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LONG-RUN MONEY DEMAND FUNCTION: A NON-STATIONARY PANEL DATA APPROACH

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ABSTRACT

This paper examines the long-run money demand function using non-stationary panel data techniques for the panel data set of selected nine countries out of which three countries are developed namely United States, Australia and Iceland, and six countries are developing namely India, South Africa, Bangladesh, Mauritius, Costa Rica and Thailand for the period 1990 to 2014. The variables in the model are Real M3 (nominal broad money and GDP deflator), Real GDP, and opportunity cost (real interest rate). We used four types of panel unit root tests namely Levin, Lin and Chu (2002) test; Im, Pesaran and Shin (2003) test; Fisher ADF test; and Fisher PP test, and Panel cointegration tests (Pedroni and Kao cointegration tests) are used to analyse the annual observations. In the study, we observed that all the variables are non-stationary in levels but stationary in first differences implying that they are integrated of order one. We found a cointegration between the variables in our model which suggests a long-run relationship. The coefficients of the model have been estimated using the FMOLS and DOLS methods of Panel cointegration regression. From our study, we find a stable long-run money demand relationship for the panel data set under consideration with income elasticity close to unity and interest elasticity equal to -0.436.

Keywords: Money demand, Panel unit root, Panel cointegration, Monetary Policy

1. INTRODUCTION

The demand for money and its stability have been major issues in the field of macroeconomics as it has implications for policy-making. Having a stable relationship between money and prices holds importance since it plays a key role in the formulation of an efficient monetary policy, where interest rate is typically used as a policy instrument by the central banks of most of the nations. The stability of this relationship is usually assessed in a money demand framework, where money demand is linked to other macroeconomic variables like income and interest rates. Also, if the demand for money does not change unpredictably then money supply targeting as part of the monetary policy is a reliable way of attaining a constant inflation rate. All these factors entail our motivation to undertake the following study.

This study focuses on estimating a long-run money demand function for a panel data of nine countries namely, United States, India, Bangladesh, Costa Rica, Iceland, Australia, Thailand, Mauritius and South Africa, using the non-stationary panel data techniques. Annual observations for all variables are taken in order to carry out the panel unit root tests, panel cointegration tests and panel estimation using DOLS and FMOLS. While selecting the countries for our analysis we focussed on picking up a sample that consists of both developed and developing nations.

The paper is organised as follows. Following the introduction, Section 2 on the related literature review discussesvarious different techniques of testing and estimation in studies on the same subject undertaken for different regions from all over the world. This is followed by Section 3 on the model used, where we explain the macroeconomic theory and regression equation that is to be estimated. Then, in Section 4, we look at the estimation strategy usedwhere we examine in detail the unit root tests, the cointegration tests and the estimation techniques used to handle the panel data. Section 5discussesdata sources and definitions. Then we move to the results in Section 6 where we analyse the estimates from various unit root tests, panel cointegration and estimation. Finally,Section 7 concludes.

2. LITERATURE REVIEW

Economists have long been interested in obtaining precise estimates of money demand due to various reasons. Knowing the income elasticity of money demand helps in determining the rate of monetary expansion that is consistent with the long-run price level stability. Also, since a stable money demand function is a building block of the IS-LM (Investment and Saving equilibrium - Liquidity preference and Money Supply equilibrium) framework, economists have historically shown a keen interest in knowing how well this particular aspect of the model performed.

There are several empirical studies based on money demand using panel cointegration pertaining to different regions of the world. Hamdi et al (2015) estimated M2 demand for a panel of six Gulf Cooperation Council countries for the period 1980-2011 using quarterly data. They found an evidence for stable long-run money demand for the sample under study using the FMOLS and DOLS estimators. Considering a panel dataset consisting of six Gulf Cooperation Council

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countries, Harb (2004) tested the M1 demand using Pedroni's panel cointegration tests using annual observations for period 1979-2000 and estimated the cointegrating equation with the FMOLS estimator developed by Pedroni (2000). He found a significant effect of the interest rate on the money demand. Furthermore, in another study Dreger et al. (2006) analysed the broad money demand for 10 new European Union countries. Their income elasticity estimate is around 1.70, and interest rate semi-elasticity is negative. Fidrmuc (2008) analysed M2 demand for a panel of six Central and Eastern European countries which are getting prepared to enter the European Economic and Monetary Union (EMU). He estimated the money demand equation both with panel FMOLS and DOLS estimators and concluded that the Euro area interest rates have a significant effect on the money demand of these six countries. Another major study is from Mark and Sul (2003) where they estimated the M1 demand for a panel consisting of 19 OECD countries. Using DOLS estimator, they obtained income elasticity near 1, and an interest rate semi-elasticity of -0.02.

Dobnik (2011) examined long-run money demand function for 11 OECD countries for the period 1983-2006 using DOLS estimation technique. He found that cross-member cointegration is existent and only the common components of the variables are cointegrated. There is another study by Carrera (2012) who estimated money demand M1 for 15 Latin American countries and found a stable money demand relationship with income elasticity of 0.94 and interest semi-elasticity of –0.01 using FMOLS estimation procedure. Brand et al. (2004) analysed M3 for the Euro area using structural cointegrated VAR approach for period 1980-1999. They found a money demand function linking real M3 to long-term interest rates with semi-elasticity –1.6 and a scale variable measured by real GDP with elasticity 1.3. Oskooee et al. (2005) proposed to study whether the money demand relation is stable for the Asian developing countries using data on M1 and M2 monetary aggregates. They used ARDL, CUSUM, and CUSUMQ tests unlike the other papers. It was shown that while in India, Indonesia and Singapore, M1 aggregate is cointegrated with its determinants and the estimated elasticities are stable over time, in Malaysia, Pakistan, Philippines and Thailand it is the M2 aggregate that is cointegrated and stable. Rao et al (2009) estimated the demand for money M1 for a panel of 14 Asian countries for the period 1970-2005 using FMOLS and DOLS estimation methods. They found no evidence for instability in the demand for money. The income elasticity of demand for money is about unity and demand for money responds negatively to variations in the short term rate of interest. Lee et al. (2008) examined the long-run money demand function for six selected countries of Gulf Cooperation Council using four-dimensional VECM model. They found that the full panel test significantly rejects the hypothesis of the quantity theory of money for the long-run elasticity of income equal to unity. Hamori (2008) conducted an empirical analysis on the stability of the money demand

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function in the region of Sub-Saharan Africa. He found a stable money demand relationship using the FMOLS estimation technique.

In this paper, we analysethe long-run money demand function using non-stationary panel data techniques for the panel data set of selected nine countries out of which three countries are developed namely United States, Australia and Iceland, and six countries are developing namely India, South Africa, Bangladesh, Mauritius, Costa Rica and Thailand for the period 1990 to 2014. The study examines whether there exists a long run relation between real broad money, real GDP and opportunity cost given by real interest rate and if it exists, we would estimate it using the Panel Data techniques.

3. MODEL

What factors and what forces determine the demand for money are central issues in macroeconomics? In economic theory, by demand for money, we mean how much financial assets one wants to hold in the form of money, which does not earn interest, versus how much one wants to hold in interest-bearing securities, such as bonds.

At any given point of time, an individual has to decide how to allocate his or her financial wealth between alternative types of assets. The more bonds held, the more interest received on total financial wealth. The more money held, the more likely the individual is to have money available when he or she wants to make a purchase. How much money to hold involves a trade-off between the liquidity of money and the interest income offered by other kinds of assets. The main reason for holding money instead of interest bearing assets is that money is useful for buying things. Economists call this the Transaction Motive. On the other hand, one reason for holding bonds instead of money is that, because the market value of interest-bearing bonds is inversely related to the interest rate, investors may wish to hold bonds when interest rates are high with the hope of selling them when the interest rates fall. This is called by economists, the Speculative Motive.

For every individual, there is a wealth budget constraint which states that the sum of the individual's demand for money and demand for bonds has to add up to that person's total financial wealth. Again, the wealth budget constraint implies, given an individual's real wealth, that a decision to hold more real balances is also a decision to hold less real wealth in the form of bonds. This means that given the real wealth, when money market is in equilibrium, the bond market will also turn out to be in equilibrium.

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The money demand function is an important part of the IS-LM framework. The demand for money is the demand for real balances because people hold money for what it will buy. The higher the price level, the more the nominal balances a person has to hold to be able to purchase a given quantity of goods. The demand for real balances depends on the level of real income and the interest rate. It depends on the level of real income because individuals hold money to pay for their purchases, which, in turn, depend on income. The demand for money depends also on the cost of holding money or the opportunity cost. The cost of holding money is the interest that is forgone by holding money rather than other assets. The higher the interest rate, the more costly it is to hold money and, accordingly, the less cash will be held at each level of income.

Thus, the demand for real balances increases with the level of real income and decreases with the interest rate. The demand for real balances can be written as,

$$L = kY - hi \qquad k, h > 0 \tag{1}$$

The parameters k and h reflect the sensitivity of the demand for real balances to the level of income and the interest rate, respectively.

The stability of money in the economy is governed by equilibrium in the money market. For stating equilibrium in the money market we have to say how the money supply is determined. The nominal quantity of money, M, is controlled by the central bank, so the real money supply is given by M/P. All the combinations of the interest rates and income levels such that the demand for real balances exactly matches the available supply denote the money market equilibrium.

$$\frac{M}{P} = kY - hi \tag{2}$$

$$\Rightarrow M_s = M_d$$

$$where\ M_d = f(Y, i)$$

More formally, the LM schedule or the money market equilibrium schedule shows all the combinations of interest rates and levels of income such that the demand for real balances is equal to the supply. Along the LM schedule, the money market in equilibrium, this gives us the stability condition.

In the macroeconomics literature, the widely used representation of the long-run money demand function is,

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$$\frac{M}{P} = f(Y, I) \qquad (3)$$

Here, M represents the nominal money, P is the price level (or CPI), Y is the income, and I is the interest rate which represents the opportunity cost of holding money. According to theory, the income variable should have a positive effect on money holdings and since the opportunity cost measures the foregone earnings on alternative assets, its coefficient should be negative.

The reduced form equation that we estimate in our paper is,

$$ln\left(\frac{M_{it}}{P_{it}}\right) = \alpha_i + \beta_y lnY_{it} + \beta_R lnR_{it} + u_{it} \qquad (4)$$

where M_{it} is a money measure (broad money M3), P_{it} is a price level, Y_{it} is the real GDP, R_{it} is the interest rate, α_i refers to the country-specific effects, β_y is the income elasticity, and β_R is the interest rate elasticity; $i = 1,2, \ldots, N; t = 1,2, \ldots, T$; with N = 9 and T = 25.

4. ESTIMATION STRATEGY

Based on the model in the previous section, we evaluate the long run relationship between real broad money M3, real GDP and interest rate using the panel estimation techniques. First the tests for unit roots are conducted, followed by tests of panel cointegration, and finally panel estimation using FMOLS and DOLS regressions.

4.1 Tests for Non-stationarity

In order to avoid the situation of a spurious regression where we get high R^2 and many significant t statistics without any economic model behind it, we want the dependent and independent variables in the model to be stationary. A stationary series exhibits a mean reversion, has a finite, time invariant variance and a finite covariance between two values that depends only on their distance apart in time, not on their absolute location in time. To be able to formulate the variables into a meaningful economic model, it is necessary that all variables are stationary and thus the first econometric exercise would be to check for unit root in all individual series. The conventional unit root tests for individual time series (Augmented Dickey Fuller test, Phillips-Perron Test and others) are known to have a lower power against the alternative of stationarity of the series, particularly for small samples. So, literature suggests panel based unit root tests.

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4.1.1. Tests assuming common unit root

a. The Levin, Lin and Chu Test (LLC Test)

Levin-Lin-Chu (2002) suggested that the individual unit root tests have a limited power. The power of a test is the probability of rejecting the null when it is false and the null hypothesis is the presence of a unit root. It follows that we find too many unit roots if we use individual unit root tests. So LLC suggested a more powerful panel unit root test than performing individual unit root tests for each cross-section. The maintained hypothesis is,

$$\Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mt} + \varepsilon_{it} \qquad (5)$$

The following are the hypotheses for the test,

H_0: Each time series contains a unit root (H_0: $\rho = 0$)

H_1: Each time series is stationary (H_1: $\rho \neq 0$)

The lag order p_i is permitted to vary across individuals. There is a three step procedure for the implementation of this test and Eviews allows us to directly run the test by selecting the relevant options.

4.1.2. Tests assuming individual unit root

a. The Im, Pesaran and Shin Test (IPS Test)

The LLC test is restrictive in the sense that it requires ρ to be homogeneous across i. So Im-Pesaran-Shin (2003) gave a new test which allows for a heterogeneous coefficient of y_{it-1} and proposed an alternative testing procedure based on averaging individual unit root test statistics. The null hypothesis is that each series in the panel contains a unit root, i.e. $H_0: \rho_i = 0$ for all i, and alternative hypothesis allows for some (but not all) of the individual series to have unit roots, i.e.

$$H_1: \quad \begin{cases} \rho_i < 0 \; for \; i = 1,2,\dots,N_1, \\ \rho_i = 0 \; for \; i = N_1+1,\dots,N. \end{cases}$$

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The alternative hypothesis requires the fraction of the individual time series that are stationary to be non-zero. This condition is necessary for the consistency of the panel unit root test. In this test, if we are not able to reject the null hypothesis, it implies the presence of a unit root and the series is non-stationary.

b. Fisher-type tests (Fisher-ADF and Fisher-PP Tests)

There are two tests under this category; one is the Fisher-ADF test and the other is the Fisher-PP test. R.A. Fisher proposed these tests which combine the p-values from independent tests to obtain an overall test statistic and is frequently called a Fisher-type test. In the context of panel data unit-root tests, we perform a unit-root test on each panel's series separately, and then combine the p-values to obtain an overall test of whether the panel series contains a unit root. The null hypothesis being tested is that all panels contain a unit root. For a finite number of panels, the alternative is that at least one panel is stationary. As N tends to infinity, the number of panels that do not have a unit root should grow at the same rate as N under the alternative hypothesis.

4.2 Panel Cointegration Tests

Like the panel unit root tests, panel cointegration tests can be motivated by the search for more powerful tests than those obtained by applying individual time series cointegration tests. In our study, we have used two types of panel cointegration tests given by Pedroni and Kao.

4.2.1. Pedroni Cointegration Test (Engle-Granger based)

Pedroni proposed several tests for the null hypothesis of no cointegration in a panel data model that allows for considerable heterogeneity. Pedroni (1999) extended the Engle and Granger (1987) two-step procedure to panels and rely on ADF and PP principles. First, the cointegration equation is estimated separately for each panel member. Second, the residuals are examined with respect to the unit root feature. If the null hypothesis is rejected then a long-run equilibrium exists, although the cointegration vector may be different for each cross-section. Pedroni test refers to seven different statistics for this test. They are Panel v-statistic, Panel rho-statistic, Panel PP-statistic, Panel ADF-statistic, Group rho-statistic, Group PP-statistic, and Group ADF-statistic. The first four statistics are known as panel cointegration statistics and are based on within approach; the last three are group panel cointegration statistics and are based on between approach. In the presence of a cointegrating relationship, the residuals are expected to be stationary.

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4.2.2. Kao Cointegration Test (Engle-Granger based)

The Kao test is based on the Engle-Granger two-step procedure and follows the same basic approach as the Pedroni tests, but specifies cross-section specific intercepts and homogeneous coefficients for members of the panel.

4.3 Estimation of Panel Cointegration Model

The Panel cointegration tests discussed in the last section are only able to indicate whether or not the variables are cointegrated and if a long-run relationship exists between them. The panel cointegration models are directed at studying questions that surround long-run economic relationships which are often predicted by economic theory, and it is of central interest to estimate the regression coefficients and test whether they satisfy theoretical restrictions. The long-run equilibrium coefficients can be estimated by using single equation estimators such as the fully modified OLS procedures (FMOLS) developed by Pedroni (2000) and dynamic OLS (DOLS) estimator given by Mark and Sul (2003). In case of panel data, it is observed that the OLS estimator gives inconsistent estimates. The asymptotic distribution of the OLS estimator depends on the nuisance parameters arising from endogeneity of the regressors and serial correlation in the errors. To solve these problems, Kao and Chiang (2000) suggested FM and DOLS estimators in a cointegrated regression and showed that their limiting distribution is normal. The FMOLS estimators use the nonparametric corrections for bias and endogeneity problems in the OLS estimator. The DOLS estimators, on the other hand, add leads and lags of the differenced regressors into the regression as parametric corrections for the bias and endogeneity problems. DOLS estimators are asymptotically equivalent to their FMOLS counterparts.

5. DATA SOURCES AND DEFINITIONS

The variables used in the paper are real money M3, real GDP and real interest rate. All the data for the construction of these variables are taken from the World Bank database. The annual data istaken for nine countries, namely, United States, India, Bangladesh, Australia, Iceland, Costa Rica, South Africa, Mauritius, and Thailand for the period 1990 to 2014 (T=25).

The data on broad money in local currency is taken from the World Bank which is converted in USD using the official exchange rate (LCU per US$) from the same data source. Broad money is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than the central government; bank and traveller's checks; and other securities such as certificates of deposit and

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commercial paper. These figures are converted from nominal to real terms using the consumer prices (annual %) which is finally referred to as real M3 in our paper.

The data for GDP at market prices is also available from the World Bank database. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used. These values are converted to what is referred to as real GDP in the paper, after dividing them by GDP deflator (annual %).

In this paper, the opportunity cost of holding money is represented by the real interest rate whose data is also taken from the World Bank. Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator.

The trends in GDP and broad money are presentedin Figures 1 and2, respectively. We observe a rising trend in the GDP and its volume is highest in US and South Africa followed by Thailand. Trends in India are similar to those of Mauritius and Iceland. From the figures, it can also be observed that all countries experienced an increase in the money stock over the period under consideration with highest levels in United States and South Africa. There is a declining trend in interest rates with high volatility over time except in Australia and Bangladesh (Figure 3).

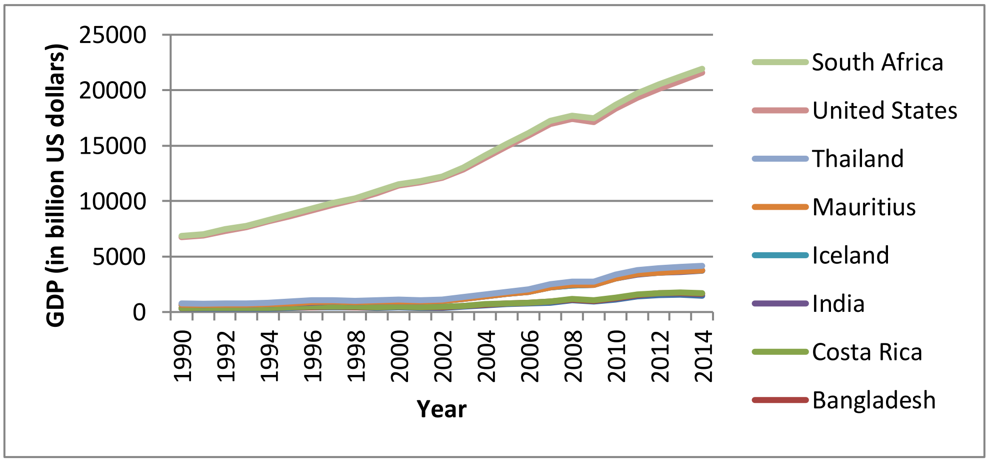

Figure 1: Trends in GDP

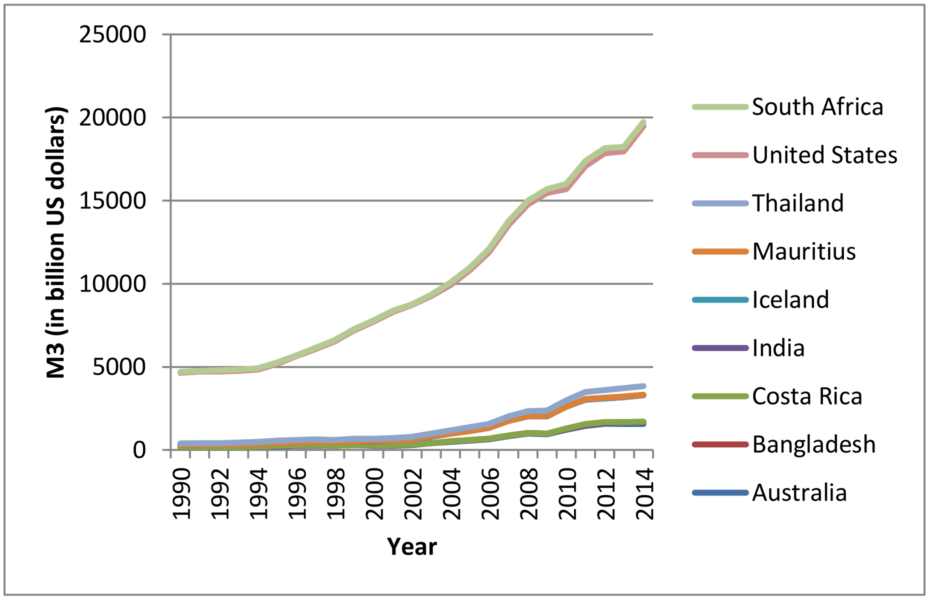

Figure 2: Trends in Broad Money

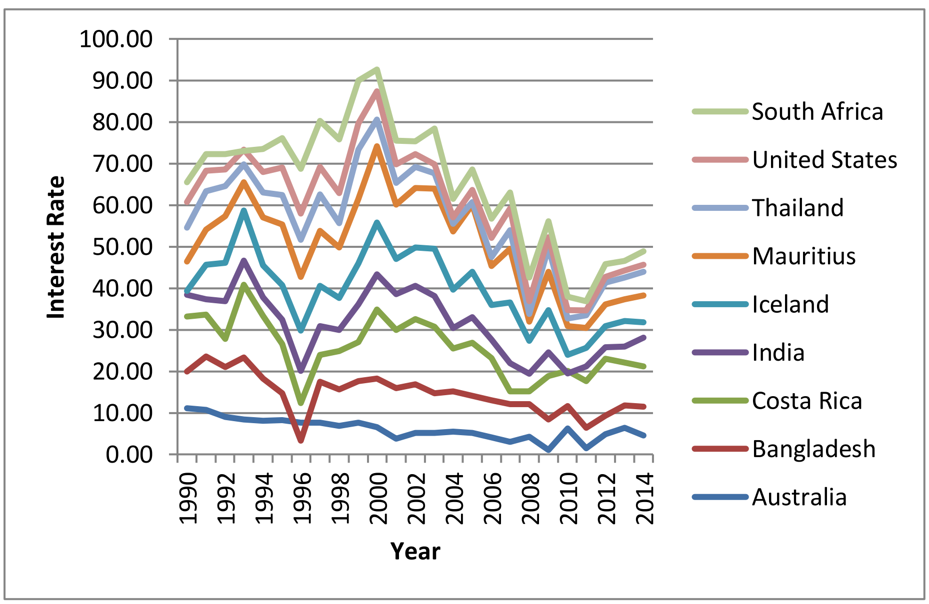

Figure 3: Trends in Interest Rate

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6. RESULTS

The variables used in the paper are real GDP, real M3 and real interest rate. This section shows the empirical results of all the tests and estimation techniques described earlier.

6.1 Panel Unit Root Tests

The first step of the econometric exercise is to check the order of integration of the variables in the money demand equation which is tested via panel unit root tests. The results of various panel unit root tests for each of the variables, taken in levels and first differences, are presented in Tables 1 to 4.

The unit root tests are conducted using intercept only. For real interest rate (Table 1), when we run the tests in levels, we are not able to reject the null hypothesis of the presence of unit root at 5% level of significance in case of LLC, IPS and ADF-Fisher tests. However, PP-Fisher test gives opposite results. Going by majority rule, we do not reject the null hypothesis at 5% level of significance and thus we conclude that the series is non-stationary. Next, we run the tests in first differences, and now we are able to reject the null hypothesis even at 1% level of significance. Thus, we conclude that real interest rate is stationary in first differences, that is, it is integrated of order one.

Table 1: Panel Unit Root test for Real Interest Rate (intercept only)

Real Interest Rate	In Levels			In First Difference		
Method	Obs.	Statistic	p-value	Obs.	Statistic	p-value
Null: Unit root (assumes common unit root process)						
Levin, Lin & Chu test	207	-0.597	0.275	198	-2.723	0.003
Null: Unit root (assumes individual unit root process)						
Im, Pesaran and Shin test	207	-1.512	0.065	198	-8.414	0.000
Fisher – ADF test	207	24.130	0.151	198	99.265	0.000
Fisher – PP test	216	47.367	0.000	207	236.26	0.000

Notes: Probabilities for Fisher tests are computed using asymptotic Chi-square distribution. All other tests assume asymptotic normality. The time period for consideration is 1990-2014.

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For real GDP (Table 2), in case of unit root tests in levels, we are not able to reject the null hypothesis of the presence of unit root at 10% level of significance in case of LLC and IPS tests, and at 1% level of significance in case of ADF-Fisher test. However, in case of PP-Fisher test, we reject the null at 1% level of significance. Again going by the majority rule,we do not reject the null and thus we conclude that the series is non-stationary. So, we run the tests in first differences, and now we are able to reject the null hypothesis even at 1% level of significance. Thus we conclude that real GDP is also stationary in first differences or is integrated of order one.

Table 2: Panel Unit Root test for Real GDP (intercept only)

Real GDP	In Levels			In First Difference		
Method	Obs.	Statistic	p-value	Obs.	Statistic	p-value
Null: Unit root (assumes common unit root process)						
Levin, Lin & Chu test	207	-0.029	0.488	198	-3.242	0.001
Null: Unit root (assumes individual unit root process)						
Im, Pesaran and Shin test	207	-0.621	0.267	198	-6.799	0.000
Fisher – ADF test	207	32.954	0.017	198	89.088	0.000
Fisher – PP test	216	77.397	0.000	207	971.25	0.000

Notes: Probabilities for Fisher tests are computed using asymptotic Chi-square distribution. All other tests assume asymptotic normality. The time period for consideration is 1990-2014.

Checking the same results for real money M3 (Table 3), for unit root tests in levels, we do not reject the null at 1% level of significance in case of LLC,IPS and ADF Fisher tests, though we reject the null in case of PP-Fisher test as in the earlier cases. So, we run the unit root tests in first differences and we are able to reject the null hypothesis at 1% level of significance using all tests concluding that real M3 is also stationary in first differences.

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Table 3: Panel Unit Root test for Real Money M3 (intercept only)

Real Money M3	In Levels			In First Difference		
Method	Obs.	Statistic	p-value	Obs.	Statistic	p-value
Null: Unit root (assumes common unit root process)						
Levin, Lin & Chu test	207	2.578	0.995	198	-8.723	0.000
Null: Unit root (assumes individual unit root process)						
Im, Pesaran and Shin test	207	1.576	0.942	198	-9.439	0.000
Fisher – ADF test	207	18.603	0.417	198	113.21	0.000
Fisher – PP test	216	35.440	0.008	207	364.99	0.000

Notes: Probabilities for Fisher tests are computed using asymptotic Chi-square distribution. All other tests assume asymptotic normality. The time period for consideration is 1990-2014.

Table 4: Unit Root tests summary (intercept and trend case)

	In Levels			In First Difference		
Method	Real GDP	Real Interest Rate	Real M3	Real GDP	Real Interest Rate	Real M3
Null: Unit root (assumes common unit root process)						
Levin, Lin & Chu test	-1.15	0.73	-0.71	-6.15***	-11.78***	-8.26***
Null: Unit root (assumes individual unit root process)						
Breitung t-stat	2.73	-1.74	2.95	1.33	-11.08***	-0.65
Im, Pesaran and Shin test	-1.25	-0.71	-0.85	-10.2***	-15.74***	-8.02***
Fisher – ADF test	34.33	19.43	24.19	132.8***	173.43***	92.31***

Notes: *** denotes significance at 1% level implying that the null of unit root is rejected. Results imply all variables are I(1).

Even if we run the unit root tests using intercept and trend (Table 4), we arrive at the same conclusions as above. We are not able to reject the null hypothesis in levels but we are able to reject the null hypothesis at 1% level of significance when we run unit root tests in first

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differences by LLC, IPS and ADF-Fisher tests. Thus again, we arrive at the conclusion that all the series are non-stationary in levels but stationary in first differences.

6.2 Panel Cointegration Tests

Test results for cointegration between the three variables of equation (4) are shown in Table 5 and 6. In case of Pedroni cointegration test (Table 5), out of the seven reported test statistics, we are able to reject the null hypothesis of no cointegration at 5% level of significance using four test statistics (panel-PP, panel-ADF, group-PP, and group-ADF) and at 10% level of significance using Panel rho-statistic. Of these seven tests, the two ADF tests have more power against the null and they reject conclusively the null of no cointegration. So, by using this criteria and by the rule of majority (five out of seven), we conclude that the variables in equation (4) are cointegrated and a long run money demand function exists for the group as a whole and the members of the panel.

Table 5: Pedroni Cointegration Test (lnM3, lnGDP, lnINTRate)

Method	Obs.	Statistic	p-value
Null hypothesis: No cointegration			
Alternative hypothesis: common AR coefs. (within-dimension)			
Panel v-statistic	225	-0.348	0.636
Panel rho-statistic	225	-1.360	0.087
Panel PP-statistic	225	-2.217	0.013
Panel ADF-statistic	225	-3.872	0.000
Alternative hypothesis: common AR coefs. (between-dimension)			
Group rho-statistic	225	-0.495	0.310
Group PP-statistic	225	-2.274	0.011
Group ADF-statistic	225	-3.632	0.000

Notes: The time period for consideration is 1990-2014.

From Kao cointegration test results (Table 6), we can clearly reject the null hypothesis of no cointegration at 1% level of significance, again implying that there is a long-run relationship between real money, real GDP and real interest rate.

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Table 6: Kao Cointegration Test (lnM3, lnGDP, lnINTRate)

Method	Obs.	t-Statistic	p-value
Null hypothesis: No cointegration			
Panel v-statistic	225	-6.702	0.000
Residual variance		0.190	
HAC variance		0.129	

Notes: The time period for consideration is 1990-2014.

6.3 Panel Estimation

Cointegrating parameters of pooled estimation using DOLS and FMOLS are presented in Tables 7 and 8. Estimated panel group cointegrating parameters and the individual coefficients are also displayed using the Pedroni's FMOLS estimation. From all the three methods, we infer that log of GDP and log of interest rate are statistically significant at 1% level of significance. The estimates of income elasticity and interest elasticity differ only marginally in the three methods. Coefficient of the rate of interest has the expected negative sign and income elasticity is close to unity in all estimates. From these results, we conclude that money demand is responsive to changes in interest rate albeit this response is small. It makes more sense to take into consideration the results from group estimation as compared to pooled estimation. FMOLS has various advantages over DOLS estimation. And thus, we infer that the income elasticity is close to unity and interest elasticity is -0.436. Also, looking at the individual estimates for all the panel members in Table 9, we observe that coefficient of log of interest rate is negative as expected from theory and that of log of GDP is positive for all the countries. Thus, we get valid cointegrating vectors not only for the group of countries as a whole but also for individual members of the panel data set.

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Table 7: Panel Dynamic Least Squares Estimates (DOLS)

Dependent variable: ln(M3)			
	Coeff.	Std. error	p-value
ln(GDP)	1.07	0.053	0.000
ln(INTRate)	-0.29	0.089	0.001
R-squared	0.982		
No. of observations	191		

Notes: The time period for consideration is 1991-2014. These are the results using pooled estimation for panel dynamic least squares.

Table 8: Panel Fully Modified Least Squares Estimates (FMOLS)

Dependent variable: ln(M3) – Pooled estimation			
	Coeff.	Std. error	p-value
ln(GDP)	1.05	0.056	0.000
ln(INTRate)	-0.38	0.091	0.000
R-squared	0.970		
No. of observations	202		
Dependent variable: ln(M3) – Grouped estimation			
	Coeff.	Std. error	p-value
ln(GDP)	1.01	0.047	0.000
ln(INTRate)	-0.44	0.087	0.000
No. of observations	202		

Notes: The time period for consideration is 1991-2014. These are the results using pooled and grouped estimation for panel fully modified least squares.

Table 9: Panel Fully Modified Least Squares Estimates (FMOLS) - Individual coefficients

	ln(GDP)	ln(INTRate)	C
Australia	0.89	-0.91	4.02
Bangladesh	0.60	-1.54	11.55
Costa Rica	1.24	-0.29	-5.58
India	1.12	-0.32	-3.24
Iceland	0.88	-0.46	3.11
Mauritius	1.02	0.15	-0.98
Thailand	1.01	-0.20	0.06
United States	1.03	-0.32	-1.07
South Africa	1.21	-0.01	-5.32

Notes: The time period for consideration is 1991-2014. These are the results using grouped estimation for panel fully modified least squares.

7. CONCLUSION

This study has been done to estimate the long-run money demand relationship for a panel data set of nine countries namely, United States, India, Bangladesh, Costa Rica, Iceland, Australia, Thailand, Mauritius and South Africa, using the non-stationary Panel Data techniques for the period 1990-2004. The above discussion implies that the volatility of money demand matters for how monetary policy should be conducted. If most of the aggregate demand shocks which affect the economy come from the expenditure side, the IS curve, then a policy of targeting the money supply will be stabilizing, relative to a policy of targeting interest rates. However, if most of the aggregate demand shocks come from changes in the money demand, which influences the LM curve, then a policy of targeting the money supply will be destabilizing.

In order to be consistent with the IS-LM model, knowing the effects of income over moneydemand facilitates the determination of the rate of monetary expansion that is consistentwith the long-run price level stability. Moreover, due to the effects of interest rate in futureconsumption, knowing the interest rate effects over money demand eases the calculation ofthe welfare costs of long-run inflation. In this study, we finda stable long-run money demand relationship for the panel dataset under consideration using non-stationary panel data techniques implying a monetary policy targeting interest rates. We observed that the signs of coefficients were as expected from economic theory that is negative relation with interest rate and positive relation with real GDP. Also, we find that the income elasticity is close to unity and interest elasticity is −0.436.

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