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An Empirical Analysis of the Money Demand Function in India

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Abstract

This paper empirically analyzes India's money demand function during the period of 1980 to 2007 using monthly data and the period of 1976 to 2007 using annual data. Cointegration test results indicated that when money supply is represented by M1 and M2, a cointegrating vector is detected among real money balances, interest rates, and output. In contrast, it was found that when money supply is represented by M3, there is no long-run equilibrium relationship in the money demand function. Moreover, when the money demand function was estimated using dynamic OLS, the sign conditions of the coefficients of output and interest rates were found to be consistent with theoretical rationale, and statistical significance was confirmed when money supply was represented by either M1 or M2. Consequently, though India's central bank presently uses M3 as an indicator of future price movements, it is thought appropriate to focus on M1 or M2, rather than M3, in managing monetary policy.

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1. Introduction

In India, financial sector deregulation was undertaken beginning in the mid-1980s, when steps like the introduction of 182-day Treasury bills, lifting of the call money interest-rate ceiling, and the introduction of certificates of deposit and commercial paper were taken in a bid to make the government securities market and the money market more efficient (Sen and Vaidya, 1997). Furthermore, with the balance of payments crisis in 1991, there began an intermittent series of more systematic financial sector reforms that continues even today. For example, the reform of the Indian interest-rate structure, which had been strictly managed by the Reserve Bank of India (RBI), began with the April 1992 deregulation of deposit rates and has progressed to the point where commercial banks are now permitted to freely set term deposit rates and lending rates for loans above Rs.2 lakh.[1] Moreover, the RBI, which had long been constrained by the Indian government's fiscal management, entered into an agreement with the government in September 1994 to limit the issuance of 91-day ad hoc Treasury bills, which were used to finance fiscal deficits, and eventually eliminated these securities altogether in April 1997, greatly reining in the central bank's automatic monetization of fiscal deficits.[2]

The above are just a few examples of how interest-rate structure deregulation and the introduction of new financial products have progressed in India over the past 20 years. Theoretical research and empirical analyses, using primarily data on developed countries, have shown that the money demand function can become unstable as a result of such financial innovations and financial sector reforms. Partly because of instability in the money demand function, many central banks have in recent years switched from money supply targeting focused on monetary aggregates as the intermediate target, to inflation targeting, which seeks to stabilize prices by adjusting interest rates based on inflation forecasts. The RBI abandoned the flexible monetary targeting approach in favor of the multiple indicator approach in April 1998, putting an end to the use of money supply as the intermediate target, but retaining it as an important indicator of future prices. Consequently, examining the characteristics of the money demand function of India's financial sector, which has undergone significant change since the 1980s, should bear significant meaning for present and future considerations of the RBI's monetary policy. This paper, therefore, uses annual data for the period of 1976 to 2007 and monthly data for the period of January 1980 to December 2007 to estimate India's money demand function, which is derived from real money balances, interest rates, and output, and shed light on its characteristics.

The next section of this paper consists of a review of relevant prior research and a discussion of the unique contributions of this paper. In the third section, the models are presented and in the fourth section, variables are defined, sources are provided, and data characteristics are explained. Moving into the fifth section, cointegration tests are performed using both monthly and annual data, the long-term stability of the money demand function is examined, and dynamic OLS (DOLS) is used to examine the sign conditions and significance of output and interest-rate coefficients. Lastly, analysis results are used to discuss the characteristics of India's money demand function and the implications for India's monetary policy.

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[1] Except for bank savings deposits, non-resident deposits, loans for less than 200,000 rupees, and export credit, interest rates have been greatly deregulated.

[2] Financial deregulation beginning in the 1990s also loosened requirements, like those requiring commercial banks to keep central bank balances equal to a certain percentage of their own deposits and purchase government bonds and government-specified bonds, and the deregulation relaxed barriers to entering the banking sector and opened stock markets to foreign participants.

2. Literature Review

India's money demand function has been the subject of numerous quantitative research efforts. Among these was the first study to explicitly consider the stationarity of, and cointegration relationships among, the variables of the money demand function. Moosa (1992) used three types of money supply – cash, M1, and M2 – to perform cointegration tests on real money balances, short-term interest rates, and industrial production over the period beginning with the first quarter of 1972 and extending through the fourth quarter of 1990. Results indicated that for all three types of money supply, the money balance had a cointegrating relationship with output and interest rates. However, greater numbers of cointegrating vectors were detected for cash and M1 than for M2, so Moosa (1992) states that narrower definitions of money supply are better for pursuing monetary policy.

Bhattacharya (1995), like Moosa (1992), considered three types of money supply – M1, M2, and M3 – and used annual data for the period of 1950 to 1980 to analyze India's money demand function. Bhattacharya (1995) performed cointegration tests for real money balances, real GNP, and long-term and short-term interest rates, detected a cointegrating relationship among variables only when money supply was defined as M1, and clearly showed that long-term interest rates are more sensitive to money demand than are short-term interest rates. In addition, Bhattacharya (1995), after estimating an error correction model based on cointegration test results, found that, in the case of M1, the error correction term is significant and negative, and held that monetary policy is stable over the long term when money supply is narrowly defined.

Bahmani-Oskooee and Rehman (2005) analyzed the money demand functions for India and six other Asian countries during the period beginning with the first quarter of 1972 and ending with the fourth quarter of 2000. Using the ARDL approach described in Pesaran et al. (2001), they performed cointegration tests on real money supplies, industrial production, inflation rates, and exchange rates (in terms of US dollar). For India, cointegrating relationships were detected when money supply was defined as M1, but not M2, so they concluded that M1 is the appropriate money supply definition to use in setting monetary policy.

Contrasting with the above, there is also prior research that uses money supply defined broadly in holding that India's money demand function is stable. In one example, Pradhan and Subramanian (1997) employed cointegration tests, an error correction model, and annual data for the period of 1960 to 1994 to detect relationships among real money balances, real GDP, and nominal interest rates. They estimated an error correction model using M1 and M3 as money supply definitions and found the error correction term to be significant and negative. Their position, therefore, was that the money demand function is stable not only with M1 but also with M3.

Das and Mandal (2000) considered only the M3 money supply in stating that India's money demand function is stable. They used monthly data for the period of April 1981 to March 1998 to perform cointegration tests and detected cointegrating vectors among money balance, industrial production, short-term interest rates, wholesale prices, share prices, and real effective exchange rates. Their position, therefore, was that long-term money demand relevant to M3 is stable. Similarly, Ramachandran (2004), too, considered only the M3 money supply in using annual data for the period of 1951/52 to 2000/01 to perform cointegration tests on nominal money supply, output, and price levels. Because stable relationships were discovered among these three variables, Ramachandran (2004) states that, over the long term, it is possible to use an increase in M3 as a latent indicator of future price movements.

As is the case with the studies referred to above, prior research in general states that India's money demand function is stable.[3] Furthermore, studies performed using multiple money supply definitions have tended to draw the conclusion that because India's money demand function is more stable when money supply is defined narrowly, the central bank should adopt cash or M1 as the narrow definition of money supply when determining monetary policy. Contrasting with that position, however, other studies have concluded that the money demand function is stable when money supply is broadly defined. Views on what definition of money supply to use for monetary policy, therefore, differ.

This paper uses both monthly and annual data, considers three types of money supply – M1, M2, and M3, and comprehensively estimates India's money demand functions for each case. It also discusses the implications of empirical results for the RBI's monetary policy formation. In contrast with prior studies, this paper, after performing cointegration tests on money supply, output, and interest rates as money demand function variables, applies DOLS and sheds light on the characteristics of India's money demand function through examinations of the sign conditions and statistical significance of variable coefficients.

3. Models

There are various theories concerning the money demand function. For example, Kimbrough (1986a, 1986b) and Faig (1988) came up with the following money demand function as a result of explicitly considering transaction costs.

$$\frac{M_t}{P_t} = L(Y_t, R_t) \qquad L_Y > 0, \quad L_R < 0 \tag{1}$$

In this formula, M_t represents nominal money supply for period t; P_t represents the price index for period t; Y_t represents output for period t; and R_t represents the nominal interest rate for period t. Increases in output bring increases in money demand, and increases in interest rates bring decreases in money demand.

We use two models corresponding to equation (1) in order to conduct an empirical analysis.

Model 1: $$\ln(M_t) - \ln(P_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 R_t + u_t, \quad \beta_1 > 0, \beta_2 < 0 \tag{2}$$

Model 2: $$\ln(M_t) - \ln(P_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(R_t) + u_t, \quad \beta_1 > 0, \beta_2 < 0 \tag{3}$$

Both Models (2) and (3) are log linear models, but Model (2) uses the level of interest rates and Model (3) uses the logarithm value of interest rates.

4. Data

This paper uses both monthly data and annual data for empirical analysis. For monthly data, we use data over the period of January 1980 to December 2007. The data source for the industrial production index (seasonally adjusted by X12) and the wholesale price index is

[3] Nag and Upadhyay (1993), Parikh (1994), Rao and Shalabh (1995), Rao and Singh (2006), and others as well have also performed quantitative analyses of India's money demand function.

IMF (2008). We obtained M1, M2, and M3 from various issues of the RBI Bulletin. We deflate these monetary aggregates by the wholesale price index, and we use the call rate as the interest rate. The call rate was obtained from RBI (2006) over the period of January 1980 to December 2005, RBI (2007a) and RBI (2008) over the period of January 2006 to December 2007.

For annual data, we use data over the period of 1976 to 2007. Real GDP and the GDP deflator were taken from IMF (2008). We obtained M1, M2, and M3 from various issues of the RBI Bulletin. We deflate these monetary aggregates by the GDP deflator, and we use the call rate as the interest rate. The call rate was obtained from RBI (2007b) and RBI (2008). Logarithm values are used for money supply, price levels, and output (industrial production and GDP). Interest rates are analyzed in two ways, taking a logarithm in one case and not in the other.

As a preliminary analysis, we carried out the augmented Dickey-Fuller tests for the logs of real money balances, output, and interest rates (Dickey and Fuller, 1979). As a result, the level of each variable was found to have a unit root, whereas the first difference of each variable was found not to have a unit root. Thus, we can say that each variable is a nonstationary variable with a unit root.

5. Empirical Results

5.1 Monthly Data

First, we analyzed the money demand function in relation to the use of M1 using the monthly data over the period of January 1980 to December 2007. For that analysis, we conducted Johansen cointegration tests for the money demand function (Johansen, 1991). There are two kinds of Johansen-type tests: the trace test and the maximum eigen-value test.

Table 1 shows the results of cointegration tests for Model 1 and Model 2. Model 1 includes the logs of real money balances, the logs of industrial production, and the interest rate; whereas Model 2 includes the logs of real money balances, the logs of industrial production, and the logs of interest rates. As is evident from Table 1, the null hypothesis of no cointegrating relation is rejected at the 5% significance level for both models. As the existence of the cointegrating relation was supported, we estimated the money demand function using dynamic OLS (DOLS).[4] Table 2 shows the estimation results with respect to Model 1. As is evident from this table, the output coefficient is significantly estimated to be at positive values (1.1484 for K=1, 1.1498 for K=2, and 1.1556 for K=6). The interest rate coefficient is significantly estimated to be at negative values (-0.0043 for K=1, -0.0049 for K=2, and -0.0050 for K=6). Thus, the sign condition of the money demand function holds for all cases. Table 3 shows the estimation results with respect to Model 2. As is evident from this table, the sign condition of the money demand function holds for all cases. The output coefficient was significantly estimated at positive values (1.1432 for K=1, 1.1437 for K=2, and 1.1478 for K=6), while the interest rate coefficient was significantly estimated at negative values (-0.0480 for K=1, -0.0548 for K=2, and -0.0595 for K=6). As is evident from the above results, it became clear that a cointegrating relation was supported and that the existence of a money demand function with respect to M1 was statistically supported.

Next, we considered the money demand function when using M2 for the money supply component. Table 4 indicates the results of cointegration tests for Model 1 and Model 2. As is evident from the table, the null hypothesis of no cointegration is rejected at the 5% significance level for both models. As the existence of the cointegrating relation was

[4] Standard errors are calculated using the method of Newey and West (1987).

supported, we estimated the money demand function using DOLS. Table 5 shows the estimation results with respect to Model 1. As is evident from this table, the sign condition of the money demand function holds. The output coefficient was significantly estimated at positive values of 1.0966 for K=1, 1.0977 for K=2, and 1.1023 for K=6, while the interest rate coefficient was significantly estimated at negative values of -0.0049 for K=1, -0.0055 for K=2, and -0.0059 for K=6. Table 6 shows the estimation results with respect to Model 2. As is evident from this table, the sign condition of the money demand function holds. The output coefficient was significantly estimated at positive values of 1.0907 for K=1, 1.0908 for K=2, and 1.0934 for K=6, while the interest rate coefficient was significantly estimated at negative values of -0.0543 for K=1, -0.0617 for K=2, and -0.0685 for K=6. As is evident from the above results, it became clear that a cointegrating relation was supported and that the existence of a money demand function with respect to M2 was statistically supported.

Finally, we considered the money demand function when using M3 for the money supply component. Table 7 indicates the results of cointegration tests for Model 1 and Model 2. As is evident from this table, the null hypothesis (in which there is no cointegrating relation) is not rejected at the 5% significance level for either of the models. It became clear that a cointegrating relation was not supported and thus that the existence of a money demand function with respect to M3 was not statistically supported.

5.2 Annual Data

We also analyzed the money demand function in relation to the use of M1 using the annual data over the period from 1976 to 2007. Since industrial production does not necessarily reflect the total level of output in the Indian economy, it is worthwhile to analyze the money demand function using annual data, which enables us to use the GDP data. Table 8 shows the results of cointegration tests for Model 1 and Model 2. As is evident from Table 8, the null hypothesis of no cointegrating relation is rejected at the 5% significance level for both models. As the existence of the cointegrating relation was supported, we estimated the money demand function using DOLS. Table 9 shows the estimation results with respect to Model 1. As is evident from this table, the output coefficient is significantly estimated to be positive (1.0037 for K=1, 0.9812 for K=2, and 0.9769 for K=3). The interest rate coefficient is significantly estimated to be negative (-0.0366 for K=1, -0.0260 for K=2, and -0.0242 for K=3). Thus, the sign condition of the money demand function holds for all cases. Table 10 shows the estimation results with respect to Model 2. As is evident from this table, the sign condition of the money demand function holds for all cases. The output coefficient was significantly estimated to be positive (1.0020 for K=1, 1.0011 for K=2, and 1.0624 for K=3), while the interest rate coefficient was significantly estimated to be negative (-0.3399 for K=1, -0.2321 for K=2, and -0.2378 for K=3). As is evident from the above results, it became clear that a cointegrating relation was supported and that the existence of a money demand function with respect to M1 was statistically supported.

Next, we considered the money demand function when using M2 for the money supply component. Table 11 indicates the results of cointegration tests for Model 1 and Model 2. As is evident from the table, the null hypothesis of no cointegration is rejected at the 5% significance level for both models. As the existence of the cointegrating relation was supported, we estimated the money demand function using DOLS. Table 12 shows the estimation results with respect to Model 1. As is evident from this table, the sign condition of the money demand function holds. The output coefficient was significantly estimated at positive values of 0.9402 for K=1, 0.9173 for K=2, and 0.9132 for K=3, while the interest rate coefficient was significantly estimated at negative values of -0.0397 for K=1, -0.0295 for

K=2, and -0.0278 for K=3. Table 13 shows the estimation results with respect to Model 2. As is evident from this table, the sign condition of the money demand function holds. The output coefficient was significantly estimated at positive values of 0.9381 for K=1, 0.9374 for K=2, and 0.9988 for K=3, while the interest rate coefficient was significantly estimated at negative values of -0.3669 for K=1, -0.2648 for K=2, and -0.2715 for K=3. As is evident from the above results, it became clear that a cointegrating relation was supported and that the existence of a money demand function with respect to M2 was statistically supported.

Finally, we considered the money demand function when using M3 for the money supply component. Table 14 indicates the results of cointegration tests for Model 1 and Model 2. As is evident from this table, the null hypothesis (in which there is no cointegrating relation) is not rejected at the 5% significance level in three out of four cases. It became clear that a cointegrating relation may not be supported and thus that the existence of a money demand function with respect to M3 may not be statistically supported.

Our empirical results using annual data are consistent with those using monthly data. Thus, the cointegrating relation for the money demand function is statistically supported for M1 and M2, but not for M3 for both monthly and annual data.

6. Some Concluding Remarks

If an equilibrium relationship is observed in the money demand function, financial authorities can employ appropriate money supply controls to maintain a reasonable inflation rate. This paper empirically analyzed India's money demand function over the period of 1980 to 2007 using monthly data and the period of 1976 to 2007 using annual data. Results supported the existence of an equilibrium relation in money demand when money supply was defined as M1 or M2, but no such relation was detected when money supply was defined as M3. These results were obtained for both monthly and annual data, so they were not affected by data intervals and were robust in this sense.

What are the implications of these results for India's monetary policy? In the mid-1980s, the RBI adopted monetary targeting focused on the medium-term growth rate of the M3 money supply. Monetary targeting was used as a flexible policy framework to be adjusted in accordance with changes in production and prices, rather than as a strict policy rule. However, amid ongoing financial innovations and financial sector reforms, the RBI announced in April 1998 that it would switch to the multiple indicator approach in order to be able to consider a wider array of factors in setting policy. Under this new policy framework, the M3 growth rate is used as one reference indicator.

In general, a reference indicator, as an indicator of future economic conditions, is used as something between an operating instrument and a final objective, and no target levels are set, as is the case, for example, with intermediate targets. However, in India, where it is used as a reference indicator, the forecast growth rate for the M3 money supply is publicly announced on an annual basis, and it is focused on as a measure of future price movements. Consequently, Indian financial authorities, despite the fact that they have changed their policy framework, continue to pay significant attention to M3 movements. The empirical results of this paper, though, suggest that the RBI would be able to more appropriately control price levels if it would refer to the M1 and M2, rather than the M3, money supplies in managing monetary policy.

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Table 1 Cointegration Tests (M1, Monthly data)

Model	Hypothesized Number of Cointegration Equations	Maximum Eigen-Value Test	Trace Test
Model 1	0	60.8885*	75.5725*
	At most 1	13.9371	14.6841
	At most 2	0.7470	0.7470
Model 2	0	62.6358*	77.4240*
	At most 1	14.0725	14.7883
	At most 2	0.7157	0.7157

* indicates that the null hypothesis is rejected at the 5% significance level.

Table 2 Dynamic OLS (M1, Monthly data, Model 1)

$$\log(M1_t) - \log(P_t) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 R_t + \sum_{i=-K}^{K} \gamma_{yi} \Delta \log(Y_{t-i}) + \sum_{i=-K}^{K} \gamma_{ri} \Delta R_{t-i} + u_t$$

Lead and Lag	Variable	Coefficient	SE	t-Statistic	p-value	$\bar{R}^2$
$K = 1$	Constant	2.9533	0.0741	39.8611	0.0000	0.9911
	$\log(Y_t)$	1.1484	0.0158	72.4935	0.0000	
	R_t	-0.0043	0.0012	-3.5416	0.0005	
$K = 2$	Constant	2.9478	0.0626	47.0700	0.0000	0.9923
	$\log(Y_t)$	1.1498	0.0135	85.2199	0.0000	
	R_t	-0.0049	0.0012	-4.0843	0.0001	
$K = 6$	Constant	2.9130	0.0539	54.0741	0.0000	0.9947
	$\log(Y_t)$	1.1556	0.0107	108.2575	0.0000	
	R_t	-0.0050	0.0015	-3.3923	0.0008	

Note: SE is the Newey-West HAC Standard Error (lag truncation=5).

Table 3 Dynamic OLS (M1, Monthly data, Model 2)

$$\log(M1_t) - \log(P_t) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 \log(R_t) + \sum_{i=-K}^{K} \gamma_{yi} \Delta \log(Y_{t-i}) + \sum_{i=-K}^{K} \gamma_{ri} \Delta \log(R_{t-i}) + u_t$$

Lead and Lag	Variable	Coefficient	SE	*t*-Statistic	*p*-value	$\bar{R}^2$
$K=1$	Constant	3.0363	0.0894	33.9515	0.0000	0.9911
	$\log(Y_t)$	1.1432	0.0164	69.6620	0.0000	
	$\log(R_t)$	-0.0480	0.0134	-3.5715	0.0004	
$K=2$	Constant	3.0445	0.0755	40.3038	0.0000	0.9924
	$\log(Y_t)$	1.1437	0.0138	82.8285	0.0000	
	$\log(R_t)$	-0.0548	0.0127	-4.3211	0.0000	
$K=6$	Constant	3.0247	0.0655	46.2015	0.0000	0.9950
	$\log(Y_t)$	1.1478	0.0104	109.8776	0.0000	
	$\log(R_t)$	-0.0595	0.0144	-4.1434	0.0000	

Note: SE is the Newey-West HAC Standard Error (lag truncation=5).

Table 4 Cointegration Tests (M2, Monthly data)

Model	Hypothesized Number of Cointegration Equations	Maximum Eigen-Value Test	Trace Test
Model 1	0	25.3333*	39.3050*
	At most 1	11.8306	13.9716
	At most 2	2.1411	2.1411
Model 2	0	26.2955*	39.6353*
	At most 1	11.0450	13.3398
	At most 2	2.2948	2.2948

* indicates that the null hypothesis is rejected at the 5% significance level.

Table 5 Dynamic OLS (M2, Monthly data, Model 1)

$$\log(M2_t) - \log(P_t) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 R_t + \sum_{i=-K}^{K} \gamma_{yi} \Delta \log(Y_{t-i}) + \sum_{i=-K}^{K} \gamma_{ri} \Delta R_{t-i} + u_t$$

Lead and Lag	Variable	Coefficient	SE	*t*-Statistic	*p*-value	$\bar{R}^2$
$K=1$	Constant	3.2129	0.0760	42.2970	0.0000	0.9899
	$\log(Y_t)$	1.0966	0.0165	66.5934	0.0000	
	R_t	-0.0049	0.0012	-3.9508	0.0001	
$K=2$	Constant	3.2096	0.0655	49.0098	0.0000	0.9913
	$\log(Y_t)$	1.0977	0.0143	76.7408	0.0000	
	R_t	-0.0055	0.0012	-4.5206	0.0000	
$K=6$	Constant	3.1817	0.0583	54.5536	0.0000	0.9938
	$\log(Y_t)$	1.1023	0.0117	94.5821	0.0000	
	R_t	-0.0059	0.0015	-3.8277	0.0002	

Note: SE is the Newey-West HAC Standard Error (lag truncation=5).

Table 6 Dynamic OLS (M2, Monthly data, Model 2)

$$\log(M2_t) - \log(P_t) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 \log(R_t) + \sum_{i=-K}^{K} \gamma_{yi} \Delta \log(Y_{t-i}) + \sum_{i=-K}^{K} \gamma_{ri} \Delta \log(R_{t-i}) + u_t$$

Lead and Lag	Variable	Coefficient	SE	*t*-Statistic	*p*-value	$\bar{R}^2$
$K=1$	Constant	3.3066	0.0914	36.1578	0.0000	0.9900
	$\log(Y_t)$	1.0907	0.0170	64.2289	0.0000	
	$\log(R_t)$	-0.0543	0.0139	-3.8990	0.0001	
$K=2$	Constant	3.3180	0.0787	42.1394	0.0000	0.9914
	$\log(Y_t)$	1.0908	0.0146	74.9043	0.0000	
	$\log(R_t)$	-0.0617	0.0133	-4.6363	0.0000	
$K=6$	Constant	3.3084	0.0700	47.2392	0.0000	0.9941
	$\log(Y_t)$	1.0934	0.0114	96.2653	0.0000	
	$\log(R_t)$	-0.0685	0.0149	-4.6022	0.0000	

Note: SE is the Newey-West HAC Standard Error (lag truncation=5).

Table 7 Cointegration Tests (M3, Monthly data)

Model	Hypothesized Number of Cointegration Equations	Maximum Eigen-Value Test	Trace Test
Model 1	0	20.4033	27.3507
	At most 1	5.2173	6.9474
	At most 2	1.7301	1.7301
Model 2	0	19.4088	25.9354
	At most 1	5.0979	6.5266
	At most 2	1.4287	1.4287

* indicates that the null hypothesis is rejected at the 5% significance level.

Table 8 Cointegration Tests (M1, Annual data)

Model	Hypothesized Number of Cointegration Equations	Maximum Eigen-Value Test	Trace Test
Model 1	0	29.0382*	40.3709*
	At most 1	8.8912	11.3327
	At most 2	2.4415	2.4415
Model 2	0	31.2939*	42.7403*
	At most 1	8.9359	11.4464
	At most 2	2.5105	2.5105

* indicates that the null hypothesis is rejected at the 5% significance level.

Table 9 Dynamic OLS (M1, Annual data, Model 1)

$$\log(M1_t) - \log(P_t) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 R_t + \sum_{i=-K}^{K} \gamma_{yi} \Delta \log(Y_{t-i}) + \sum_{i=-K}^{K} \gamma_{ri} \Delta R_{t-i} + u_t$$

Lead and Lag	Variable	Coefficient	SE	t-Statistic	p-value	$\bar{R}^2$
$K=1$	Constant	4.0407	0.2939	13.7502	0.0000	0.9716
	$\log(Y_t)$	1.0037	0.0768	13.0640	0.0000	
	R_t	-0.0366	0.0099	-3.7002	0.0014	
$K=2$	Constant	3.8224	0.1669	22.9069	0.0000	0.9944
	$\log(Y_t)$	0.9812	0.0448	21.9224	0.0000	
	R_t	-0.0260	0.0058	-4.4821	0.0005	
$K=3$	Constant	3.7578	0.1312	28.6378	0.0000	0.9952
	$\log(Y_t)$	0.9769	0.0470	20.7860	0.0000	
	R_t	-0.0242	0.0048	-5.0189	0.0010	

Note: SE is the Newey-West HAC Standard Error (lag truncation=5).

Table 10 Dynamic OLS (M1, Annual data, Model 2)

$$\log(M1_t) - \log(P_t) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 \log(R_t) + \sum_{i=-K}^{K} \gamma_{yi} \Delta \log(Y_{t-i}) + \sum_{i=-K}^{K} \gamma_{ri} \Delta \log(R_{t-i}) + u_t$$

Lead and Lag	Variable	Coefficient	SE	t-Statistic	p-value	$\bar{R}^2$
$K=1$	Constant	4.4896	0.3875	11.5861	0.0000	0.9738
	$\log(Y_t)$	1.0020	0.0772	12.9872	0.0000	
	$\log(R_t)$	-0.3399	0.0873	-3.8949	0.0009	
$K=2$	Constant	4.0882	0.2591	15.7774	0.0000	0.9942
	$\log(Y_t)$	1.0011	0.0524	19.1028	0.0000	
	$\log(R_t)$	-0.2321	0.0615	-3.7765	0.0020	
$K=3$	Constant	3.8970	0.1522	25.6072	0.0000	0.9944
	$\log(Y_t)$	1.0624	0.0446	23.8410	0.0000	
	$\log(R_t)$	-0.2378	0.0532	-4.4676	0.0021	

Note: SE is the Newey-West HAC Standard Error (lag truncation=5).

Table 11 Cointegration Tests (M2, Annual data)

Model	Hypothesized Number of Cointegration Equations	Maximum Eigen-Value Test	Trace Test
Model 1	0	29.4465*	40.2924*
	At most 1	8.9430	10.8459
	At most 2	1.9029	1.9029
Model 2	0	31.8685*	42.6966*
	At most 1	8.9294	10.8281
	At most 2	1.8988	1.8988

* indicates that the null hypothesis is rejected at the 5% significance level.

Table 12 Dynamic OLS (M2, Annual data, Model 1)

$$\log(M2_t) - \log(P_t) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 R_t + \sum_{i=-K}^{K} \gamma_{yi} \Delta \log(Y_{t-i}) + \sum_{i=-K}^{K} \gamma_{ri} \Delta R_{t-i} + u_t$$

Lead and Lag	Variable	Coefficient	SE	t-Statistic	p-value	$\bar{R}^2$
$K=1$	Constant	4.3669	0.2886	15.1317	0.0000	0.9676
	$\log(Y_t)$	0.9402	0.0760	12.3674	0.0000	
	R_t	-0.0397	0.0098	-4.0638	0.0006	
$K=2$	Constant	4.1610	0.1650	25.2232	0.0000	0.9936
	$\log(Y_t)$	0.9173	0.0443	20.7286	0.0000	
	R_t	-0.0295	0.0057	-5.1387	0.0002	
$K=3$	Constant	4.1007	0.1311	31.2843	0.0000	0.9948
	$\log(Y_t)$	0.9132	0.0478	19.1190	0.0000	
	R_t	-0.0278	0.0049	-5.7213	0.0004	

Note: SE is the Newey-West HAC Standard Error (lag truncation=5).

Table 13 Dynamic OLS (M2, Annual data, Model 2)

$$\log(M2_t) - \log(P_t) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 \log(R_t) + \sum_{i=-K}^{K} \gamma_{yi} \Delta \log(Y_{t-i}) + \sum_{i=-K}^{K} \gamma_{ri} \Delta \log(R_{t-i}) + u_t$$

Lead and Lag	Variable	Coefficient	SE	*t*-Statistic	*p*-value	$\bar{R}^2$
$K=1$	Constant	4.8505	0.3788	12.8058	0.0000	0.9702
	$\log(Y_t)$	0.9381	0.0757	12.3845	0.0000	
	$\log(R_t)$	-0.3669	0.0857	-4.2806	0.0004	
$K=2$	Constant	4.4693	0.2556	17.4837	0.0000	0.9935
	$\log(Y_t)$	0.9374	0.0511	18.3566	0.0000	
	$\log(R_t)$	-0.2648	0.0613	-4.31665	0.0007	
$K=3$	Constant	4.2862	0.1556	27.5495	0.0000	0.9938
	$\log(Y_t)$	0.9988	0.0463	21.5558	0.0000	
	$\log(R_t)$	-0.2715	0.0541	-5.0207	0.0010	

Note: SE is the Newey-West HAC Standard Error (lag truncation=5).

Table 14 Cointegration Tests (M3, Annual data)

Model	Hypothesized Number of Cointegration Equations	Maximum Eigen-Value Test	Trace Test
Model 1	0	20.7221	31.4139*
	At most 1	6.7122	10.6918
	At most 2	3.9796	3.9796
Model 2	0	18.0444	28.3185
	At most 1	6.5157	10.2741
	At most 2	3.7584	3.7584

* indicates that the null hypothesis is rejected at the 5% significance level.