evaluation. The structural breaks are significant among all the series and so must be included in the co-integration model. The trend and drift components are significant in the level series of dependent variable $\ln(m^d/p)$ and therefore must be the part of co-integration vector(s). In sum, the co-integration model with intercept and a trend component along with four structural breaks as exogenous variables has been selected for the analysis purpose. The execution of aforesaid model under Johnson's framework with 1–10 month lag-length provides the following Lambda Max (LM) and Trace test statistics.

Table 5. Testing the existence and No. of co-integration relationships

Hypothesis (No. of cointegration equations)	Trace test statistics	Max-eigen test statistics
None	77.29044* (0.000)	52.75649* (0.000)
At most 1	24.53395 (0.1788)	12.55152 (0.4943)
At most 2	11.98243 (0.1578)	9.874959 (0.2203)
At most 3	2.107470 (0.1466)	2.107470 (0.1466)

Notes. Figures in parenthesis of type () are *p-values*; and * represents that the hypothesis has been rejected at 5 percent level of significance.

It is evident from Table 5 that the null hypotheses of none co-integration relationship has been rejected and the existence of one vector has been confirmed by both test statistics. Thus, there exists a unique stable demand for money function in India. Hence, the condition of analyzing the effectiveness of monetary policy transmission mechanism is satisfied. The following is the long-run relationship derived using co-integration vector obtained using Johansen approach:

$$\ln(m^d/p) = -3.179 + 0.897^{***} \ln(ER) + 1.168^{***} \ln(Y) - 0.128^{***} \ln(CMR).$$

[10.132] [18.684] [4.7093]

In this relationship, all three variables are significantly affecting demand for money in India. The interest elasticity of demand for real cash balances is statistically significant to the tune of -0.128 . Thus, a one percent increase in interest rate will reduce the demand for real balances by 0.12 percent and *vice-versa*. The impact of both income and exchange rate is positive and sta-

tistically significant as per the *a-priori* expectations. A one percent increase in national output will bring about 1.168 percent increases in demand for money. Further, the exchange rate change has been observed to bring about a 0.897 percent increase in demand for real balances. Thus, a stable demand for money function (i.e., stationary function at levels) is available in India. The next step involves testing the stability property for the observed long-run function.

4.1. Stability of demand for money function estimates

The Dickey–Fuller *min-t* unit-root with break test has been applied to test the stability of the estimated demand function. Using the co-integration vector, a co-integration variable Z_t is constructed to infer whether the Z_t is stationary over the study period without any structural break or not. The null hypothesis of non-stationarity has been rejected as the observed value of ADF statistics is -6.759 with a *p-value* below 0.05 (i.e. 5 percent level of significance). However, one structural break of 1995:M11 has been noticed in the co-integration variable. The two panels of the following figure (Fig. 1) represent a huge dip in the Dickey–Fuller *t-statistics* and autoregressive coefficient in the said period 1995:M11. However, except the said break, oscillations around a stationary value have been noticed in *t-statistics* and autoregressive coefficients.

Thus, it may be inferred that beyond 1995:M11, the estimated demand for money function is stable and may be used as a proxy variable for the real demand for money, i.e. demand for real balances. To provide for operational freedom independence and develop a competitive spirit, many steps were taken in 1995–96 to reduce controls and remove operational constraints in the banking system. These include interest rate decontrol, liberalization and selective removal of Cash Reserve Ratio (CRR) stipulation, freedom to fix foreign exchange open position limit and enhanced refinance facilities against government and other approved securities. These liberal moves seem to be the dominating reasons for huge dip in the plotted values of Dickey–Fuller *t-statistics* and autoregressive coefficients.

4.2. VECM and short-run analysis of demand for money

Further, Table 6 provides the estimates of error correction terms along with the estimates of short-run parameters which help to ascertain the short-run effectiveness of the independent variables in demand for money function. As per econometric theory, the sample estimate of the diagonal elements in the matrix of error-correction terms for given co-integration matrix (i.e. α_{ii})

Table 6. Bayesian Vector Error Correction estimates

Variables	D (LM)	D (LCMR)	D (LY)	D (LER)
Bayesian Error Correction term	a_{11}	a_{21}	a_{31}	a_{41}
Sample Estimates of EC term	-0.0356^{***} (0.0115)	-0.6033^{***} (0.2833)	0.2301^{***} (0.0392)	0.0945^{***} (0.0182)

Notes. Bayesian VAR has been estimated with first difference variables as endogenous with co-integration variable and four structural breaks as exogenous variables. *** represents significance at 1 percent level. Figures in parentheses are standard errors.

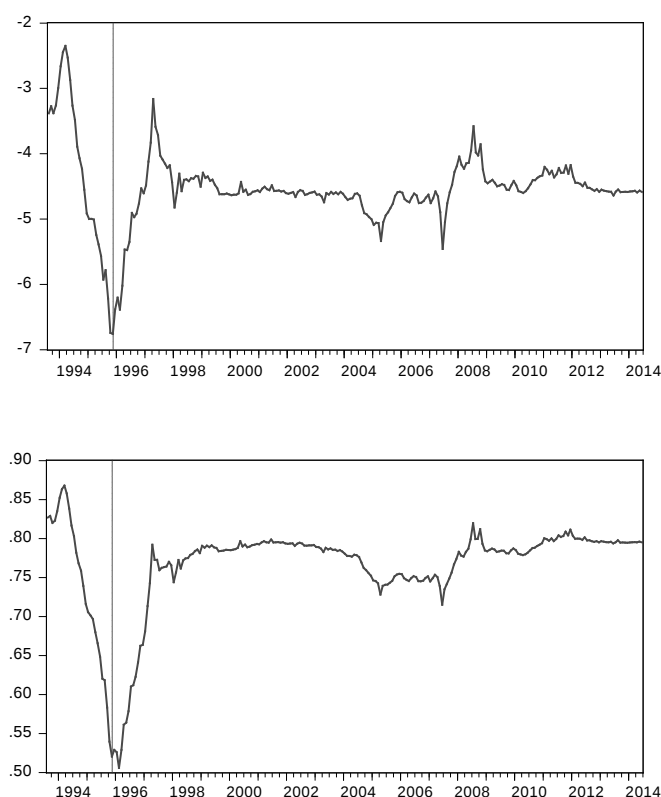


Fig. 1. Dickey–Fuller t -statistics and auto-regressive coefficients for cointegration vector

must be negative to ensure the stability/convergence in the model. In simple, if one co-integration vector is observed then α_{11} must be negative and if two vectors are observed then α_{11} & α_{12} must be negative to ensure convergence towards long-run equilibrium relationships.

In Table 6, the first error-correction term is negative and significant that satisfies the requirement of the stability of the model. In a monthly data set, the formula $12/\alpha_{11}$ will provide the number of months that the system will take to restore the equilibrium if it is initially off it. In our case the same number comes out to be 336.757 months, i.e. 28.06 years. It simply means that if the observed long-run equilibrium relationship will be disturbed, it will take about 28.06 years to restore the relationship back. In addition to error correction term, a large number of parameters are available with a lag length of 10 under *VECM* framework. This large number is difficult to interpret and the best method suggested in econometric textbooks is to interpret the short-run coefficients using the impulse response function and Granger block exogeneity test. Figure 1 provides the impulse response graph obtained from the estimated *VECM* model. From Figure 2, it can be observed that any disturbance/shock in one of the endogenous variables will converge to zero and thus, the demand for money function is stable. From response to *LM* (i.e. demand for real balances), it may be observed that the disturbance/shock in *LER* (i.e. interest rate) and *LER* (i.e. exchange rate) variables will die down earliest than the shock in *LY* (i.e. output) and *LM* (i.e. demand for real balances) variables.

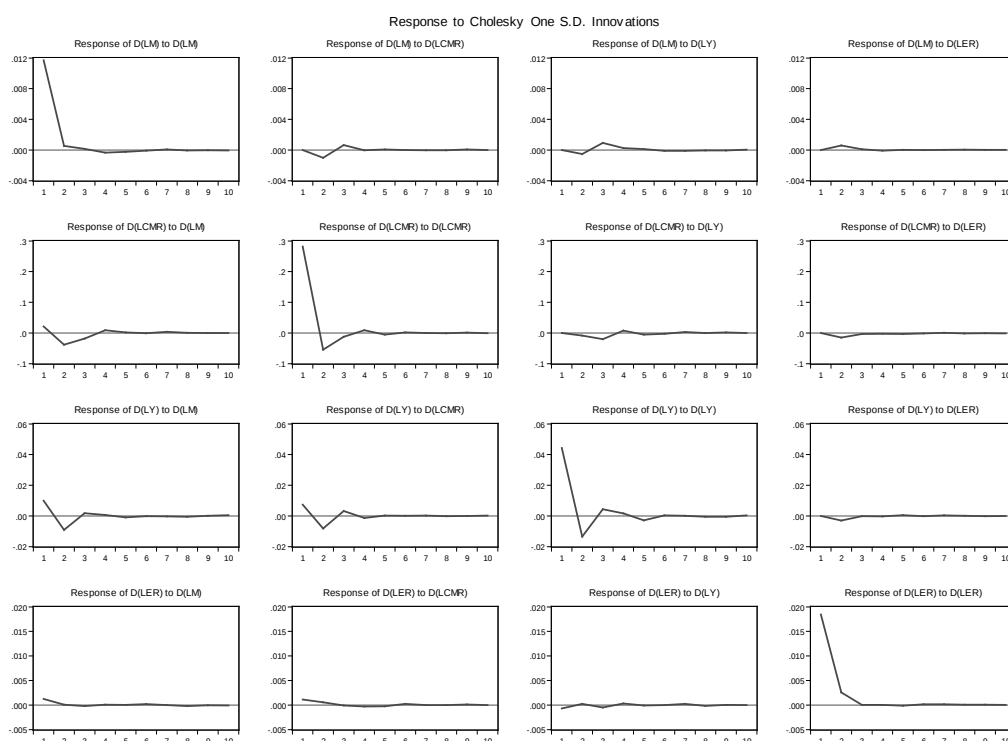


Fig. 2. Impulse response function and stability of model

Further, the cause and effect relationship among variables has been tested using the Granger Block Exogeneity test. Table 7 provides Chi-square test statistics along with *p-values* to test the null hypothesis that cause variable doesn't affect the dependent/effect variable. From table it can be inferred that a unidirectional short-run relationship exists from *LM* (demand for money) to *CMR* (interest rate), i.e. *CMR* bears insignificant short-run impact on demand for money rather demand for

Table 7. Vector Error Correction Granger Causality/Block Exogeneity Wald test

Variable	Effect			
	D (LM)	D (LCMR)	D (LY)	D (LER)
D (LM)	—	22.68** (0.0120)	31.09*** (0.0006)	13.73 (0.1858)
D (LCMR)	10.47 (0.4003)	—	20.94** (0.0215)	6.86 (0.7382)
D (LY)	30.02*** (0.0009)	16.98* (0.0749)	—	10.43 (0.4037)
D (LER)	5.56 (0.8505)	23.43*** (0.0093)	12.98 (0.2249)	—
Total	45.79** (0.0325)	67.31*** (0.0001)	84.49*** (0.0000)	30.50 (0.4405)

Notes. Granger Causality estimates of Bayesian *VAR* are not available and thus, the results using *VECM* estimation have been reported. *, **, and *** represent significance at 10, 5, and 1 percent levels, respectively. Figures in parentheses of types () are *p-values*.

money causes movement in interest rate in short-run. The insignificant effect of ΔCMR on ΔLM reiterates earlier finding that the disturbance in interest rate will not persist for long-run and die down at the earliest. In simple, any change in growth of interest rate won't affect the growth of demand for real balances for a very long-period. After a few months, the demand for money will restore the steady state equilibrium value with zero growth rates. Further, a bidirectional relationship exists between LM and LY variables. Thus, a change in output, in short run, is both cause and effect of change in demand for real cash balances. The third variable exchange rate observed to be ineffective in short run as LM and LER both observed to be orthogonal with insignificant Chi-square values.

5. Summary, conclusions and policy implications

The study is based upon the objective to test the existence and stability of money demand function in India. To pursue the objectives, monthly data has been used over the period 1991:M4–2014:M9. First of all, using *HEGY* test, the presence of seasonal and regular unit roots has been tested. Both of these statistics confirms the presence of regular unit root and absence of seasonality in all four variables under evaluation. To confirm the order of integration, *ADF*, *PP*, *KPSS* and *ADF-GLS* tests statistics have been executed. The analysis of four test statistics confirms that $(M^d/p)_t$, Y_t , R_t and ER_t are non-stationary at levels and stationary at first difference. Further, the co-integration model with intercept and a trend component along with four structural breaks as exogenous variables has been selected for the analysis purpose. The execution of model under Johanson's framework with 1–10 months lag-length confirms the existence of one co-integration vector among the model variables.

In the observed vector, all the three variables found to be significantly affecting demand for money in India. The interest elasticity of demand for real cash balances is negative and unitary less elastic to the tune of -0.128 . However, the impact of both income and exchange rate is positive and statistically significant as per the *a-priori* expectations. The output elasticity of demand for money is unitary more elastic to the tune of 1.168 while, the demand for money is unitary less elastic to the tune of 0.897 with respect to exchange rate. The use of Dickey–Fuller *min-t* unit-root with break test confirms that the estimated demand for money function is stable after 1995:M11. Thus, a stable long-run demand for money function (i.e. stationary function at levels) exists in India during the post-reforms period and the precondition for the effectiveness of monetary policy in long-run is satisfied.

However, the *VECM* analysis substantiates the fact that interest rate and exchange rate disturbances are not significant enough to disrupt the long-run equilibrium relationship between the component variables of demand for money function. However, any disturbance in output is significant enough to cause disequilibrium among the component variables of demand for money function. Thus, the policy planners must try to avoid the disturbance in optimum growth rate of national output so as the effectiveness of monetary policy can be maintained via maintaining the stability of demand for money function.

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