Testing for Long-Run Stability - An Application to Money Multiplier in India

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Abstract

In testing for a stable long-run relation between monetary aggregates and reserve money most previous studies have used the conventional tests for cointegration. Using the recently developed residual-based cointegration tests of Gregory and Hansen (1996) that explicitly allow for regime shifts, the present paper, contrary to the findings of the previous studies, finds that there exists a stable, but time varying, long-run relation between measures of money stock and reserve money in the Indian context. It also finds that the observed variation in cointegrating relations is better characterized by a discrete one-time shift, rather than a gradually evolving random walk process, attributable, probably, to discrete changes in monetary policy.

Key Words: Money Multiplier, Regime Shifts, Cointegration, Stability tests.

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1 Introduction

The existence of a stable long run relationship between various monetary aggregates, such as M1, M3 etc., and Reserve Money (RM) and the controllability of the latter by the monetary authorities are two important assumptions supporting the argument for money supply to be an effective policy target variable (Parkin (1971) and Brunner (1997)). Among the different approaches to the process of money supply creation, there is a considerable degree of disagreement over the issues of stability of money multiplier and the controllability of reserve money. The proponents of the Money Multiplier approach argue that while the variations in money multiplier, being dependent upon changes in public's and banks' portfolio of cash, demand deposits, time deposits and reserves, may dominate the variations in money stock in the short run, over longer time horizon these variations become relatively stable and predictable (Brunner (1997)). The critics of the Money Multiplier approach, on the other hand, point out that the 'proximate determinants' of money multiplier such as ratios of currency to demand deposits, demand to time deposits, and bank reserves to total deposits are determined by agents' portfolio behavior and hence sensitive to changes in relative rates of return, risk, technology in financial markets, income and preferences of agents. With an increasing role of market forces in financial transactions and continuous improvements in agents' asset-liability management techniques, the critics argue that, there is little reason to believe either in a stable money multiplier relation or in the controllability of reserve money by the monetary authorities (Goodhart (1989)).

Most of the empirical works in this area have examined the issue of stability and predictability of money multiplier using various time series techniques. For example, Bonhoff (1977), Johannes and Rasche (1981), Chitre (1986), Nachane and Ray (1989) and Ray and Madhusoodan (1992) use the time series forecasting techniques to assess the empirical predictability of the money multiplier, while Nachnae (1992), Ford and Morris (1996) and Baghestani and Mott (1997) and Sen and Vaidya (1997) test for the stability of a long run relation between money stock and reserve

\[ M3 = m \cdot \text{RM}, \]

with \( m = (1 + c + t)/(c + (1 + t)r) \) where \( c \) is currency-demand deposit ratio, \( t \) is demand to time deposit ratio, and \( r \) is bank reserves to total deposit ratio.

\[ ^2 \text{The different approaches are the Money Multiplier Approach (Friedman and Schwartz (1963) and Brunner and Meltzer (1961)) and the Portfolio Approach (Goodhart (1989)). See Cuthbertson (1988) for a comparative analysis.} \]

\[ ^3 \text{Formally stated money multiplier approach treats money stock as a multiple of the reserve money, i.e. } M3 = m \cdot \text{RM}, \text{ with } m = (1 + c + t)/(c + (1 + t)r) \text{ where } c \text{ is currency-demand deposit ratio, } t \text{ is demand to time deposit ratio, and } r \text{ is bank reserves to total deposit ratio.} \]
money within the framework of cointegration. The empirical finding of no cointegration (cointegration) is considered as evidence against (in favor of) a stable long run money multiplier relation. Using the conventional augmented Dickey-Fuller (ADF) and Philips-Perron (PP) tests, these studies find that the null of no cointegration could not be rejected and attribute this 'instability' to significant discrete changes in the financial system and the conduct of monetary policy.\footnote{Ford and Morris (1996) interpret such a finding as indicative of misspecification in the money supply function.}

An important limitation of the above mentioned empirical studies is that they use the conventional ADF and PP tests of cointegration to infer about the instabilities in the long run money multiplier presumably generated by discrete changes in the financial system. The finding of not being able to reject the null of no cointegration using the ADF and PP tests, however, do not necessarily imply that the 'instability' in the parameters is due to discrete regime shifts as the former is also consistent with a gradual change in parameters characterized by a random walk over the entire sample. Similarly, a discrete change in a policy regime may lead to a one-time shift in the parameter vector and does not imply the absence of a stable long run relation, i.e. the variables under study may be cointegrated, in the sense of a linear combination of non-stationary variables being stationary, but this linear combination (the cointegrating vector) may have shifted at one probably unknown point in the sample. In this context the standard tests for cointegration are not appropriate, since they presume that the cointegrating vector is time-invariant under the alternative hypothesis and hence have low power in detecting the regime shift (Gregory and Hansen (1996)). The inference based on sub-sample (cointegration) regressions is also problematic since the choice of 'date' to identify the regime switch is typically unknown a priori and with 'data based' identification of break points the conventional test statistics are not valid (Zivot and Andrews (1992)).

In this paper, we explicitly address some of these limitations. Following Gregory and Hansen (1996), we test for the null of no cointegration between various measures of money stock and reserve money against the alternative of cointegration with a regime shift at an unknown point in the sample. Having found that there exists cointegration, we next examine the nature and significance of the shifts in the cointegrating vector using the stability tests of Hansen (1992).
Using monthly data on M1, M3 and adjusted Reserve Money from India for the period 1978.04 to 1996.06, we find that there exists a stable long run relation between money stock variables and reserve money with a regime shift around 1989.06, and the nature of variation in money multiplier is of discrete one-time shift rather than a gradually moving martingale process. The rest of the paper is organized as follows. Section II presents the econometric methodology. Section III presents data details and discusses the results. Section IV concludes.

2 Econometric Methodology

The money multiplier relation is usually written in a proportional form: \( MS_t = m(.)H_t \), where \( MS_t \) is a money stock aggregate, \( H_t \) is reserve money and \( m \) is money multiplier. Taking logs, we can write it in a general form:

\[
m_s t = \alpha + \beta h_t
\]

where \( m_s t = \log(MS_t) \), \( h_t = \log(H_t) \) and \( \alpha = \log(m(.)) \), with \( \beta = 1 \) implying proportionality relation.

If \( m_s t \) and \( h_t \) are \( I(1) \) variables, then for (1) to be a stable long-run equilibrium relation we need them to be cointegrated\(^5\).

2.1 Tests for cointegration with regime shifts (Gregory and Hansen (1996))

In order to allow for shifts in the long-run equilibrium at an unknown point in testing for cointegration, we write equation (1) as:

\[
\begin{align*}
\text{(2)} \quad m_s t & = \alpha_1 + \alpha_2 \phi_{t \tau} + \beta h_t + \epsilon_t, t = 1...n \\
\text{(3)} \quad m_s t & = \alpha_1 + \alpha_2 \phi_{t \tau} + \beta_1 h_t + \beta_2 h_t \phi_{t \tau} + \epsilon_t, t = 1...n
\end{align*}
\]

where

\[
\phi_{t \tau} = \begin{cases} 
0 & \text{if } t \leq [n\tau] \\
1 & \text{if } t > [n\tau]
\end{cases}
\]

\(^5\)Note that the intercept in equation (1) corresponds to money multiplier if the proportionality relation holds.
and the unknown parameter $\tau$ which belongs to (0,1) denotes the relative timing of the change point, and $\lfloor \cdot \rfloor$ denotes the integer part. In parameterization (2) the structural break is modelled in the form of a shift in the intercept while in (3) both the intercept and the slope coefficients are allowed to shift\(^6\). The residual based cointegration tests of ADF t-statistic($\tau$) and Phillips-Perron $Z_o(\tau)$ and $Z_i(\tau)$ are computed using the standard formulae for each of the models and for each of $\tau$. The test statistics of our interest are the smallest values of the above statistics across all values of $\tau$. The smallest values are examined since they constitute evidence against the null hypothesis of no cointegration. The test statistics are

\[
Z_o^* = \inf_{\tau \in \mathbb{R}} Z_o(\tau) \quad Z_i^* = \inf_{\tau \in \mathbb{R}} Z_i(\tau) \quad ADF^* = \inf_{\tau \in \mathbb{R}} ADF(\tau)
\]

The asymptotic distribution and the appropriate critical values of these statistics are reported in Gregory and Hansen (1996).

### 2.2 Stability tests in cointegrated relationships (Hansen(1992))

It is important to note that Gregory-Hansen’s modified cointegration tests are not informative about the nature and significance of the regime shift itself, since the alternative hypothesis contains as a special case the traditional model of cointegration with no regime shift. Hansen (1992) provides three test statistics ($\sup F$, $\text{mean} F$ and $L_c$) that test for parameter stability in cointegrated relationships based on the residuals of a Fully Modified - OLS (FM-OLS) regression. The $\sup F$ statistic, like the recursive Chow test, tests for the null of cointegration with no regime shifts against the alternative of cointegration with a discrete shift in the parameter vector at an unknown point, while the $\text{mean} F$ and $L_c$ statistics test for the null of cointegration against the alternative of a random walk type variation in the parameter vector. Hansen(1992) provides details on asymptotic distributions and computational aspects of these test statistics.

\[^6\text{This parameterization corresponds to what Gregory and Hansen (1996) call level and regime shift models respectively.}\]
3 Data and Results

The empirical exercise is carried out with monthly observations for the period 1978:04 to 1996:06 for India\(^7\). The variables used in this study are narrow money (M1), broad money (M3) and adjusted reserve money (H)\(^8\). The data has been compiled from various issues of Report on Currency and Finance, Reserve Bank of India.

Before we start our analysis it is necessary to check for the time series properties of the data. Table 1 reports the ADF tests for both the log-levels and log-differences of each series.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Log-levels</th>
<th>Log-Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>-2.889</td>
<td>-3.96</td>
</tr>
<tr>
<td>M3</td>
<td>-2.025</td>
<td>-3.47</td>
</tr>
<tr>
<td>RM</td>
<td>-1.49</td>
<td>-5.65</td>
</tr>
<tr>
<td>Critical Values (5%)</td>
<td>-3.45</td>
<td>-2.9</td>
</tr>
<tr>
<td>Critical Values (10%)</td>
<td>-3.15</td>
<td>-2.59</td>
</tr>
</tbody>
</table>

\(^8\) The lag selection in ADF-tests for each variable is made on the BIC

The results show that all the series are I(1). We next test for cointegration based on the conventional and modified ADF and Z statistics\(^9\). Results reported Table 2 indicate that the conventional ADF tests cannot reject the null of no cointegration between m1 and rm and m3 and rm.

\(^7\) The choice of the sample period is guided by the Reserve Bank of India's (RBI) definitional changes with respect to monetary aggregates.

\(^8\) The high powered or reserve money is adjusted to control for variations in statutory reserve requirements, following Rangarajan and Singh (1984).

\(^9\) We specify a range of (0.1, 0.9) for \(r\) in computing Gregory-Hansen test statistics.
Table 2: Tests for cointegration with regime shifts*  

<table>
<thead>
<tr>
<th>Test</th>
<th>MI on RM</th>
<th>M3 on RM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADF</td>
<td>-0.84(-3.15)</td>
<td>-0.98(-3.15)</td>
</tr>
<tr>
<td>ADF*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-5.07(-4.61)</td>
<td>-4.67(-4.61)</td>
</tr>
<tr>
<td>Intercept/Slope</td>
<td>-5.36(-4.95)</td>
<td>-5.83(-4.95)</td>
</tr>
<tr>
<td>Zt*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-85.3(-40.5)</td>
<td>-80.9(-40.5)</td>
</tr>
<tr>
<td>Intercept/Slope</td>
<td>-94.4(-47.1)</td>
<td>-81.2(-47.1)</td>
</tr>
<tr>
<td>Zt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-7.83(-4.61)</td>
<td>-7.52(-4.61)</td>
</tr>
<tr>
<td>Intercept/Slope</td>
<td>-8.53(-4.95)</td>
<td>-7.54(-4.95)</td>
</tr>
</tbody>
</table>

*Values in the paranthesis are the critical values for the tests at 5% level of significance reported in Gregory and Hansen(1996)

This may have induced some researchers to conclude that there exists no stable long-run relationships between monetary aggregates and reserve money (Sen and Vaidya(1997)). The modified ADF and Z tests, however, reject the null of no cointegration against the alternative of cointegration with structural break at 5% level of significance. The estimated break point is around 1989.06 (59% to 62% of the sample) for all test statistics for both narrow and broad money regressions. The results also remain robust across model specification allowing for change only in intercept and in intercept as well as slope coefficients. The evidence is in tune with the findings of Gregory, Nason and Watt (1996) that the conventional ADF tests have low power against structural breaks. It also raises important questions regarding the existence of a stable long-run money multiplier relation.

One way to interpret this result is that the cointegration relation between measures of money stock and reserve money holds over some (fairly long) period of time, and then has shifted to a new long-run relationship. As pointed out earlier, GH tests are not useful in detecting the nature and significance of the regime shift. To examine the latter we compute Hansen’s supF, meanF and \( L_c \) statistics from the FM-OLS regression residuals of equation 1.10

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10Following Hansen(1992), the covariance parameters are estimated using the Quadratic-Spectral kernel on residuals pre-whitened with VAR(1). The bandwidth parameter was selected according to Andrews(1991).
Table 3: Stability Tests in cointegrated relations*

<table>
<thead>
<tr>
<th>Test statistics</th>
<th>M1 on RM</th>
<th>M3 on RM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SupF</td>
<td>13.78(0.029)</td>
<td>14.46(0.02)</td>
</tr>
<tr>
<td>MeanF</td>
<td>3.79(0.062)</td>
<td>3.89(0.058)</td>
</tr>
<tr>
<td>$L_c$</td>
<td>0.41(0.12)</td>
<td>0.37(0.162)</td>
</tr>
</tbody>
</table>

*Values in the parenthesis are the asymptotic p-values associated with the computed statistics taken from Hansen (1992)

The results reported in Table 3 indicate that while the supF test rejects the null of cointegration at 5% level of significance against the alternative of cointegration with one time regime shift for both narrow and broad money multiplier relations, the meanF and $L_c$ tests fail to reject the null of cointegration against the alternative of random walk type variation in parameters in these regressions\(^{11}\). As pointed out by Hansen (1992), while we cannot conclude from this evidence alone that there is only one single regime shift in the cointegration relation, we can certainly say that the variation in the cointegrating vector defining long-run money multiplier relation is better described by a discrete one-time shift rather than a gradually evolving random walk process. In our context, this could be interpreted as indicating that the changes in the money multiplier relation are brought about by sudden changes in the conduct of monetary policy such as removal of ceiling rates in inter-bank money markets, relaxation of deposit rate controls etc. undertaken in India during late 80s and early 90s.

4 Conclusion

The stability of money multiplier, besides the controllability of reserve money, is of crucial significance for the effective control of money supply by the monetary authorities. Most empirical studies have examined the long-run stable relation between monetary aggregates and reserve money within the framework of cointegration and have interpreted their inability to reject the hypothesis of no cointegration as an indication of instability in money multiplier. In this paper we test for the existence of a stable long-run money multiplier using recently developed residual based tests for

\(^{11}\)Hansen (1992) suggests that such a finding can also be interpreted as an evidence inflavour of the null of cointegration against the alternative of no cointegration.
cointegration that explicitly allow for the possibility of regime shifts. Our results indicate that, contrary to the findings of earlier studies, there exists a stable, but time-varying, long-run relationship between monetary aggregates (M1 and M3) and adjusted reserve money. The results also indicate that the observed variation in parameters could be characterized by a discrete shift around 1989, generated possibly by discrete changes in the conduct of monetary policy such as the removal of controls on interest rates in the inter-bank call money ceiling rates in inter-bank money markets, deregulation of deposit rates etc.

In terms of policy implications, the study points out that the money multiplier is forecastable with reasonable degree of accuracy over longer time horizon and hence the monetary authority’s control over money supply lies in its ability to control reserve money. Even when discrete changes in the conduct of monetary policy result in sudden one-time shift in money multiplier relation, to the extent such a shift is anticipated, variations in money multiplier are predictable.

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References


