# A CROSS COUNTRY EVALUATION OF THE DEMAND FOR MONEY

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A thesis submitted to Auckland University of Technology in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD)

2011

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## ATTESTATION OF AUTHORSHIP

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

# ACKNOWLEDGEMENTS

I would like to formally acknowledge and thank a number of people who encouraged, supported and assisted me through the demanding and challenging years of my PhD study.

First, I would like to thank my two supervisors, Associate Professor Don. J. Webber and Dr Scott Fargher. They have guided me in the selection of empirical tests and provided me with timely assistance and feedback. Their confidence in me encouraged me to achieve what I believed I could. Both supervisors have inspired me and nurtured my research endeavours. I am greatly indebted to you both for your consistent support, enthusiastic encouragement and valuable feedback throughout the dissertation process.

I would also like to acknowledge late Professor B. Bhaskara Rao for his continuous guidance in my research. His critical comments and suggestions on all aspects of this thesis were very useful. Moreover, I would like to thank the following people for providing valuable comments on the flowchart I developed in this dissertation: Joerg Breitung, Dimitris Christopolous, Ron Smith, Stefano Fachin, Vasudeva Murthy, Donggyu Sul, Peter C.B. Phillips, Helmut Herwartz, Gail Pacheco, Erkan Erdil, William Greene, Alberto Bagnai, Tsangyao Chang, Mark Strazicich and Junsoo Lee.

To my mum and dad, a special thank you for instilling in me the true value of education from an early age. This gave me the much needed drive and determination to be successful in my endeavours.

Finally, this dissertation was only made possible by the unwavering support, affection, and limitless patience of my wife Doreen Chandra. Words are not enough to describe how fortunate I feel to have you in my life. It means so much to me that you are always proud of my achievements.

## LIST OF ABBREVIATIONS

| | |
|---|---|
| ADF | Augmented Dickey Fuller |
| AIC | Akaike Information Criterion |
| ARDL | Autoregressive Distributed Lag Model |
| ARG | Argentina |
| AUS | Australia |
| AUT | Austria |
| BGD | Bangladesh |
| BOL | Bolivia |
| BP | Bai-Perron |
| BRA | Brazil |
| CAN | Canada |
| CHE | Switzerland |
| CHL | Chile |
| CIV | Ivory Coast |
| CMR | Cameroon |
| COL | Columbia |
| CUSUM | Cumulative Sum of Recursive Residuals |
| CUSUMSQ | Cumulative Sum of Squares of Recursive Residuals |
| DNK | Denmark |
| DOLS | Dynamic Ordinary Least Squares |
| DW | Durbin Watson |
| EBA | Extreme Bounds Analysis |
| ECM | Error Correction Model |
| ECU | Ecuador |
| EG | Engle and Granger |
| EGY | Egypt |
| EMU | European Monetary Union |
| ERS | Elliot Rothernberg and Stock |
| ETH | Ethiopia |
| EU | European Union |

| | |
|---|---|
| FJI | Fiji |
| FMOLS | Fully Modified Ordinary Least Squares |
| GETS | General to Specific |
| GH | Gregory and Hansen |
| GRC | Greece |
| IMF | International Monetary Fund |
| IND | India |
| IPS | Im, Pesaran and Shin |
| IRN | Iran |
| IS | Investment Savings |
| ISR | Israel |
| JML | Johansen Maximum Likelihood Technique |
| JOR | Jordon |
| JPN | Japan |
| KEN | Kenya |
| KOR | Korea |
| KPSS | Kwiatkowski–Phillips–Schmidt–Shin |
| KWT | Kuwait |
| LAC | Latin American Countries |
| LKA | Sri Lanka |
| LLC | Levin, Lin and Chu |
| LM | Liquidity Money |
| LS | Lee and Strazicich |
| LSE | LondonSchool of Economics |
| MEX | Mexico |
| MMR | Myanmmar |
| MWI | Malawi |
| MYS | Malaysia |
| MW | Maddal-Wu |
| M1 | Narrow Money |
| NGA | Nigeria |
| NLLS | Non Linear Least Squares |

| | |
|---|---|
| NOR | Norway |
| NPL | Nepal |
| NZL | New Zealand |
| OECD | Organization of Economic Cooperation and Development |
| OLS | Ordinary Least Squares |
| OMN | Oman |
| PAK | Pakistan |
| PAM | Partial Adjustment Model |
| PER | Peru |
| PHL | Philippines |
| PICs | Pacific Island Countries |
| PNG | Papua New Guinea |
| PP | Phillips- Perron |
| RWA | Rwanda |
| SBC | Schwarz Bayesian Criterion |
| SER | Standard Error of Estimation |
| SGP | Singapore |
| SLB | Solomon |
| SYR | Syria |
| THA | Thailand |
| TSLS | Two Stage Least Squares |
| UGA | Uganda |
| UK | United Kingdom |
| URY | Uruguay |
| USA | United States |
| VAR | Vector Auto-regressions |
| VECM | Vector Error Correction Model |
| VEN | Venezuela |
| VUT | Vanuatu |
| WSM | Samoa |
| ZA | Zivot-Andrews |
| ZAF | South Africa |

# ABSTRACT

A stable demand for money function is a necessary condition for the supply of money to be utilized as an instrument of monetary policy (Serletis, 2001). Poole (1970) showed that the rate of interest (supply of money) should be used as an instrument of monetary policy when the money demand function is unstable (stable). Due to financial reforms since the 1980s, it is widely recognized that the condition for a stable demand for money relation has broken down (Orden and Fisher, 1993). Evidence suggests that the switch from reliance on the money supply to the interest rate as the primary monetary policy instrument has taken place in advanced OECD countries because of an instability in money demand functions. Following this change many developing countries have also moved towards using interest rates without significant evidence that their money demand functions have become unstable.

The purpose of this study is to re-assess the stability of *M1* (narrow money) demand for selected advanced OECD and developing countries using more up-to-date econometric techniques and data. This allows us to re-evaluate the contemporary stance on monetary policy because it appears that most central banks of developing countries could still utilise the supply of money as an instrument of monetary policy. According to Poole (1970), selecting the wrong instrument may result in large fluctuations in output. He suggested that money demand stability information helps to serve the central banks to formulate an optimal monetary policy. This study emphasizes the importance of monitoring demand for money in monetary policy decisions.

Money demand stability is an empirical issue and given the importance of the topic, robust empirical results are required. Contradictory evidence exists on the income elasticity estimates of money demand and their stability. Regrettably, the existing literature does not offer guidelines for identifying strong empirical evidence given the multitude of econometric methods that are on offer. Given the emphasis placed on the interest rate it appears that most central banks now pay less attention to the stability of the money demand functions. This study establishes that money demand

stability is useful for policy but it requires strong empirical investigations. To this end, utilising a wide range of new empirical tests, this study presents estimates of the canonical and extended specifications of the demand for *M1* for selected advanced OECD and developing countries.

This thesis offers a structured, logical and detailed way of navigating through the empirical issues and challenges that have emerged in the literature. The first major contribution to the literature is that a wide array of recently developed time series and panel data techniques are used to examine the *M1* demand relationships for a large sample of countries (10 advanced OECD, 5 Pacific Islands, 18 Asian, 10 African and 10 Latin American). Results show that the income elasticity is less (around or slightly higher) than unity in advanced OECD (developing) countries; contrary to what is achieved by most studies in the literature.  To this end, financial markets seem to be relatively well developed in the advanced OECD countries.

The second major contribution of this study is that a comprehensive set of unit root and cointegration tests are organised in the form of flowcharts to illustrate the possible instances in which they could be utilised. This will serve as a useful guide to applied economists who are working with non-stationary time series and panel data. This study also applies the flowcharts to provide a comprehensive body of examples and cross-checks of the results for specific countries and regions using the appropriate methodologies. This thesis therefore serve as an examination of other's studies while also offering new results and establishing the degree of importance of following the correct technique.

The third major contribution of this study is associated with the process of monetary policy procedures. The stability tests on *M1* demand imply that the developing countries should re-consider their choice of using the rate of interest as an instrument of monetary policy; perhaps using the supply of money is a feasible alternative. It appears that most developing countries are imitating the monetary policy procedures of the advanced OECD countries. It is pragmatic for the advanced OECD countries, especially Switzerland and the USA, to utilise the rate of interest policy because their money demand functions are found to be temporally unstable.

# CHAPTER 1: INTRODUCTION

## 1.1 Introduction to the Study

A stable demand for money function is a necessary condition for the supply of money to be used as an instrument of monetary policy (Goldfeld, 1994; Serletis, 2001). Due to widespread financial deregulation and reforms since the early 1980s, it has become widely recognized that the condition for a stable demand for money relation has broken down (Orden and Fisher, 1993). Consequently, many economists have seriously questioned the reliability of the supply of money as a reliable indicator of economic activity and a useful tool in conducting monetary policy, for instance since October 1982, the Federal Reserve has de-emphasized *M1* as a guide to policy and since 1987 even refused to set a target range for *M1* (Monetary Policy Report to Congress, 1987). The same policy stance was adopted by a number of advanced OECD and developing countries. The fact that the advanced OECD countries are industrialised economies and have sophisticated financial system, this renders no doubt that their money demand functions have become unstable. However, imitating the advanced OECD countries, most developing countries have also de-emphasised the supply of money as a policy tool. I define developing countries as non-industrialised economies that are seeking to develop their resources through industrialisation and that these countries generally lack sophisticated financial markets. Since the stability of money demand dictates the choice of monetary policy instruments, it is therefore vital to re-examine the stability of the money demand function for both advanced OECD and developing countries.

Poole (1970) detailed the optimal choice of monetary policy instruments within a standard *IS-LM* (investment and saving/ liquidity and money) model. He assumed that the monetary authority can control one of the two instruments of monetary policy with precision i.e. money supply or the rate of interest. If the aim is to minimize the squared deviation of real output from its target value, Poole showed that the choice of the optimal instrument depends on the variance of the error term in the *LM* function, the covariance of the two error terms, and the size of the parameters. Explicitly, he argued that the rate of interest (supply of money) should be targeted if the demand for money function is unstable (stable). To this end, it is interesting to examine whether the use of the rate of interest as a monetary policy instrument by developing countries can be justified. This research investigates the validity of Poole's conjectures and makes policy recommendations in light of the findings.

'Does money matter?' is the central issue of the ground breaking works in monetary economics by Keynes (1936) and Friedman (1956). Keynes (1936) postulated that the demand for money depends negatively on the rate of interest. He criticised the quantity theorists for their assumption of a constant velocity and argued that velocity is affected by behavioral economic variables. Keynes extended the Cambridge theory of money demand by analysing not only the effects of changes in income on money demand, but also the effect of changes in interest rates and expectations of future changes in the interest rate on money demand. He argued that liquidity preference is based on three motives for holding money: transactions, precautionary and speculative. Keynes did not regard the demand for money arising from the transactions and precautionary motives as technically fixed in their relationships with the level of income, see Laidler (1969, p. 52). The primary result of the Keynesian speculative theory is that there is a negative relationship between demand for money and the interest rate.

Keynes argued that when the rate of interest is expected to fall, the demand for money is relatively low, since people hold bonds in anticipation of capital gains. However, when the rate of interest is expected to rise, the demand for money is greater as people seek to avoid making capital losses on holding bonds (Laidler, 1969, p. 53). To this end, he regarded the current level of the interest rate as an indicator of interest rate changes or expectations. This implies that the speculative demand for money, which is the leading component in the Keynesian demand for money, depends on the nominal interest rate and people's expectation of future rates.

Monetarist Milton Friedman opposed the Keynesian view that money does not matter. Friedman (1956) presented the quantity theory as a theory of demand for money. Friedman assumed that money is abstract purchasing power, meaning that people hold it with the intention of using it for upcoming purchases of goods and services, integrated as asset and transactions theories of the demand for money within the context of neoclassical microeconomic theory of consumer and producer behaviour (Serletis, 2001, p. 62). To households, money is one kind of asset, one way of holding wealth. To firms, money is a capital good that combined with other sources of productive services yields products that firms sell. Friedman interprets the theory of demand for money as a special topic in the theory of capital; see Serletis (2001) for further discussion.

According to Friedman, the Keynesian distinction between ‘active balances’ and ‘idle balances’ and ‘transaction balances’ and ‘speculative balances’ are irrelevant (Laidler 1969, p. 59). It is important to recognise that each unit of money renders a variety of services that the household or firm equates at the margin. Friedman argued that money matters a great deal for nominal income and prices in the long run and has an important effect on fluctuations in nominal and real income in the short run. Money does not matter, however, over the long run for real magnitudes. The real wealth of a society depends on its institutional structure, the abilities, initiatives, driving force of its people, on investment potentialities, and on technology. The value of output is usually measured in monetary terms (Friedman, 1956).

Whether money demand is stable is an empirical question that provides important insights for theory and policy making. Over the past several decades, a large number of empirical studies on money demand have attempted to answer this question.[1] Majority of the studies is based on advanced OECD countries but studies related to the developing countries have increased enormously over the last two decades. A significant number of studies show that the demand for money has become unstable due to financial reforms and therefore support the use of rate of interest by the central banks , for instance see McPhail (1991), Haug (1999), Caporale and Gil-Alana (2005) and Maki and Kitasaka (2006). Alternatively, several studies favour

[1] Demand for money is a widely researched topic in macroeconomics. A Google search with the string ‘demand for money developed and developing countries’gave about 3,890,000 results. For more useful insights on the demand for money, it is feasible to split the sample into advanced OECD and developing countries.

the use of monetary aggregates because they find limited evidence of instability in the money demand functions (Bahmani-Oskooee and Rehman, 2005; Hussain and Liew, 2006; Das and Mandal, 2000; Rao and Kumar, 2009a). The contrasting findings in these and many other earlier empirical studies has motivated the re-examination of the effects of financial reforms on the demand for money in developing and advanced OECD countries using modern time series and panel data techniques and updated data.

Until the 1980s, most of the research on demand for money used the Partial Adjustment Models (PAM) in which the money demand is expressed as a function of real output and a vector of opportunity cost variables.[2] While PAM is a simple approach to apply and test theories, it is however unable to explain the dynamic adjustments in the model. A considerable number of the earlier studies also ignored the time series properties of the variables in their estimations and as a result their findings cannot be relied upon. Since the 1990s, a huge number of studies have used error correction models to estimate the money demand for both advanced OECD and developing countries, for example Hafer and Kutan (1994), Baba et al. (1992) and Nielson (2004), among others. This type of approach offers dynamic error correction representation in which the long run equilibrium relationship is embedded in an equation that captures the short run dynamics as well. These methods are fairly standard, however it would be useful to compare the findings using the recently developed empirical tests which are based on structural changes, panel cointegration and panel Granger causality; this is performed in Chapter 4 of this thesis.

In the empirical time series literature much of the controversy is on the relative merits of alternative estimation techniques. There are a number of estimation techniques and it is difficult to argue that a particular method is the best. While some prefer the system-based method of Johansen (JML), others are more comfortable with the simpler single-equation methods like the autoregressive distributed lag model (ARDL), London School of Economics Hendry's General to Specific (GETS), Engle and Granger's two step method (EG), Stock-Watson's dynamic ordinary least

[2] For examples, see Sriram (2001).

squares (DOLS) and the Phillip-Hansen's fully modified ordinary least squares (FMOLS) approaches. Application of the latest empirical tests that utilise panel data (Pedroni, 2004; Mark and Sul, 2003; Breitung, 2005; Westerlund, 2007) and structural changes (Gregory and Hansen, 1996a & b; Zivot and Andrews, 1992; Lee and Strazicich, 2003; Bai and Perron, 2003; Westerlund, 2006) are limited in the money demand literature. Emphasising the superiority of these methods is not helpful, but it is important to explain when and how these methods could be utilised. This study will attempt to fill these gaps. The next section of this chapter details the objectives of this study.

## 1.2 Objectives

Empirical studies on the demand for money are numerous and therefore it is vital to provide justification for yet another applied study on this relationship. There are three reasons for this. First, this thesis presents estimates of standard specifications of the demand for narrow money (*M1*) using recent developments in econometric techniques. Second, it offers useful methodological guidelines to estimate other equilibrium long run relationships. To this end, I developed flowcharts which illustrate the relevance and step-by-step processes of different unit root and cointegration methods. Third, I tested for the stability of *M1* demand and the empirical findings provide useful insights on the conduct of monetary policy in the advanced OECD and developing countries. This thesis therefore offers guidance and updated estimates which at times corroborates and other times challenges the contemporary literature. Below I shall discuss in some detail these three objectives of the thesis:

*1. Presentation of estimates for the standard specifications of the demand for narrow money using recently developed time series and panel data estimation techniques.*

Utilising the latest time series and panel data estimation techniques and updated data, this thesis estimates the canonical and extended specifications of the demand for *M1* for selected advanced OECD and developing countries.[3] A number of the earlier studies did not test for the integrated properties of the variables and those who did mostly employed the conventional tests for unit roots.[4] Perron (1989) criticized the traditional tests for unit roots for not addressing the structural changes in the unit roots. To this end, he argued that the unit root null can be equivocally accepted or rejected if there are breaks in the data series. To fill this gap, I have tested for the integrated properties of the variables using both conventional (Augmented Dickey Fuller (ADF); Phillips-Perron (PP); Kwiatkowski-Phillips-Schmidt-Shin (KPSS)) and structural break (Zivot-Andrews (ZA), 1992; Lee and Strazicich (LS), 2003 and 2004; Bai and Perron (BP), 1998 and 2003) unit root tests.

The existing studies on the demand for money have utilised mainly the cointegration estimation methods such as the EG, ARDL, GETS, FMOLS, JML and DOLS.[5] These methods estimate the long run and short run cointegrating equations in the context of the error correction models, however there is an important feature which these methods do not include i.e. structural changes. Indeed Rao (2007b) postulated that developments in the structural break tests have raised uncertainty on the earlier findings that used standard estimation methods. Given that some major financial reforms were implemented in advanced OECD and developing countries, it is likely that structural changes might have distorted the equilibrium long run relationship of the demand for money. In this study, I investigate this aspect of the demand for money through the application of the Gregory and Hansen (1996a & b) and Westerlund (2006) tests. The stability of *M1* demand is also analysed with the CUSUM (Cumulative Sum) and CUSUMSQ (CUSUM of Squares) of recursive residuals tests.

In the empirical literature there are a number of studies that have attained unexpected or implausible income elasticities, for example, Owoye and Onafowora (2007)

[3] This study consists of 53 countries i.e. 5 Pacific Island countries (1970-2009 period), 18 Asian countries (1965-2009 period), 10 African countries (1970-2009 period), 10 Latin American countries (1970-2009 period) and 10 advanced OECD countries (1960-2009 period).
[4] For example, see Diz (1970) for Argentina, Hossain (2006) for Bangladesh, Arize et al. (1990) for African countries and Brissimis and Leventakis (1981), Panayiotopoulos (1984) and Prodromidis (1984) for Greece.
[5] For studies that were undertaken during the 1980s and 1990s, see Sriram (1999 & 2001).

attained a value of 2 while Anoruo (2002) obtained a value of 5 for Nigeria, Wesso (2002) found an income elasticity of 1.8 for South Africa, Siddiki (2000) obtained a value of 3 for Bangladesh, and Siklos (1995a & b) found income elasticities varying between 2 to 6 for New Zealand. While it is plausible that the broader monetary aggregates would yield an income elasticity of money demand slightly higher than the narrower aggregates, income elasticity estimates of this magnitude are difficult to interpret. These studies and many others in the literature should have acknowledged that they attained implausible elasticities possibly due to omitted variable bias, inconsistent data, or the econometric issues that might have affected the results. This study attempts to fill this gap in the following two ways. First, the country-specific income elasticities of the canonical and extended specifications are estimated and compared across the five time series techniques viz. ARDL, GETS, EG, FMOLS and JML. Rao (2007b) suggested that for the sake of robustness, crucial parameters should be estimated across a number of estimation techniques. Second, I performed the Leamer's (1983 & 1985) extreme bounds analysis to investigate the robust determinants of the demand for money.

It is logical to expect that income elasticity in advanced OECD countries to be much lower than unity (see Ball, 2001; Baba et al., 1992), which is consistent with the Baumol-Tobin (1952) model. In advanced OECD countries, following the financial reforms and liberalisation policies of the mid 1980s, it is expected that the income elasticity may have declined, which implies that there are increased economies of scale in the demand for money. In other words, lower income elasticity is plausible for advanced countries because they have better financial systems which lowers the cost of transactions and reduces the use of liquid assets such as *M1*.[6] However, for developing countries the income elasticity of money demand is expected to be much higher at around unity or slightly above unity (Sriram, 1999); this is more in line with the quantity theory of money (Friedman, 1956). The underdeveloped financial markets in many developing countries generally lack the features like diversified financial sectors and financial market policy instruments, payments technologies, and high standards of living. Such income elasticity would imply underdeveloped

[6] See Kumar et al. (2011) and Mark and Sul (2003) for more details on income elasticities of *M1* demand in advanced OECD countries.

financial markets where most transactions involve the use of narrow money as opposed to other forms of monetary aggregates.

This study also attempts to address and fill two other gaps in the literature. First, only a relatively small number of studies have estimated the money demand functions using a panel data estimation method.[7] In particular, the application of the error correction based panel methods (for example, Westerlund, 2007) has been rarely applied in the literature.[8] Generally, panel data methods provide estimates related to two important models viz. fixed and random effects. In the context of money demand, panel data sets may cover different countries over long time periods and would be useful in assessing and comparing long run elasticities, like the income elasticity. To help address the relative paucity of existing panel data estimates in this study I have employed the panel data methods of Pedroni (2004), Mark and Sul (2003), Breitung (2005) and Westerlund (2007) to estimate the *M1* demand functions. Note that the latter technique is an error correction based panel method. Second, to examine the causal relationship between supply of money, inflation and output, I have employed Hurlin (2004) and Hurlin and Venet's (2001) panel Granger causality tests. This provides useful insights on how the three variables viz. inflation, money and output are inter-related. To the best of my knowledge, there are no published studies that have examined the causality relationship between these variables using a panel data method. Moreover, there are a few studies in the literature that has used the country-specific time series data and Granger causality tests.[9]

*2. Provision of methodological guidelines to estimate other equilibrium long run relationships*

Given the plethora of techniques available, many applied economists face the difficulty of selecting an appropriate estimation method to estimate long run and

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[7] For a survey of panel data studies on money demand, see Dreger et al. (2007) and Kumar et al. (2011).
[8] To the best of my knowledge, Rao and Kumar (2011) is the only study that has utilised a panel error correction method to estimate the money demand functions.
[9] For example, see Choudhry (1995a), Bruggemann and Nautz (1997) and Baunto et al. (2011).

short run equilibrium relationships. It is not new that methodological debates exists on the relative merits of the time series and panel data estimation techniques to test theoretical relationships. It is difficult to evaluate their relative merits because empirical verifications seldom consistently favour one particular method. Often applied economists argue that multivariate cointegration tests are relatively better than the single-equation estimation methods. However, many researchers use a technique that is simple and easy. Prior to applying any empirical test it is vital to draw a distinction between the three stages of research programme, as suggested by Smith (2000), see also Rao (2007b):

i. Purpose (objective)
ii. Summary of facts and
iii. Interpretation of facts

According to Smith (2000), statistical techniques are regarded as tools that provide summaries of the observed facts. He noted that in the empirical works relatively less attention is paid to the first and third stages, i.e. purpose and interpretation which relates to the preferred economic theory. Rao (2007b) suggested that in evaluating the relative merits of the alternative estimation methods, it is vital to ask how good a particular method is for summarizing the observed facts. Based on my empirical results, I argue that if time series techniques are applied appropriately, it is unlikely they will give varying summaries, at least qualitatively, with the same set of observed facts. In other words, robust estimates could be achieved if the method is applied appropriately and data is reliable.

Since there are a number of unit root tests that could be used to ascertain the time series properties of the variables, it is important to ask: when and how these tests could be used. According to Engle and Granger (1987), it is vital to determine the non-stationarity properties of the variables to avoid spurious regression problems. Perron (1997) showed the importance of testing for structural breaks in the unit roots. As noted earlier, a number of empirical studies did not test for the unit roots and those who did mostly utilised the traditional tests. In some cases, it is observed that the conventional unit root tests may provide conflicting summaries, for example

KPSS or Elliot-Rothernberg-Stock (ERS) tests may yield different results than the ADF. Similarly, some differences may exist in the results of conventional and structural break unit root tests. To this end, clearer guidance would be useful to researchers working with non-stationarity data and tests.

There are a variety of estimation methods and it is difficult to decide which method to apply. According to Engle and Granger (1987), when the variables are I(1) then the two step procedure of EG could be utilised. The same applies for JML, FMOLS and DOLS techniques. However, generally cointegration methods like GETS and ARDL do not require pre-testing of the variables. Put simply, these methods could be used irrespective of whether the variables are I(1) or I(0). Most studies in the literature have employed the JML technique because it is treated as one of the efficient methods of estimation. However, for the sake of robustness, it may be worthwhile to employ a range of different estimation techniques.[10]

Application of the structural break tests is popular in empirical works, however in the money demand literature, only a few studies utilised the structural break tests.[11] A number of studies have employed the Bai and Perron (2003) method to test for breaks in the cointegrating vector. To estimate breaks within a time series cointegrating framework, Rao and Kumar (2009a) suggest the application of Gregory and Hansen (1996a & b) break tests. According to Rao and Kumar (2009a), the Bai and Perron (2003) method provides tests for breaks in the unit roots. To this end, it is vital to identify the distinctive features of these alternative structural break tests.

In this study, I developed flowcharts which illustrate different unit root and cointegration methods and when it is appropriate to apply them. This could serve as a useful guide to applied economists working with non-stationary time series and panel data. I show that alternative estimation methods give robust results if they are applied appropriately and data is reliable. Given this guidance, economists focused

[10] The sensitivity analysis in this study is performed through the application of Leamer's (1983 & 1985) extreme bounds tests.

[11] For a survey, see Rao and Kumar (2009a) and Kumar and Webber (2011).

on issues related to the demand for money could refocus their efforts on the first and third stages of research.

*3. Testing the stability of M1 demand for selected advanced OECD and developing countries*

The level and stability of the demand for money are crucial criteria for selecting the appropriate monetary policy instrument (Goldfeld, 1994; Serletis, 2001). According to Poole (1970), selecting the wrong instrument will cause further instability in a country's output. Evidence suggests that the switch from a reliance on the money supply to the interest rate as the primary monetary policy instrument has taken place in advanced OECD countries largely because of an instability in money demand functions (McPhail, 1991; Haug, 1999; Caporale and Gil-Alana, 2005; Maki and Kitasaka, 2006). Following this change many developing countries have also moved towards using interest rates without significant evidence that their money demand functions have become unstable, for example Fiji (since 1997), Indonesia (since 2005), Thailand (since 1997), the Philippines (since 2002), South Africa (since 2000) and Brazil (since 1999).

Controversy remains in the literature with respect to the stability of money demand functions for advanced OECD and developing countries. In the context of developing countries, a number of studies have found unstable money demand functions and therefore seem to support the use of the rate of interest policy, for example see, Narayan and Narayan (2008) and Katafono (2001) for Fiji, Narayan (2007) for Indonesia and Wesso (2002) for South Africa.  On the other hand, a number of studies support the supply of money as an instrument of monetary policy because they found that money demand functions are largely stable, for example, see Bahmani-Oskooee and Rehman (2005) and Yu and Gan (2009) for Asian countries, James (2005) for Indonesia, Teriba (2006) for Nigeria and Rao and Singh (2005c) for India. If the central banks of developing countries switch to the rate of interest instrument then there should be sufficient evidence of instability in their money demand functions.  However, when the demand for money function is stable, it would be imprudent for the central bank to control inflation with the rate of interest policy.

Findings in my earlier work (Kumar et al., 2011a; Kumar, 2011; Singh and Kumar, 2011; Singh and Kumar, 2010; Kumar, 2010a; Rao and Kumar, 2009a; Rao and Kumar, 2009b; Kumar and Manoka, 2008; Rao and Kumar, 2007; Kumar, 2007) challenges the use of the rate of interest policy by the central banks of developing countries. Explicitly, these studies showed that money demand functions are largely stable in developing countries over the time period 1970-2007 and continued use of the money supply as the monetary policy instrument by the respective central banks is feasible.

In this study I re-evaluate the stability aspects of *M1* demand (canonical and extended specifications) using the CUSUM and CUSUMSQ tests. The structural break tests of Gregory and Hansen (1996a & b) and Westerlund (2006) will also be applied to analyse the *M1* demand stability. This allows me to provide policy recommendations in the light of Poole's (1970) conjectures. Testing the stability of *M1* demand also provides the opportunity to re-investigate whether the income elasticity of money demand is unity as found in many earlier studies. Further, the re-examination of *M1* demand stability is necessary due to recent turmoil in financial markets and methodological developments in unit roots and cointegration. This is timely as many central banks are now setting quantitative targets to help stimulate their economies out of the current worldwide depression. Structure of this study is discussed in the following section.

### 1.3 Structure of the Study

There are five chapters in this thesis: the current chapter provides the introduction, background and motivation for the thesis. Chapter 2 provides a critical review of the literature, Chapter 3 details the methods used in this study, Chapter 4 provides the empirical results and discussion, and finally, Chapter 5 summarises the findings and draws relevant conclusions. The purpose and content of each chapter is discussed in detail below.

*Chapter 1*

Chapter one introduced the research and outlined the relative importance of enhancing our understanding of the demand for money. There were three sub-sections in this chapter. First, I briefly described the main theories of the demand for money, empirical approaches to the topic and how this study fills some major gaps in the literature. Second, I detailed the three objectives of the study i.e. present estimates of the standard specifications of the demand for *M1* using recently developed time series and panel data estimation techniques; provide methodological guidelines to estimate other equilibrium long run relationships; and test the stability of *M1* demand for selected advanced OECD and developing countries. The final section details the structure of this study.

*Chapter 2*

Chapter two provides a review of the theoretical and empirical literature on the demand for money. First, following a brief introduction, the theoretical literature on the demand for money is reviewed. This includes the classical quantity theory in which the main approaches are the Cambridge and Fisher's equation of exchange. This part also includes the Keynesian and Monetarist debates on the importance of money. These mainstream theories of the demand for money have played a crucial role in explaining the money demand behaviour, but the recent developments in the literature attempts to fill some existing gaps. The recent developments in the literature are also reviewed.

Second, I reviewed the empirical literature on the demand for money. Empirical studies on the demand for money are many and I reviewed these studies by employing two approaches viz. traditional and meta-regression. The traditional review of the empirical literature is divided into several sections: empirical approaches to the topic, time series studies from advanced countries, structural changes and money demand in advanced countries, time series studies from developing countries, structural changes and money demand in developing countries, panel data studies on money demand, and money demand, currency substitution and capital mobility. To investigate the sources of variation in the results of individual money demand studies, I performed the meta-regression analysis. Lastly, a brief conclusion is provided to summarise the chapter.

Kumar (2011) examined earlier studies on money demand in developing countries and noted that the majority of these studies are subject to various limitations. In most cases, the income elasticity of money demand is either over- or under-estimated, and as a result the stability tests are unreliable. This chapter builds on Kumar (2011). This chapter has summarised the major theoretical developments in the literature and the features of previous empirical studies, particularly, the long run elasticities and stability of the demand for money. The information presented in this literature survey would allow researchers to compare their own results and methods with what were undertaken previously in a wide range of countries.

*Chapter 3*

Chapter three describes the methods used in this study. Following a brief introduction, an overview of the unit roots and cointegration tests is provided. Here I developed flowcharts which illustrate when and how different unit root and cointegration tests could be used in applied works. The next part discusses the time series and panel data unit root tests that are employed in this study. These tests are ADF, PP, KPSS, ZA, LS, BP, Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS), Maddala-Wu (MW), Breitung (2000), and Hadri (2000). The time series and panel data estimation methods are discussed in the next two parts. The time series methods used in this study are GETS, EG, FMOLS, JML and ARDL. Panel data cointegration methods are also popular in empirical works and I employed four techniques viz. Pedroni, Mark and Sul's DOLS, Breitung and Westerlund's panel ECM. The next part briefly details Hurlin (2004) and Hurlin and Venet's (2001) panel Granger causality tests. The existence of cointegration implies Granger causality among the variables and therefore to test for causality I employed the Hurlin (2004) and Hurlin and Venet's (2001) panel Granger causality tests. The last two part details the structural change tests (Gregory and Hansen, 1996a & b;

Westerlund, 2006) and extreme bounds analysis (Leamer, 1983 & 1985), respectively. Finally, a brief conclusion is given to summarise the chapter.

The alternative time series techniques are detailed in Singh and Kumar (2011) where it is demonstrated that if these techniques are implemented properly, then they do provide robust results. The flowcharts I developed in this chapter illustrate the relevance of these methods. The structural break tests of Bai and Perron (2003) and Gregory and Hansen (1996a & b) are frequently employed to investigate the break dates in the data. However, Rao and Kumar (2009a, 2009b, 2007) criticised Bai and Perron tests because their approach does not estimate cointegrating equations with the breaks. Instead Rao and Kumar proposed the use of Gregory and Hansen (1996a & b) tests to address this deficiency. In the empirical literature, there are limited works that have tested for structural breaks in the panel data. Therefore, this research introduces and applies Westerlund (2006) structural break techniques in the context of money demand.

*Chapter 4*

Chapter four is perhaps the most significant component of the thesis because it will provide new empirical results and will discuss various policy implications. A brief introduction is given to highlight the objectives of this chapter. Specification and data description is provided in the first part. The second part is fairly comprehensive in which I utilised a number of empirical tests to derive the results. First, I tested for the integrated properties of the variables using conventional (ADF, PP and KPSS) and structural break (ZA, LS and BP) unit root tests. Second, the country-specific time series results are detailed. The tests for cointegration among the variables is performed using the JML method and the cointegrating equations of *M1* demand are estimated through the application of five time series methods viz. ARDL, GETS, EG, FMOLS and JML. For countries where the JML method failed to yield plausible results, I applied the Gregory and Hansen tests. Third, I discuss the panel data results. Here I tested for unit root tests in the panel data and then employed the Pedroni and Westerlund techniques to test for cointegration. Three panel data methods (Pedroni, 2004; Breitung, 2005; Mark and Sul, 2003) are used to estimate the cointegrating equations for *M1* demand. The structural breaks in the panel data is tested with the Westerlund (2006) method. Fourth, I conduct the panel Granger causality (Hurlin, 2004; Hurlin and Venet, 2001) and extreme bounds (Leamer, 1983 & 1985) tests. The last part tests for stability in the *M1* demand functions and provides discussion on financial reforms and monetary policy. The stability of *M1* demand is analysed with the CUSUM and CUSUMSQ of recursive residuals tests. A brief conclusion is given to sum-up the chapter.

The major argument proposed in Kumar et al. (2011), Singh and Kumar (2011 & 2010), Kumar (2011 & 2007), Rao and Kumar (2009a, 2009b, 2007) and Kumar and Manoka (2008) is that money demand functions are relatively stable in developing countries when compared to industrial countries. Evidence in this study implies that the switch from the money supply to the interest rate as the primary monetary policy instrument in developing countries is unreasonable. The recent structural reforms and/or global financial instability are yet to have an impact on the demand for money in the developing countries. For example, many East Asian countries liberalized their financial markets in the early 1980s. Many of these economies also suffered major problems during the 1997-1998 financial crisis. If the central banks of developing countries choose to use the rate of interest policy then this will cause further instability in their output, see Poole (1970). To this end, these central banks should consider altering the money supply as a policy choice. Monetary policy in these economies had only a small role in reducing the ill-effects of the crises (Rao and Kumar, 2009b). Perhaps these economies should re-consider their strategies through which financial reforms are implemented.

*Chapter 5*

The final part of the thesis details conclusions derived from this research. These include the useful insights from the literature, key contributions of the research, and main findings and discussion. It also discusses the potential limitations of the study and identifies future research avenues related to this topic.

The next chapter provides a review of the theoretical and empirical literature on the demand for money. The chapter attempts to identify what economists have learned, which issues have been resolved and which issues remain to be addressed on the demand for money. Meta-regression analysis is performed to examine the sources of variation in the results of individual money demand studies.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

The demand for money relationship is one of the fundamental behavioral relationships in macroeconomics. The stability of the money demand function has useful implications on the conduct of monetary policy. To this end, Poole (1970) argued that to diminish fluctuations in the level of economic activity, money supply (rate of interest) should be used as an instrument of monetary policy when the *LM* relation is stable (unstable). Since instability in the demand for money is a major factor contributing to instability in the *LM*, therefore it is important to test for the stability of the money demand function. Using an incorrect instrument will cause more instability in the country's output (Poole, 1970, p. 202). Therefore, this thesis re-examines the stability of money demand for selected advanced OECD and developing countries.

Also known as liquidity preference, demand for money theory deals with the desire to hold money rather than other forms of wealth (for example, stocks and shares). Keynes (1936) extended the Cambridge theory of money demand by analysing not only the effects of changes in income on money demand, but the effect of changes in the interest rates and expectations of future changes in the interest rate on money demand. He regarded the quantity theory equation in its Cambridge cash balance version to be valid as an identity but useless for policy or for predicting short run fluctuations in income, see Laidler (1969) and Serletis (2001).

Keynes liquidity preference theory is based on three motives for holding money viz. transactions, precautionary and speculative motives. He did not regard the demand for money arising from transactions and precautionary motives as technically fixed in its relationship to the level of income (Laidler, 1969, p. 52). The most important innovation in Keynes' analysis of the demand for money is his speculative proposition. The primary result of the Keynesian speculative theory is that there is a negative relationship between demand for money and the rate of interest (Serletis, 2011, p. 60).

Monetarist Milton Friedman opposed the Keynesian perspective that money does not matter. Friedman (1956) presented the quantity theory as a theory of demand for money. Friedman assumed that money is abstract purchasing power, meaning that agents hold it with the purpose of using it for upcoming purchases of goods and services, integrated as asset and transactions theories of the demand for money within the context of neoclassical microeconomic theory of consumer and producer behaviour (Serletis, 2001, p. 62). Friedman interprets the theory of demand for money as a special topic in the theory of capital.

Further, Friedman treated the money demand function as highly stable. This implies that the quantity of money demand can be forecasted precisely by the money demand function. His view that the demand for money is insensitive to interest rates, this means that the velocity of money is highly predictable. It is therefore said that a permanent change in income changes permanent income by the same amount, whereas a temporary change in income changes permanent income by a small amount (Serletis, 2001, p. 64). Friedman's theory of demand for money is a reformulation of the quantity theory of money, because it leads to the quantity theory conclusion that money is the primary determinant of aggregate nominal spending.

Over the past twenty-five years the world has experienced substantial financial market deregulation, a major abolition of capital controls and information and communication technological advances that gave a boost to international financial transactions. The policy of monetary targeting requires that the target variables can be controlled by the monetary authorities and most importantly, it requires a stable money demand function. While the seminal works of Keynes (1936) and Friedman (1954) have highlighted on the importance of money demand, recent developments in the literature have explored the monetary policy operating procedures. This thesis investigates the relevance of the demand for money given the interest rate based operating procedures. A significant number of studies show that the demand for money has become unstable due to the financial reforms, which therefore supports the use of rate of interest policy by the central banks (for instance, see Haug 1999; Caporale and Gil-Alana 2005; Maki and Kitasaka 2006). In contrast, several studies favour the use of monetary aggregates as a policy tool because they found limited evidence of instability in the money demand functions (for instance, see Bahmani-Oskooee and Rehman 2005; Das and Mandal 2000; Rao and Kumar, 2009a & b). The contrasting findings in these and many other earlier empirical studies have motivated a re-examination of the effects of financial reforms on the demand for money in advanced OECD and developing countries. Meta-regression analysis shows that there are variations in the estimates of the demand for money arising from financial reforms, among others. This thesis uses updated data and recently developed time series and panel data techniques to re-examine the demand for money relationship.

Previous surveys of the literature on money demand have focused on research from the 1970s and 1980s (Judd and Scadding, 1982; Barnett et al., 1992; Laidler, 1993; Thompson, 1993), with the exception of Sriram (2001), who primarily summarised the elasticity estimates obtained in different countries. Recently, Duca and VanHoose (2004) provided a comprehensive survey of theoretical and empirical money demand literature. This chapter presents an extensive survey of the research related to the demand for money and specifically aims to identify what economists have learned, which issues have been resolved and which issues remain to be addressed. It differs from others' attempts not only because it offers an updated list of the relevant works, but also it investigates the sources of variation in the estimates of the demand for money through the application of meta-regression analysis. This chapter summarises the major theoretical developments in the literature and the features of previous empirical studies, especially the long run elasticities and stability of the demand for money.

The rest of the chapter is organised as follows. Section 2.2 details the theoretical approaches to the demand for money. Section 2.3 provides an overview of the empirical studies on money demand in advanced OECD and developing countries. Section 2.4 details the results from meta-regression analysis, and finally, Section 2.5 concludes.

## 2.2 Theoretical Approaches to the Demand for Money

### *2.2.1 Classical Approaches*

The well known classical quantity theory brings forth a direct and proportional relationship between the quantity of money and the price level. Serletis (2001) has reviewed the two versions of the classical quantity theory i.e. Irving Fisher's equation of exchange and the Cambridge approach. Both the versions present transactions demand for money in which money is treated as a medium of exchange. Fisher (1911) introduced the transactions version of the equation of exchange as follows:

$$M^{s}V = PT \qquad (2.1)$$

where $M^s$ is the actual money supply, $V$ is the velocity of circulation, $P$ is the price level and $T$ is the volume of transactions. On the other hand, the income version of the equation of exchange is as follows:

$$M^{s}V = PY \qquad (2.2)$$

where $Y$ is the real output. The income version includes income velocity and assumes that real income and volume of transactions are proportionately related; see Serletis (2001, p. 56). Fisher assumed that within the monetary sector the price level is the only endogenous variable and real income and money supply are exogenously determined. To this end, the velocity has a constant equilibrium value. The equation of exchange can be transformed into a version of the quantity theory of money as:

$$\overline{M}^{s}\overline{V} = P\overline{Y} \qquad (2.3)$$

The above equation states the conditions under which nominal income is determined exclusively by movements in the quantity of money. The quantity theory of money is treated as a theory of money demand when one assumes that the money market is in equilibrium. In such situations, the demand for money depends only on the real income. The rate of interest has no impact on the demand for money, see Fisher (1930).

Comparable to Fisher, the Cambridge approach assumed that real income is exogenous and demand for money is proportional to prices. The Cambridge equation is as follows:

$$M^d = kPY \tag{2.4}$$

where $M^d$ is the demand for money, $P$ is the price level, $Y$ is the real income and $k$ is the income elasticity parameter. The quantity theory implies that the price (real income) elasticity of the demand for nominal (real) money is unity. The Cambridge approach is primarily associated with the neoclassical economists Pigou (1917) and Marshall (1923). It is assumed that money supply is exogenous and money is willingly held so that money market equilibrium (money demand equals money supply) is maintained. The Cambridge cash balance equation also implies the quantity theory prediction that nominal income is determined by the quantity of money (Serletis, 2001, p. 59). Unlike the quantity theorists, the Cambridge economists allowed for the possibility of interest rate effects on the demand for money in the short run. This led Keynes to develop a theory of the demand for money that emphasized on the significance of interest rate and liquidity preference. The next section discusses the Keynesian and Monetarist debates on the demand for money.

### *2.2.2 The Keynesian and Monetarist Debate: 'Does Money Matter?'*

Keynes (1930 and 1936) and Friedman (1956) discussed the relevant importance of money in the economy. The Keynesian theory of liquidity preference assumes that money demand is a negative function of the interest rate. Keynes (1936) criticized the quantity theorists for their assumption of a constant velocity and argued that velocity is affected by behavioral economic variables like the nominal rate of interest (Serletis, 2001, p. 65). Keynes extended the Cambridge theory of money demand by analysing not only the effects of changes in income on money demand, but also the effect of changes in the interest rates and expectations of future changes in the interest rate on money demand. Money supply is assumed to be fixed by the central bank. In an *IS-LM* framework, a rise in income increases money demand, which requires a rise in the interest rate to restore equilibrium in the money market.

In the pure Keynesian case, *LM* is horizontal and interest is perfectly elastic because everyone expects that the rate of interest has reached its lowest rate and it will increase in the future. Since holding bonds (alternative asset to holding money) will result in enormous capital losses, wealth holders forego the return on bonds and hold cash instead. The effectiveness of monetary policy depends on where *IS* intersects *LM* in the Keynesian flat zone of *LM*. Keynes believed that any change in the supply of money in the main would be offset by a change in velocity. Thus, he regarded the quantity theory equation in its Cambridge cash balance version to be valid as an identity but useless for policy or for predicting short run fluctuations in income; see Keynes (1930 & 1936).

According to Keynes, liquidity preference is based on three motives of holding money. First, the transactions motive which implies that people hold cash balances to be able to make payments. Second, the precautionary motive where people hold cash balances for unexpected events or emergencies. Finally, the speculative motive considers the preferences for holding money relative to other forms of wealth, for example bonds. The Keynesian liquidity preference function is as follows:

$$\left(\frac{M}{P}\right) = \mathrm{f}\left(Y, r\right) \qquad (2.5)$$

Equation (2.5) serves to illustrate that the real money demand (*M/P*) is positively related to real income (*Y*) and negatively related to the nominal interest rate (*r*). An implication of the Keynesian liquidity preference theory is that velocity is not constant but positively related to the nominal interest rates. This also implies that the velocity is procyclical since procyclical interest rate movements induce procyclical velocity movements, see Serletis (2001, p. 62) for more details.

Keynes did not regard the demand for money arising from transactions and precautionary motives as technically fixed in its relationship to the level of income (Laidler, 1969, p. 52). The most crucial innovation in Keynes' analysis of the demand for money is his speculative demand for money which explicitly states that there is a negative relationship between money demand and the rate of interest. This result is derived by Keynes through analysing the choices between interest yielding bonds and money as an issue of liquidity preference. Along these lines, Keynes highlighted the importance of variables such as interest rates, expectations and uncertainty in the money demand analysis.

Keynes postulated that when the rate of interest is expected to fall, the demand for money is relatively low, since people hold bonds in anticipation of capital gains; when the rate of interest is expected to rise, the demand for money is greater as people seek to avoid making capital losses on holding bonds (Laidler, 1969, p. 53). Keynes considered the current level of interest rate as an indicator of interest rate changes or expectations. This implies that the demand for speculative money balances, which is the largest component in the demand for money, depends on the nominal interest rate and people's expectation of future rates.

Further, Keynes argued that people's decision to hold bonds or money is in terms of some 'normal value' based on the interest rates.[12] If interest rates exceed this normal value, people will expect them to fall and therefore the bond prices rise which will induce capital gains. In such cases, people would be more willing to hold their liquid wealth as bonds rather than money and to this end the demand for money would be low. In contrast, if interest rates do not exceed the normal value, people will expect them to rise, bond prices to fall and capital losses to be realized. As a result, people would be more willing to hold money than bonds and the demand for money would be high.

[12] See Serletis (2001, p. 61) for details.

Keynesian analysis is based on the proposition that at any time there is a normal rate of interest. Whether the normal rate of interest is constant overtime is something not regarded in Keynes' analysis. However, the speculative demand for money depends on the current level of interest rate relative to this normal level. According to Laidler (1969 & 1977), this implies that the relationship between money demand and the interest rate would be unstable overtime, therefore, effectiveness of monetary and fiscal policies are difficult to assess on the basis of a model that treats this relationship as a stable one. The main Keynesian view is that the demand for money should be treated not as some special matter but rather as a particular application of the general theory of demand.

The speculative demand for money becomes discontinuous of its current level for an individual with expectations about the future level of interest rate, see Laidler (1969, p. 54). Keynes argued that at some low level of interest rate everyone will expect the rate to rise and people would be unwilling to hold bonds and prefer holding money. Here the demand for money at aggregate level becomes perfectly elastic with respect to interest rates. The rate of interest will not change and any rise in quantity of money would leave interest rate unchanged. This is regarded as the liquidity trap, meaning that interest elasticity of money demand becomes infinity at low levels of the rate of interest. To this end, monetary policy becomes ineffective and thus fiscal policy is the only means of economic stabilization (Laidler, 1969, p. 55).

Monetarist Milton Friedman opposed the Keynesian view that money does not matter. Friedman (1956) presented the quantity theory as a theory of demand for money. Friedman assumed money is 'abstract purchasing power'. He took the view that people hold money with the intention of utilising it for upcoming purchases of goods and services, integrated as asset and transaction theories of the demand for money within the context of neoclassical microeconomic theory of consumer and producer behaviour (Serletis, 2001, p. 62). The importance of money to the households and firms are obvious, i.e. households treat money as an asset while firms regard money as a capital good that combined with other sources of productive services yields the products that firms sell. Friedman interprets the theory of demand for money as a special topic in the theory of capital.

The household demand for money depends on a number of factors, for instance, the budget restraint, expected price of money, expected return on money, various forms of wealth, inter-temporal rates of substitution, and tastes and preferences. Friedman distinguishes between real and nominal magnitudes and casts the demand for money by households as a demand for real balances - a function of real variables independent of nominal money values. The firm's demand for money may depend on three things i.e. cost of the productive services money yields, the cost of substitute productive services and the value of the product the productive service yields. Similar to households, a firm's demand for money is observed as a demand for real balances, responsive to rates of return on bonds (equities or other assets) and the inflation rate (refer to Laidler, 1969 & 1977 for comprehensive details). Friedman did not specify, as Keynes did, any motives for holding money. He viewed money as a durable good and each unit of money renders a variety of services that the household or firm equates at the margin. Friedman's money demand function (see Serletis, 2001, p. 62) can be expressed for an individual wealth holder as follows:

$$\left(\frac{M}{P}\right) = \mathrm{f}\left(Y_p, R_b - R_m, R_e - R_m, \Pi^e - R_m, \ldots\right) \qquad (2.6)$$

where $Y_p$ is real permanent income, $R_b$ is expected nominal rate of return on bonds, $R_e$ is expected nominal rate of return on equities, $R_m$ is expected nominal rate of return on money, and $\Pi^e$ is expected inflation rate. The dots (...) stand for other variables, for example, the ratio of human to non-human wealth which play no vital role in Friedman's theory and has no useful implications for monetary policy. The expected nominal rate of return on bonds (equities) includes expected capital gains and losses (expected changes in their prices). Further, the expected inflation rate is used as a proxy for expected nominal rate of return on physical assets.

Friedman argued that money is vital for nominal income and prices in the long run. In the short run, money might have important impacts on fluctuations in nominal and real income. Money does not matter, however, over the long run for real magnitudes.

Like Keynes, Friedman did not assume that the expected rate of return on money is constant. Through assuming that the money demand depends on the incentives for holding other assets relative to money, Friedman argued that the demand for money is insensitive to interest rates (Serletis, 2001, p. 64). Although money demand is sensitive to changes in the incentives for holding other assets relative to money, these incentives remain fairly stagnant when interest rates change, thus implying that the money demand is insensitive to interest rates.

Unlike Keynes, Friedman suggested that the money demand function is vastly stable. This implies that the quantity of money demanded can be predicted precisely by the money demand function. His proposition that money demand is insensitive to interest rates implies that money velocity is highly predictable. To this end, it is inferred that a permanent change in income changes permanent income by the same amount, whereas a temporary change in income induces a small change in permanent income (Serletis, 2001, p. 64). Friedman's theory of demand for money is a reformulation of the quantity theory of money, because it leads to the quantity theory conclusion that money is the key determinant of aggregate nominal spending.

In the early 1980s, the decline in the US income velocity raised doubts on the predictable link between money and nominal income, i.e. a stable demand for money; see Goodhart (1989). This period was also interpreted as the 'demise of monetarism', for example see McCallum (1989). Mascaro and Meltzer (1983) and Friedman (1984) argued that the observed velocity decline was mainly due to the increased volatility of money growth following the changes in the Federal Reserve policies. Friedman's volatility hypothesis suggests that increased volatility of money growth increases the degree of perceived uncertainty and therefore it raises (reduces) the demand for money (income velocity). Hence, following Friedman, the failure of US monetary policy in the early 1980s even strengthens, rather than weakens, the case for the monetarist proposition of a constant growth rule of money supply.

Thus, it is well known that the Monetarist and Keynesian theories of the demand for money play a very crucial role in the monetary economics literature, however, the recent developments in the literature attempts to fill some existing gaps and highlight some key features. The following section discusses some recent developments in the demand for money.

### *2.2.3 Recent Theoretical Developments in the Literature*

Is the demand for money irrelevant in the process of monetary policy procedures?[13] To provide important insights on this issue, I review some recent developments on the demand for money. In a classic study, Poole (1970) showed that under certainty-equivalent outcomes of optimal monetary policy, either the rate of interest or monetary aggregates is identical (see Duca and VanHoose, 2004, p. 249). He argued that the selection of the monetary policy instruments should depend on the stability of money demand. Instability in the money demand function could be an indication of an interest rate based policy. In my view, Pooles' analysis is important because it identifies the importance of understanding money demand for the design and formulation of optimal monetary policy. Friedman (1975) opposed the inferences made by Poole (1970) and instead argued that monetary aggregates has no direct role in the process of monetary policy. He asserted that monetary aggregates are observed to serve better as intermediate targets. Friedman also considered other macroeconomic variables as potential instruments for monetary policy, among others is the indicator indexes suggested by Brunner and Meltzer (1967).[14]

Subsequently, Goodfriend (1987) postulated that if central banks treat interest rate volatility as their prime objective, then expectations of induced future price level adjustments can result in price changes simultaneously, thereby generating inherent nonstationarities in the price level (Duca and VanHoose, 2004, p. 250). Goodfriend's interpretations seem to imply that monetary aggregates are useful for monetary policy in achieving inflation stability. Later, VanHoose (1989) criticised this

[13] This question was originally raised by Duca and VanHoose (2004, p. 249). They reviewed a number of recent studies to provide some useful insights on this issue. I shall not go into much detail on these new developments and would recommend the reader to Duca and VanHoose (2004) for a comprehensive survey.
[14] The indicator index proposed by Brunner and Meltzer (1967) is essentially a weighted average of a group of potential monetary variables. For more details, see Duca and VanHoose (2004).

interpretation. VanHoose (1989) pointed out that monetary aggregates are endogenous and results in emergence of non-stationarity price levels if money supply is targeted. To this end, economies that aim for inflation stability through the monetary aggregates will find it difficult to achieve their targets.

Barro (1989) extended Goodfriend's approach but found contrasting results. He found that interest rate policy may result in nominal changes in expected price levels and this implies that monetary policy is feasible via the interest rate instrument. The interest rate based policy is also supported by 'Taylor rule', proposed by Taylor (1999), where monetary policy is introduced into the dynamic and general equilibrium macro models. Sorensen and Whitta-Jacobsen (2005) distinguish between the standard and modified Taylor rules. In the standard Taylor rule, the current rate of interest plays a crucial role while the modified Taylor rule considers the lagged interest rates and rational expectations. Taylor rules are optimal when markets are forward looking. On the basis of Taylor rules, many central banks have opted monetary targeting and tend to engage in interest rate smoothing. The rationale for utilising the rate of interest policy is based on the belief that it enhances the ability of the central bank to stabilize changes in prices and to stimulate the economic activity. Rotemberg and Woodford (1999) analysed the Taylor rule, and they argued that in the case of the USA, Federal Reserve Bank can minimize consumer welfare loss by setting interest rates as a function of all past values of output gap, inflation gap and interest rate. However, there are practical problems with such models, for example see Minford et al. (2001). More recently, supporting the Taylor rule, Thornton (2004) argued that monetary policy can be accomplished successfully through an interest rate instrument, exclusive of monetary aggregates.

McCallum (1988) proposed the monetary base-nominal GDP targeting rule for monetary policy. This is so called the 'McCallum rule'. The policy instrument is the monetary base instead of the short-term rate of interest as suggested by Taylor rule. In this framework, the monetary-base growth rate changes in response to deviation of the nominal GDP growth rate from a desired target value that grows at a specified rate (see Razzak, 2001b, p. 1). The rule also permits for gradual changes in base velocity. Nominal GDP targeting and money base targeting are equivalent when changes in base velocity are not large. In another study, McCallum (2004) showed that interest rate changes will have significant effects on nominal aggregate demand and therefore enables central banks to control inflation in the economy. This reflects a perspective that under the interest rate based policy procedures implemented by most central banks, the equilibrium quantity of money is a residual and, hence, not a variable of interest to policy makers seeking to stabilize output and inflation (Duca and VanHoose, 2004, p. 248). Most central banks now de-emphasize on the quantity of money and instead focus on the short-term interest rates as a policy instrument. With this perspective, Walsh (2003, p. 4) argued that the demand for money analysis has become less relevant nowadays and may be appealing only at theoretical level. To this end, Duca and VanHoose (2004) provide some useful avenues of future research at theoretical level on this topic.

Svensson and Woodford (2003) and Aoki (2003) explored the possibility of utilising forward-looking indicators such as the output gap for monetary policy. Dotsey and Hornstein (2003) include monetary aggregates to the list of potential indicator variables (see Duca and VanHoose (2004, p. 251). They argued that the stability of money demand is a useful indicator of productivity shocks that are not directly observable to the central banks. Following Koenig (1990 & 1996), Meltzer (2001) analysed the effectiveness of monetary policy transmission mechanism under interest rate based policy. Meltzer claims that in interest rate models there is limited recognition of the relevance of real balance effects on aggregate expenditures. Meltzer argues that effects of real monetary base growth on consumption arise independently of expenditure inducing effects of changes in central banks' nominal interest rate instruments (for more details, see Duca and VanHoose, 2004, p. 251).

Utilising the optimization *IS-LM* model proposed by McCallum and Nelson (1999), Nelson (2002) found that real money base does influence the real output in the USA and UK. These effects are observed as independent to the interest rates. In another study, Nelson (2003) analysed the role of asset substitution and inferred that a change in monetary aggregates induces changes in long-term interest rates. To this end, he argued that the long-term interest rates should be included in the money demand functions. Reflecting on the arguments made by McCallum and Nelson

(2005), Svensson (2005) argued that there is no plausible reason to limit a study of monetary policy rules to ‘instrument rules’. He showed that simple ‘targeting rules’ may have more desirable properties for conduct of monetary policy.

The recently developed transactions theories of money demand are the Baumol-Tobin, shopping-time and cash-in-advance models.[15] Baumol (1952) and Tobin (1956) analyse the costs and benefits of holding money. The Baumol-Tobin model shows how the use of money in completely foreseen transactions implies economies of scale and induces interest rate elasticity significantly different from zero. It is noted that the Baumol-Tobin model does focus on the role of money as a medium of exchange in goods and services market. However, it does not pay attention to the holding of money in terms of the transactions facilitating services provided by money. Money demand models such as shopping-time and cash-in-advance focuses explicitly on transactions services.

Saving (1971) proposed the shopping-time model which focuses on the distinguishing features of money. It is argued that trade with money generates significant savings which is referred as ‘shopping-time’. Such savings are enviable because shopping time decreases leisure which in turn decreases utility (Serletis, 2001, p. 70). McCallum and Goodfriend (1989) presented a more formal model of shopping-time in which time allocation issues encountered by agents are explored. They showed that money allows an agent to reduce the time allocated for consumption purposes and hence permitting more time for work and leisure. The time allocations do seem to have significant impacts on agent’s utility and income. Feenstra (1986), Croushore (1993) and Choi and Oh (2003) discuss some limitations of the shopping-time models, see Duca and VanHoose (2004, p. 254) for details.

Clower’s (1967) cash-in-advance model explains the role of money by entailing that a transaction is feasible only when the money required for the transaction is held in advance. This model tends to question why rational economic agents hold money. For an application of this model, see Lucas and Stokey (1983). Duca and VanHoose

[15] Serletis (2001) contains detailed analysis of Baumol-Tobin, shopping-time and cash-in-advance models.

(2004) argued that most cash-in-advance models provide us limited guidance on how real life factors influences the demand for money. According to them, an exception is Ireland (1995), who analysed the significance of financial innovation in the cash-in-advance model. It is found that the dynamics of money demand naturally reflect financial innovations. Money demand theories that emphasize the role of money as a store of value are known as asset or portfolio theories, see Tobin (1958). These models emphasize that people hold money as part of their asset portfolio and predicts that demand for money depends on the return and risk offered by money and other assets that people can hold instead of money. Serletis (2001, p. 87) argued the portfolio models are theoretically interesting, but unrealistic since they ignore money's most obvious characteristic i.e. its ability to function as a medium of exchange. However, portfolio theories of money demand do yield useful implications on how the economy operates, see Laidler (1993).

Building on Samuelson's (1958) original study, Wallace (1977) used the overlapping-generations framework to explain the demand for money. Duca and VanHoose (2004, p. 253) and Serletis (2001, p. 82-86) provided some good details on the overlapping-generations approach. Kahn and Roberds (2001) utilised this framework to analyse the interbank payments periods with maturities shorter than a day. Nevertheless, this framework also provides useful insights on the design of monetary institutions; see Faust (1996). McCallum (1983) pointed out that there are issues associated with the overlapping-generations approach. In the context of money demand, it is limited in explaining the rationale for holding money even when other assets are risk free and offer generous returns.

Recently, Alvarez et al. (2003) developed a dynamic optimization model that is a substitute for cash-in-advance constraint. They showed the usefulness of dynamic optimization in the inventory approach of money demand. The model assumes that all agents can transfer cash from a brokerage account to a deposit account at regular intervals (Duca and VanHoose, 2004, p. 255); this is fairly consistent with Carlstrom and Fuerst (1995).

Thus, the inferences drawn from these studies appear to be reasonable under current circumstances, however, I argue that the stability of money demand is not a one-shot investigation but rather entails a continued assessment. To this end, a continued research on the empirical front is not irrelevant. It is important to ask: Are the effects of reforms still observable or have they worn out? If latter is the outcome then money demand stability may have been reverted and the present monetary policy procedures need to be adjusted accordingly. Since it is nearly three or four decades now from the time many countries had implemented some major financial reforms and the fact that not all countries continually liberalise their markets, it is likely that the effects of reforms may have worn out. Therefore, money demand stability requires a re-investigation using updated data. In the following sections, I review the empirical literature of the demand for money.

## 2.3 Empirical Literature of the Demand for Money

### *2.3.1 Empirical Approaches to the Topic*

While much of the theoretical literature on money demand has attempted to explain the theory of desired money holdings within broader frameworks, empirical work has focused on a number of specific issues. Since the 1980s, many researchers have focused on analysing the impact of financial reforms and liberalisation on the demand for money.[16] Recent studies that examined the effects of financial reforms on money demand are Swamy (1987), Dooley and Spinelli (1989), Orden and Fisher (1993), Haug and Lucas (1996), Cassard et al. (1997), Lutkepohl et al. (1999), Ericsson and Sharma (1998), Dekle and Pradhan (1999), Fujiki (1999), Asano (1999), Karfakis and Opoulos (2000), Nagayasu (2003), Nell (2003), Pradhan and Subaramanian (2003), Hafer and Kutan (2003), Choi and Oxley (2004), Bahmani-Oskooee and Rehman (2005), James (2005) and Rao and Kumar (2007), among others.[17]

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[16] As asserted by Gurley and Shaw (1960), Tobin (1965) and more recently, Bordo and Jonung (1987, 1990) and Arrau et al. (1995), the financial sector reforms and liberalisation are not likely to be captured in canonical specifications of the demand for money. Further, it appears that these reforms cannot be measured as an element of stationary error term since often these processes induce permanent shifts in the demand for money. Guidotti and Rodriguez (1992) provide a good discussion on monetary velocity and unstable economic structures.

[17] These studies are discussed in the later sections.

The money demand estimations based on cross-section data has made significant contributions to the literature, for instance, see Meltzer (1963), Lee (1964), Stroup and Fraser (1969), Karathanassis and Tzoannos (1977), Peterson (1974), Feige (1964; 1974), Mandell (1972), White (1976), Mulligan and Sala-i-Martin (1992; 2000), Duca and Whitesell (1995) and Fujiki and Mulligan (1996). Fujiki and Mulligan (1996) used Japanese prefecture data to estimate the parameters of demand for broad money (*M2*) for the period 1967-1993. Their cross-section estimates of the income elasticity are in the range of 1.2 to 1.4 and appear to be stable overtime.

Using US state cross-section data, Mulligan and Sala-i-Martin (1992) obtain income elasticities of money demand between 1.3 and 1.5. They find that the money demand is a stable function over the period 1929-1990. Their result relies on the assumption that cross-state differences in income are not correlated with state-specific shifts in the money demand function. Duca and Whitesell (1995) examine the effects of credit card ownership on household deposit balances and the determinants of deposit account ownership. Their results show that credit card ownership is associated with lower transactions deposits. They find cross-sectional evidence that income and assets are significant scale variables for transactions deposits.

The Cowles Commission approach and Partial Adjustment Models (PAM) were popular before the present developments in the time series econometrics, for example, see Himarios (1986) and Apostolou and Varelas (1987).[18] Literature search on this topic revealed that most studies have utilised the time series techniques. In other words, money demand specifications have shifted towards using error-correction and structural break methods. To this end, the single-equation (Hendry's General to Specific (GETS); Engle and Granger's two step procedure (EG); Phillip and Hansen's fully modified OLS (FMOLS); Stock and Watson's dynamic OLS (DOLS)) and system-equation (Johansen's maximum likelihood (JML)) techniques and the structural break (Gregory and Hansen, 1996a & b; Bai and Perron, 1998 & 2003) techniques are popular in money demand analysis, for instance see, Oxley

[18] Moreover, a number of the earlier studies (for example, Diz, 1970; Brissimis and Leventakis, 1981; Panayiotopoulos, 1984) have ignored testing the order of integration of the variables.

(1983), Felmingham and Zhang (2001), Rao and Kumar (2007 and 2009a), Choi and Jung (2009) and Singh and Pandey (2009). Among others, these studies are reviewed in the later sections.

Further, re-estimation of money demand is essential due to the recent developments in non-stationary panels and structural breaks. A few econometricians have pursued the trend set by the seminal paper of Perron (1989) and developed cointegration tests with breaks for panel data; for example, see Banerjee and Carrion-i-Silvestre (2006) and Westerlund (2006). Recently, Mark and Sul (2003) proposed the DOLS estimator to estimate cointegrating equations in the panel data. In doing so, they estimated the *M1* demand for a panel of 19 advanced countries with data from 1957 to 1996. Combining observations across countries allowed them to attain a long run demand for money relation with real GDP and nominal interest rate. Recent studies that estimated the money demand functions in a panel framework are Slok (2002), Valadkhani and Alauddin (2003), Serletis and Vaccaro (2006), Dreger et al. (2007), Valadkhani (2008), Rao and Kumar (2009b), Rao et al. (2009), and Narayan et al. (2009).[19]

This study follows the flowcharts developed in Chapter three to estimate the *M1* demand relationship for selected advanced OECD and developing countries. Specifically, I employed the time series (GETS, EG, FMOLS, ARDL and JML) and panel data (Pedroni, Mark and Sul, Breitung and Westerlund) estimation techniques. To investigate the structural breaks in the cointegrating vector of *M1* demand, I used the Gregory and Hansen and Westerlund tests. Hurlin, and Hurlin and Venet's panel Granger causality and Leamer's extreme bounds tests are also utilised. The following section reviews studies on money demand in the advanced OECD countries.

[19] These studies are discussed in Section 2.3.4.

### *2.3.2 Money Demand in Advanced OECD Countries*

#### *2.3.2.1 Time Series Studies from Advanced OECD Countries*

There is a vast amount of literature on demand for money in the advanced OECD countries. Prior to further discussion, it would be useful to take an overview of the long run estimates of the demand for money. Figure 2.1 illustrates how income elasticity should be interpreted for advanced OECD and developing countries. Since real income is the scale variable in money demand specifications and its magnitude (income elasticity) provides useful insights on the development of the financial market, therefore it is vital that this parameter is estimated accurately. Majority of the estimates of income elasticity in the literature are largely misguided and offers limited economic meaning. I expect the income elasticity of money demand in the advanced OECD countries to be different than the developing countries. Since the advanced OECD countries have well-developed financial system, a lower income elasticity is feasible.

Moreover, it is plausible that the broader measures of money (for example *M2*, *M3* and *M4*) may produce slightly higher estimates of the income or wealth elasticity than the narrower aggregates (*M1*). This is logical because as income grows, individuals will economize more on cash (i.e. narrow money) and substitute with the check/savings accounts (i.e. broader aggregates). Higher income elasticity of broad money is justified on the basis of portfolio decisions that influence the money demand behaviour. However, this inference should be interpreted cautiously because growth in income may be lower in developing countries and as a result their substitution effects may be minimal. Higher substitution effects may be observed in the advanced OECD countries. Rao and Kumar (2009a & b) and Kumar et al. (2011) argued that the income elasticity is expected to be lower (around or slightly higher) than unity in the advanced OECD (developing) countries. Ball (2001) pointed out that low income elasticity estimates would imply that the Friedman rule is not optimal and that the money supply should grow more sluggishly than income to attain price stability.

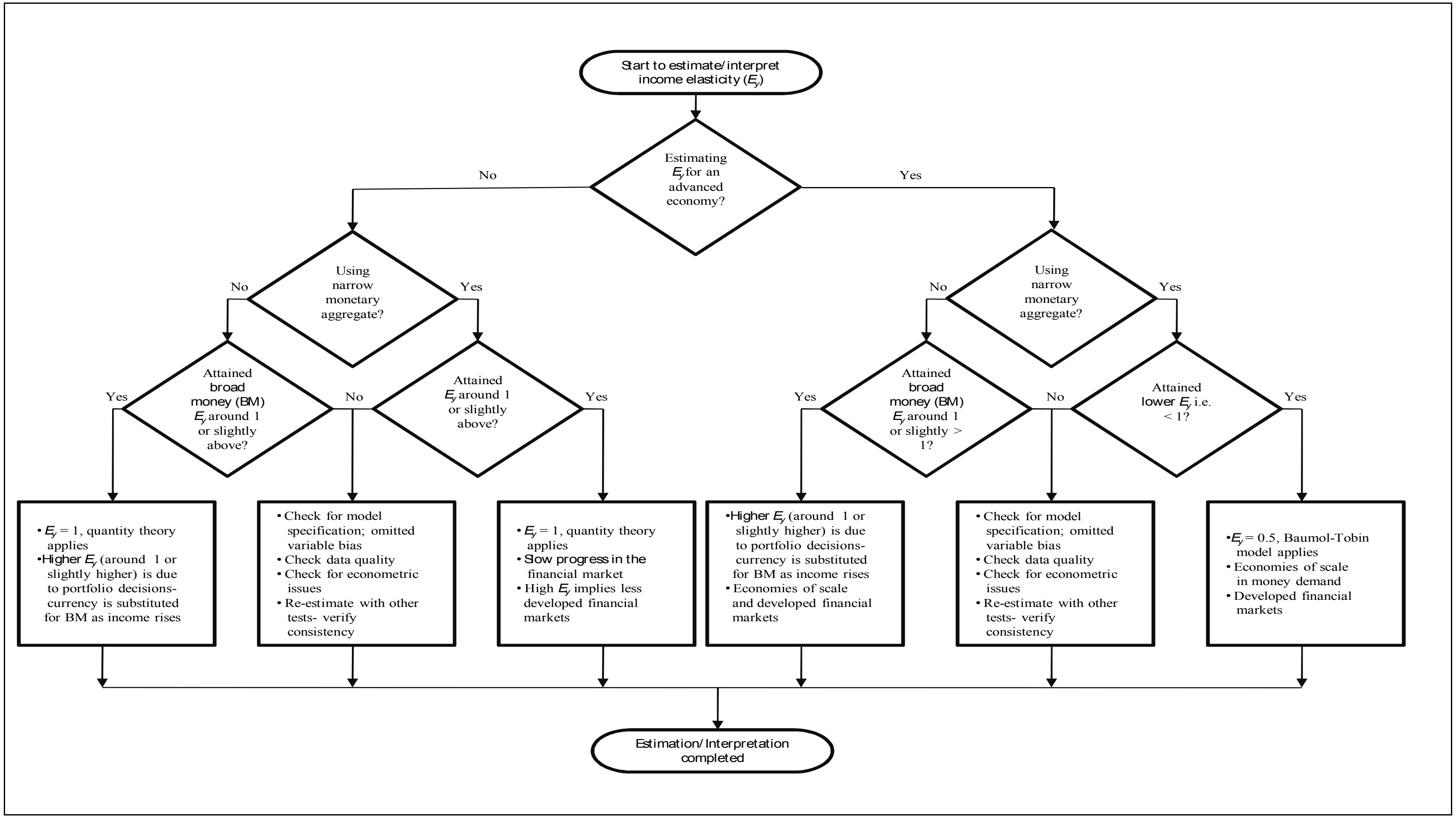


**Figure 2.1 Estimating and Interpreting the Income Elasticity of Demand for Money**

Following the financial reforms and liberalisation policies of the mid 1980s, it is reasonable to assume that the money demand elasticity with respect to income may have declined and the rate of interest elasticity may have increased in absolute value. There is no doubt that advanced OECD countries have diversified financial sector instruments and offers more opportunities to improve savings and efficiency. There are also more non-bank financial institutions with established track record. Such diversification in the financial system ensures that capital is mobilized from several avenues than from the traditional banking sector. In light of these observations, it could be argued that the income elasticity of money demand in advanced OECD countries is expected to be much lower than unity; consistent with the Baumol-Tobin model. To this end, it naturally reflects their better financial system in which economies of scale in the money demand reduces the cost of transactions and also reduces the use of liquid assets such as *M1*.[20] The same may be observed for transitional economies; however, it depends on the extent of financial sophistication that has been achieved through the financial liberalisation policies in these countries.

On the other hand, most developing countries generally lack the features like diversified financial sector and instruments, and payments technology. Therefore, it is pragmatic to assume that income elasticity in developing countries is around unity (or slightly above). Such income elasticity would imply underdeveloped financial markets where most transactions involve the use of narrow money as opposed to other forms of monetary aggregates. To this end, it is likely that the quantity theory of money may hold for majority of the developing countries. I shall use Figure 2.1 to review the income elasticity estimates of money demand achieved by existing studies.

The key findings of selected studies from advanced OECD countries are reported in Table 2.1; see pages 53-60 below. In particular, Table 2.1 is constructed to highlight the variations between the individual studies in relation to their nature of monetary aggregate, country and sample size, econometric methods and long run elasticities. Eventually, information from Table 2.1 is used together with other studies from

[20] For more details on long run elasticities of the demand for money, see Sriram (1999), Mark and Sul (2003), Duca and VanHoose (2004), and Rao ad Kumar (2009b).

Economic Literature (EconLit) and Research Papers in Economics (RePec) databases to perform a meta-regression analysis.

The time series studies on the demand for money in Australia are Cohen and Norton (1969), Adams and Porter (1976), Sharpe and Volker (1977), Pagan and Volker (1981), Swamy (1987), Blundell-Wignall and Thorp (1987), Lim and Martin (1991), Juselius and Hargreaves (1992), de Brouwer et al. (1993), Orden and Fisher (1993), Lim (1995), Hoque and Al-Mutairi (1996), Asano (1999), Felmingham and Zhang (2001) and Valadkhani (2005).[21] The empirical findings of de Brouwer et al. (1993) were refuted by Felmingham and Zhang (2001). Using monthly data from 1976(M3)-1998(M4), Felmingham and Zhang (2001) estimated the *M2* demand function for Australia. They used the JML and Gregory and Hansen (1996a) techniques. The income elasticity estimate is high as 1.2 and their stability tests do provide useful implications on the conduct of Australian monetary policy. They found that the demand for *M2* is stable over the sample period subject to a regime shift occurring during the 1991 recession in Australia. Felmingham and Zhang argued that money supply is the optimal monetary policy instrument for Australia; consistent with Poole (1970). This supports the findings by Lim (1995) and Juselius and Hargreaves (1992) that there exists a cointegrating relationship of money demand and Asano (1999) and Lim and Martin (1991) that the demand for money is stable in Australia.

Hoque and Al-Mutairi (1996) used quarterly data for the period 1970(Q1)–1993(Q1) and the EG technique to find a long run relationship between *M1*, income, interest rate and the price level in Australia. They conclude that this long run relationship

[21] Prior to 1990s, several studies have reported conflicting results on money demand in Australia. Cohen and Norton (1969) can be considered as pioneers of money demand analysis in Australia. They used a modified stock adjustment model to estimate money demand functions with the limited available quarterly data for various monetary aggregates in Australia. Unlike Adams and Porter (1976) who argue against stability of *M1*, Pagan and Volker (1981) employed a conventional specification of the demand for money function and found a stable relationship for *M1*. Sharpe and Volker (1977) and Lim and Martin (1991) in their study of *M3* in Australia supported the stability of the money demand function, while Blundell-Wignall and Thorp (1987) modelled *M0*, *M1* and *M3* and found the opposite.

shows no sign of instability.[22] Valadkhani (2005) used the JML technique to examine the long and short run determinants of the *M2* demand for Australia. Using quarterly data for the period 1976(Q3)–2002(Q2), he found the income elasticity of *M2* demand close to unity, see Table 2.1. The near unit income elasticity implies the validity of the quantity theory of money demand; see Figure 2.1. It is observed that most studies on the Australian money demand stability did not utilise the structural change tests. To this end, they offer less guidance on how significant structural reforms were on the demand for money. This study attempts to fill this gap by using updated data and modern estimation techniques that utilise structural change tests.

Pollan (1978), Ziegelschmidt (1985), Gluck (1987), Schebeck and Thury (1987), Komlos (1987) and Hayo (1999 and 2000) are the time series studies on Austrian demand for money.[23] Hayo (2000) used quarterly data from 1965(Q1) to 1996(Q3) period and the JML technique to estimate the demand for *M1*, *M2*, and *M3* for Austria. The money demand was specified in the standard way, with a scale variable (real GDP) and nominal interest rate to capture the costs of holding money. The income elasticity was constraint to unity in all the cases, see Table 2.1. The interest rate coefficients have expected signs and magnitudes. They asserted that a stable money demand exists for all monetary aggregates in Austria. In an earlier study, Hayo (1999) also used the JML technique to arrive at similar conclusions that demand for *M1* and *M2* are stable across 11 EMU countries for the period 1964-1994.[24] In both studies, the quantity theory of demand for money applies.

The demand for money estimates for Canada virtually supports the Baumol-Tobin inventory-theoretic approach, for example see, Haug and Lucas (1996) and Georgopoulos (2000). The Baumol-Tobin model represents a significant departure

[22] In an earlier study, Orden and Fisher (1993) estimated demand for *M1* and *M3* and found instability in the money demand functions for Australia.
[23] Earlier studies on Austrian money demand have used the traditional estimation methods, for example, Pollan (1978), Ziegelschmidt (1985), Gluck (1987), Schebeck and Thury (1987) and Komlos (1987).
[24] These countries are Germany, France, the Netherlands, Belgium, Ireland, Austria, Finland, Italy, Spain and Portugal. Useful summary of issues surrounding the estimation procedure and a survey of existing national money demand estimates for the EU are provided by Monticelli and Strauss-Kahn (1992), Fase (1994), Monticelli and Papi (1996) and Browne et al. (1997). Fair (1987) also provides an extensive survey of money demand estimates involving 27 countries, including the EU members.

from the classical quantity theory of money, as it implies economies of scale in the demand for money and provides interest rate elasticity away from zero. Haug and Lucas (1996) used DOLS method to estimate *M1* demand for Canada using quarterly data for the period 1953(Q1) to 1990(Q4). They obtained an income elasticity of around 0.4. This is consistent with Georgopoulos (2000), see Table 2.1 for comparison. Georgopoulos (2000) employed quarterly data from 1953(Q4) to 1991(Q3) found a stable money demand relationship for Canada from 1953 to 1991. Other related studies on the demand for money for Canada are White (1976, 1979), Cameron (1979), Poloz (1980), Kabir and Mangla (1988), Boothe and Poloz (1988), Ebrill (1989), McPhail (1991), Arestis et al. (1992), Hendry (1995), Shekar and Hafizur (1996), Choudhry (1996), Haug and Lucas (1996), Haug (1999 & 2006) and Kia (2006). On the stability front, McPhail (1991) and Haug (1999) attained an unstable *M2* demand for Canada.[25]

Kia (2006) assumed that equities have a strong substitution or complementary relationship with real cash balances. According to Friedman (1988), the real demand for money, depending on the net outcome of the wealth, risk-spreading and substitution effects, will increase or decrease with the real stock price. Within this theoretical framework and using Canadian monthly data for the period 1975(M1) to 2001(M6), Kia (2006) examined the *M1* demand for Canada with and without fiscal and monetary policy regime changes. The findings confirm that the demand for *M1* in Canada is stable when these policy regime changes are incorporated and the estimated coefficients have correct signs (income elasticity around 0.7, see Table 2.1).

Bahmani–Oskooee and Chomsisengphet (2002) used *CUSUM* and *CUSUMSQ* stability tests to his JML equations to test for stability of *M2* for 11 OECD countries.[26] The income elasticity of *M2* ranges from 0.6 to 3.9. Based on Figure 2.1,

[25] Generally, earlier studies on the demand for *M1* for Canada concluded that the *M1* demand function is unstable. For example, Clark (1973) found some evidence of a structural break in the *M1* demand. Boothe and Poloz (1988) attained an unstable demand for *M1* due to the financial innovations. Hoffman et al. (1995) incorporate an intercept dummy for the period 1981–1990 to avoid instability in the demand for various monetary aggregates for Canada.

[26] These countries are Australia, Austria, Canada, France, Italy, Japan, Norway, Sweden, Switzerland, UK and the USA. They used quarterly data 1979(Q1)-1998(Q3) for Australia; 1967(Q1)-1998(Q3)

it could be argued that some estimates of the income elasticity are unexpected. Their stability tests do reveal some sign of instability in *M2* for Switzerland and the UK. In the remaining nine cases, demand for *M2* appears to be stable.[27] Ewing and Payne (1999b) examined the demand for *M1* for 9 OECD countries (Australia, Austria, Canada, Finland, Italy, Germany, Switzerland, UK and the USA). They used the JML technique and attained income elasticity ranging from 0.5 to 1.2. The demand for *M1* is stable in Australia, Austria, Finland, Italy, UK and the USA when *M1* is cointegrated with real income and the nominal interest rate while in Canada, Germany and Switzerland when exchange rate is incorporated. Artis et al. (1993) present results for demand for *M1* and *M2* for seven EC countries (Germany, France, Italy, the Netherlands, Denmark, Belgium and Ireland), using quarterly data for the period 1979(Q1) to 1990(Q4) .The income elasticities are at around 1.2 and the interest rate elasticities are around -0.7. Similar estimates were attained by Monticelli and Strauss-Kahn (1993) for EC countries. On the basis of Figure 2.1, it could be asserted that fairly high income elasticities were attained by Bahmani–Oskooee and Chomsisengphet (2002) and Artis et al. (1993), while Ewing and Payne (1999b) and Monticelli and Strauss-Kahn (1993) for some countries achieved reasonable income elasticities.

The empirical analysis of Juselius (1998) focused on the dynamics of 'excess money' and its effects on prices, income, and interest rates. The specification of the long run money demand is based on the *IS-LM* model augmented by a short run Phillips curve, similar to Laidler (1985). Money is assumed to be the sum of the transactions, precautionary and speculative demands for money. Using the JML technique and quarterly data over 1974(Q1)-1993(Q4) period, Juselius investigated the impact of changing monetary regimes on the demand for *M2* for Denmark. The empirical evidence supports a stable money demand relationship with strong interest rate effects. Bond et al. (2007) examined the demand for *M2* for Denmark and

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for Austria; 1957(Q1)-1998(Q4) for Canada; 1977(Q)-1998(Q3) for France; 1974(Q1)-1998(Q3) for Italy; 1966(Q1)-1998(Q4) for Japan; 1966(Q1)-1998(Q3) for Norway; 1969(Q1)-1998(Q4) for Sweden; 1975(Q4)-1998(Q4) for Switzerland; 1957(Q1)-1998(Q2) for the UK and 1957(Q1)-1998(Q4) for the USA.

[27] In an earlier study, Hoffman et al. (1995) provides support for a stable demand for *M1* for five industrial countries (Japan, Canada, the USA, West Germany and the UK) when income elasticity is constraint to unity. They used post war data (1955 -1990) and DOLS and JML techniques.

Finland for the period 1974-1987. They pointed out the limitations of conventional unit root and cointegration tests and argued that fractional integration and random field regressions achieve bias-free estimates.

Hansen (1996) provides empirical support that the German interest rate and the exchange rate return have significant effects on money demand in Denmark. Recently, Andersen (2004) found insignificant evidence to support Hansen's claim. Andersen (2004) estimated the demand for *M2* for Denmark using quarterly data over 1980(Q1)-2002(Q4) period. The JML technique revealed plausible income elasticity at around 0.8 and their results imply that stable inflation and exchange rates in the recent years have made return expectations highly homogeneous. Other studies for instance, La Cour (1996 and 1999), focused on comparing the performance of different monetary aggregates in Denmark.[28]

Nielsen et al. (2004) asserted that the demand for *M2* is stable in Italy over the period 1972 to 1998. They found plausible income elasticity of *M2* around 0.6 (see Table 2.1) which is comparable to the estimates found by Angelini et al. (1994) and Bagliano (1996). These income elasticity estimates are consistent with the Baumol-Tobin framework and with the development of close substitutes to *M2* in the Italian financial system. Other studies on money demand for Italy are Muscatelli and Papi (1990), Bagliano and Favero (1992), Muscatelli and Spinelli (1996, 2000), Rinaldi and Tedeschi (1996), Sarno (1999) and Gennari (1999). Sarno (1999) and Muscatelli and Spinelli (1996 & 2000) used annual data from 1861 to 1991, 1861 to 1990 and 1861 to 1996, respectively, to estimate *M1* demand using single-equation estimation techniques. They found a single cointegrating relationship exists for *M1* demand. Similar findings were attained by Bagliano and Favero (1992) and Muscatelli and Papi (1990).[29] In contrast, a few studies have found more than one cointegrating relationship for money demand in Italy, for instance, see Gennari (1999), Bagliano (1996) and Rinaldi and Tedeschi (1996).

[28] Earlier, Christensen and Jensen (1987) argued that the return on foreign investments is also likely to affect the demand for money.

[29] Bagliano and Favero (1992), who specify a feedback and a feed-forward model for quarterly data for the sample 1964–1986. Muscatelli and Papi (1990) modelled the process of financial innovation in an error correction model for quarterly data for the period 1963–1987.

Friedman's (1956) view that inflation is essentially a monetary phenomenon (a continuous increase in general price level is due to the rate of expansion in money supply) was empirically tested by Lutkepohl and Wolters (1998). They constructed a small macroeconomic model to examine the dynamic relationship between money growth and inflation using quarterly data from 1976(Q1) to 1996(Q4). They found a stable demand for *M3* in Germany. Using the Stock (1987) approach the income elasticity was constraint to unity, fairly consistent with the quantity theory. Their findings are comparable to Bundesbank (1995), except the income elasticity achieved by Bundesbank was slightly high at around 1.4. According to Bundesbank, during the 1980s the monetary policy in Germany was made considerably more difficult by the increased volatility of short-term monetary growth.

Thornton (1995) and Bruggemann and Nautz (1997) examined Friedman's volatility hypothesis for Germany. This hypothesis states that increased volatility of money growth raises the degree of perceived uncertainty and thereby increases (reduces) the demand for money (income velocity). Thornton (1995) suggested that the case of Germany seems to be most favourable for Friedman's volatility hypothesis. However, Bruggemann and Nautz (1997) showed that for Germany, the development of the monetary target aggregate *M3* sharply contradicts Friedman's hypothesis. Their volatility-augmented money demand functions revealed that increased money growth volatility decreases the demand for money. Other time series studies on the demand for money in Germany are Akhtar and Putnam (1980), Herz and Roeger (1990), Hansen and Kim (1995), Scharnagl (1996), Lutkepohl et al. (1999), Hamori and Hamori (1999), Bahmani-Oskooee and Bohl (2000), Arnold (2003) and Herwatz and Reimers (2003).[30] Most of these studies conclude that money demand functions have become unstable in the German re-unification period. However, I argue that

[30] Lutkepohl et al. (1999) and Hamori and Hamori (1999) found that stability of money demand tends to be rejected when the sample period is extended to cover German re-unification. Arnold (2003) found that re-unification has not destabilized monetary relationships within West-Germany. However, Herz and Roeger (1990), Hansen and Kim (1995) and Herwatz and Reimers (2003) found stable money demand functions for Germany. Bahmani-Oskooee and Bohl (2000) showed that the variables in the money demand function could be cointegrated but the estimated cointegrating vector could be unstable. Bahmani-Oskooee and Bohl argue that cointegration does not imply stability.

appropriate structural change tests should be applied to confirm the stability aspect of German monetary aggregates.

Recent empirical works on the money demand for Greece are Karfakis (1991), Psaradakis (1993), Papadopoulos and Zis (1997), Ericsson and Sharma (1998), Karfakis and Opoulos (2000), Loizos and Thompson (2001) and Bahmani-Oskooee and Economidou (2005).[31] Loizos and Thompson (2001) employed quarterly data for the period 1963(Q2) to 1998(Q3) and estimated demand for *M1* for Greece using the JML technique. They used real industrial production as a proxy for real income. The income elasticity is reasonable at around 0.8. The elasticity with respect to interest and inflation rates are plausible and have expected signs. Bahmani-Oskooee and Economidou (2005) used quarterly data over 1975(Q1) to 2002(Q4) period to estimate demand for *M1* and *M2* for Greece with the JML procedure. They used different interest rates in order to search for a long run relationship. Using the treasury-bill rate, the income elasticity of *M1* is 0.75 and semi-interest rate elasticity is -0.003. However, their income elasticity for *M2* is high as 1.4, see Table 2.1 for these estimates. Using the *CUSUM* and *CUSUMSQ* stability tests they found that the demand for *M1* (*M2*) is stable (unstable) in Greece. Psaradakis (1993) estimated a vector autoregression (VAR) model for the period 1960(Q1) to 1989(Q1). The main findings reveal that interest and inflation rates, and income are the key determinants of the demand for money. Psaradakis concluded that the demand for *M1* is stable over the sample period. Other empirical works such as Karfakis (1991), Sharma (1994), Papadopoulos and Zis (1997), Ericsson and Sharma (1998), Karfakis and Opoulos (2000) also tested for the stability of money demand function in Greece.[32]

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[31] Earlier studies on money demand in Greece include Apostolou and Varelas (1987), Alexakis (1980), Brissimis and Leventakis (1981, 1983 and 1985), Himarios (1983, 1986 and 1987), Palaiologos (1982), Panayotopoulos (1983 and 1984), Prodromidis (1984) and Tavlas (1987). For a brief background of these studies, see Loizos and Thompson (2001).

[32] Karfakis (1991) employed quarterly data over the period 1975(Q1)-1988(Q3) and found that the demand for *M1* was stable in Greece. Papadopoulos and Zis (1997) used quarterly data from 1957(Q3)-1991(Q1) and the JML technique to investigate the determinants and the stability of the demand for money in Greece. Neither the empirical findings of Papadopoulos and Zis (1997) nor Sharma (1994) provide support for the conclusion that the demand for *M2* and *M3* are unambiguously stable. Ericsson and Sharma (1998) developed a constant, data-coherent, equilibrium correction model for *M3* in Greece over the period 1976 to 1994. Their estimated *M3* model is stable for Greece. Karfakis and Opoulos (2000) examined the stability of the long run demand for *M1* in Greece over the

Miyao (1996a) used quarterly data over 1964(Q1)-1993(Q3) period to show that real *M2* for Japan is not cointegrated with real income and nominal rate of interest. Miyao utilised three techniques viz. EG, DOLS and JML. Bahmani–Oskooee and Shabsigh (1996) used the JML technique and found income elasticity of demand for *M1* and *M2* as 0.62 and 1.02, respectively. Note that these income elasticities are consistent with Figure 2.1. They emphasized the importance of nominal exchange rate in attaining a long run relationship of *M2*. In another study, Bahmani-Oskooee (2001) employed the ARDL approach combined with *CUSUM* and *CUSUMSQ* tests to show that not only *M2* is cointegrated with income and interest rate, but the estimated relationship is stable for Japan. The income elasticity of *M2* demand is around 1.1. Amano and Wirjanto (2000) examined a long run money demand function for Japanese *M2* plus certificates of deposit. The empirical evidence suggests that there is a cointegrating relationship between real *M2*, real income and interest rates, and that this relationship is structurally stable over the sample period (1967-1993) that includes instances of financial market innovations and deregulations. The long run elasticities of Bahmani–Oskooee and Shabsigh (1996), Bahmani-Oskooee (2001) and Amano and Wirjanto (2000) are provided in Table 2.1.

Supporting the quantity theory of demand for money, Lucas (1988) argued that the money demand function is stable if unit income elasticity is imposed. By allowing for asymmetric adjustment (see Enders and Siklos, 2001), Maki and Kitasaka (2006) applied Lucas framework to investigate the long run relationship of real *M1* for Japan. The threshold cointegration approach provides clear evidence of the cointegration relationship between money, income, interest rate and prices in Japan. They found that the demand for money is stable in Japan only if unit income elasticity is imposed. Other previous studies on money demand for Japan are Boughton (1981), Hamada and Hayashi (1983), Ishida (1984), Fair (1987), Ito (1989), Baba (1989), Yoshida (1990), Yoshida and Rasche (1990), Hoffman and

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deregulated period 1986(Q1) to 1995(Q4). Their stability analysis provide evidence that the long run money demand equation is stable over the sample period, implying that the narrow money aggregate could be used as an intermediate target of monetary policy in Greece.

Rasche (1991), Arize and Shwiff (1993), Fujiki and Mulligan (1996), Fujiki (1999), Nagayasu (2003) and Miyagawa and Morita (2004).[33]

The Keynesian liquidity preference theory does include wealth as an explanatory variable, however, in several empirical works wealth has been ignored because they assume it is proportional to income (GDP). Friedman (1956) and Tobin's (1956) approaches also use wealth to explain the money demand behaviour. Fase and Winder (1996) examined the importance of wealth in money demand functions for Belgium and the Netherlands. The demand for *M1*, *M2* and *M3* was estimated within an ECM framework. Using quarterly data over 1979(Q4)-1994(Q4) and 1970(Q1)-1994(Q4) period, respectively, they found that with the exception of demand for *M1* in Belgium, all other aggregates showed substantial wealth elasticities. Another finding is that very often income and wealth elasticities add up to 1.[34] For a preliminary analysis on the effects of wealth on money demand, see Fase and Winder (1990). The finding that the income and wealth elasticities sum to 1 corresponds with the results obtained by Sterken (1992) for the Netherlands. This result has also been reported for other countries, for example, Bundesbank (1995) for Germany, Hall et al. (1989) for the UK, Hunt and Volker (1981) for Australia, and Corker (1990) for Japan. In my view, wealth undoubtedly plays a crucial role in money demand specifications, however, practically it is difficult to measure wealth. In such situations, income is observed as a readily available measure and hence widely used as a scale variable.

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[33] Japan was one among others considered by Boughton (1981) and Fair (1987), who both provided evidence indicating structural instability in the Japanese demand for money. Hamada and Hayashi (1983) and Ishida (1984) also found instability in Japanese money demand function. Other early studies of money demand in Japan are typically built on Goldfeld's (1973) partial adjustment model and have led to mixed results. Ito (1989), Baba (1989), Yoshida (1990) and Yoshida and Rasche (1990) report evidence suggesting that the broad money demand functions in Japan are structurally stable. These earlier results are also supported by Fujiki and Mulligan (1996), Tang (2004) and Miyagawa and Morita (2004), who also found some instability in the demand for money relationships. Recently, Nagayasu (2003) used quarterly data over 1958(Q3)–2000(Q4) period and found income elasticity of *M2* between 1 and 1.2 with the FMOLS technique. The Hansen (1992) tests revealed that the *M2* function is unstable in Japan.

[34] An important implication of wealth dependency on the demand for money is that the velocity of money will also depend on wealth. For the Netherlands, incorporating wealth effects on the demand for money seems to mitigate the volatility of the money demand. For Belgium this is not the case, indicating that interest and inflation rates are an important factor in understanding monetary developments.

Using the ECM method, Cesar et al. (1990) estimated the money demand for *M1* and *M2* for the Netherlands using quarterly data over 1959(Q1) to 1984(Q4) period. They present evidence that does not support the choice of *M2* as intermediate target for monetary policy in the Netherlands. However, there is cointegration between demand for *M1*, net national product and interest rates. They argued that this does not imply that *M1* is a good indicator of monetary policy. Earlier studies on the demand for money in the Netherlands concluded that the money demand (especially, *M2*) is stable (for example, Butter and Fase, 1981; Taylor, 1986; Kuipers and Boertje, 1988).[35]

The demand for money in New Zealand requires further attention because the stability aspects of various monetary aggregates are yet to be investigated. Siklos (1995a & b) used the JML technique to examine the cointegrating links between *M3*, expected inflation rate and short-term interest rates (difference between NZ and US rates) for New Zealand (NZ). Using quarterly data over 1981(Q1)-1994(Q2) period, he obtained income elasticities varying between 2 to 6. With respect to Figure 2.1, these estimates of income elasticity are implausibly high. Further, he asserted that consumer price index (CPI) is the most relevant index for deflating nominal money in NZ. Choi and Oxley (2004) estimated the *M3* demand for NZ using quarterly data for the period 1988(Q3)-2002(Q2) and the JML technique. The income elasticity of *M3* is around 1.7 is also fairly high for the New Zealand economy, see Table 2.1. They argued that it is necessary to include dummy variables to capture idiosyncratic policy changes.

Mundell (1963) conjectured that in addition to the interest rates and the level of real income, the determinants of the demand for money should be augmented by the exchange rate. Following Mundell's framework, Valadkhani (2002) examined the long run determinants of the demand for *M3* in New Zealand by employing the JML technique and quarterly data for the period 1988(Q1) to 2002(Q2). He found that the income elasticity is around 1.5 and the semi-elasticities of interest rate spread,

[35] An interesting study by Traa (1991) on *M1* demand in the Netherlands suggest that the guilder-US dollar exchange rate in Dutch money demand, alongside domestic interest rates, could act as a valuable monetary indicator.

inflation and real effective exchange rate are -4.03, -4.08 and -0.208, respectively. Similar to Siklos (1995a & b) and Choi and Oxley (2004), the income elasticity is fairly high. The demand for *M3* is generally stable in NZ, except a minor outlier at 1996. Razzak (2001a) estimated a Keynesian demand for money function linking the real monetary base (*M0*) with real output and various types of interest rates for NZ. His results indicated that the correlation between money and real output is stronger than that between money and inflation. Using quarterly data from 1988(Q1)-1997(Q4) and the EG technique, he found that quantity theory of demand for money applies for NZ.

Vega (1995 & 1998) found that the structural break in the Spanish economy, especially capturing openness of the financial system, has affected the stability of the broad money. Recently, Bahmani-Oskooee et al. (1998) examined the determinants of the *M1* and *M2* demand in Spain. Their results support Mundell (1963) that exchange rate is vital in the money demand relationship. Using quarterly data over the 1974(Q1)-1992(Q4) period and the JML procedure, they found the nominal effective exchange rate to be a significant determinant of *M2* demand but not for M1. Using the Hansen and Johansen test for constancy of the estimated parameters, the estimates of *M2* demand were shown to be stable over time. Ordonez (2003) provided strong empirical evidence of asymmetric non-linear adjustment of real balances towards long run equilibrium, and this is consistent with the target-bounds and buyer-stock models for money demand.[36] Specifically, they used non-linear techniques to estimate demand for *M3* for Spain using quarterly data from 1978(Q1)–1998(Q2). Stability tests indicated the existence of a stable *M3* demand function in the long run but not in the short run. They concluded that such instabilities are caused by non-linear adjustments of real balances towards stable long run equilibrium.[37]

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[36] According to target-bounds and buyer stock models, the presence of adjustment costs introduces a band within which short run deviations of actual money balance from long run equilibrium relationships are persistent. Adjustments to the equilibrium level take place as actual money balances approach the bands so that the functional form for the money demand at the aggregate level is characterized by non-linear adjustment towards the long run equilibrium.

[37] Conventionally, it has been concluded that the money demand in Spain is stable. However, Mauleon (1987), Cabrero et al. (1992) and Maudos (1995) opposed the traditional results of money demand and asserted that Spanish money demand functions have become unstable overtime.

Recent studies that support monetary targeting in Switzerland are Gerlach-Kristen (2001), Baltensperger et al. (2001) and Peytrignet and Stahel (1998). Gerlach-Kristen (2001) used annual data for the period 1936 to 1995 to estimate demand for *M3* for Switzerland. The JML procedure was used to investigate the long run relationship of money demand. The income elasticity is high as 1.259 which is comparable to Chowdhury (1995) and Peytrignet and Stahel (1998), see Table 2.1.[38] The interest rate spread has a coefficient of -0.221. Most importantly, Gerlach-Kristen found a stable demand for money function for Switzerland.

Baltensperger et al. (2001) examined the importance of money in controlling inflation. Friedman's (1959) viewpoint that inflation and deflation deteriorates the long run prospects of the economy implies that monetary policy should aim at stabilizing the price level. Baltensperger et al. (2001) argued that *M3* growth is a powerful indicator of future inflation in Switzerland. They used the JML technique and quarterly data for the period 1978(Q1)-1999(Q2) and found that output and price elasticities are close to unity and the interest semi-elasticity is about -0.05, see Table 2.1. The improvement in the inflation forecasts over the short- and long-run periods are due to combining the information of money growth and excess money. Further, they asserted that excess money is a better predictor of cumulative inflation than of annual inflation.[39]

Several studies have developed empirical models for the UK money demand utilising various data spans and different estimation techniques. Hendry and Ericsson's (1991) findings supports the quantity theory of demand for money (the income elasticity is constraint to unity, see Table 2.1). Using the quarterly data over 1963(Q1) to 1989(Q2) period, they developed a parsimonious conditional

[38] Chowdhury (1995) used quarterly data over 1973(Q2) to 1991(Q4) period to estimate demand for *M1* for Switzerland with the JML technique. The income elasticity is around 0.9. Peytrignet and Stahel (1998) found income elasticity of *M2* around unity for the period 1977-1997. They also found that Switzerland's *M2* and *M3* aggregates are stable over the sample period.

[39] Other studies on money demand for Switzerland are Kohli (1984), Belongia (1988), Fischer and Peytrignet (1990 &1991), Peytrignet (1996), Boswijk and Urbain (1997), and Jordan et al. (2000). These studies found fairly high income elasticities of broad money (*M2* or *M3*) (i.e. more than unity), except for Belongia (1988). Peytrignet (1996) also obtained implausible income elasticity of *M3* at around 2. Most of them have used quarterly data from mid 1970s to early 1990s.

equilibrium correction model for demand for *M1* where real *M1* depends on real total final expenditure and net interest rate. The semi-elasticity with respect to net interest rate is around -0.6. While Nielsen (2007) and Escribano (2004) argued that the long run structures of money demand are reasonably stable in the UK, Caporale and Gil-Alana (2005) to some extent found instability in the UK money demand and therefore opposes monetary targeting by the central bank. Caporale and Gil-Alana (2005) applied fractional cointegration to estimate demand for *M1* for Japan, Germany, Canada, the USA and the UK.[40]Their results are consistent with the claims made by Hoffman et al. (1995) and Hoffman and Rasche (1996) that a stable money demand exists. Further, Caporale and Gil-Alana asserted that money targeting would appear to be a suitable monetary policy framework for the three countries (Canada, Germany and the US), but not in either the UK, where the income elasticity is estimated to be negative, or Japan, where the relationship is not stable, implying that the standard transmission mechanisms of monetary policy cannot be relied upon. The Japanese case could be interpreted as a 'liquidity trap' i.e. a situation where money and bonds become perfect substitutes (the lower zero bound on interest rates has already been reached). This causes a fundamental shift in the equilibrium money demand relationship, with conventional monetary policies being ineffective to raise output or stabilise prices.

Escribano (2004) re-examined the UK money demand from 1878 to 2000 utilising the specification proposed by Ericsson et al. (1998). The non-linear error correction model is stable in the parameters and satisfies all necessary misspecification tests. Nielsen (2007) examined the UK money demand for the period 1873-2001. Using a cointegrated VAR approach and accounting for the effects of extreme episodes related to the world wars and the oil price shocks, he found evidence of long run relationships of *M2*, *M3* and *M4*. The results imply that money demand functions are largely stable and excess money will have significant impacts on inflation. Other studies on money demand for the UK are Mills (1978), Boylan and OMuircheartaigh

[40] For the UK, M0 is used. The sample periods are 1960(Q1)–2004(Q2) for Canada; 1970(Q1)–2003(Q4) for Germany; 1970(Q1)–2004(Q1) for the UK; and 1970(Q1)–2004(Q2) for the USA and Japan. The income elasticity with semi-interest elasticity in parentheses are 1.167 (-0.053), 0.499 (-0.024), -0.289 (-0.024), 0.902 (-0.055),1.746 (-0.034), respectively, for Canada, Japan, Germany, the UK and the US.

(1981), Friedman and Schwartz (1982), Longbottom and Holly (1985), Grice and Bennett (1984), Adam (1991), Thomas (1997a & b) and Janssen (1998).[41]

The USA demand for money function and its stability have been analysed by many studies. Some often cited works are Goldfeld (1976), Judd and Scadding (1982), Lucas (1988), Poole (1988), Baba et al. (1992), McNown and Wallace (1992), Stock and Watson (1993), Hoffman et al. (1995) and Yossifov (1998), Ball (2001) and Choi and Jung (2009).[42] According to Friedman and Kuttner (1992), the USA canonical specification for *M1* is cointegrated with income and the rate of interest for the period 1960–1979, but becomes unstable if samples are extended to include data from the 1980s.[43] However, Ball (2001), in an insightful study, noted that stability tests did not show breaks in the demand for *M1* with data up to 1987, but a break is generally found if the samples include data through to 1996. He also found that when the data is extended beyond 1987, the pre 1970s estimates of income and interest rate elasticities reduce by half so that income and semi-interest rate elasticity is 0.5 and -0.05, respectively. According to Ball, an income elasticity less than unity has a number of implications for monetary policy, for instance, the Friedman rule is not optimal in this case and the supply of money should grow more sluggishly than output to achieve the goal of price stability.

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[41] Mills (1978) estimated the UK demand for money by a generalized functional form utilising the Box and Cox family of power transformations. Applying an algorithm, Boylan and OMuircheartaigh (1981) criticised Mills that his estimates are inconclusive. Friedman and Schwartz (1982) estimated a demand relation for broad money in a series of regressions using averages over phases of business cycles for the sample 1867−1975. The non-error correction (NEC) model was introduced and applied to money demand in the UK (1878 to 1970) by Escribano (2004 & 1986). Later, Hendry and Ericsson (1991) used these NEC models together with insights from Longbottom and Holly (1985) to produce a better specification of the UK money demand. Further, a number of studies have analysed wealth effects on the UK money demand functions, for example see, Jansen (1998) for narrow money demand and Grice and Bennett (1984), Adam (1991), and Thomas (1997a & b) on broader money aggregates.

[42] Lucas (1988), Poole (1988), Stock and Watson (1993) and Hoffman et al. (1995) asserted that the demand for *M1* in the USA is stable over the 20th century. However, Goldfeld (1976) and Judd and Scadding (1982) found that the money demand is unstable during 1970s. Further, Yossifov (1998) obtained implausible income elasticities for *M1* and *M2*.

[43] The cointegration and demand for *M2* in USA received much attention during 1990s, for example see Hafer and Jansen (1991), Miller (1991) and Friedman and Kuttner (1992). Friedman and Kuttner (1992) showed the evidence of no cointegration of *M2* and its determinants and argued that monetary aggregates are generally no longer useful for intermediate target or as an information variable. In contrast, Hallman et al. (1991), Feldstein and Stock (1993) and Konishi et al. (1993) found a cointegrating relationship of *M2* demand and argued that *M2* is useful as a predictor of real activities.

**Table 2.1 Long run Elasticities of Demand for Money in Advanced OECD Countries**

| Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| de Brouwer et.al (1993) | | *Australia* | | | | | | For de Brouwer et.al (1993) *R* is treasury bill rate. They also used 2 and 10 years bond rates. The income elasticity remains around 1.35 and interest rate elasticity with very minor changes. The income elasticities for *M3* is around 2 and 3. |
| | *M2* | 1970(Q3)-1991(Q10) | JML | 1.352 (32.16)* | -0.004 (1.18) | | | |
| Ewing and Payne (1999b) | | *Australia* | | | | | | Ewing and Payne (1999b) find that demand for *M1* is stable when M1 is cointegrated with real income and nominal interest rate in Australia. |
| | *M1* | 1979(Q1)-1995(Q4) | JML | 0.979 | -0.566 | | | |
| Felmingham and Zhang (2001) | | *Australia* | | | | | | Felmingham and Zhang (2001) used interest rate spread for *R*. |
| | *M2* | 1976(M3)-1998(M4) | JML | 1.210 | 0.250 | | -0.280 | |
| | *M1* | 1957-1999 | DOLS | 0.068 | -0.048 | | | |
| Ewing and Payne (1999b) | | *Austria* | | | | | | |
| | *M1* | 1973(Q1)-1995(Q2) | JML | 1.023 | -0.652 | | | |
| Hayo (2000) | | *Austria* | | | | | | Hayo (2000) also used a step dummy variable from second quarter of 1979 to capture appreciation of schilling. This estimate is -0.23. |
| | *M1* | 1965(Q1)-1996(Q3) | JML | 1.000 | | | | |
| | *M2* | 1965(Q1)-1996(Q3) | JML | 1.000 | -0.260 | | | |
| | *M3* | 1965(Q1)-1996(Q3) | JML | 1.000 | -0.340 | | | |

**Table 2.1 Long run Elasticities of Demand for Money in Advanced OECD Countries**

| Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Fase and Winder (1996) | *M1*<br>*M2*<br>*M3* | Belgium<br>1979(Q4)-<br>1994(Q4) | ECM | 0.699<br>(7.08)*<br>0.503<br>(2.09)*<br>0.523<br>(3.71)* | -0.003<br>(2.66)*<br>0.040<br>(1.46)<br>0.026<br>(2.62)* | | -0.003<br>(2.66)*<br>-0.040<br>(1.46)<br>-0.026<br>(2.62)* | Wealth variable was also significant at 5% level, except for *M1*. The wealth elasticity for *M2* and *M3* is 0.497 and 0.477, respectively. |
| Haug and Lucas (1996) | *M1* | Canada<br>1953(Q1)-<br>1990(Q4) | DOLS | 0.420 | -0.033 | | | |
| Ewing and Payne (1999b) | *M1* | Canada<br>1975(Q1)-<br>1996(Q2) | JML | 0.714 | -0.832 | 1.708 | | Ewing and Payne (1999b) find stable demand for *M1*. |
| Georgopoulos (2000) | *M1* | Canada<br>1953(Q4)-<br>1991(Q3) | JML | 0.431 | -0.225 | | | |
| Kia (2006) | *M1* | Canada<br>1975(M1)-<br>2001(M6) | JML/<br>DOLS | 0.73 | -0.02 | | | Kia (2006) find stable demand for *M1*. |
| Bond et al. (2007) | *M2* | Denmark<br>1974(Q1)-<br>1987(Q4) | JML | 0.930 | 0.610 | | | |
| Ewing and Payne (1999b) | *M1* | Finland<br>1978(Q1)-<br>1996(Q2) | | 1.173 | -1.843 | | | Ewing and Payne (1999b) find demand for *M1* is stable in Finland. |
| Bond et al. (2007) | *M1* | Finland<br>1974(Q1)-<br>1987(Q4) | JML | 0.300 | 0.310 | | | |

**Table 2.1 Long run Elasticities of Demand for Money in Advanced OECD Countries**

| Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Cassard et al. (1997) | *M3* | France 1979(Q2)-1990(Q2) | JML | 1.590 | -0.031 | | | |
| Yildirim (2003) | *M2* | France 1978(Q3)-1993(Q4) | JML | 1.000 | -0.008 | | -0.670 | |
| Bundesbank (1995) | *M3* | Germany 1970(Q1)-1994(Q4) | EG | 1.400 | -1.220 | | | |
| Lutkepohl and Wolters (1997) | *M3* | Germany 1976(Q1)-1996(Q4) | Stock | 1.000 | -0.582 | | | For Lutkepohl and Wolters (1997) R is spread between long term interest rate and own rate of *M3*. |
| Ewing and Payne (1999b) | *M1* | Germany 1978(Q3)-1997(Q2) | JML | 0.606 | -0.103 | 2.177 | | Ewing and Payne (1999b) find stable demand for *M1* in Germany. |
| Cassard et al. (1997) | *M3* | Germany 1979(Q2)-1990(Q2) | JML | 1.700 | -0.035 | | | |
| Yildirim (2003) | *M2* | Germany 1979(Q1)-1993(Q4) | JML | 2.210 | -0.035 | | -0.035 | Yildirim (2003) also used unification dummy variable (unification caused sharp jumps in population). The dummy estimate is -0.28. |
| Loizos and Thompson (2001) | *M1* | Greece 1963(Q2)-1998(Q3) | JML | 0.814 | -0.272 | | -0.189 | Loizos and Thompson (2001) used real industrial production to proxy real income. |

**Table 2.1 Long run Elasticities of Demand for Money in Advanced OECD Countries**

| Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Bahmani-Oskooee and Economidou (2005) | *M1* | Greece 1975(Q1)-2002(Q4) | JML | 0.750 (10.49)* | -0.003 (0.77) | | | Bahmani-Oskooee and Economidou (2005) used treasury bill rate for R. |
| | *M2* | 1975(Q1)-2002(Q4) | JML | 1.450 (3.82)* | 0.113 (4.25)* | | | |
| Ewing and Payne (1999b) | *M1* | Italy 1973(Q1)-1996(Q4) | JML | 0.960 | -0.236 | | | Ewing and Payne (1999b) find that demand for *M1* is stable in Italy. |
| Yildirim (2003) | *M2* | Italy 1980(Q1)-1993(Q4) | JML | 1.000 | -0.002 | | -3.130 | |
| Nielsen et al. (2004) | *M2* | Italy 1972(Q1)-1998(Q4) | EG | 0.62 (0.08)* | -1.04 (0.23) | | | Nielsen et al. (2004) find demand for *M2* is stable in Italy. |
| Bahmani-Oskooee and Shabsigh (1996) | *M1* | Japan 1973(Q1)- | JML | 0.62 | -0.03 | | | Bahmani-Oskooee and Shabsigh (1996) emphasize the use of nominal exchange rate to attain stable demand for money in Japan. |
| | *M2* | 1990(Q4) | | 1.02 | -0.42 | 0.33 | | |
| Amano and Wirjanto (2000) | *M2* | Japan 1967-1993 | FMOLS | 1.514 (0.037)* | -0.011 (0.005)* | | | Amano and Wirjanto (2000) find stable demand for *M2* in Japan. |
| | | | Park (1992) | 1.508 (0.033)* | -0.010 (0.003)* | | | |
| Bahmani-Oskooee (2001) | *M2* | Japan 1966(Q1)-1996(Q2) | ARDL | 1.072 (8.75)* | -0.036 (1.86)** | | | Bahmani-Oskooee (2001) find stable demand for *M2* in Japan. |

**Table 2.1 Long run Elasticities of Demand for Money in Advanced OECD Countries**

| Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Maki and Kitasaka (2006) | *M1* | Japan 1964(M1)-2003(M4) | Enders and Siklos (2001) | 0.836 (80.61)* | -0.128 (55.52)* | | | Enders and Siklos (2001) proposed TAR (threshold autoregression) tests. |
| Cesar et al. (1990) | *M1* | Netherlands 1959(Q1)-1984(Q4) | ECM | 0.90 (5.24)* | -0.21 (4.44)* | | | A cointegrating vector does not exist for *M2*, real net national product and long- and short-term interest rates. |
| Fase and Winder (1996) | *M1* | Netherlands 1970(Q1)-1994(Q4) | ECM | 0.807 (20.92)* | -0.021 (2.55)* | | -0.012 (2.47)* | Wealth variable was also significant at 5% level. The wealth elasticity for *M1*, *M2* and *M3* is 0.193, 0.407, 0.365, respectively. |
| | *M2* | | | 0.593 (8.64)* | 0.010 (1.59) | | -0.010 (1.59) | |
| | *M3* | | | 0.635 (18.56)* | 0.025 (5.16)* | | -0.015 (4.27)* | |
| Yildirim (2003) | *M2* | Netherlands 1978(Q3)-1993(Q4) | JML | 1.000 | | | -0.770 | Yildirim (2003) also used unification dummy variable (unification caused sharp jumps in population). The dummy estimate is -0.019. |
| Orden and Fisher (1993) | *M3* | New Zealand 1965(Q2)-1989(Q4) | JML | 0.410 | -0.014 | | 1.130 | Price level is used for P. |
| Valadkhani (2002) | *M3* | New Zealand 1988(Q1)-2002(Q2) | JML | 1.47 | -4.03 | -0.21 | -4.08 | R is difference between long- and short-term interest rate. |
| Choi and Oxley (2004) | *M3* | New Zealand 1988(Q3)-2000(Q2) | JML | 1.650 | 2.081 | | -1.548 | Choi and Oxley (2004) used dummy variables to capture effects of monetary policy changes. P is price level. |

**Table 2.1 Long run Elasticities of Demand for Money in Advanced OECD Countries**

| Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Bahmani-Oskooee et al. (1998) | *M1* | Spain 1974(Q1)-1992(Q4) | JML | 4.65 (9.81)* | -1.00 (12.4)* | | | Bahmani-Oskooee et al. (1998) find demand for *M2* stable in Spain. |
| | *M2* | | | 1.52 (26.8)* | -0.62 (11.7)* | 0.01 (5.00)* | | |
| Ordonez (2003) | *M3* | Spain 1978(Q1)-1998(Q2) | JML | 0.71 (0.07)* | -0.014 (0.00)* | | | *M3* demand is stable in long run but not in short run. |
| Chowdhury (1995) | *M1* | Switzerland 1973(Q2)-1991(Q4) | JML | 0.887 | | | | Chowdhury's (1995) estimate of alternative return is -0.310. |
| Ewing and Payne (1999b) | *M1* | Switzerland 1975(Q4)-1997(Q2) | JML | 1.082 | -0.468 | -0.612 | | Ewing and Payne (1999b) find stable demand for *M1* in Switzerland. |
| Gerlach-Kristen (2001) | *M3* | Switzerland 1936-1995 | JML | 1.259 | -0.221 | | | Gerlach-Kristen (2001) used Swiss interest rate spread (bond yield and deposit rate) for R. |
| Hendry and Ericsson (1991) | *M1* | United Kingdom 1964(Q3)-1989(Q2) | ECM | 1.000 | -0.630 | | | Hendry and Ericsson (1991) used net interest rate for R. |
| Drake and Chrystal (1994) | *M1* | United Kingdom 1976(Q2)-1993(Q3) | JML | 3.372 | | | -3.765 | Drake and Chrystal's (1994) income elasticity for *M2* and *M3* is around 2.6. |

**Table 2.1 Long run Elasticities of Demand for Money in Advanced OECD Countries**

| Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Ewing and Payne (1999b) | *M1* | United Kingdom 1973(Q1)-1997(Q2) | JML | 0.897 | -0.322 | | | Ewing and Payne (1999b) find demand for *M1* is stable in UK. |
| Yildirim (2003) | *M2* | United Kingdom 1978(Q3)-1993(Q4) | JML | 1.000 | -0.013 | | -0.310 | |
| Baba et al. (1992) | *M1* | United States 1960(Q3)-1988(Q3) | JML | 0.510 | -6.640 | | -5.510 | Baba et al. (1992) also used financial innovation and volatility measure of long term bond. The estimates, respectively, are -3.960 and 3.720. |
| McNown and Wallace (1992) | *M1* | United States 1973(Q2)-1988(Q4) | JML | 1.001 | -9.600 | | | |
| | *M2* | 1973(Q2)-1988(Q4) | JML | 1.128 | -1.747 | 0.131 | | |
| Ewing and Payne (1999b) | *M1* | United States 1973(Q1)-1997(Q2) | JML | 0.524 | -0.244 | | | Ewing and Payne (1999b) find that demand for *M1* is stable in US. |
| Ball (2001) | *M1* | United States 1946-1996 | JML plus 6 other techniques | 0.5 | -0.05 | | | Data reject stability of *M1* across prewar and postwar periods. |

**Notes for Table 2.1**

1. The absolute t-ratios are reported below the coefficients. * and ** denotes significance at 5% and 10 % levels, respectively.
2. *Y* is real income, *R* is nominal rate of interest, *E* is exchange rate and *P* is the inflation rate. These remain as it is unless suggested in the remarks column.
3. The semi-interest rate elasticity is reported in all cases.
4. For Nielsen et al. (2004), Amano and Wirjanto (2000) and Ordonez (2003), p-values are given in the parenthesis.
5. Not all authors have reported the significance level of the long run estimates. Therefore, for these studies we only report the long run estimates.
6. JML, DOLS, EG, ECM, ARDL represent Johansen Maximum Likelihood, Dynamic Ordinary Least Squares, Engle and Granger, Error Correction Method and Autoregressive Distributed Lag Models, respectively.

Baba et al. (1992) used quarterly data from 1960(Q3) to 1988(Q3) period to estimate the demand for *M1* for USA with the JML technique. The income elasticity is around 0.5, comparable to Ball (2001). Note that the results of Ball (2001) and Baba et al. (1992) imply that Baumol-Tobin theoretic approach is applicable (see Figure 2.1). Further, McNown and Wallace's (1992) estimate of income elasticity for the USA is around unity. On the basis of Figure 2.1, the long run estimates of Yossifov (1998) are disregarded because they are incorrectly signed. Other studies such as Hafer and Jansen (1991) and King et al. (1991) found evidence of cointegration using the JML technique and quarterly data for the period 1953(Q1)-1988(Q4). Using five time series estimators and quarterly data over 1959(Q1)-1993(Q4) period, Miyao (1996b) found that cointegration of *M2* demand may exist in the earlier sub-samples before 1990. However, evidence does not support *M2* cointegration over the full sample period. Earlier studies such as Gibson (1972) and Serletis (1987) on the USA seem to show the relevance of various estimation methods.

The findings of many time series studies on money demand in advanced countries are inconclusive. First, a number of studies have obtained implausibly high income elasticity of the demand for various monetary aggregates for advanced countries.[44] The income elasticity of narrow (broad) money demand in the advanced countries is expected to be below (below or around) unity, see Figure 2.1. Second, the measurement of variables is not accurate in some of these studies, particularly, the use of seasonally unadjusted data when testing for unit roots and cointegration.[45] Lee and Siklos (1993 & 1997) argued that seasonally unadjusted data could be used in cointegration analysis when considerable seasonal fluctuations are observed. Otherwise, the cointegrating coefficients may be biased. Third, a few earlier studies have ignored the implications of the time series methods of estimation. The absence of tests for the integrated properties of the variables implies that the findings of such

[44] See for example, de Brouwer et al. (1993) for Australia, Cassard et al. (1997) for some EU countries, Yildirim (2003) for Germany, Siklos and Eckhold (1997), Valadkhani (2002) and Choi and Oxley (2004) for New Zealand, Bahmani-Oskooee et al. (1998) for Spain, Drake and Chrystal (1994) for the UK and Yossifov (1998) for the USA. All of these studies found that the income elasticity of money demand is considerably above unity.

[45] Seasonally unadjusted data was used by for example, Scharnagl (1996) and Wolters et al. (1998).

studies cannot be relied upon.[46] Fourth, the well known *PAM* approach was widely used in earlier studies.[47] These studies and many others in the literature used the *PAM* approach to estimate the demand for monetary aggregates. It is well known that *PAM* does not allow for dynamic lag structure that is consistent with the underlying data generating process; see Taylor (1994). Finally, the variables in the money demand function could be cointegrated but the estimated cointegrating vector could be unstable.[48] Following Bahmani-Oskooee and Bohl (2000) and Rao and Kumar (2009b), I argue that once cointegration is established, formal tests for stability must be applied to determine constancy of the cointegrating vector. Thus, this study attempts to fill these gaps in the demand for money literature by applying latest time series and panel data techniques. Figure 2.1 is used to evaluate the income elasticity of money demand.

#### *2.3.2.2 Structural Changes and Money Demand in Advanced OECD Countries*

The possibility of structural change in money demand creates formidable empirical challenges and frustrating efforts to identify stable money demand function. Structural changes in the demand for money are mostly due to the financial sector reforms (even crises) and institutional changes. In principle, financial liberalisation can be captured in the money demand equation in various ways: by including dummy variables (Friedman and Schwartz, 1982), a time trend (Arrau et al., 1995; Dekle and Pradhan, 1999; Moore et al., 1990), institutionally-related variables (Akhtar, 1983; Bordo and Jonung, 1981, 1987, 1990; Klovland, 1983; Siklos, 1993), by adjusting monetary indices (Binner et al. 2004), or estimating for sub-sample periods (Ball, 2001 and Rao and Kumar, 2009b). Most importantly, the effects of

[46] Unit root tests were ignored by Brissimis and Leventakis (1981), Panayiotopoulos (1984) and Prodromidis (1984) among others.
[47] For example see, Himarios (1986) and Apostolou and Varelas (1987) for Greece and Santomero and Seater (1981) for USA.
[48] Bahmani-Oskooee and Bohl (2000) and Rao and Kumar (2009b) argued that existence of cointegration does not imply stability of the long run cointegrating equation. Many studies interpret their finding of cointegration as a sign of stable demand for money, for example see, Arestis (1988), Karfakis (1991), Papadopoulos and Zis (1997) and Karfakis and Sidiropoulos (2000).

structural changes could be adequately captured if relevant structural change tests are performed, for example, Hansen (1992) and Gregory and Hansen (1996a & b).

Felmingham and Zhang (2001) found a stable *M2* demand function for Australia over 1976-1998 period subject to a regime shift occurring at 1991. They interpret the break date as the 1991 recession in Australia. Brissimis et al. (2003) examined the behaviour of the demand for money in Greece over the period 1976(Q1)-2000(Q4). The vector error correction (VECM) and second-generation random coefficients models confirm that financial liberalisation had significant effects on the demand for *M3* in Greece. In particular, the income elasticity of *M3* declined overtime as a result of technological improvements in the payments system and the development of money substitutes.

Nagayasu (2003) used quarterly data over 1958(Q3)–2000(Q4) period to analyse the effects of structural changes on the stability of Japanese demand for *M2* (*M2* plus certificates of deposits of private corporations, individuals, and local governments). Using Hansen's (1992) parameter instability tests, they found a structural shift located in 1992 that appears to have resulted from the bursting of the 'bubble' and the economy going into recession. Similarly, Corker (1990) inferred that wealth effects and opportunity cost of holding broad money were strongly influenced by the rapid pace of financial reforms in Japan during the period 1986-88. In contrast, Sekine (1998) showed that the underlying demand for *M2* has been stable in Japan, despite the introduction financial liberalisation policies. Sekine utilised quarterly data over 1975(Q1)-1994(Q4) period and the ARDL technique. Nakashima and Saito (2007 & 2004) also provide useful discussion on varying interest elasticities using break points within the error correction models.

Choi and Sosin (1992) applied the Generalized Axiom of Revealed Preference (GARP) approach to identify the structural shifts in the demand for monetary aggregates for the USA. Using quarterly data for the period 1969(Q1)-1985(Q1), they found structural shifts in 1976 (Q1) and 1982(Q3). Beck et al. (2001) utilised the Fourier approximation to test for structural changes in the *M3* demand for the

USA over the period 1959(Q1)–2001(Q1). They observed an unstable relationship between *M3*, real income, price level and the short-term interest rate. However, by including the time-varying intercept in the model did result in a stable money demand function. Breuer and Lippert (1996) performed the structural break tests of Gregory and Hansen (1996a) to the USA quarterly data over the period 1961(Q2)-1990(Q4). For credit money measure, the results indicated that a stationary money demand relationship exists after accounting for a structural break at 1980(Q1). For *M1*, there is a structural break occurring in 1975(Q2) implying that *M1* demand is stationary. However, they found no support for stationarity in the *M2* demand.

Orden and Fisher (1993) and Siklos and Eckhold (1997) examined the impacts of financial innovations on the money demand for New Zealand. Orden and Fisher (1993) analysed the dynamic impacts of financial deregulation in the 1980s on money, prices and output for New Zealand and Australia. They used quarterly data over 1965(Q2)-1989(Q4) period. Utilising the JML tests, they found that there exists one cointegrating vector among the non-stationary money, prices and output series prior to financial liberalisation in both countries. Moreover, the series for New Zealand are cointegrated over the full sample period when the effects of deregulation are accounted for by a deterministic shift parameter. The estimated coefficients are similar in the pre-liberalisation and full-sample periods, implying that the demand for *M3* have been stable in New Zealand.

Siklos and Eckhold (1997) specified two models to capture the behaviour of *M3* velocity for New Zealand. In the extended velocity model, they included a number of proxies for institutional changes and asserted that financial deregulations had a significant impact on the demand for *M3*. Choi and Oxley (2004) used three dummies to capture the impacts of some key events relevant to the monetary policy developments in New Zealand. Essentially, these dummies are forms of intercept shifts in the *M3* relationship, and they are statistically significant at the conventional levels.

Oxley (1983) used quarterly data over the 1963(Q1)-1979(Q4) period to examine demand for *M1* and *M3* for the UK. The Box-Cox routine developed by Huang et al. (1978) and the Local *F,* Chow and $\chi^2$ tests were used to identify the structural instability in *M1* and *M3* relationships. The *M3* demand function exhibits structural instability from 1972(Q1), while the *M1* instability occur only at 1972(Q4). Choi and Jung (2009), using quarterly data (1960Q1 to 2000Q2) found that there are two breaks in the USA demand for money i.e. 1974Q2 and 1986Q1. They have used the Bai and Perron (2003) and JML tests.

Recognizing the gaps in Ball (2001) and Choi and Jung (2009), Rao and Kumar (2011a) examined the demand for *M1* for USA using annual data from 1962-2008. The Gregory and Hansen tests were applied to identify the structural changes in *M1* and its determinants. They found that *M1* relationship has been largely stable but there was a downward intercept shift in 1998. Financial reforms have reduced the demand for *M1* by about 2 to 2.5% annually and the response to the cost of holding liquidity has remained at about -0.36.

Hansen and Kim (1995) found little evidence against a cointegrated *M3* money demand function in Germany for the period 1990(Q1)-1992(Q4). In contrast to this result, cointegration is rejected for *M1* and its determinants for the period 1960(Q1)-1992(Q4).The Hansen (1992) tests provide evidence against stability of *M1*. The SupF test indicated a breakpoint in 1973 which highlights the changes in the monetary regime. For *M3* demand, although the SupF test identifies a break in 1990, the *M3* demand relationship is stable. They concluded that monetary targeting based on *M3* would be a viable strategy for stabilizing the price level.

Mariscal et al. (1995) used quarterly data over 1963(Q1)-1990(Q2) period for Germany and the UK to examine the demand for *M3* and *M4*, respectively.[49] Using

[49] In this case, *M3* = currency in circulation + sight deposits + time deposits for less than 4 years + savings deposits at statutory notice. *M4* = currency in circulation + sight deposits + time deposits + building society shares, deposits and CDs.

the EG and JML techniques, the income elasticity is much closer to unity (1.177) in the German case than for the UK (1.686). In the long run equations, the risk term and the own rate of money are observed to be significant for the UK but not for Germany. They asserted that this finding is not surprising given the level of financial innovations in the UK since 1970s.

Other key studies that investigated the impacts of structural changes (mostly due to financial reforms and deregulation) on money demand are Asano (1999) and Hoque and Al-Mutairi (1996) for Australia, Komlos (1987) for Austria, Dooley and Spinelli (1989) for France and Italy, Ericsson and Sharma (1998) for Greece, Maudos (1995) for Spain, Valadkhani (2003) for NZ, Orden and Fisher (1993) for Australia and New Zealand, Amano and Wirjanto (2000) for Japan, and Clark (1973) and Hoffman et al. (1995) for Canada. The impact of German re-unification on the money demand also received vast attention, for example, see Lutkepohl et al. (1999), Hamori and Hamori (1999) and Herwatz and Reimers (2003). Ball (2001) examined the pre- and post-war impacts on *M1* demand for the USA, and motivated by Ball's findings, Choi and Jung (2009) and Rao and Kumar (2011a) further investigated these issues.

There are limitations in most of these studies that have attempted to analyse the structural changes in the demand for money. Some have used the dummy variables to capture the reform impacts, however, such approach does not provide information about shifts in the intercept and regime or both, for example see, Choi and Oxley (2004), Hayo (2000) and Hoffman and Rasche (1991). Gregory and Hansen (1996a & b) have proposed four models of structural changes and these are useful to determine and measure the breaks in the cointegrating vectors.[50] Recent study that utilised this approach is Felmingham and Zhang (2001). Unlike Gregory and Hansen, other structural change techniques like Zivot and Andrews (1992), Bai and Perron (1998 & 2003) and Lee and Strazicich (2003 & 2004) are tests for breaks in the non-stationary process. Narayan and Narayan (2008), Narayan et al. (2009) and

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[50] See Section 3.6.1 for details on these models.

Choi and Jung (2009) are examples of empirical studies that have used the unit root structural break tests. To provide more clarity on when to apply various unit root and cointegration tests, I developed flowcharts in Chapter 3 for this purpose. Therefore in this study I shall use the Gregory and Hansen (1996a & b) and Westerlund (2006) structural change tests. The next section reviews empirical studies on the demand for money in developing countries.

### *2.3.3 Money Demand in Developing Countries*

#### *2.3.3.1 Time Series Studies from Developing Countries*

In what follows, I discuss the main findings of the time series studies on the demand for money that focused on developing countries. As illustrated in Figure 2.1, it is reasonable to expect that the income elasticity of money demand in developing countries to be around unity (or slightly above). Such income elasticity would imply underdeveloped financial markets where most transactions are performed using the narrow money. The interest rate elasticity of money demand is expected to be negative with very small magnitude. The financial reforms may influence the long run elasticities of money demand, however, it is always useful to evaluate the nature of such reforms and the ways they have been implemented.

The main findings of selected money demand studies from developing countries are reported in Table 2.2; see pages 85-94 below. Table 2.2 also shows the variations between individual studies in relation to their nature of monetary aggregates, country and sample size, econometric methods and long run elasticities.[51]

Diz (1970) provides an empirical investigation into Argentina's money demand function between 1935 and 1962, using the OLS regressions and Chow tests; the study confirmed a stable money demand function in Argentina. Ericsson and Kamin (2008) builds on Kamin and Ericsson's (1993) model of the demand for *M3* using monthly data from 1977(M1)-1993(M1). Using the ECM tests, they found

[51] Studies from Table 2.2 are also included in the meta-regression analysis.

cointegration between *M3*, inflation, interest rate and the exchange rate depreciation. Choudhry (1995a) empirically examined the long run demand for *M1* and *M2* for Argentina over the periods 1935-1962 and 1946-1962.[52] Choudhry (1995a) found that real income is purely exogenous in the money demand equations. This implies the existence of a Cagan-style high inflation demand for money function in Argentina. The Cagan (1956) model of real money demand under conditions of hyperinflation states that changes in real money balances in hyperinflation result from variations in the expected rate of change in prices only. The income elasticity of *M1* demand is 1.97 and 1.91 and for *M2* demand is 1.68 and 3.45, respectively, for the two periods, see Table 2.2. Following Figure 2.1, I argue that these income elasticities are implausibly high for a developing country. Results from the error correction models provide evidence of bi-directional causality between the real money balances and the inflation rate.

Bangladesh has quite a few empirical works on money demand. Siddiki (2000) used annual data from 1975 to 1995 to estimate the demand for *M2* for Bangladesh with the ARDL procedure. His estimate of the income elasticity is implausibly high at around 3.3 (see Table 2.2). The implied interest rate elasticity has the expected negative sign and its magnitude is plausible but the coefficient of the proxy for the effects of the foreign interest rate is insignificant at the conventional levels. Hossain (2006) estimated demand for *M1* and *M2* for Bangladesh using the PAM approach. [53] The findings support quantity theory conclusion, i.e. the income elasticity of demand for *M1* is significant and around unity (see, Table 2.2). The interest rate elasticity has correct negative sign but is statistically insignificant at conventional levels. Further, the *CUSUMSQ* stability tests indicated that the demand for *M1* is unstable during the

[52] Ahumada (1992) examined the demand for *M1* for Argentina using data for the period 1977-1988. The cointegration techniques of EG and JML showed that real *M1*, income and inflation are cointegrated. The selected models appear to be stable despite the major policy changes in Argentina during 1985-1988. For a discussion of monetary policy in the Argentine economy, see Howard (1987), Kamin (1991), Kiguel (1991), Manzetti (1991), Beckerman (1992), Helkie and Howard (1994) and Dominguez and Tesar (2007).

[53] Another study by Hossain (1993) on the demand for money for Bangladesh contains similar findings. Using quarterly data from 1976(Q1) to 1989(Q4), he found that the income elasticity for *M1* demand was 0.63.

period 1973 to 2003, but when the model is estimated for the sub-sample period 1985 to 2003, it is found to be stable, indicating significant structural changes.

Recently, Rao and Kumar (2009a) have used the Gregory and Hansen technique for structural breaks to estimate the demand for *M1* for Bangladesh for the period 1973 to 2003. They found income elasticity of *M1* demand around 1.26. An important implication of their study is that the demand for *M1* function is stable in Bangladesh. Kumar (2007) estimated the *M1* demand for Bangladesh using the GETS and JML techniques. He used annual data from 1973 to 2003. Both estimators gave income elasticity of *M1* demand around unity, consistent with Figure 2.1. His *CUSUM* and *CUSUMSQ* stability tests showed that the demand for *M1* is stable and therefore monetary targeting is feasible in Bangladesh. Both studies (Rao and Kumar, 2009a and Kumar, 2007) adopted the theoretical insights of Poole (1970), i.e. the central bank should use the rate of interest (supply of money) when the money demand is unstable (stable).

Following the influential study by Mundell (1963), Bahmani-Oskooee and Rehman (2005) included the exchange rate into the specification of the demand for money. They estimated the *M1* demand for seven Asian countries (India, Indonesia, Malaysia, Pakistan, the Philippines, Singapore and Thailand) using quarterly data over 1973-2000 period.[54] Using the ARDL technique they achieved less than unity income elasticities for India, Thailand and the Philippines. Further their *CUSUM* stability tests showed that the demand for *M1* is stable in all the selected countries. However, using *CUSUMSQ* stability tests, the money demand functions for India, Malaysia and Pakistan showed some instability.

Generally, there is no evidence of instability in the demand for money in the African countries, see for example, Arize et al. (1990), Fielding (1994) and Nachega

[54] They assumed that the real *M1* demand is a function of the index of industrial production (proxy for real income), rate of inflation, and the exchange rate.

(2001).[55] Fielding (1994) extended the classical money demand function to include terms reflecting the variability of real rates of return. Specifically, he used quarterly data to estimate the *M2* demand for four African countries viz. Cameroon, Nigeria, Ivory Coast and Kenya. The JML procedure was used to test and estimate the cointegrating equations. The income elasticities for Cameroon, Nigeria and Ivory Coast are 1.5, 0.72 and 1.58, respectively, see Table 2.2. For Kenya, three cointegrating vectors were attained and income elasticity was statistically insignificant. Fielding's findings imply that given the degree of heterogeneity in the selected four countries, it would be difficult to formulate an efficient monetary policy which is invariant for all countries (monetary union). To this end, different policies would be appropriate for different countries.

Arize et al. (1990) used the TSLS technique to estimate demand for *M1* for seven African countries for the period 1960 to 1987. These countries are Egypt, Gambia, Mauritania, Morocco, Niger, Nigeria and Somalia. The demand for *M1* was assumed to be a function of real GDP, inflation rates, foreign interest rates, expected exchange rates, and capital mobility. The coefficient of capital mobility is statistically insignificant at conventional levels in all cases. Note that their income elasticities range between 0.2 to 0.5. Based on Figure 2.1, these estimates of income elasticities are considered as implausibly low for developing countries. On the stability front, they found a stable money demand relationship in these countries. The results of Arize et al. (1990) cannot be relied upon because they ignored the implications of the time series properties of the variables.

For the purpose of testing stability of *M2* demand, Bahmani-Oskooee and Gelan (2009) used quarterly data over 1971(Q1)-2004(Q3) period for 21 African countries.

[55] Nachega (2001) applied the error correction model to investigate the stability of the demand for *M2* in Cameroon from 1963 to 1993. The income elasticity was unity and the demand for *M2* was found to be stable. Karanja (2006) used the Two Stage Least Squares (TSLS) technique to examine the demand for *M1* for Kenya over 1967-2005 period. The income elasticity was around unity, see Table 2.2. Adam (1992) successfully established a series of single-equation demand for money functions (*M0, M1, M2* and *M3*) for the Kenyan economy from 1973 to 1989. The JML method offered the income elasticities around unity for *M0* and slightly low at around 0.8 for other monetary aggregates. He found that the demand for *M1* is stable.

The list of countries include Burkina Faso, Burundi, Cameroon, Cote d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Kenya, Madagascar, Mauritius, Morocco, Niger, Nigeria, Rwanda, Senegal, the Seychelles, Sierra Leone, South Africa, Tanzania, and Togo. Using the ARDL technique, they obtained a long run relationship between *M2*, the inflation rate, income and the nominal effective exchange rate for all countries. Application of the *CUSUM* and *CUSUMSQ* tests revealed that the estimated models are stable in all cases. For Ghana, Ghartey (1998a) also found a stable money demand function.[56] Thus, majority of these existing studies seems to support the use of monetary aggregates in achieving inflation stability in Africa.

The links between money demand and monetary policy is well investigated by Hafer and Kutan (1994) for China. For the monetary aggregates *M0* and *M2*, the JML technique provides income elasticity of 1.1 and 1.3, respectively. Further they suggested that *M2* demand is a better guide for monetary policy, and this is consistent with findings from Hafer and Jansen (1991) and Hallman et al. (1991) for the USA. Deng and Liu (1999) used quarterly data over the 1980(Q1)-1994(Q4) period to examine the demand for *M1* and *M2* for China within an ECM framework. The income elasticity for *M1* and *M2* is nearly 1.3 and 1.8, respectively, see Table 2.2. Their estimated money demand function appears to be stable and they concluded that the monetarization process is not complete and alternative assets are limited in China. To this end, they argued that the financial markets are not fully developed to absorb the excess money.

Arize and Malindretos (2000) analysed the effect of volatility of inflation on real money balances (*M0*, *M2* and *M3*) for China. As inflation uncertainty increases, it

[56] Ghartey (1998a) estimated the demand for money in Ghana using the EG as well as the JML techniques. Simmons (1992) estimated the *M1* demand for five African countries (Democratic Republic of the Congo, Cote d'Ivoire, Mauritius, Morocco and Tunisia) within an ECM framework. In the case of Cote d'Ivoire, Mauritius and Morocco, he found that the domestic interest rate played a significant role in explaining the demand for *M1* in the long run. Sterken (2004) used quarterly data over 1966(Q4)-1994(Q4) period to estimate the *M1* demand for Ethiopia. Using the JML method, he identified a long run equilibrium relationship between real per capita money demand, real per capita GNP, shortage and the real export price of coffee. The income elasticity exceeds unity and there is some evidence of instability in *M1* demand during the period 1974–1975, perhaps due to changes in political regimes and natural disasters.

may affect the demand for money in opposite directions i.e. it will increase the precautionary demand, and on the other hand, the risk of holding real money balances rises relative to other assets, inducing changes in portfolio composition and substitution away from real balances. Using data for the period 1952-1994, Arize and Malindretos found that inflation variability is vital in modelling the money demand for China. Their income elasticities range between 1.1 and 1.6 (with FMOLS and JML). The evidence from Hansen's (1992) stability test indicates that *M2* may be a better measure of monetary policy. Baharumshah et al. (2009) shed light on the cointegrating properties of *M2*, income, interest rate, and stock price for China using the JML technique. Using quarterly data over 1990(Q4)–2005(Q3) period, they extended the conventional money demand to include stock prices. The initial income elasticity of *M2* (0.65) was constraint to unity, see Table 2.2. This finding implies that Friedman's (1988) rule is optimum in the case of China, i.e. money supply should grow at the same rate as output to achieve the goal of price stability. Further, they found that the inclusion of stock prices is important for the stability of *M2* in China. Other studies on money demand in China are Chow (1987), Portes and Santorum (1987), Feltenstein and Farhadian (1987), Blejer et al. (1991) and Chen (1989 & 1997).[57]

Relatively fewer empirical attempts have been made to analyse the Chilean money demand. Ewing and Payne (1999a) draws attention to the omitted variable bias in the demand for money. They pointed out that for the purpose of attaining a stable money demand function, New Classical monetary models, and even some New Keynesian and real business cycle models incorporate inflation and the general price level.

[57]Hafer and Kutan (1993) provided a good overview of the earlier studies on money demand in China. Chow (1987) estimated a simple money demand function (*M1*) derived from the quantity theory. Using annual data for the period 1952-1982, he concluded that the quantity theory holds for China. Portes and Santorum (1987) used the Granger Causality tests and real and nominal adjustment specifications to examine the homogeneity of money demand with respect to price level and real income. Feltenstein and Farhadian (1987) estimated the money demand based on Cagan's work. Blejer et al. (1991) estimated an ECM model using data for only 1980s. Feltenstein and Farhadian (1987) and Blejer et al. (1991) found that the demand for real money balances depend on real income and opportunity cost measures. Chan et al. (1991) used data from 1952-1987 and OLS estimator to confirm that interest rates and anticipated inflation are important determinants of *M1* demand in China. Chen (1989 & 1997) also made similar conclusions.

Goldfeld (1976) also documented the periods of 'missing money' using the USA data. In the context of Chilean money demand, Ewing and Payne found that omission of exchange rate will create instability in the Chilean money demand function. It is also likely that the estimates of income elasticity will not be robust due to this omission, see Figure 2.1. They found that the *M1* and *M2* aggregates are stable in Chile when exchange rate is incorporated in the model. The JML technique provided income elasticity of around 0.8 and 1.4, respectively (see Table 2.2).

Sanchez-Fung (2007) analysed the role of monetary and open economy indicators for two inflation targeting Latin American countries: Chile and Mexico. The nested P-star/Phillips curve model was estimated. This model is a mixture of a Phillips curve and a price gap model of inflation in which the actual and expected inflation rates, output and potential output, and actual and long run real money balances are estimated empirically. Using monthly data over 1991(M1)-2001(M7) and 1988(M1)-2001(M6) periods, respectively for Chile and Mexico, the ARDL technique provided income elasticity of *M2* as 1.72 and 1.38. The main findings reveal that for Chile and Mexico real money gap and real output indicators contain significant information on deviations of inflation from the target. In contrast, for Mexico diverse real exchange rate indicators are consistent and relevant in predicting the inflation gap. Other studies on money demand for Chile are Hynes (1967), Arrau and Gregorio (1993), Adam (2000) and Soto and Tapia (2001).[58]

Taylor (1993) proposed that central banks should set relatively high interest rate when inflation is above its target and a relatively low interest rate in the opposite situations. Many existing studies support the Taylor rule thereby recommending the central banks to adjust the short-term interest rates. An example is Katafono (2001).

[58] Hynes (1967) found that Chilean real money balances (*M1* and *M2*), real income and the cost of holding money have undergone large variation through the period 1935-1960. Arrau and Gregorio (1993) examined the demand for *M1* using quarterly data for Chile (1975-1989) and Mexico (1980-1989). They argued that financial innovation should be included in the money demand specification. Adam (2000) examined the transactions demand for money in Chile over the period from 1986 to 2000. Using the JML technique, he surmised that money demand is conditioned on real wealth, real income, and the nominal interest rate. The recent study by Soto and Tapia (2001) found that the estimated demand for money in Chile is remarkably stable throughout the 1977 to 2000 period.

She employed annual data from 1975-1999 to estimate the demand for *M1* and *M2* for Fiji with the JML technique. She obtained implausibly low income elasticities (at around 0.6 for *M1* and 0.5 for *M2*) and asserted that the demand for *M1* and *M2* is temporally unstable. Therefore, her findings support the use of rate of interest policy in Fiji. However, her results were refuted by Rao and Singh (2005a). Rao and Singh (2005a) have applied the GETS and JML techniques with annual data for Fiji from 1971 to 2002. They found that demand for *M1* in Fiji is stable and well-determined.[59] The implied income elasticity is around unity and semi-interest elasticity is also plausible, see Table 2.2. Later, Rao and Singh (2005b) have used Hendry and Krolzig's (2001) PcGets software and arrived at the same conclusion about the income and interest rate elasticities. Rao and Singh (2005a & b) support Poole's (1970) analysis and identify money supply as the appropriate instrument of monetary policy.

Recently, Rao and Kumar (2007) used the Gregory and Hansen procedure to test the stability of the demand for *M1* in Fiji for the period 1970 to 2002. Their findings support the quantity theory of the demand for money. Most importantly, they found stable demand for *M1* in Fiji despite the presence of structural breaks in the model. In contrast, Narayan and Narayan (2008) failed to find any evidence for a long run relationship of *M1*. They used data for the period 1971-2002 and the ARDL technique. In the second stage, they applied the Bai and Perron (1998) structural break tests and found unstable demand for *M1* in Fiji. Narayan and Narayan's findings support the Taylor rule i.e. the use of the rate of interest to control inflation in Fiji. For an overview of other empirical studies on money demand in Fiji, see Rao and Singh (2005a).[60]

For India, many empirical studies found that the money demand relationships are stable. This implies that the scale economies with respect to the money demand have

[59] Similar findings were attained by Jayaraman and Ward (2000) and Singh and Kumar (2010) that the demand for money is stable overtime in Fiji.
[60] These are Luckett (1987), Jayaraman and Ward (2000), Kumar (2010a) and Singh and Kumar (2010 & 2011). Studies prior to Rao and Singh (2005a) have limitations and these are well detailed in Rao and Singh (2005a).

not improved significantly. Clearly, many studies support the Friedman rule or the quantity theory of the demand for money, which is consistent with Figure 2.1. For instance, see Moosa (1992), Pradhan and Subramanian (1997), Das and Mandal (2000), Ramachandran (2004) and Rao and Singh (2005c). An interesting study by Pradhan and Subramanian (1997) used annual data for the period of 1960-1994 and ECM tests to detect relationships among real money (*M1* and *M3*), real GDP, and nominal interest rates. They found no instabilities in the demand for *M1* and *M3*. Similar findings were also attained by Das and Mandal (2000) and Ramachandran (2004) for *M3* demand for India. Recently, Rao and Singh (2005c) and Inoue and Hamori (2008) re-investigated the money demand relationships for India using more up-to-date data. Rao and Singh (2005c) estimated the demand for *M1* for India with annual data from 1953 to 2003. Using the JML technique they found the income elasticity of *M1* demand about 1.2 and the semi-interest rate elasticity is about -0.02, see Table 2.2. Moreover, they found a stable *M1* demand for India and hence propose that monetary targeting is feasible. Inoue and Hamori (2008) utilised two data sets comprising the monthly data from 1980(M1)-2007(M1) and annual data from 1976-2007. The DOLS and JML tests indicated that an equilibrium relationship in money demand exists, only when money supply was defined as *M1* and *M2* and not for *M3*. Consequently, they suggested that India's central bank should focus on *M1* or *M2*, rather than *M3*, in formulation of their monetary policy.[61]

For five Asian countries (Malaysia, Thailand, Singapore, the Philippines and Indonesia), Yu and Gan (2009) estimated the demand for *M1* and *M2* using monthly data 1987(M1)-2007(M4). The EG method revealed that there exists a long run and short run dynamic equilibrium relationship between the monetary aggregates (*M1* and *M2*), real income, interest rates, inflation rate and lending rates. They found that money demand is stable across the five countries and they emphasize the use of

[61] Moosa (1992) performed cointegration tests for *M1* and *M2* money balances, short-term interest rates, and industrial production with quarterly data over the period 1972(Q1)-1990(Q4). The main findings imply that narrower definitions of money supply are better for pursuing monetary policy. A similar approach was taken by Bhattacharya (1995). Using annual data from 1950-1980, Bhattacharya estimated *M1*, *M2* and *M3* demand within an ECM framework. Other studies, for example, Bhattacharya (1974), Kamath (1985), Nag and Upadhyay (1993), Parikh (1994) and Rao and Shalabh (1995) also found that real money demand balances are stable in India.

narrower or broader definitions of money to achieve inflation stability. Earlier, Dekle and Pradhan (1999) also obtained a stable money demand function for these countries over the period 1974-1995.[62] Using the JML tests, Dekle and Pradhan (1999) found that *M2* demand and its determinants are cointegrated for four Asian countries (Indonesia, Malaysia, Singapore and Thailand). The financial reforms were proxied with time dummy variables.

James (2005) extended the conventional specification of money demand (see Goldfeld, 1992) to analyse the effects of financial reforms on Indonesia. He used quarterly data over 1983(Q1)-2000(Q4) period and found that the proxies for financial reforms and deterministic trend are vital for modelling the *M2* demand. The ARDL based income elasticity is around 1.5 (see Table 2.2) and the results support stability of *M2* demand in Indonesia. Recently, Narayan (2007) examined the money demand for Indonesia utilising the cash-in-advance model. Cash-in-advance models assume that transactions take place only if money required for those transactions are held in advance (Clower, 1967). In such models the specification of the transactions subject to the liquidity constraint is important. Following Hueng (1998), Narayan (2007) estimated Indonesia's demand for *M1* and *M2* functions over the period 1970–2005. The JML technique confirmed that both monetary aggregates are cointegrated with real income, real exchange rate and short-term domestic and foreign interest rates. The stability results are contrary to Dekle and Pradhan (1999), Anglingkusumo (2005) and James (2005).[63] Narayan's findings provide support for

[62] For five South East Asian countries, Tang (2007) found that the demand for *M2*, disaggregated components of real income (final consumption expenditure, expenditure on investment goods, exports), exchange rate and the rate of inflation are cointegrated for Malaysia, the Philippines, and Singapore. However, the same result does not hold for Indonesia and Thailand. The sample periods are Malaysia (1961-2004), Singapore (1972-2005), the Philippines and Thailand (1961-2005) and Indonesia (1967-2005). The ARDL technique provided evidence of stable money demand functions for all countries, except Indonesia.

[63] Price and Insukindro (1994) used the EG technique to obtain an income elasticity of *M1* as 1.3 for Indonesia. McNelis (1998) also made useful conclusions about financial distress and money demand. In particular, McNelis (1998) used monthly data (1984-1997) to examine the demand for currency and quasi-money for Indonesia. Anglingkusumo (2005) used quarterly data and JML technique to estimate demand for *M1* for Indonesia for the period 1981 to 2002. The major finding of their study is that *M1* demand is stable in Indonesia.

the Taylor rule i.e. rate of interest is the optimal instrument of monetary policy to stabilise inflationary pressures in Indonesia.

The Iranian economy also received some empirical attention on this topic.[64] Following Lucas and Stokey (1983), Moradi (1999) constructed a money demand function using the cash-in-advance model with the purpose of examining the relationship between seigniorage revenue and inflation in Iran. Annual data over 1961-1996 period was used. The JML based income elasticity of *M0* is implausibly high as 2.4, see Table 2.2. They found evidence of a Laffer curve relationship between seigniorage revenue and the rate of inflation. This implies that the actual rate of inflation generally exceeded the corresponding rate that would maximize the seigniorage revenue. To this end, higher seigniorage revenue could be attained through maintaining the rate of inflation at lower levels.

In the context of Israel, Melnick (1995) found that financial services play a crucial role in the cointegrating relationship of money demand. Melnick illustrate the usefulness of measuring financial services by components such as the share of business sector employees in the banking system, the per capita number of automatic teller machines, the per capita area of the branches in the banking system, the standard deviation of inflation over time and the expected rate of inflation. The main finding implies that the long run money demand relationship is stable even after the period of the Israeli stabilization program in 1985. Yashiv (1994) found that following the acceleration of inflation during the 1970s and 1980s, and the introduction of liquid, interest-bearing or indexed assets, there ocurred a shift in the money demand function for Israel. The elasticity of money demand with respect to

[64] Bahmani-Oskooee (1996) examined the Iranian *M2* demand over the period 1959-1990. He applied the JML technique and found that the *M2* demand is cointegrated with real income, inflation rate, and the black market exchange rate. Tabesh (2000) used Bahmani-Oskooee's (1996) specification of money demand to examine the demand for *M1* and *M2* for Iran over 1959-1991 period. Their findings suggest that the estimated *M1* and *M2* demand equations fit the data fairly well and exhibit structural stability over the sample period. Hamid and Hosein (2007) used quarterly data over 1985(Q3)-2006(Q1) period to investigate the stability of the demand for *M1* and *M2* for Iran. The JML results do support for cointegration but the estimated income elasticity is implausibly high. By incorporating stability tests, they found that the *M1* demand is stable but not *M2*.

the interest rate is smaller than unity and the inflation tax is indeed a credible explanation for this.[65]

For Jamaica, Ghartey (1998b) found that a long run equilibrium relationship exists among *M1* demand, real income, prices, interest rates, exchange rates, and exchange rate risk. Using quarterly data over the 1961(Q2)-1993(Q4) period, the six estimators including JML provided around unit income elasticity, see Table 2.2. This finding supports the quantity theory of the demand for money, see Figure 2.1. Further, the stability tests indicated that the demand for *M1* is stable in Jamaica. Atkins (2005) used the JML technique to estimate the demand for *M2* for Jamaica over the period 1962 to 2002. The income elasticity of *M2* is 1.56, see Table 2.2. Using *CUSUM* and *CUSUMSQ* stability tests, they found that there exists a stable demand for broad money in Jamaica.[66]

Marashdeh (1998) used JML technique to estimate the demand for *M1* for Malaysia with quarterly data from 1980(Q1) to 1994(Q10). The Chow tests yield a stable demand for *M1* for Malaysia. Similar findings were attained by Marashdeh (1997), Majid (2004) and Hussain and Liew (2006).[67] Nair et al. (2008) utilised the ARDL technique and found that the demand for *M1*, *M2*, and *M3* are cointegrated with real

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[65] Kogar (1995) used quarterly data for Israel for the period 1977(Q1) to 1988(Q4) to estimate the demand for *M1* and *M2*. The implied income elasticity is around 0.5 and 0.3, respectively. These long run elasticities are consistent with Choudhry (1995b). Choudhry (1995b) attempted to determine whether there exists a stationary long run money demand (*M1* and *M2*) functions for Argentina, Israel and Mexico. The time period involved ranges from the mid 1970s to the late 1980s. The JML tests provided strong support for a stationary function in all the three countries. Recently, Offenbacher and Kamel (2007) provided new estimates of the demand for *M1* for Israel for the period 1990- 2006. Their findings suggest that from 2003 to 2006, the quantity of *M1* increased by an accumulated rate of 62 percent, well above than the increase in GDP and the inflation target. This is mainly due to the sharp reduction in interest rates and the increase in real GDP.

[66] Recently, Luciano (2006) investigated the demand for *M1* for Jamaica with data from 1962-1997. The ARDL method provided income elasticity at around 1.1. Bynoe (2002) also support the existence of cointegration of real money balances in Jamaica. Bynoe's analysis considered the impact of financial reforms on various monetary aggregates in Jamaica.

[67] Majid (2004) examined the money demand in Malaysia from 1974 to 2001, a period characterised by various events particularly the financial sector liberalisation, changes in monetary policy framework and currency crises. Their results support the existence of a stable long run money demand function despite the various changes and developments in the economy. They argued that monetary targeting framework in Malaysia seems to be appropriate and monetary aggregate should continue to be a useful long-term indicator in the formulation of monetary policy. Similar conclusions were made by Hussain and Liew (2006).

income, interest rate and the price level. The data over 1970-2004 period was used. In all cases, the monetary aggregates are structurally stable, which implies that monetary targeting could be an option in monetary policy decisions. Tan (1997) estimated the demand for *M0*, *M1* and *M2* using the JML and GETS techniques for the period 1973(Q1)-1991(Q4). The findings imply that liberalisation and innovation in the Malaysian financial system have not ruled out the existence of stable long run money demand relationships, however, the short run relationships have become unstable. Dahalan et al. (2005) used quarterly data for the period 1976(Q1)-2001(Q4) to estimate the demand for *M1* and *M2* for Malaysia. They used the JML technique. They found that *M2* demand is more stable and useful in predicting inflation and real economic activity. Other empirical studies such as Semudram (1981), Habibulah and Ghaffar (1987), Habibulah (1989) and Ibrahim (1998 & 2001) supports the existence of cointegrating relationships of money demand in Malaysia.

Thornton (1996) used the ECM approach to estimate the demand for *M1* and *M2* for Mexico. The results favour *M2* as the monetary aggregate to be used for policy in Mexico. Khamis and Leone (1999) used the JML technique to estimate the demand for *M1* for Mexico with quarterly data from 1983(Q1) to 1997(Q6). They obtained an income elasticity of around 0.45. In view of Figure 2.1, this estimate of income elasticity is implausibly low for a developing economy. Cuthbertson and Galindo (1999) analysed the demand for *M1* and *M3* and in particular the presence of a portfolio balance effect for Mexico over the period 1978 to 1990. The empirical evidence indicates that there is a stable money demand function even when data from the 'crisis period' of the 1980s is included.[68] Arrau and Gregorio (1993) and Turner and Benavides (2001) provided comprehensive details on the demand for money and monetary policy in Mexico.

Hoffman and Tahiri (1994) used Moroccan quarterly data over 1959(Q1)-1988(Q2) period to show that the Swiss treasury bill rate can adequately serve as a proxy for

[68] Ramos-Francia (1993) also found that money demand is remarkably stable in Mexico.

the opportunity cost of maintaining the domestic Moroccan dirham balances. For *M1* and *M2*, the stochastic and deterministic trend is important for stability purposes. Their results provided considerable evidence of stability in *M1* and *M2* demand and thus support the use of monetary aggregates in attaining inflation and macroeconomic stability.

Recent empirical studies on money demand in Nigeria are Arize et al. (1990), Fielding (1994), Nwaobi (2002), Anoruo (2002), Akinlo (2006), Teriba (2006) and Owoye and Onafowora (2007).[69] Akinlo (2006) examined the *M2* demand with quarterly data over 1970(Q1)- 2002(Q4) period for Nigeria. The income elasticity is around unity with the ARDL technique, thus supporting the quantity theory of money demand. With respect to stability, the results showed that the *M2* demand is stable. Teriba (2006) estimated the demand for *M1* for Nigeria with quarterly data over 1960(Q1)-1995(Q4) period. The long run transactions' responses of the demand for *M1* significantly exceeded unity, suggesting that *M1* is a luxury good in the long run. Most vitally, they found that the *M1* demand relation is stable in Nigeria. Recently, Owoye and Onafowora (2007) employed JML technique with quarterly data from 1986(Q1) to 2001(Q4) to examine the demand for *M2* in Nigeria. Their findings suggest that income elasticity is approximately 2.1 (see Table 2.2) and broad money demand is stable in Nigeria. Based on Figure 2.1, the income elasticity is unexpectedly high.

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[69] Earlier studies on money demand in Nigeria are Ajayi (1977), Darrat (1986) and Arize and Lott (1985). Utilising the traditional estimation methods, these studies asserted that the money demand functions are stable in Nigeria. Nwaobi (2002) used data from 1960-1995 and the JML technique to find a cointegrating relationship between *M1*, real GDP, inflation and interest rates. The stability tests imply that money demand function is stable in Nigeria. Anorou (2002) tested the stability of the demand for *M2* for Nigeria in the Structural Adjustment Program (SAP) period. He used quarterly data from 1986(Q2) to 2000(Q1) and utilized the JML technique. The elasticity with respect to industrial production is implausibly high as 5.70 (see Table 2.2). The major finding was that the Nigerian *M2* demand function is stable in the SAP period and money supply is a viable monetary policy tool in Nigeria.

Considerable effort has been made in estimating the money demand functions for Pakistan, see for example, Akhtar (1974), Abe, et al. (1975), Mangla (1979), Khan (1980 & 1982), Nisar and Aslam (1983), Ahmed and Khan (1990), Hossain (1994), Khan and Ali (1997), Qayyum (1998, 2001 & 2005), Price and Nasim (1999), Bahmani-Oskooee and Rehman (2005) and Hussain et al. (2006). However, only a few of them (Ahmed and Khan, 1990; Qayyum, 2001 & 2005; Bahmani-Oskooee and Rehman, 2005) have tested for stability of their estimated money demand functions. Generally, they found *M2* demand is stable. With the exception of Arize (1994), Hossain (1994), Khan and Ali (1997), Price and Nasim (1999), Bahmani-Oskooee and Rehman (2005), Qayyum (1998, 2001 & 2005) and Hussain et al. (2006), other studies suffer from spurious regression problems because they have ignored the time series properties of the variables.

Hussain et al. (2006) estimated the demand for *M0*, *M1* and *M2* for Pakistan using annual data from 1972 to 2005. Using the JML technique the implied income elasticity with respect to *M0*, *M1* and *M2* are 0.75, 0.74 and 0.80, respectively (see Table 2.2). The income elasticities are comparable to Bahmani-Oskooee and Rehman (2005). Other studies such as Price and Nasim (1999) and Qayyum (2005) emphasized the use of inflation rate in money demand analysis. In particular, Qayyum (2005) found that *M2* demand is stable over 1960-1999 period for Pakistan and hence supports the use of money supply in the process of monetary policy. For Papua New Guinea (PNG), Kannapiran (2001) applied the EG procedure to estimate the demand for *M2* for the period of 1979 to 1995. The income elasticity is implausibly low at around 0.20. For detailed analysis of the demand for money in Asian countries, see Khalid (1999) and Chaisrisawatsuk et al. (2004).

Using the Philippines data for *M0*, *M1* and *M3* over the period 1980-1998, Hafer and Kutan (2003) found no cointegration between real money (*M1* and *M3*), real income and interest rates. However, when they allowed for the impact of financial innovations, this finding was reversed for *M1*. Their findings imply that *M1* aggregate could be used as a monetary policy instrument to reduce inflation in the Philippines. Arize (1994) empirically investigated the money demand (*M1* and *M2*) relationship for Korea, Pakistan and Singapore over the quarterly period, 1973(Q1)-1990(Q1). The major finding is that a statistically robust demand for *M1* and *M2* can be estimated for these economies using the ECM dynamic specification. This approach reduces the mis-specification errors and parameter instability.

The money demand studies for South Africa are Moll (1999 & 2000), Nell (1999 & 2003), Jonsson (2001), Wesso (2002), Tlelima and Turner (2004), Todani (2005) and Hall et al. (2008). Nell (1999) used the JML technique to estimate the long run demand for money function over the period 1965 to 1997. His empirical results suggest that there exists a stable long run demand for *M3* in South Africa, while the demand for *M1* and *M2* display parameter instability following the financial reforms since the 1980s. Wesso (2002) used JML technique to estimate the demand for *M3* for South Africa using quarterly data over the 1971(Q1) to 2000(Q4) period.[70] Note that the long run income elasticity is high as 1.84, see Table 2.2. Wesso found that the demand for *M3* is structurally unstable in South Africa. Other studies on South Africa also yield useful implications for monetary policy.[71]

Dekle and Pradhan (1999) used JML technique to estimate the demand for *M1* for Thailand for the period 1978 to 1995. They obtained plausible income elasticity around 1.1, consistent to what is suggested in Figure 2.1. The income elasticities obtained by Valadkhani and Alauddin (2003) and Bahmani-Oskooee and Rehman (2005) are implausibly low for Thailand. Recently, Sumner (2009) used the ARDL procedure with annual data from 1967 to 2002 and found that the demand for money

[70] After using 1971(Q1) to 2000(Q4) as the estimation sub-sample period, a forecast was generated from 2001(Q1) to 2002(Q2) using a varying parameter regression model, which was then compared to that of the simpler money demand function. Allowing some coefficients to vary overtime also improved the forecasting performance of the money demand equation significantly over the forecasting period.

[71] Moll (1999) used South African quarterly data over 1960(Q1)-1996(Q4) period and found that *M3* demand relationship is not cointegrated. Using an error correction model and data over the period 1970(Q1)-2002(Q3), Tlelima and Turner (2004) found strong evidence of instability in the money demand. Similar findings were attained by Todani (2005) and Jonsson (2001). In contrast, Moll (2000) used quarterly data for the period 1965(Q3)-1998(Q3) and the GETS technique to obtain a stable money demand for South Africa. Recently, Hall et al. (2008) found that the demand for *M3* is stable in South Africa. They argued that wealth is an important determinant of the money demand.

is stable overtime in Thailand. Supporting Poole (1970), Sumner concluded that money supply is the optimal instrument of monetary policy in Thailand.

It is worth noting that bulk of the empirical studies that focused on developing countries have attained implausibly high or low income elasticity. It is expected that income elasticity of money demand in developing countries to be around unity, see Figure 2.1. Unexpectedly high income elasticities were obtained by, for example, Choudhry (1995a) for Argentina, Siddiki (2000) for Bangladesh, Moradi (1999) and Hamid and Hosein (2007) for Iran, Nair et al. (2008) for Malaysia, Anoruo (2002) and Owoye and Onafowora (2007) for Nigeria, and Wesso (2002) for South Africa. On the other hand, studies that have achieved implausibly low income elasticity are for instance, Arize et al. (1990) for African countries, Katafono (2001) for Fiji, Bahmani-Oskooee and Rehman (2005) for Asian countries, Kogar (1995), Melnick (1995) for Israel, Choudhry (1995b) for Israel and Mexico, Valadkhani and Alauddin (2003) for Malaysia, Khamis and Leone (1999) for Mexico, and Kannapiran (2001) for PNG. Further, the results from meta-regression analysis also highlight that there are significant variation in the income elasticities in developing countries.[72]

Some studies suffer from variable measurement problems, for example, Bahmani-Oskooee and Rehman (2005) used seasonally unadjusted data (1973-2000) to examine the demand for *M1* and *M2* for Asian developing countries. They have used the index of industrial production as the scale variable and proxy for real income (GDP). Similarly, Anoruo (2002) also used industrial production proxy to estimate the *M1* demand for Nigeria. For limitations in the use of industrial production as a proxy for GDP, see Rao and Singh (2005a).

The frequently used proxies for the cost of holding money are interest rates, exchange rates, inflation rates and capital mobility. There are a few studies that have attained unexpected estimates for these proxies. Examples are Luciano (2006) for Jamaica and Hussain et al. (2006) for Pakistan. Luciano (2006) estimated the

[72] Results of meta-regression analysis are presented in Section 2.4.

demand for *M1* for Jamaica using data for the period 1962-1997. The semi-interest elasticity of *M1* demand has unexpected positive sign. Similarly, Hussain et al. (2006) estimated the demand for various monetary aggregates for Pakistan using data over 1972 to 2005 period. The estimate of financial innovation has a negative sign which is contrary to expectations. The financial innovation sensitivity of money demand may indicate better management of monetary policy and therefore a positive sign is expected.

Many empirical studies have used the exchange and inflation rates in modelling money demand for developing countries. Inflation rate is a reasonable proxy for the nominal rate of interest but inclusion of the exchange rate is difficult to justify for developing countries, especially in cases where the holdings of foreign exchange is exceptionally inadequate. Perhaps exchange rate is a realistic choice in advanced economies.[73] The results from meta-regression analysis also support this. The same perspective was also taken by Rao and Kumar (2009a & b) and Singh and Kumar (2010 & 2011). Some of these studies that have utilised the exchange rate in the context of developing countries are Nachega (2001) for Cameroon, Ewing and Payne (1999) for Chile, Katafono (2001) for Fiji, Bahmani-Oskooee and Rehman (2005) for Asian countries, Bahmani-Oskooee (1996) and Hamid and Hosein (2007) for Iran, Kogar (1995) for Israel, Ghartey (1998b) for Jamaica, Valadkhani and Alauddin (2003) for Malaysia, Arize et al. (1990) for African countries and Owoye and Onafowora (2007) for Nigeria.

There also seems to be some perplexity about whether the interest rate variable should be nominal or real rate.[74] Generally nominal interest rates show less variation than real interest rates in the developing countries. Since real rates show more variation, mainly due to the larger variation in the inflation rate, the real rate is

[73] However, many studies on advanced countries have ignored the exchange rate in their specification of money demand, see Table 2.1.
[74] For example, Ahmed (2001), Jayaraman and Ward (1998) and Padhan (2006) used the real rate of interest as a proxy for cost of holding money.

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Ahumada (1992) | | *Argentina* | | | | | | P is inflation rate. Stable demand |
| | *M1* | 1977-1988 | EG | 0.53 | | | -2.30 | for *M1* exists for Argentina. |
| Choudhry (1995a) | | *Argentina* | | | | | | P is inflation rate. There is bi- |
| | *M1* | 1935-1962 | JML | 1.97 | | | -0.025 | directional causality between the |
| | *M2* | 1935-1962 | | 1.68 | | | -0.033 | real money balances and the |
| | *M1* | 1946-1962 | | 1.91 | | | -0.034 | inflation rate. |
| | *M2* | 1946-1962 | | 3.45 | | | -0.041 | |
| Choudhry (1995b) | | *Argentina* | | | | | | The estimate for change in |
| | *M1* | 1975(Q3)- | JML | 0.95 | | | -0.06 | exchange rate is -0.03 and -0.06, |
| | *M2* | 1987(Q1) | | 0.78 | | | -0.35 | respectively, for *M1* and *M2*. |
| Siddiki (2000) | | *Bangladesh* | | | | | | Siddiki 's (2000) foreign interest |
| | *M2* | 1975-1995 | ARDL | 3.260 | 0.088 | | | rate estimate is -0.145. |
| | | | | (10.86)* | (4.50)* | | | |
| Hossain (2006) | | *Bangladesh* | | | | | | Hossain's (2006) one period |
| | *M1* | 1973-2003 | PAM | 1.030 | -0.120 | | | lagged real money estimate is |
| | | | | (5.73)* | (1.41) | | | 0.10. |
| Kumar (2007) | | *Bangladesh* | | | | | | Demand for *M1* is stable. |
| | *M1* | 1971-2002 | JML | 1.072 | -0.019 | | | |
| | | | | (12.68)* | (2.45)* | | | |
| | | | GETS | 1.000 | -0.043 | | | |
| | | | | (12.75)* | (2.92)* | | | |
| Rao and Kumar | | *Bangladesh* | | | | | | Demand for *M1* is stable. |
| (2009a) | *M1* | 1973-2003 | GH | 1.261 | -0.030 | | | |
| | | | | (7.23)* | (1.88)** | | | |
| Fielding (1994) | | *Cameroon* | | | | | | The estimate of annual moving |
| | *M2* | 1976(Q1)- | JML | 1.490 | -8.910 | | -1.310 | average is -8.1. |
| | | 1987(Q2) | | | | | | |

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Country/Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Nachega (2001) | | *Cameroon* | | | | | | The exchange rate estimate is the depreciation of the rate of the CFA franc per US dollar. The French money market rate estimate is -1.200 |
| | *M2* | 1963-1993 | ECM | 1.100 | 7.700 | -0.800 | -1.500 | |
| Hafer and Kutan (1994) | | *China* | | | | | | P is GDP deflator. |
| | *M0* | 1952-1988 | JML | 1.13 | -0.13 | | 2.48 | |
| | *M1* | | | 1.33 | -0.15 | | 1.52 | |
| Deng and Liu (1999) | | *China* | | | | | | Money demand functions are stable. |
| | *M1* | 1980(Q1)- | ECM | 1.29 | -0.12 | | -0.34 | |
| | *M2* | 1994(Q4) | | 1.80 | 0.97 | | | |
| Baharumshah et al. (2009) | | *China* | | | | | | P is the stock price. Demand for *M2* is stable. |
| | *M2* | 1990(Q4)–2005(Q3) | JML | 0.652 (0.24)* | -0.024 (0.01)* | | 0.287 (0.117)* | |
| Ewing and Payne (1999a) | | *Chile* | | | | | | Demand for money functions are stable when exchange rate is incorporated. |
| | *M1* | 1980(Q1)-1996(Q1) | JML | 0.841 (5.07)* | -0.086 (1.39) | 0.078 (0.86) | | |
| | *M2* | 1980(Q1)-1996(Q1) | JML | 1.407 (11.35)* | -0.156 (2.24)* | -0.292 (3.84)* | | |
| Sanchez-Fung (2007) | *M2* | *Chile* | | | | | | |
| | | 1991(M1)-2001(M7) | ARDL | 1.720 (0.07)* | -0.020 (0.01)* | | | |
| Arize et al. (1990) | | *Egypt* | | | | | | The estimate of capital mobility is -0.14. |
| | *M1* | 1960-1987 | TSLS | 0.440 (2.27)* | | | 0.850 (1.12) | |
| Sterken (2004) | | *Ethiopia* | | | | | | P is the real price of coffee. The shortage estimate is -0.28. |
| | *M1* | 1966(Q4)-1994(Q4) | JML | 1.39 | | | 0.72 | |

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Country/Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Katafono (2001) | | *Fiji* | | | | | | Demand for *M1* and *M2* are unstable. |
| | *M1* | 1975-1999 | JML | 0.610 | -0.190 | -0.048 | | |
| | *M2* | | | 0.512 | -2.098 | -2.745 | | |
| Rao and Singh (2005a) | *M1* | *Fiji* 1971-2002 | JML | 1.133 | -0.037 | | | Demand for *M1* is stable. |
| | | | GETS | 1.074 (4.22)* | -0.036 (2.97)* | | | |
| Singh and Kumar (2010) | *M1* | *Fiji* 1974-2004 | GETS | 1.034 (5.87)* | -0.013 (3.83)* | | | Demand for *M1* is stable. |
| | | | JML | 1.044 | -0.023 | | | |
| Arize et al. (1990) | *M1* | *Gambia* 1960-1987 | TSLS | 0.330 (1.74)** | | | -0.430 (0.53) | The estimate of capital mobility is -0.001. |
| Bahmani-Oskooee and Rehman (2005) | *M1* | *India* 1973(Q1)-2000(Q4) | ARDL | 0.550 (8.40)* | | 0.270 (5.39)* | -2.730 (3.12)* | Bahmani-Oskooee and Rehman's (2005) income elasticity for *M2* is -3.83. |
| Rao and Singh (2005c) | *M1* | *India* 1953-2002 | JML | 1.190 (27.93)* | -0.023 (3.33)* | | | Demand for *M1* is stable. |
| Singh and Pandey (2009) | *M3* | *India* 1952-2007 | GH | 0.82 | -0.01 | | | Demand for money was unstable during 1975-1998 but it is stable afterwards. |
| Price and Insukindro (1994) | *M1* | *Indonesia* 1969(Q1)-1987(Q4) | EG | 1.300 | -1.900 | | | |

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Country/Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Bahmani-Oskooee and Rehman (2005) | *M1* | *Indonesia* 1973(Q1)-2000(Q4) | ARDL | 1.290 (2.29)* | | 0.650 (8.88)* | -16.690 (3.41)* | Bahmani-Oskooee and Rehman's (2005) income elasticity for *M2* is 3.92. |
| James (2005) | *M2* | *Indonesia* 1983(Q1)-2000(Q4) | ARDL | 1.526 | -0.160 | | | The semi-foreign interest elasticity is -1.021. |
| Bahmani-Oskooee (1996) | *M2* | *Iran* 1959-1990 | JML | 1.330 | | 0.020 | -1.610 | |
| Moradi (1999) | M0 | *Iran* 1961-1996 | JML | 2.38 | | | -4.31 | P is the inflation rate. |
| Hamid and Hosein (2007) | M1 | *Iran* 1985(Q3)-2006(Q1) | ARDL | 2.65 (10.83)* | | 0.67 (10.22)* | -0.055 (3.52)* | |
| | M2 | | | 14.50 (0.17) | | 0.81 (0.19) | 0.28 (0.13) | |
| Kogar (1995) | *M1* | *Israel* 1977(Q1)-1988(Q4) | JML | 0.481 | | -0.049 | -0.715 | |
| | *M2* | 1977(Q1)-1988(Q4) | JML | 0.348 | | -0.029 | 0.348 | |
| Melnick (1995) | *M1* | *Israel* 1968(Q1)-1989(Q4) | Stock (1987) | 0.59 (5.70)* | -2.40 (5.90)* | | -1.83 (6.30)* | |
| Choudhry (1995b) | *M1* | *Israel* 1974(Q2)-1988(Q4) | JML | 0.43 | | | -0.67 | The estimate for change in exchange rate is -0.03 and -0.05 respectively for *M1* and *M2*. |
| | *M2* | | | 0.37 | | | -0.18 | |

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Country/Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Fielding (1994) | *M2* | *Ivory Coast*<br>1974(Q3)-<br>1987(Q4) | JML | 1.580 | -3.040 | | 2.430 | The estimate of annual moving average estimate is -1.63. |
| Ghartey (1998b) | *M1* | *Jamaica*<br>1961(Q2)-<br>1993(Q4) | JML | 1.110<br>(11.14)* | -0.070<br>(5.37)* | 0.510<br>(3.78)* | 1.09<br>(22.60)* | Ghartey (1998b) also used 5 other estimators and all consistent estimates as JML. |
| Atkins (2005) | *M2* | *Jamaica*<br>1962-2000 | JML | 1.560<br>(13.35)* | 1.460<br>(5.23)* | | 0.720<br>(18.04)* | *P* is the logarithm of consumer price index. |
| Luciano (2006) | *M1* | *Jamaica*<br>1962-1997 | ARDL | 1.161 | 0.013 | | | The unrestrcited ECM also provides similar estimates. |
| Adam (1992) | *M0* | *Kenya*<br>1973(Q1)-<br>1989(Q2) | JML | 1.01 | | | -6.15 | *M1* demand is stable. |
| | *M1* | | | 0.89 | -0.52 | | -5.46 | |
| | *M2* | | | 0.84 | -2.25 | | -6.73 | |
| | *M3* | | | 0.84 | | | -5.51 | |
| Fielding (1994) | *M2* | *Kenya*<br>1975(Q2)-<br>1989(Q2) | JML | | | | | The annual moving average estimate, respectively, for vectors 1, 2 and 3 are 16.627, 9.752 and 4.663. Note that Kenya has three cointegrating vectors. |
| | | | Vector-1 | | -0.271 | | 0.752 | |
| | | | Vector-2 | | -1.268 | | 3.259 | |
| | | | Vector-3 | | -0.528 | | 0.861 | |
| Karanja (2006) | *M1* | *Kenya*<br>(1967-2005) | TSLS | 1.043<br>(2.78)* | -0.006<br>(0.93) | | | |
| Valadkhani and Alauddin (2003) | *M2* | *Malaysia*<br>1979-1999 | SUR | 0.567 | | | | |

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Country/Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Bahmani-Oskooee and Rehman (2005) | *M1* | *Malaysia* 1973(Q1)-2000(Q4) | ARDL | 1.200 (16.50)* | | -0.640 (1.79)** | 13.060 (2.13)* | Bahmani-Oskooee and Rehman's (2005) income elasticity for *M2* is 1.25. |
| Nair et al. (2008) | *M1* | *Malaysia* 1970-2004 | ARDL | 1.733 | -0.032 | | -1.095 | P is the CPI. |
| | *M2* | | | 2.784 | 0.031 | | -2.572 | |
| | *M2* | | | 3.244 | 0.089 | | -3.633 | |
| Arize et al. (1990) | *M1* | *Mauritania* 1960-1987 | TSLS | 0.420 (3.38)* | | -0.010 (1.89)** | 2.060 (20.60)* | The foreign interest rate estimate is -0.001. |
| Choudhry (1995b) | *M1* | *Mexico* 1976(Q1)-1987(Q4) | JML | 0.47 | | | -1.81 | The estimate for change in exchange rate is -0.01 and -0.02 respectively for *M1* and *M2*. |
| | *M2* | | | 1.38 | | | -1.28 | |
| Khamis and Leone (1999) | *M1* | *Mexico* 1983(Q1)-1997(Q6) | JML | 0.450 | | | | Alternative return estimate is -9.730. It includes both net effective exchange rate and foreign interest rates. |
| Sanchez-Fung (2007) | *M2* | *Mexico* 1988(M1)-2001(M6) | ARDL | 1.38 (0.14)* | -0.003 (0.00)* | | | |
| Arize et al. (1990) | *M1* | *Morocco* *1960-1987* | TSLS | 0.300 (2.01)* | | 0.0004 (0.43) | 0.440 (0.59) | The foreign interest rate estimate is -0.019. |
| Hoffman and Tahiri (1994) | *M1* | *Morocco* *1959(Q1)-1988(Q2)* | JML | 1.10 (0.11) | -0.06 (0.02) | | 0.97 (0.07) | |
| | *M2* | | | 1.17 (0.08) | -0.04 (0.01) | | 0.87 (0.09) | |

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Country/Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Arize et al. (1990) | | *Niger* | | | | | | The foreign interest rate estimate |
| | *M1* | 1960-1987 | TSLS | 0.320 | | -0.004 | -0.190 | is -0.04. |
| | | | | (1.61) | | (1.55) | (0.34) | |
| | | *Nigeria* | | | | | | Arize et.al's (1990) capital |
| Arize et al. (1990) | *M1* | 1960-1987 | TSLS | 0.200 | | | 0.090 | mobility estimate is -0.001. |
| | | | | (3.11)* | | | (0.15) | |
| Fielding (1994) | | *Nigeria* | | | | | | Fielding's (1994) annual moving |
| | *M2* | 1976(Q1)- | JML | 0.720 | 1.180 | | -1.420 | average estimate is -4.43. |
| | | 1989(Q2) | | | | | | |
| Anoruo (2002) | | *Nigeria* | | | | | | Anoruo (2002) used real discount |
| | *M1* | 1986(Q2)- | JML | 5.700 | -5.440 | | | rate for *R*. |
| | | 2000(Q1) | | (8.56)* | (7.92)* | | | |
| Owoye and | | *Nigeria* | | | | | | Owoye and Onafowora's (2007) |
| Onafowora (2007) | *M2* | 1986(Q1)- | JML | 2.067 | 0.306 | -0.371 | -0.041 | foreign interest rate estimate is - |
| | | 2001(Q4) | | (5.35)* | (8.19)* | (3.91)* | (5.05)* | 0.207. |
| Arize (1994) | | *Pakistan* | | | | | | R is the difference between |
| | *M1* | 1973(Q1)- | JML | 1.03 | -0.04 | | -5.48 | domestic and foreign interest rate |
| | *M2* | 1990(Q1) | | 0.77 | -0.008 | | -7.88 | plus exchange rate. |
| Bahmani-Oskooee | | *Pakistan* | | | | | | Bahmani-Oskooee and Rehman's |
| and Rehman (2005) | *M1* | 1973(Q1)- | ARDL | 0.860 | | -0.150 | -20.390 | (2005) income elasticity for *M2* |
| | | 2000(Q4) | | (3.13)* | | (0.46) | (1.00) | is 0.58. |
| Hussain et al. (2006) | | *Pakistan* | | | | | | Hussain et al.'s (2006) financial |
| | *M0* | 1972-2005 | JML | 0.752 | -0.060 | | -0.032 | innovation estimate for *M0*, *M1*, |
| | | | | (6.91)* | (2.96)* | | (3.95)* | *M2*, respectively, are -13.432, |
| | *M1* | | | 0.740 | -0.079 | | -0.035 | -16.289 and -11.169. |
| | | | | (7.80)* | (4.13)* | | (4.71)* | |
| | *M2* | | | 0.799 | -0.081 | | -0.037 | |
| | | | | (6.98)* | (3.81)* | | (4.54)* | |

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Country/Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Kannapiran (2001) | | *PNG* | | | | | | |
| | *M2* | 1979-1995 | EG | 0.200 | | | | |
| Valadkhani and Alauddin (2003) | *M2* | *PNG* 1979-2002 | SUR | 0.629 (7.50)* | | | | |
| Valadkhani and Alauddin (2003) | *M2* | *Philippines* 1979-1999 | SUR | 1.443 (7.60)* | | | | |
| Hafer and Kutan (2003) | | *Philippines* | | | | | | Estimates are reported with shift term. |
| | *M0* | 1980(Q1)- | JML | 0.58 | 0.17 | | | |
| | *M1* | 1998(Q1) | | 1.54 | -0.10 | | | |
| | *M3* | | | 1.40 | -0.08 | | | |
| Bahmani-Oskooee and Rehman (2005) | *M1* | *Philippines* 1973(Q1)-2000(Q4) | ARDL | 0.300 (1.97)* | | -0.040 (0.15) | -15.690 (1.99)* | Bahmani-Oskooee and Rehman's (2005) income elasticity for *M2* is 1.13. |
| Arize (1994) | | *Korea* | | | | | | The estimate of foreign interest rate is -0.018 and -0.08, respectively for *M1* and *M2*. |
| | *M1* | 1973(Q1)- | JML | 0.57 | -0.034 | | | |
| | *M2* | 1990(Q1) | | 1.161 | | | -9.15 | |
| Valadkhani and Alauddin (2003) | *M2* | *Sierra Leone* 1979-1999 | SUR | 0.331 (1.90)** | | | | |
| Arize (1994) | | *Singapore* | | | | | | |
| | *M1* | 1973(Q1)- | JML | 0.71 | -0.11 | | | |
| | *M2* | 1990(Q1) | | 1.12 | -0.03 | | | |
| Bahmani-Oskooee and Rehman (2005) | *M1* | *Singapore* 1973(Q1)-2000(Q4) | ARDL | 0.730 (13.78)* | | -0.520 (3.07)* | -7.600 (3.59)* | The income elasticity for *M2* is 1.48 |

**Table 2.2 Long run Elasticities of Demand for Money in Developing Countries**

| Country/Study | Money | Country/Period | Method | ln*Y* | *R* | ln*E* | *P* | Remarks |
|---|---|---|---|---|---|---|---|---|
| Arize et al. (1990) | *M1* | *Somalia* 1960-1987 | TSLS | 0.490 (3.68)* | | | -0.310 (1.46) | Capital mobility estimate is -0.002. |
| Wesso (2002) | *M3* | *South Africa* 1971(Q1)-2000(Q4) | JML | 1.840 | -2.760 | | | *R* is the long term market interest rate. The short term interest rate spread estimate is -5.11. |
| Dekle and Pradhan (1999) | *M1* | *Thailand* 1978-1995 | JML | 1.130 | -0.009 | | 0.670 | Dekle and Pradhan (1999) used price level for *P*. |
| Valadkhani and Alauddin (2003) | *M2* | *Thailand* 1979-1999 | SUR | 0.553 (6.00)* | | | | |
| Bahmani-Oskooee and Rehman (2005) | *M1* | *Thailand* 1973(Q1)-2000(Q4) | ARDL | 0.140 (0.04) | | 2.570 (0.11) | -153.380 (0.13) | Bahmani-Oskooee and Rehman's (2005) income elasticity for *M2* is 0.90. |

**Notes for Table 2.2**

1. The absolute t-ratios are reported below the coeffients. * and ** denotes significance at 5% and 10 % levels, respectively.
2. *Y* is real income, *R* is nominal rate of interest, *E* is exchange rate and *P* is the inflation rate. These remain as it is unless suggested in the remarks column.
3. The semi-interest rate elasticity is reported in all cases, except Fielding (1994) and Nachega (2001).
4. Baharumshah et al. (2009) and Sanchez-Fung (2007), standard errors are given in the parenthesis. Hoffman and Tahiri (1994) used p-values.
5. Not all authors have reported the significance level of the long run estimates. Therefore, for these studies we only report the long run estimates.
6. JML, GETS, PAM, EG, GH, ECM, ARDL, SUR and TSLS represent Johansen Maximum Likelihood, General to Specific, Partial Adjustment Method, Engle and Granger, Gregory and Hansen, Error Correction Method, Autoregressive Distributed Lag Models, Seemingly Unrelated Regression, and Two Stage Least Squares, respectively.

mistakenly thought to be a better explanatory variable. Including the real interest rate have implausible implication that the money demand increases with the expected rate of inflation. Therefore, the appropriate variable is the nominal interest rate. For additional details, see Rao and Singh (2005c).

In time series econometrics, testing the integrated properties of the variables is useful, see Engle and Granger (1987). However, some studies ignored the time series properties of the variables for example, Diz (1970) for Argentina, Hossain (2006) for Bangladesh and Arize et al. (1990) for African countries. Further, Engle and Granger (1987) and Enders (2004) criticised the OLS estimator employed in the earlier studies. They argued that the estimation methods should account for endogeneity problem in the regressors.[75] To this end, Flowchart 3.2 developed in Chapter three identifies some estimators that address endogeneity bias. Thus, this study attempts to address the above mentioned issues by employing recently developed time series and panel data techniques.

#### *2.3.3.2 Structural Changes and Money Demand in Developing Countries*

Structural changes influences the money demand relationships and this is primarily attributed to the financial reforms and innovations, for example see Gurley and Shaw (1960) and Tobin (1965). Among others, political stability, institutional changes, and changes in policy legislations also seem to affect the demand for money. Here I shall discuss the studies that utilised structural change tests to explain the money demand relationships for developing countries.

Arrau et al. (1995) pointed out the problems that may emerge from the failure to account for financial innovations. They used quarterly data to examine the *M1*

[75] For example, many macroeconomic and growth models show that income (GDP) plays a dependent role. In any case, if income is used as an exogenous variable, then endogeneity tests are necessary to determine whether the estimates suffer from endogeneity bias. Several studies support these arguments (Tobin, 1983; Koskela and Viren, 1986; Sterken, 2004; Tesfatsion and Veitch, 1990; Cogley, 1993). Studies such as Diz (1970), Khan (1977), Ungar and Zilberfarb (1980), and Zilberfarb (1983) used standard normal regression procedures (for example, OLS) and these techniques are inappropriate if data is non-stationary.

demand for ten developing countries.[76] Financial innovation was modelled as a deterministic drift and stochastic process. In doing so, they obtained more plausible long run elasticities. Randa (1999) investigated whether the economic reforms had any significant impacts on Tanzania's demand for *M0*, *M1* and *M2* over the 1976(Q1)-1996(Q2) period. Using the JML technique, money demand is found to be stable despite the presence of economic reforms since the 1980s. Although Arrau et al. (1995) and Randa (1999) identified the useful determinants of the money demand, however, no formal structural change tests were applied to examine the effects of financial reforms.

Adam (1999) used quarterly data over 1971(Q4)-1998(Q1) period to examine the *M1* demand for Zambia. His JML tests indicated that the model has been subject to a large structural break which could be observed as the portfolio stock adjustments between 1992 and 1994. To this end, the equilibrium real currency demand fell sharply in response to the liberalisation of asset markets. Further, Adam asserted that while it is possible to recover a stable money demand for Zambia over this period, however, financial reforms have created considerable variations in *M1* demand in the short run.

Rao and Kumar (2009a) have used the Gregory and Hansen technique for structural breaks to estimate the demand for *M1* for Bangladesh over the period 1973 to 2003. It is well known that Gregory and Hansen method tests for breaks in the cointegrating vector, see Flowchart 3.3 developed in Chapter three. Their study revealed that there exist a cointegrating relationship between real *M1*, real income and nominal rate of interest after allowing for structural breaks. Particularly, the break date is 1989 that has an intercept shift. Their estimates imply that there is a well-determined and stable demand for *M1* in Bangladesh and money supply could still be used as a monetary policy instrument. Rao and Kumar (2007) used a similar approach for Fiji data for the period 1972-2002. The Gregory and Hansen tests

[76] These countries and their sample periods are Argentina 1977(Q1)-1987(Q2), Brazil 1975(Q1)-1985(Q4), Chile 1975(Q1)-1989(Q3), India 1971(Q1)-1988(Q3), Israel 1974(Q2)-1988(Q3), Korea 1974(Q1)-1984(Q4), Malaysia 1980(Q1)-1988(Q2), Mexico 1980(Q)-1989(Q2), Morocco 1978(Q3)-1988(Q2) and Nigeria 1975(Q1)-1983(Q4).

revealed that there was an intercept shift in 1987 possibly caused by political coups. They also found a stable *M1* demand for Fiji.

Narayan and Narayan (2008) analysed the impacts of coups; the implementation of policies, such as devaluations and value added tax; and the trade liberalisation policies on the demand for *M1* for Fiji. Using data from 1971-2002 and Bai and Perron (1998) structural break tests, they found instability in *M1* demand for Fiji. However, it is well known that the method proposed by Bai and Perron (1998 & 2003) essentially tests for breaks in the non-stationary processes and not for breaks in the cointegrating vector. The latter is useful to investigate stability in money demand functions. Singh and Pandey (2009) used data for the period 1953-2007 and Hansen (1992) and Gregory-Hansen (1996a) tests to show the presence of cointegration between *M3* demand, real GDP and nominal interest rate with structural break at 1965. Further, their study also suggests for downward shift of about 0.33 percent in the demand for money. The stability in the Indian *M3* demand is supported, except for the period 1975-1998.

Using the Gregory-Hansen tests, Nair et al. (2008) examined whether the Malaysian demand for money (*M1*, *M2* and *M3*) relationships had undergone any structural breaks. Using data over the period 1970 to 2004, they found that the 1997 Asian financial crisis did not have any significant impacts on the cointegration relationship of money demand and its determinants. In other words, the stability of money demand is supported.

The standard time series techniques (for example, GETS, EG, FMOLS and JML) are unlikely to yield information on structural breaks such as level shift or regime shifts. Consequently, many studies have used dummy variables to account for these structural shifts. Although it appears that dummy variables are successful in capturing the intercept shifts, this approach provides neither endogenous break points nor regime shifts. For developing countries, most studies have adopted the dummy variable approach to analyse the structural changes in the money demand functions, for instance see Pinon-Farah (1998), Hafer and Kutan (1993), Arize et al. (2005) and Peria (2002). Pinon-Farah (1998) estimated an ECM model for *M1* and

*M2* demand with monthly data over 1991(M1)-1997(M9) period for Mozambique. The results suggest that there is a structural break during 1996/97. This is interpreted as high money demand growth due to high economic expansion and low yields of foreign instruments resulting from lower (higher) depreciation (appreciation) of the exchange rate. For the Philippines, Hafer and Kutan (1993) found evidence of a long run equilibrium relationship between real *M1* and its determinants only when reforms dummy is included.

Arize et al. (2005) examined the impacts of structural changes on inflation for 50 developing countries. For majority of the countries, inflation is found to be non-stationary. Peria (2002) investigated the monetary impacts of banking crises in Chile, Colombia, Denmark, Japan, Kenya, Malaysia and Uruguay during the period 1975-1998. Using the ECM tests, Peria found no evidence that banking crises have caused money demand instability. However, the results on price stability are mixed i.e. for three out of the seven countries there appears to be evidence of price instability.

Dobson and Ramlogan (2001) used quarterly data over 1982(Q2)-1998(Q2) period to estimate *M0*, *M1* and *M2* demand for Trinidad and Tobago. Based on their OLS estimates, they argued that there exist structural breaks in the *M2* demand for both countries. However, *M0* and *M1* are largely stable and therefore may serve as useful tools for monetary policy. Maghyereh (2003) used the ECM tests to examine the impacts of financial reforms on broad money demand for Jordon over the period 1976-2000. Despite the substantial financial market liberalisation in the 1988, the broad money demand is found to be stable in Jordon.

Blevins et al. (1999) examined the effects of financial liberalisation on the demand for *M1* for Peru over the period 1979(M1)-1997(M11). Their results suggest that a shift in the *M1* demand was caused by measures undertaken by government to reduce inflation and as well as by the financial reforms. Lee and Chien (2008) examined whether the economic and financial reforms in China have made the *M1* and *M2* demand unstable for the period 1977-2002. The structural break tests of Zivot and Andrews (1992) and Bai and Perron (2003) indicated several structural breakpoints. The income elasticity of *M2* demand is marginally larger than *M1*; consistent with the Figure 2.1.

Other studies that examined the impacts of financial reforms on the money demand are Ahumada (1992) for Argentina, Dekle and Pradhan (1999) and Arrau and Gregorio (1993) for developing countries, James (2005) for Indonesia, Bynoe (2002) for Jamaica, Majid (2004) for Malaysia and Hafer and Kutan (2003) for Philippines.[77] The impact of political instabilities on the money demand also received some attention, for example see, Sterken (2004) for Ethiopia and Rao and Kumar (2007) and Rao and Singh (2005a & b) for Fiji.

Given that structural change techniques like Zivot and Andrews (1992), Lee and Strazicich (2003 & 2004) and Bai and Perron (1998 & 2003) are tests for unit roots and does not estimate breaks in the cointegrating equation, this study utilises the Gregory and Hansen (1996a & b) tests to determine and estimate the cointegrating vectors with breaks. Breaks in the deterministic components are analysed with the Westerlund (2006) test. The next section reviews studies on money demand that utilised the panel data.

### *2.3.4 Panel Data Studies on Money Demand*

The use of panel data estimation methods has become increasingly popular among empirical researchers in testing growth and other macroeconomic models. However, in the money demand literature there are few studies that have used panel data methods to estimate the demand for money. The classic study by Cagan (1956) highlighted that demand for real cash balances is a function of the public's expectations of the future course of inflation. Cagan hypothesized that expectations of future inflation rates are formed by applying exponentially declining weights to past inflation rates. Garcia-Hiernaux and Cerno (2006) estimated the *M1* demand function of Cagan (1956) using the Pedroni (2000) technique for 27 (developed and developing) countries over the period 1988-1998. The static fixed effects and the

[77] See section 2.3.3.1 for discussion of these studies.

dynamic fixed effects models revealed that there is a long run equilibrium relationship of *M1* demand. The income elasticity is in the range from 0.18 to 0.20, somewhat in contrast to Cagan. However, in the context of developing countries, these income elasticities are unexpectedly low, see Figure 2.1.

Should the euro be introduced in the new EU member states is an empirical issue that requires further investigation. Recently, Dreger et al. (2007) used panel cointegration techniques of Pedroni (2000), Mark and Sul (2003) and Breitung (2005) to estimate the *M2* demand for ten EU countries.[78] Quarterly data over 1995(Q1)-2004(Q2) period was used. The panel income elasticity is fairly high at around 1.70 while the interest rate elasticity is negative. Moreover, in order to attain a long run money demand function, the exchange rate of each country in relation to the US dollar was considered. Dreger et al. (2007) argued that sudden introduction of the euro in all new EU member states may cause problems for the stability of the euro area money demand function. The introduction of the euro requires that the Maastricht convergence criteria are fulfilled and the probability that all countries would achieve the criteria at the same time is small.[79]

Harb (2004) used the Pedroni (2000) technique to estimate the demand for *M1* and *M2* for six Gulf Cooperation Council (GCC) countries, viz. Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. The data used covers the period 1979-2000. The panel income elasticity for *M1* and *M2* is 0.78 and 0.42, respectively. The semi-interest rate elasticity for both monetary aggregates is significant with expected negative sign. Using data similar to Harb (2004), Lee and Chang (2006) used the panel multivariate test of Larsson et al. (2001) to examine the *M1* demand. They found that there exist at least two cointegrating vectors for *M1* demand. On the stability front, they argued that the *M1* demand functions are stable in the GCC countries and hence monetary authorities should use *M1* as an instrument of monetary policy.

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[78] These EU countries are Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic and Slovenia.

[79] Note that the number of inhabitants in these countries is small and their GDP is markedly less than the average of actual EU. Therefore, their weights inside the euro area are relatively small.

Elbadawi and Schmidt-Hebbel (2007) utilised DOLS estimator to analyse the behavior of the demand for *M1* in 48 countries that have gone through an armed conflict (civil war) between 1975 and 2004, in comparison to a control group of 51 non-conflict countries. They found that the world income elasticity of money demand is between 0.61 and 0.86. For non-conflict (conflict) country group, the income elasticities range between 0.78 and 1.04 (0.48 and 0.82). They concluded that the *M1* demand is highly unstable during the conflict cycle.

Combining observations across Latin American countries for the period 1948-2003, Carrera (2008) estimated the *M1* demand using Pedroni's FMOLS technique.[80] The estimate of income elasticity is 0.94 and the interest semi-elasticity is -0.008. The near unit income elasticity implies the existence of economies of scale in money management. Valadkhani and Alauddin (2003) utilised the Seemingly Unrelated Regression (SUR) panel technique to examine the determinants of the demand for *M2* for eight developing countries viz. Malaysia, Chile, Thailand, PNG, Bangladesh, Sri Lanka, Sierra Leone and the Philippines.[81] The country specific income elasticity is from 0.3 to 1.4. [82]

Rao and Kumar (2009b) and Rao et al. (2009) found empirical support that money demand functions are stable in developing countries. In particular, Rao and Kumar (2009b) used three panel data techniques (Pedroni, 2004; Mark and Sul, 2003; and Breitung, 2005) to estimate the cointegrating equations for the demand for *M1* for a panel of 14 Asian countries over the period 1970-2005.[83] In all cases, the panel income elasticity is around unity. The effects of financial reforms are examined with two set of sub-samples and the long run elasticities of *M1* demand are not significantly different across the sub-samples. Supporting Poole's (1970)

[80] These countries are Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Mexico, Costa Rica, Dominican Republic, Guatemala, and Honduras.
[81] Data used was from 1979 to 1999.
[82] In another study, Valadkhani (2008) examined the long- and short-run determinants of *M2* demand for six Asian-Pacific countries (China, Japan, Malaysia, the Philippines, Singapore and Fiji). Using data from 1975-2002 and the fixed effects estimator, they found that there exists a long run relationship between *M2* demand, real income, interest rate spread, inflation rate, real effective exchange rate, and the US real interest rate. The income elasticity is found to be above unity.
[83] The selected countries are Bangladesh, Indonesia, India, Iran, Korea, Malaysia, Myanmar, Nepal, the Philippines, Pakistan, Papua New Guinea, Singapore, Sri Lanka and Thailand.

conjectures, they argued that the supply of money is the feasible instrument of monetary policy in Asian developing countries. Rao et al. (2009) used the systems *GMM* technique of Blundell and Bond (1998) to estimate the *M1* demand for 11 Asian countries over the period 1970 to 2007.[84] Their results show that the income elasticity of *M1* demand is around unity and the rate of interest is not the best proxy for cost of holding money. They tested for structural stability with the Mancini-Griffoli and Pauwels (2006) test and found that there is a well-defined *M1* demand.

Hamori and Hamori (2008) analysed the stability of the money demand (*M1*, *M2* and *M3*) function using the Pedroni FMOLS technique and data from January 1999 to March 2006, covering 11 EU countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain). Their finding that the money demand functions are stable implies that the monetary aggregates are suitable instruments for monetary policy. Nevertheless, *M3* is European Central Bank's (ECB) preferred monetary aggregate.[85]

Narayan et al. (2009) used panel DOLS and SUR methods to estimate *M2* demand for five South Asian countries (Bangladesh, India, Pakistan, Sri Lanka and Nepal) for the period 1974–2002. They found evidence of cointegration between *M2* demand and its determinants (real income, real exchange rate, and short-term domestic and foreign interest rates). The long run elasticities for individual countries revealed that real income and real exchange rates have had positive and statistically significant impacts on real *M2* demand, while the domestic interest rate was negatively signed and only significant for Bangladesh and India.

For Euro area, fairly high income elasticities were attained by Setzer and Wolff (2009). Using the panel DOLS technique, Setzer and Wolff (2009) estimated the *M3*

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[84] These countries are Bangladesh, China, Hong Kong, India, Indonesia, Korea, Malaysia, the Philippines, Singapore, Sri Lanka and Thailand.

[85] For 35 Sub-Saharan countries, Hamori (2008) used panel data over 1980-2005 period to examine the *M1* and *M2* demand. The empirical results revealed that there exists cointegration relationship of *M1* and *M2* demand. The Pedroni method provided income elasticity around 0.9 and 1 for *M1* and *M2* demand, respectively. The semi-interest elasticities are also plausible. Their findings are consistent with the quantity theory of demand for money and they asserted that money supply (*M1* or *M2*) is the reliable monetary policy instrument from the intermediate-target perspective.

demand for the Euro area. They found income elasticity of *M3* demand at around 1.6 for the sample 2003 to 2008, while for the sample starting from 2001, the income elasticity is at around 1.2. The semi-interest rate elasticity is negative and statistically significant. Fidrmuc (2006) used Pedroni's FMOLS and Kao's DOLS techniques to examine the *M2* demand for six Central and Eastern European countries (CEEC) (Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia) over 1994-2003 period. They asserted that money demand is significantly determined by the euro area interest rates and the exchange rate against the euro, which implies existence of instability in the money demand function. They argued that inflation targeting is appropriate in the CEEC.

From an applied perspective, there are drawbacks in majority of the above studies that used panel data techniques. First, the income elasticities of money demand seem to be over- or under-estimated; not consistent with Figure 2.1. It is logical to assume that the income elasticity of money in advanced OECD (developing) countries to be lower (around or slightly higher) than unity because they have developed (under-developed) financial markets. Second, the stability of money demand has received less attention in panel data studies. Simply put, the structural change tests (for example, Westerlund, 2006; Banerjee and Carrion-i-Silvestre, 2006; Mancini-Griffoli and Pauwels, 2006) could be applied to determine breaks in the cointegrating equations. Therefore, this study attempts to fill these gaps by employing recently developed panel tests (Pedroni, 2004; Mark and Sul, 2003; Breitung, 2005; Westerlund, 2007). The stability of *M1* demand in the panel is analysed with the Westerlund (2006) technique. The next section reviews empirical studies on money demand, currency substitution and capital mobility.

### *2.3.5 Money Demand, Currency Substitution and Capital Mobility*

A possible source of specification bias in the case of national money demand equations is international currency substitution. This idea was first suggested by McKinnon (1982) who argued that international liquidity shifts among financially integrated countries may lead to instability in their national money demand functions. However, these shifts would not necessarily affect the stability of the multi-country aggregate money demand, as long as the currency shifts were sufficiently internalised. Recently, a number of studies attempted to examine the demand for money and currency substitution.[86] In what follows, I shall review some recent studies on currency substitution and for a comprehensive survey, see Yildirim (2001) and Calza and Sousa (2003).

### *2.3.5.1 Evidence from Advanced OECD Countries*

The existence of currency substitution in the USA is supported by Brittain (1981), Miles (1978 & 1981) and Day (1998). Brittain (1981) found that the instability of velocity in the USA during the 1980s was caused by currency substitution. Miles (1978 & 1981) found existence of currency substitution in the Canada, Germany and the USA. Day (1998) asserted that money substitution can have an important effect on the demand for money and the Federal Reserve Bank should consider foreign sector when formulating the monetary policy.

Kremers and Lane (1990) asserted that the greater performance of European-wide money demand relative to national money demand models may reflect the internalisation of currency substitution. Lane and Poloz (1992) and Filosa (1995) argued that currency substitution is important financial behaviour in the European countries. Investigating the existence of currency substitution in the EU countries, Monticelli and Strauss-Kahn (1993) found that the money demand functions exhibit similar price and income elasticities.[87] Imrohoroglu (1991) found existence of modest currency substitution between the Canadian and the US dollar. Ram and Jeong (1994) showed that in the long run the ratio of domestic to foreign money

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[86] Calza and Sousa (2003) and Yildirim (2001) provided a good survey of studies on currency substitution. Theoretical analysis on currency substitution can be found in Calvo and Rodriguex (1977), Engel (1989), Guidotti (1989), Weil (1991), Woodford (1991) and Canzoneri et al. (1991).

[87] For detailed analysis on money demand in EU countries, see for example, Beckx and Tullio (1989), Kremers and Lane (1990), Angeloni et al. (1994), Bayoumi and Kenen (1992), Fase and Winder (1992), Artis et al. (1993), Monticelli and Strauss-Kahn (1993) and Monticelli (1993). For European countries, Mizen and Pentecost (1996) asserted that an increase in the financial diversification over a wider set of assets including foreign currency provides evidence in support of currency substitution. Tavlas (1996) argued that the degree of economic integration and relative inflation performance are vital factors in determining the presence of currency substitution in the European countries.

balances responds elastically to the changes in real exchange rate, thus indicating the existence of currency substitution between the Canadian and the US dollar.

Yildirim (2003) estimated the demand for *M2* with JML technique and quarterly data for the period 1978(Q3) to 1993(Q4) for France, the Netherlands, Germany, Italy and the UK. The income elasticity of *M2* demand for Germany is 2.2, implausibly high for a developed country. With the exception of Germany, the income elasticity for the other four countries is constraint to unity.[88] Yildirim asserted that an increased degree of currency substitution in the EU countries could cause instability in the national money demand functions while an EU-wide money demand function could be stable. de Freitas (2006) found that the US dollar long-term interest rate plays a significant role in the European money demand relationship. Cassard et al. (1997) provided evidence supporting the existence of a stable *M3* demand relationship for Germany plus a core group of countries- France, Belgium, Denmark, Luxembourg and the Netherlands. Their results suggest that it may be useful to consider a core exchange rate mechanism (ERM) monetary aggregate in formulating monetary policy for Germany and also for countries proceeding to European monetary union (EMU).

Selcuk (1994) investigated the existence of currency substitution for Turkish economy. Selcuk asserted that economic agents prefer to substitute foreign currencies for domestic currency because of real exchange rate depreciations. Akcay et al. (1997) examined currency substitution and its effect on exchange rate instability in Turkey. They found evidence in favour of currency substitution. Moreover, they observed that the exchange rate instability rises with the degree of currency substitution. Recently, Kaplan et al. (2008) found that the depreciation of the Turkish Liras has resulted in a decline in the holding of monetary aggregates, thus implying the presence of currency substitution in Turkey.[89]

[88] For detailed analysis on the demand for money in Italy, see Angelini et al. (1994), Nielsen et al. (2004) and Caruso (2006). Nielsen et al. (2004) incorporated currency substitution between Italy and Germany for the period 1972-1998. By allowing for structural breaks and currency substitution, they found a stable money demand function for Italy. Artis et al. (1993) and Cassard et al. (1997) have also analysed currency substitution and the stability of money demand for EU countries.

[89] Bahmani-Oskooee and Muge (2006) found that when currency substitution is considered for Turkey, the *M1* demand becomes stable.

Using the portfolio balance model, Darrat et al. (1996) asserted that currency substitution is important determinant of money demand in Japan and monetary policy formulation will benefit by considering the effects of currency substitution. Chowdhury (1995) applied Swiss data over 1973-1991 period to investigate the demand for *M0* and *M1* for Switzerland. The results suggest that the exchange rate and foreign interest rate are necessary variables in the cointegrating equation. The findings provide support to the hypothesis of both currency substitution and capital mobility. Hsieh and Hsing (2009) examined the demand for *M1* and *M2* for Hungary over the period 1995-2005. Using the approach adopted in Hsing (2007), they found that the *M1* or *M2* demand is less sensitive to the HUF/USD exchange rate and the US treasury bill rate than the nominal effective exchange rate and the 3-month euro interest rate.

For five countries, viz. Italy, Germany, France, Spain and the UK, Angeloni et al. (1994) provided cross-correlations of residuals of the money demand equations. They found that the indices tend to be negative and statistically insignificant. A similar approach was adopted by Wesche (1997) for four countries (Germany, France, Italy and the UK). Wesche (1997) found that there is no significant negative cross-correlation between the residuals of national money demand in all cases, except for Germany and Italy. These results suggest that neutralisation of currency substitution may not be the cause of stability in the European money demand function.

Bundesbank (1995) found limited evidence for currency substitution between the Deutsche Mark and other EU currencies. Monticelli (1996) and Fagan and Henry (1998) found that currency substitution in European money demand is not a relevant issue because when extended monetary aggregates are used, the improvements in the stability of the European money demand are insignificant. Similar conclusions were made by Angeloni et al. (1994) for EU countries, except for France and Germany.

Girton and Roper (1981) showed that currency substitution could produce instability in the US exchange rates. Batten and Hafer (1985) analysed the currency substitution for Germany, Japan and the USA. They found no statistical support for currency substitution in either Germany or Japan. However, the hypothesis is supported when exchange rate movements were used as a proxy for the USA. Batten and Hafer (1986) concluded that currency substitution does not play a significant role in explaining the domestic inflation rate in the USA. Similarly, Bergstrand and Bundt (1990) showed that currency substitution may result in the loss of long-term monetary independence.

Bordo and Choudhri (1982) tested for the influence of the expected return on foreign money on the money demand (*M1* and *M2*) for Canada. They found that currency substitution is not an important factor in the demand for money function. Baade and Nazmi (1989) used the portfolio balance model of the money demand to investigate currency substitution for Japan. They found no evidence of currency substitution for Japan over the period 1965-1985. Recently, Mizen and Pentecost (1994) investigated currency substitution for the use of the British pound in major European countries. They found insignificant evidence to support the hypothesis.

#### *2.3.5.2 Evidence from Developing Countries*

Veiga and de Freitas (2006) included the expected exchange rate depreciation in the demand for money equation to make inferences on currency substitution. Using such specification for six Latin American countries, they found evidence of currency substitution in Colombia, Dominican Republic and Venezuela, but not in Brazil and Chile.[90] Rodriguez and Turner (2003) examined currency substitution for the Mexican economy over the period 1978-2000. They found significant evidence of currency substitution with respect to broad money. They concluded that the demand for US dollar deposits is very sensitive to expectations of exchange rate movements. Viren (1990) presented evidence from Finnish data that both financial innovations and currency substitution are important in modelling the demand for money.

[90] Few other studies that have examined currency substitution in these countries are Ortiz (1983), Ramirez-Rojas (1985), Rogers (1992) and Melvin and Ladman (1991).

Bahmani-Oskooee and Tanku (2006) used data from 25 developing countries to determine whether the money demand is influenced by the black market exchange rate or the official rate. The ARDL technique provided fairly mixed results i.e. either the exchange rate (black market or official rate) or the premium is important. Bahmani-Oskooee and Techaratanachai (2001) investigated whether the currency depreciation in Thailand has resulted in currency substitution away from the Thai baht. They found that Thailand devaluations resulted in a decline in the *M2* aggregate holdings.

Calvo and Ve'gh (1992) also observed currency substitution in Bolivia, Mexico, Peru and Uruguay after the financial reforms. They found that foreign reserves are insufficient to sustain the current account deficit and service external debt. Consequently, these countries substitute foreign currency for domestic currency to hedge against the exchange rate risk. Ramirez-Rojas (1985) found the existence of currency substitution in Argentina, Mexico and Uruguay. Arize et al. (1990) examined the demand for *M1* for seven African countries (Egypt, Gambia, Mauritania, Morocco, Niger, Nigeria and Somalia). Using data over 1960-1987 period, they found that the coefficient of capital mobility is statistically insignificant at conventional levels in all cases, implying that capital mobility is limited in these countries.

Adom et al. (2009) found that when US dollar is used as an anchor currency, there is no evidence of currency substitution in Ghana, Egypt, Kenya, Tunisia and Zambia, but some support is attained for Nigeria, South Africa and Morocco. Sharma et al. (2005) investigated the importance of the US dollar to six Asian economies (Indonesia, Japan, Korea, Malaysia, Singapore and Thailand), as a substitute or complement to domestic monetary assets. Their results warranty an increasing degree of currency substitution overtime in all cases, except for Malaysia.

Chaisrisawatsuk et al. (2004) asserted that capital mobility and currency substitution are significant factors in the money demand equations for Indonesia, Korea, Malaysia, Singapore and Thailand. Their results showed that the US dollar, Japanese yen and the UK pound are widely used by domestic residents together with the domestic currency in Indonesia, Korea, Singapore and Thailand. However, in the case of Malaysia, despite the existence of currency substitution between the US dollar and the Japanese yen, no evidence of currency substitution exists between the domestic currency and the UK pound.

Hsing (2007) used data over 1980-2005 period to examine the demand for *M2* for Pakistan. The extended Box-Cox transformation is applied to test whether the log-linear or linear form is appropriate. The positive sign of the real effective exchange rate shows that appreciation of the rupee leads to an increase in the demand for *M2* and implies that the substitution effect is greater than the wealth effect. The negative sign of the US treasury bond rate suggests that the capital mobility effect is greater than the cost of borrowing effect. A similar conclusion was also made by Marquez (1987) and Bahmani-Oskooee and Ng (2002).

Utilising the portfolio balance models, a number of studies have estimated a linear demand for domestic and foreign currency, for example, see Komarek and Melecky (2003) for Czech Republic, Mongardini and Mueller (1999) for Kyrgyz and Harrison and Vymyatnina (2007) for Russia. These studies have investigated the links between the demand for foreign currency and its determinants particularly interest rates on domestic and foreign bonds.[91] The dynamic non-linear methods of estimation are also widely used in examining currency substitution, for example, see Bufman and Leiderman (1993) for Israel, Imrohoroglu (1994) for Canada, Friedman and Verbetsky (2001) for Russia and Selcuk (2003) for Central and Eastern European countries. These studies found high degree of substitutability between local and foreign currencies in respective countries. The meta-analysis is presented in the next section.

[91] Asel (2009) provide a good review of studies that used the portfolio balance models to examine currency substitution.

## 2.4 Meta-Analysis

### *2.4.1 Brief Background*

Since the pioneering work of Stanley and Jarrell (1989)[92] literature reviews employing meta-analysis have been used more extensively in economics. Narrative forms of literature review may be less appealing when it comes to reviewing the empirical literature. Stanley (2001) defined meta-analysis as the body of statistical methods that have been found useful in reviewing and evaluating empirical research results. Combining the results of the individual empirical studies that use different data sets and methods, more insightful inferences could be drawn. In a meta-analysis, the dependent variable could be a summary statistic or a long run estimate drawn from each study, while the explanatory variables may include features of the estimation techniques, design and data used in these studies. Compared to the narrative literature reviews, the meta-analysis involves less subjective reasoning and judgmental arguments about what represents an acceptable empirical method (Stanley, 2001). For strengths and weaknesses of meta-analysis, see Stanley (2001).

Performing meta-analysis on the demand for money requires a justification because Knell and Stix (2005 & 2006) has already utilised this approach to review the empirical literature. Undeniably, their attempts were remarkable and they drew some useful conclusions from an empirical point of view. Knell and Stix (2005) selected 79 articles from the EconLit database published after 1994 and these studies largely focused on the European countries. In another paper, Knell and Stix (2006) performed meta-analysis for almost 1000 estimations taken from three different sub-samples viz. Knell and Stix (2003), Sriram (2001) and Fase (1993). However, these sub-samples include relatively less number of studies on developing countries. Given that in the past three decades a large number of empirical research on money demand have focused on the developing countries, it is therefore vital to include these studies. Since the income elasticity estimates of money demand signifies the development of the financial markets, it is logical to assume that the income

[92] Related studies are Stanley and Jarrell (1998), Lipsey and Wilson (2001) and Stanley (2001).

elasticity estimates in advanced OECD countries to be lower than the developing countries, see Figure 2.1. It is observed that the financial market institutions and developments and their characteristics are slightly different among advanced OECD and developing countries, for example, wide use of narrow money (notes and coins) in developing countries while in advanced countries broad money (credit cards and debit cards) is more common. To this end, it is feasible to divide the sample into advanced OECD and developing countries and then perform the meta-analysis so that such study characteristics and their impacts on income elasticity are investigated.

This study adopted the approach employed by Knell and Stix (2005 & 2006), however the analysis is extended to investigate study characteristics for two sub-samples i.e. advanced OECD and developing countries. By using Knell and Stix (2003) and Sriram's (2001) sub-samples, Knell and Stix (2006) examined some study characteristics for the non-OECD countries, however both sub-samples only contained a small number of studies published since 2000. The Fase (1993) sub-sample contains no studies on developing countries. Sriram's (2001) sub-sample contains studies published only from the 1990s; neglecting all those published prior to the 1980s and also those published in the post 2000 period. Moreover, the Knell and Stix (2003) sub-sample considered only 22 percent of the total observations were based on non-OECD countries. To this end, the value added of this analysis is that it includes more recent contributions including a large proportion of developing country estimates, the significance of this is detailed in the data section below.

The benchmark meta-regressions are used to investigate the possible sources of variation in empirical findings about the income elasticity of money demand. The fact that not all empirical studies on the demand for money are based on the same specification or have used the same data set or empirical tests, therefore it is necessary to examine the impacts of these study characteristics on the income elasticity. In particular, this study explores the possible impacts of narrower or broader monetary aggregates, wealth, financial reforms, estimation methods, and various opportunity costs of holding money on the income elasticity of money demand in advanced OECD and developing countries.

### *2.4.2 Data*

The first stage of meta-analysis involves searching and selecting relevant studies and the selection criteria is vital to avoid selection and availability biases. I selected studies from the EconLit and Research Papers in Economics (RePec) databases. Basically, the selected studies fulfilled the following two criteria: (a) the title contains either 'money demand' or 'monetary policy' or 'financial reforms/innovations or 'currency substitution' and (b) the article is dated in the post 1980 period. The list of studies used in meta-analysis can be found in Appendix 1. Table 2.3 provides details of the variables used in the meta-analysis.

**Table 2.3 Meta-Independent Variables**

| Income elasticity | = the point estimates of long run income elasticities |
|---|---|
| *Monetary aggregates* | |
| *M1* | 1 if a study uses *M1* |
| *M2* | 1 if a study uses *M2* |
| *M3* | 1 if a study uses *M3* |
| Narrow money | 1 if a study uses *M0* or *M1* |
| Broad money | 1 if a study uses *M2* or *M3* |
| *Other variables* | |
| Wealth | 1 if a study included a measure of wealth |
| Inflation rate | 1 if a study uses a measure of inflation rate |
| Exchange rate | 1 if a study uses a measure of exchange rate |
| Financial innovation | 1 if a study included a measure of financial innovation |
| Interest rate | 1 if a study uses a measure of interest rate. |
| Multivariate | 1 if a study uses multivariate cointegration technique |
| Single equation | 1 if a study uses single equation cointegration technique |
| Stability tests | 1 if a study conducted parameter stability tests |
| Number of observations | The number of observations of individual samples |
| Number of years | The number of years in the sample used for estimating income elasticities |
| Precision | The t-statistic of the estimated income elasticity |

Table 2.4 displays the descriptive statistics of the two samples viz. advanced OECD and developing country. I used 137 articles covering 27 advanced OECD countries. For developing countries, 140 articles were selected covering 44 countries. For each of these articles, I extracted information about their estimated income elasticities, monetary aggregates, explanatory variables, methods employed and data. The descriptive statistics show that the mean of income elasticities in advanced OECD and developing countries, respectively, are 0.90 and 1.05. These average income elasticities are close to unity; consistent with the quantity theory of demand for

money. At the same time, the standard deviations, respectively, are 0.35 and 0.40, indicating considerable variation in the estimated income elasticities. Further, the average income elasticities are slightly different when I split the sample into estimations that use narrow money and those that use broad money. For advanced OECD countries, the average income elasticities (with standard deviations in parentheses) for estimations that use narrow money or broad money, respectively, are 0.81 (0.38) and 1.15 (0.37). On the other hand, for developing countries the average income elasticities with corresponding standard deviations in parentheses, respectively, for narrow and broad money measures are 1.02 (0.41) and 1.08 (0.33).

**Table 2.4 Descriptive Statistics**

| | Advanced OECD Country Sample | Developing Country Sample |
|---|---|---|
| Number of observations | 251 | 268 |
| Number of studies | 137 | 140 |
| Number of different countries | 27 | 44 |
| Narrow money | 95 | 104 |
| Broad money | 156 | 135 |
| Wealth | 25 | 14 |
| Interest rate | 232 | 217 |
| Price or inflation rate | 94 | 53 |
| Exchange rate | 41 | 34 |
| Financial reforms | 30 | 22 |
| Multivariate | 153 | 144 |
| Single equation | 98 | 124 |
| Stability tests | 205 | 192 |
| Average income elasticity | 0.90 (0.35) | 1.05 (0.40) |
| Average income elasticity: narrow money | 0.81 (0.38) | 1.02 (0.41) |
| Average income elasticity: broad money | 1.15 (0.37) | 1.08 (0.33) |

NB: Advanced OECD and developing country samples, respectively, include 32 and 18 multi-country studies. Standard deviations are given in the parentheses.

These basic findings about the average income elasticity are somewhat consistent with Knell and Stix (2006). They found the following average income elasticities: 0.79 (OECD, narrow money), 1.12 (OECD, broad money), 0.89 (non-OECD, narrow money) and 0.96 (non-OECD, broad money).[93] Some marginal differences exist perhaps due to updated data employed in this study. Two interesting features emerge from these results. First, narrow monetary aggregates yield lower income elasticity estimates in advanced OECD than for developing countries. This is not unexpected

[93] These estimates are from their KS sample.

because financial systems in advanced OECD countries are relatively well developed and efficient. Second, broad monetary aggregates produce high income elasticity in the OECD countries. This result is also reasonable and could be justified in the perspective of aggregates portfolio decisions that influences money demand behaviour in the advanced OECD countries. Figure 2.2 illustrates the point income elasticity estimates for advanced OECD and developing countries (the number of estimations given in the X axis). It is well known that outliers in the sample will bias the average estimates and it is therefore important to deal with this issue. To avoid estimation bias (outliers), I selected estimations that fall in the range: $0.3 \leq$ income elasticity $\leq 2.0$. Using this criterion, I selected income elasticities that were statistically significant. To this end, the total number of observations are 251 (268) for advanced OECD (developing) countries.

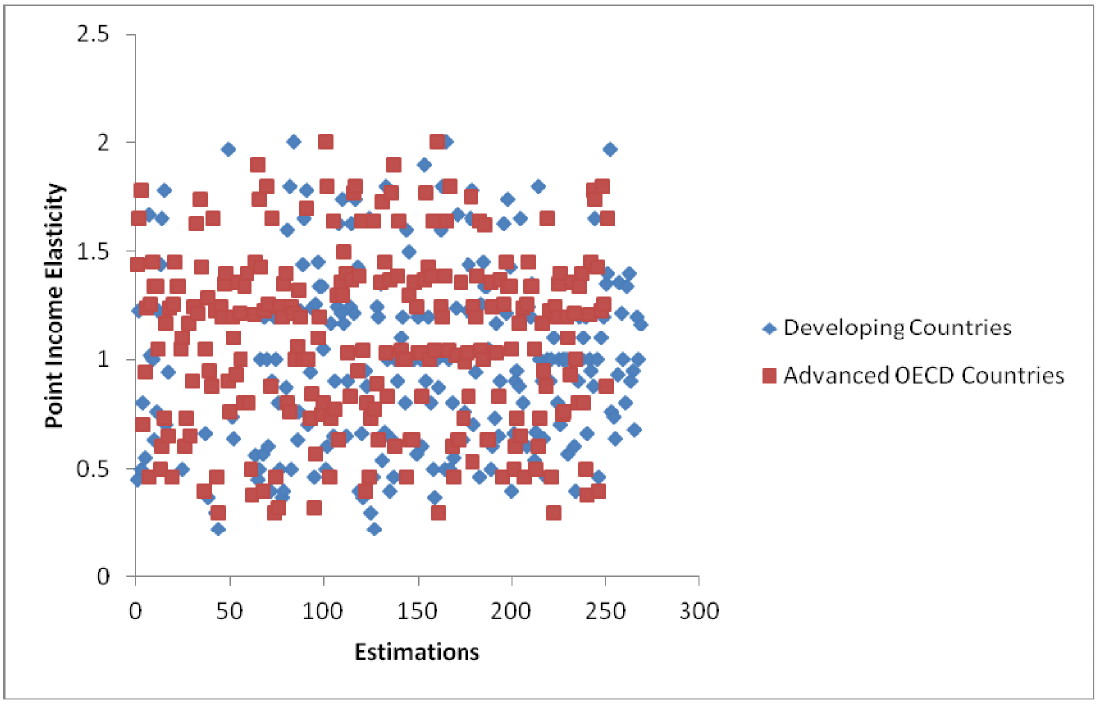



**Figure 2.2 Estimates of Income Elasticity in Advanced OECD and Developing Countries**

### *2.4.3 Monetary Aggregates and Wealth*

The Benchmark meta-regressions are employed to analyse whether the variation in income elasticities can be attributed to wealth and various forms of monetary aggregates. In doing so, the point estimates of income elasticities are regressed on independent variables i.e. monetary aggregates and wealth. The results for advanced OECD and developing countries are summarised in Table 2.5.

Knell and Stix (2005) observed that the inclusion of country-specific dummies seems to make non-negligible differences in the results. Therefore, for sake of robustness of the results, I included country-specific dummies in most regressions. Columns 1 and 3 report the results of specifications with wealth and monetary aggregates ranging from *M1* to *M3*. In columns 2 and 4, the explanatory variables are wealth and broad money (*M2* and *M3* combined). Studies that utilised the measures of wealth found significant impact of wealth on the demand for money, particularly associated with reduced income elasticity. The demand for money depends on all types of wealth is supported by the ground breaking works of Friedman (1954) and Keynes (1936). To this end, the use of the wealth dummy is justified.

**Table 2.5 Income Elasticity Responses to Monetary Aggregates and Wealth**

| Dependent variable: income elasticity | | | | |
|---|---|---|---|---|
| Variables | Advanced OECD Countries | | Developing Countries | |
| | (1) | (2) | (3) | (4) |
| *M1* | 0.104<br>(2.67)* | | 0.010<br>(1.69)** | |
| *M2* | 0.302<br>(1.78)** | | 0.092<br>(2.61)* | |
| *M3* | 0.297<br>(2.14)* | | 0.112<br>(1.98)* | |
| Broad money | | 0.284<br>(2.10)* | | 0.115<br>(3.02)* |
| Wealth | -0.152<br>(1.89)** | -0.157<br>(1.88)** | -0.014<br>(1.39) | -0.005<br>(1.53) |
| Intercept | 0.940<br>(5.57)* | 1.055<br>(4.31)* | 1.617<br>(6.62)* | 1.270<br>(3.21)* |
| Number of observations | 251 | 251 | 268 | 268 |
| $R^2$ | 0.37 | 0.35 | 0.36 | 0.34 |

The absolute t-ratios are in the parentheses. * and ** denotes significance at 5% and 10% levels, respectively.

The results in columns 2 and 4 are fairly consistent with 1 and 3. In these columns, all the estimated coefficients have the expected signs and are significant at the conventional levels, except the estimate of wealth dummy in the developing country sample. These results suggest that the income elasticity is high when broader measures of monetary aggregates are used. To this end, the income elasticity of *M2* and *M3* may be slightly higher than *M1*. However, this effect is marginally higher in advanced OECD countries than the developing countries. This is reasonable because substitution effects (portfolio decisions) seem to be more relevant in the advanced OECD countries. Moreover, the results suggest that inclusion of wealth lowers the income elasticity estimates more in advanced OECD than the developing countries, albeit these are weakly significant in advanced OECD countries and statistically insignificant in developing countries. This finding should not be interpreted that wealth is irrelevant and mostly insignificant in money demand analysis. Wealth estimates are weakly significant or insignificant possibly due to less number of studies employed wealth as an explanatory variable.

Overall, with this small set of independent variables, the benchmark meta-regressions can only explain about 34-37 percent of variation in income elasticities in advanced OECD and developing countries. Note that low r-squared is not uncommon in estimations that involve dummy variable regressors. However, when these income elasticity regressions were tested for temporal stability, the CUSUM and CUSUMSQ tests revealed that they are largely stable, see Figures 2.3 and 2.4.[94]

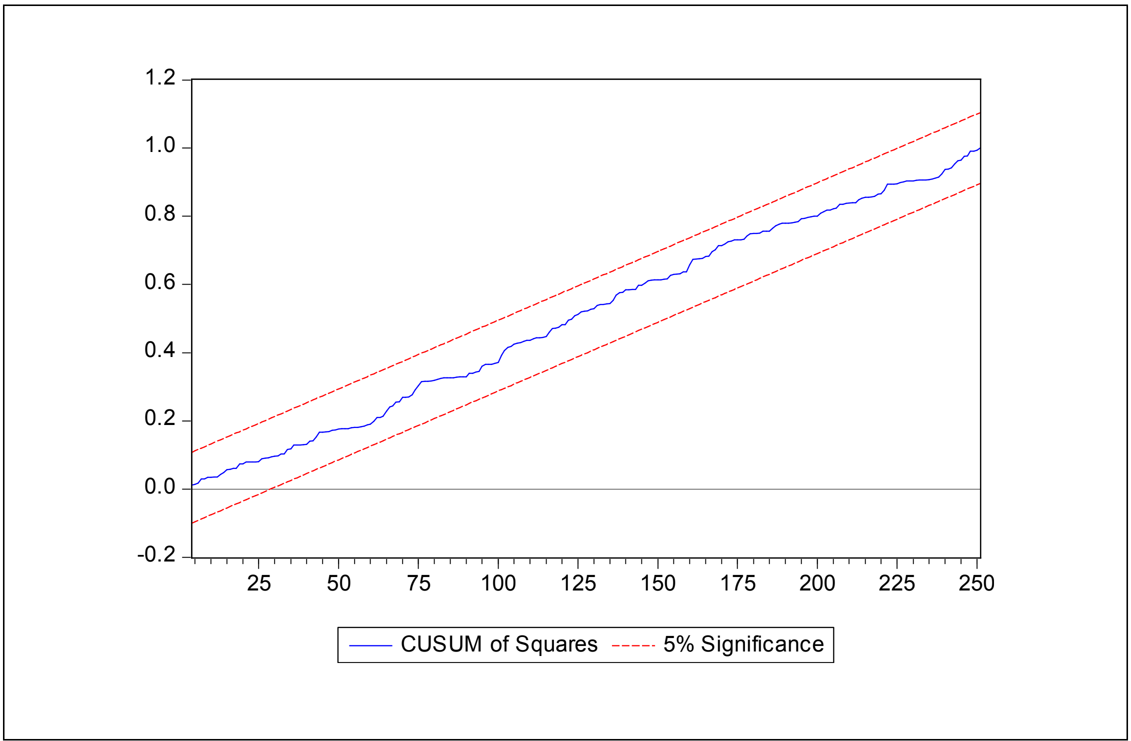



**Figure 2.3 CUSUMSQ Plot for Advanced OECD Countries**

[94]For convenience I report only the CUSUMSQ plots for columns 2 and 4.

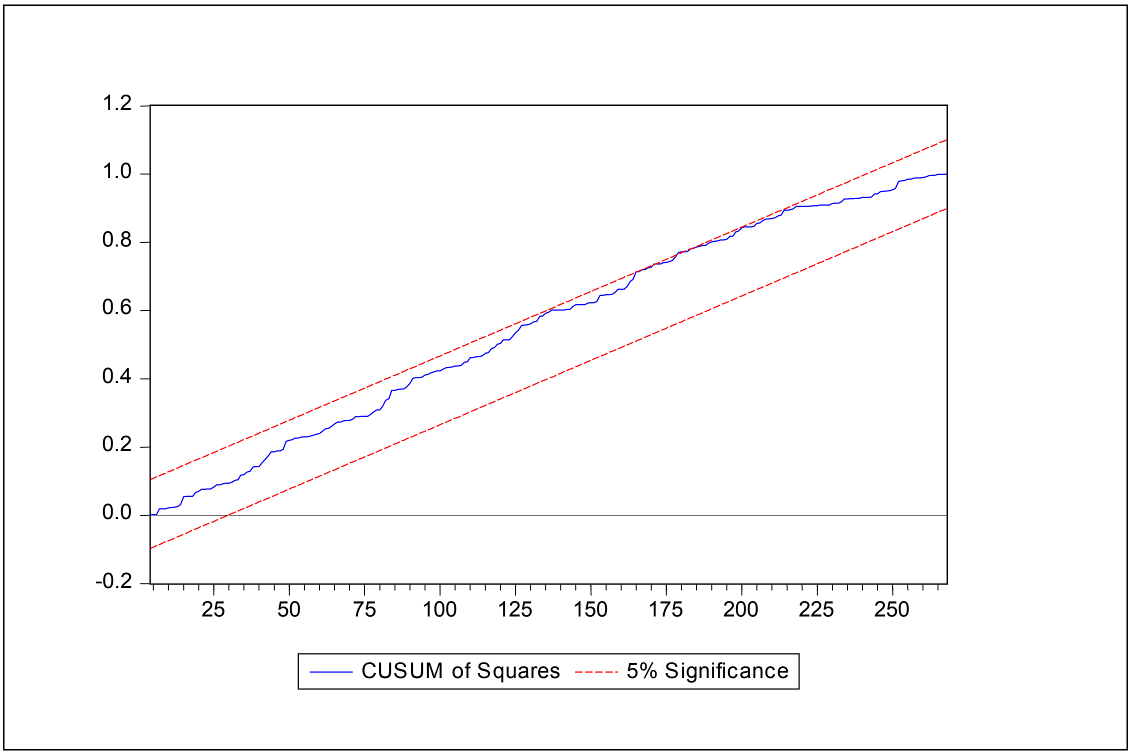



**Figure 2.4 CUSUMSQ Plot for Developing Countries**

### *2.4.4 Financial Reforms and Income Elasticity*

Most advanced countries liberalised their financial markets during the 1960s and 1970s while most developing countries were late starters and delayed reforms until the late 1980s. A number of studies in the demand for money literature have used proxies to capture the impacts of financial reforms and innovations on the money demand. It is likely that the financial sector reforms encouraged economies of scale in the money demand, thus lowering the income elasticity. To this end, we include a dummy variable indicating whether a study contains a measure of financial reforms. Table 2.6 report the estimates of financial reforms and broad money for advanced OECD and developing countries.

**Table 2.6 Income Elasticity Response to Financial Reforms**

| Dependent variable: income elasticity | | |
|---|---|---|
| Variables | Advanced OECD Countries | Developing Countries |
| Broad money | 0.301<br>(1.71)** | 0.138<br>(1.86)** |
| Financial reforms | -0.132<br>(2.09)* | -0.075<br>(1.74)** |
| Intercept | 1.068<br>(5.74)* | 0.394<br>(2.56)* |
| Number of observations | 251 | 268 |
| $R^2$ | 0.35 | 0.34 |

The absolute t-ratios are in the parentheses. * and ** denotes significance at 5% and 10% levels, respectively.

When income elasticity was regressed on only the reforms dummy, the dummy estimates were statistically insignificant. Including wealth and *M1* in the regressions did not yield any robust estimates. However, meaningful estimates were attained when both broad money and reforms dummies were regressors in the equation. For advanced OECD (developing) countries, the reforms dummy is significant at the 5% (10%) significance level and in both cases it has the expected negative sign. It is

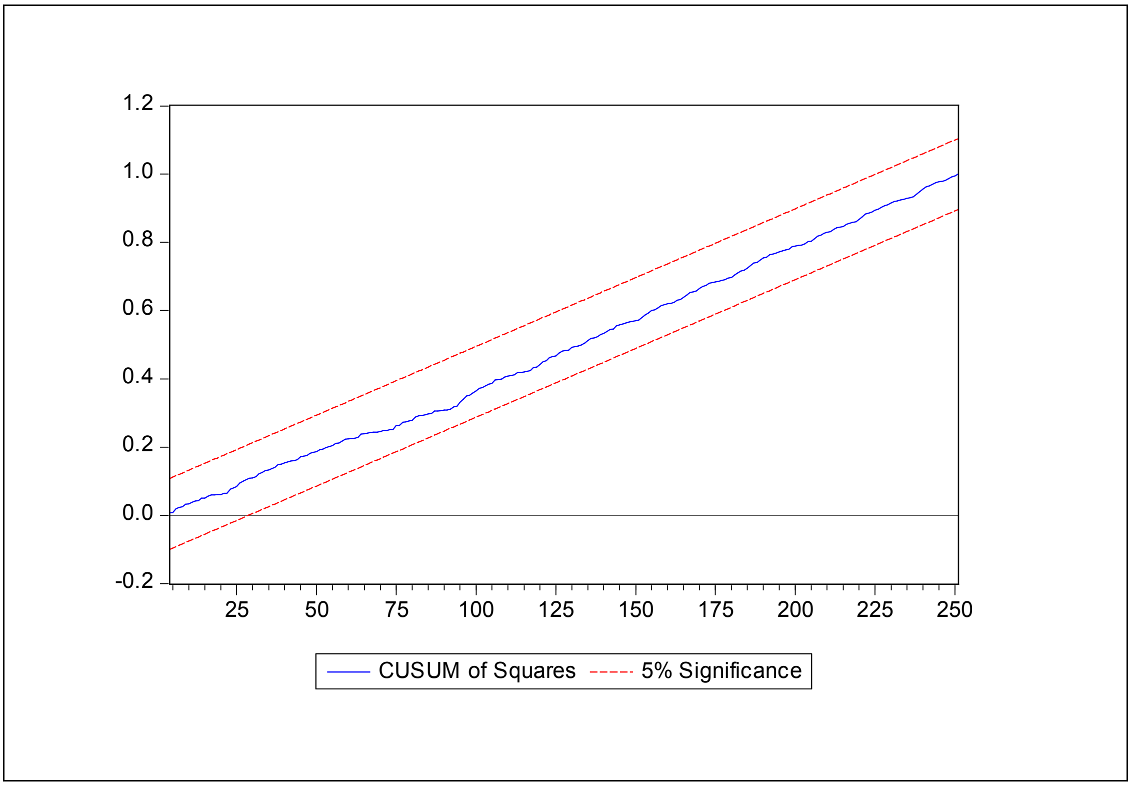



**Figure 2.5 CUSUMSQ Plot for Advanced OECD Countries**

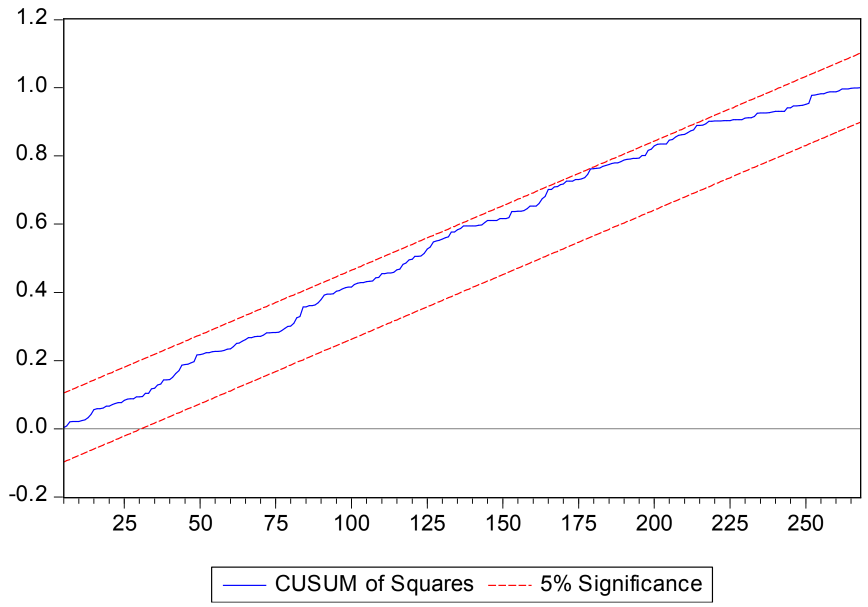



**Figure 2.6 CUSUMSQ Plot for Developing Countries**

observed that reforms had a marginally higher impact on the income elasticity of advanced OECD countries relative to the developing countries. This result is not unexpected because financial markets are still under-developed in most developing countries. Application of the CUSUM and CUSUMSQ tests indicated that the estimated income elasticity equations are stable, see Figures 2.5 and 2.6.[95]

### *2.4.5 Different Weighting Schemes*

The inclusion of a weighting scheme in meta-regression analysis has attracted some controversy (see Weichselbaumer and Winter-Ebmer 2001 and Krueger 2003). The advantage with the weighted least squares is that heteroscedasticity in the error term could be reduced, see Knell and Stix (2003 & 2005). To some extent the weighting scheme is arbitrary because it considers priori beliefs about the quality of studies. In Table 2.7, I considered utilising three different weighting schemes as suggested by Knell and Stix (2005). To this end, the weighting scheme covers number of

[95] For convenience, only CUSUMSQ plots are reported.

observations, number of years and precision of estimates. In columns 1 and 4, weights are based on the number of observations (sample size) implying that the 'quality' of point estimates should improve with higher sample sizes. Columns 2 and 5 report estimates based on the span of data. It is likely that income elasticity will be more accurate if a study allows for longer time span (number of years). Further, precision of the estimates also play a useful role in meta-analysis. Although it is difficult to measure the precision of the income elasticity, we follow Knell and Stix (2003) and use the square root of t-statistics of the income elasticities for individual studies. To this end, columns 3 and 6 relate to the precision of income elasticity and generally higher weights are allocated to more precise estimates.

The results in Table 2.7 are comparable to the results in Tables 2.5 and 2.6. In other words, the different weighting schemes do not cause significant variation in the results. The signs and magnitudes of all estimated coefficients are consistent. All the estimated coefficients are significant at the conventional levels, except narrow money in column 6. These estimates also confirm that broader measures of money may produce income elasticity slightly higher than the narrower aggregates and this impact is observed more in the advanced OECD countries. Although the goodness of fit is small in all six cases, the estimated relationship is fairly stable.[96] Based on these results, it is inferred that weigthing is not a problem in this study.

**Table 2.7 Different Weights**

| | Dependent variable: income elasticity | | | | | |
|---|---|---|---|---|---|---|
| | Advanced OECD Countries | | | Developing Countries | | |
| | (1) Number of obs. | (2) Number years | (3) Precision | (4) Number of obs. | (5) Number years | (6) Precision |
| Broad money | 0.206<br>(1.92)* | 0.301<br>(2.86)* | 0.256<br>(2.96)* | 0.156<br>(1.75)** | 0.129<br>(3.20)* | 0.135<br>(2.15)* |
| Narrow money | 0.120<br>(2.55)* | 0.168<br>(4.41)* | 0.107<br>(3.98)* | 0.086<br>(2.02)* | 0.091<br>(1.79)** | 0.101<br>(1.37) |
| Intercept | 1.933<br>(6.01)* | 1.018<br>(5.52)* | 0.722<br>(3.19)* | 0.056<br>(4.99)* | 1.840<br>(3.24)* | 1.742<br>(4.16)* |
| Number of observations | 251 | 251 | 251 | 268 | 268 | 268 |
| $R^2$ | 0.37 | 0.38 | 0.37 | 0.36 | 0.36 | 0.34 |

All models include country dummies. The absolute t-ratios are in the parentheses. * and ** denotes significance at 5% and 10% levels, respectively.

96 CUSUM and CUSUMSQ tests revealed that all six estimated equations are stable. These results are not reported but can be obtained from the author upon request.

### *2.4.6 Estimation Methods*

The individual money demand studies differs in many ways, however, there is lack of theoretical evidence to support how the additional factors influences the estimated income elasticities. Among others, estimation techniques do play a vital role in empirical analysis of money demand. A number of existing studies have used the system-based method of JML, while others have employed single-equation techniques like the GETS, EG, FMOLS, DOLS and ARDL.

It is interesting to investigate how the alternative estimation methods have influenced the income elasticities in the literature. In columns 1 and 4 (2 and 5) of Table 2.8, I focused on income elasticities that have been estimated using the multivariate (single-equation) methods. Essentially, these income elasticities are grouped so that two sets of sub-samples for advanced OECD and developing countries are developed, respectively. The third set of sub-sample is based on the stability tests. The stability of the money demand function has been tested by a number of studies and some frequently used tests are CUSUM and CUSUMSQ, Hansen (1992) and Gregory and Hansen (1996a & b) structural break tests, Nyblom (1989) type tests, and chow tests. Columns 3 and 6 relate to the sample of studies that tested for money demand stability. Using these sub-samples the income elasticity was regressed on broad and narrow money aggregates.

**Table 2.8 Sub-Sample Estimates**

| | Dependent variable: income elasticity | | | | | |
|---|---|---|---|---|---|---|
| | Advanced OECD Countries | | | Developing Countries | | |
| | (1) Multi-variate | (2) Single equation | (3) Stability tests | (4) Multi-variate | (5) Single equation | (6) Stability tests |
| Broad money | 0.273<br>(2.97)* | 0.217<br>(1.64)** | 0.305<br>(2.82)* | 0.152<br>(2.86)* | 0.124<br>(2.21)* | 0.117<br>(1.71)** |
| Narrow money | 0.154<br>(1.70)** | 0.111<br>(1.91)** | 0.090<br>(2.18)* | 0.108<br>(1.69)** | 0.095<br>(1.71)** | 0.072<br>(2.35)* |
| Intercept | 1.285<br>(3.08)* | 0.936<br>(2.64)* | 1.013<br>(3.95)* | 1.609<br>(3.84)* | 2.984<br>(3.40)* | 1.527<br>(1.91)** |
| Number of observations | 153 | 98 | 205 | 144 | 124 | 192 |
| $R^2$ | 0.37 | 0.36 | 0.39 | 0.37 | 0.37 | 0.36 |

All models include country-specific dummies. The absolute t-ratios are in the parentheses. * and ** denotes significance at 5% and 10% levels, respectively.

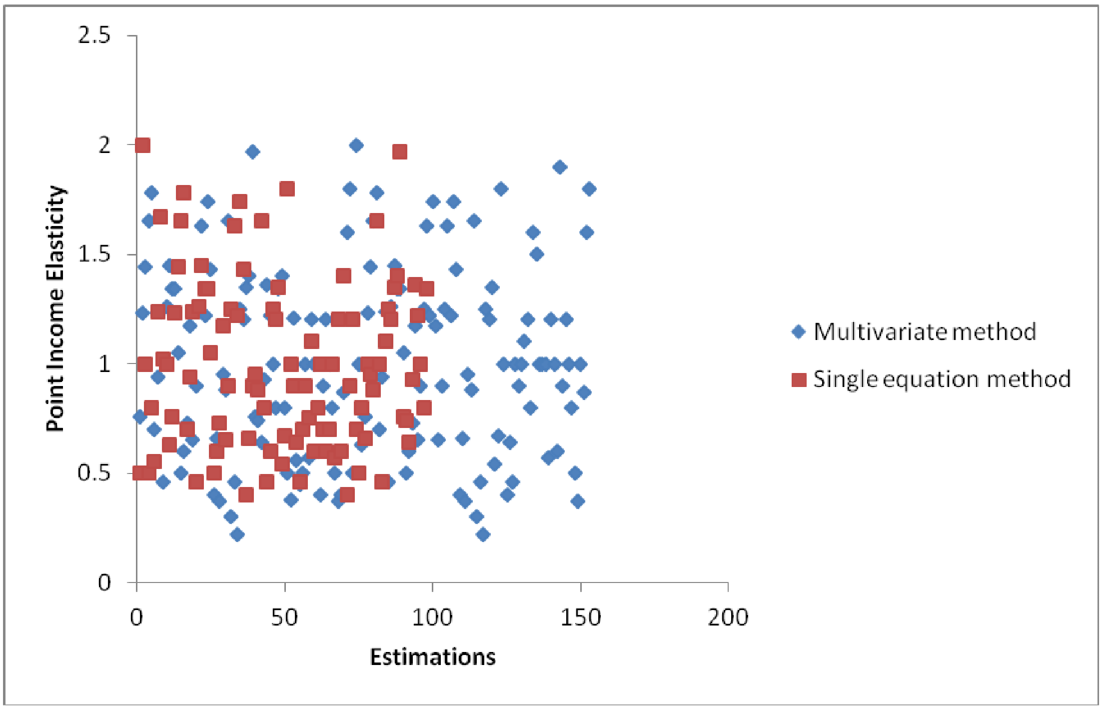



**Figure 2.7 Income Elasticity Estimates of Advanced OECD Countries**

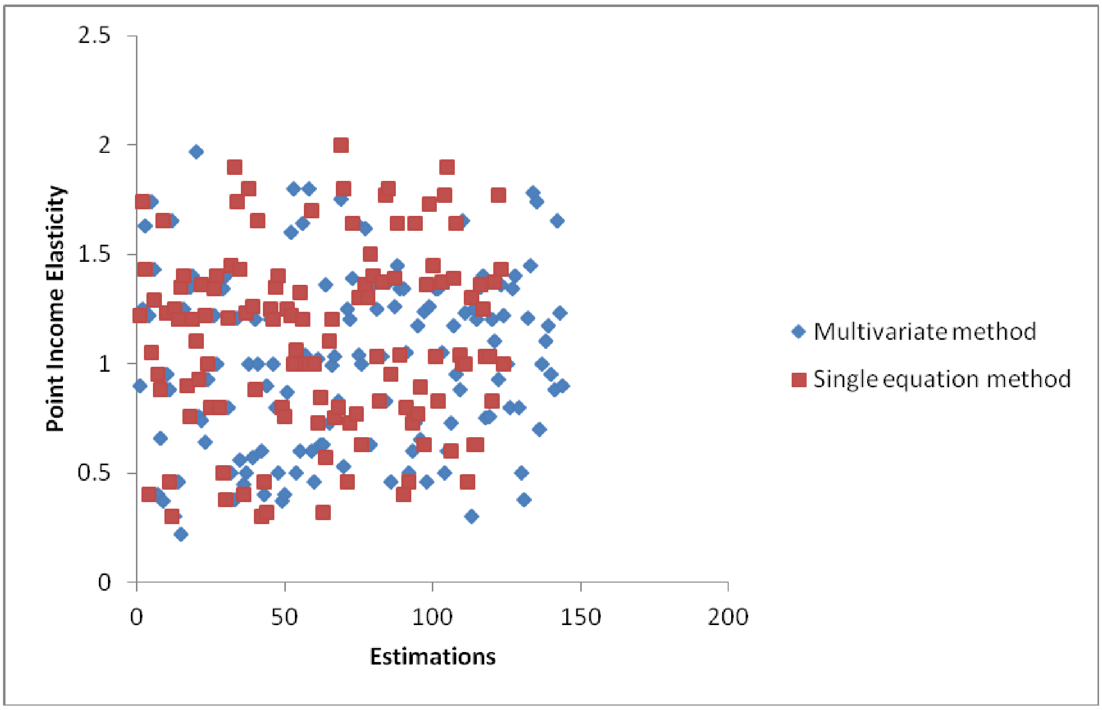



**Figure 2.8 Income Elasticity Estimates of Developing Countries**

In Table 2.8, all the estimated coefficients have expected signs and are statistically significant at the conventional levels. These estimates provide a clear indication that there are no significant differences in the income elasticities when multivariate or single equation techniques are used. This is also quite apparent in Figures 2.7 and 2.8 (the number of estimations given in the X axis). In the time series literature, Smith (2000) and Rao (2007b) argued that alternative estimation methods may yield consistent estimates if they are applied appropriately and if data is reliable. Further, the stability tests seem to have negligible impacts on the income elasticities. Stability tests confirmed that all the estimated equations are largely stable.[97]

### *2.4.7 Opportunity Costs of Money*

Almost all individual studies use proxies to capture the true cost of holding money. Knell and Stix (2005) have explored the possible impacts of interest and inflation rates on the income elasticities, but they ignored to include the exchange rate. To fill this gap, I examined how the various cost of holding money variables (rate of interest, inflation rate and exchange rate) have influenced the income elasticities in advanced OECD and developing countries. Inflation and income elasticity may have inverse relationship, implying that during the periods of extreme inflation, the money velocity rises and likely that income elasticity will fall because agents may economise their holdings of money. The interest and exchange rates also provide considerable uncertainties about asset returns. These two proxies may also be associated with lowering the point income elasticity of money demand.

Table 2.9 report the results on how these opportunity cost variables have influenced the income elasticities. The interest rate estimate (columns 1 and 4) seems to have significant negative impact on income elasticities in both advanced OECD and developing countries. However, the inflation rate (columns 3 and 6) and exchange rates (columns 2 and 5) are statistically significant at only the 10% level in advanced OECD countries, while insignificant at conventional levels in developing countries.

[97] These results (CUSUM and CUSUMSQ) are not reported, but can be obtained from the author upon request.

**Table 2.9 Income Elasticities and Other Variables**

| Variables | Dependent variable: income elasticity | | | | | |
|---|---|---|---|---|---|---|
| | OECD Countries | | | Developing Countries | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Broad money | 0.193<br>(2.02)* | 0.256<br>(1.80)** | 0.212<br>(1.91)** | 0.132<br>(1.97)* | 0.126<br>(1.68)** | 0.018<br>(1.82)** |
| Interest rate | -0.173<br>(2.44)* | | | -0.096<br>(2.91)* | | |
| Exchange rate | | -0.080<br>(1.72)** | | | -0.022<br>(1.40) | |
| Inflation rate | | | -0.011<br>(1.88)** | | | -0.006<br>(1.09) |
| Intercept | 1.128<br>(1.31) | 0.301<br>(2.71)* | 1.011<br>(2.48)* | 1.468<br>(5.81)* | 2.729<br>(2.02)* | 1.689<br>(4.40)* |
| Number of observations | 251 | 251 | 251 | 268 | 268 | 268 |
| $R^2$ | 0.38 | 0.39 | 0.39 | 0.40 | 0.37 | 0.37 |

The absolute t-ratios are in the parentheses. * and ** denotes significance at 5% and 10% levels, respectively.

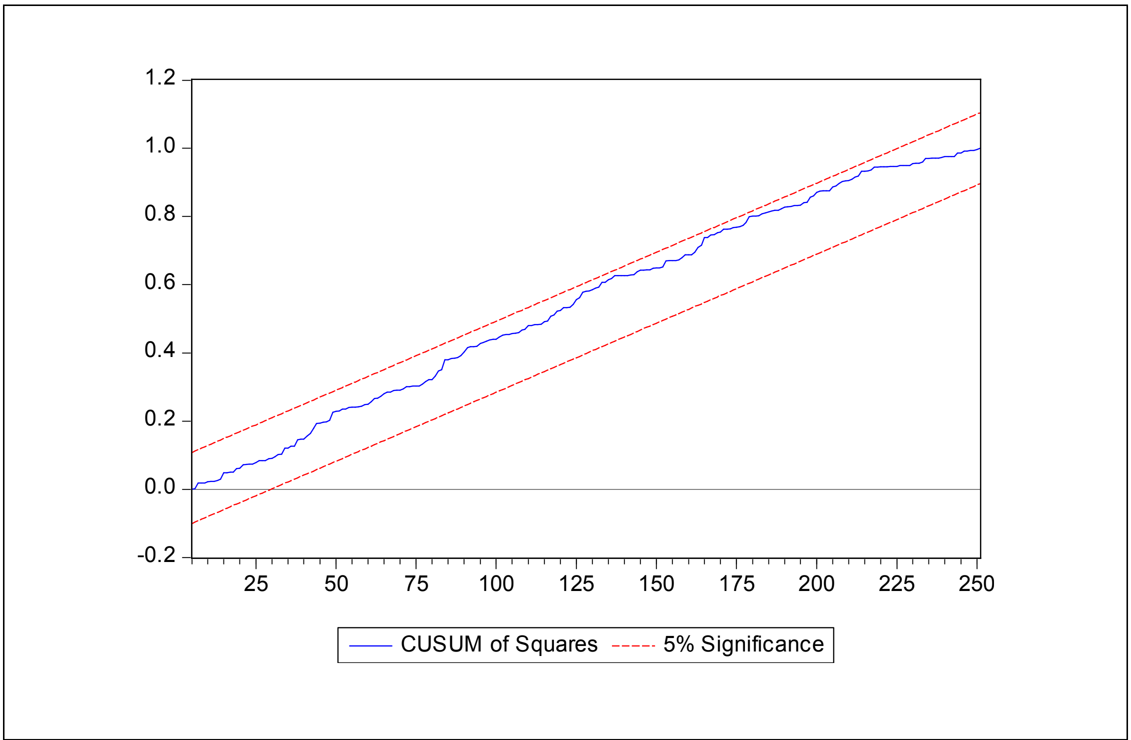



**Figure 2.9 CUSUMSQ Plot for Advanced OECD Countries**

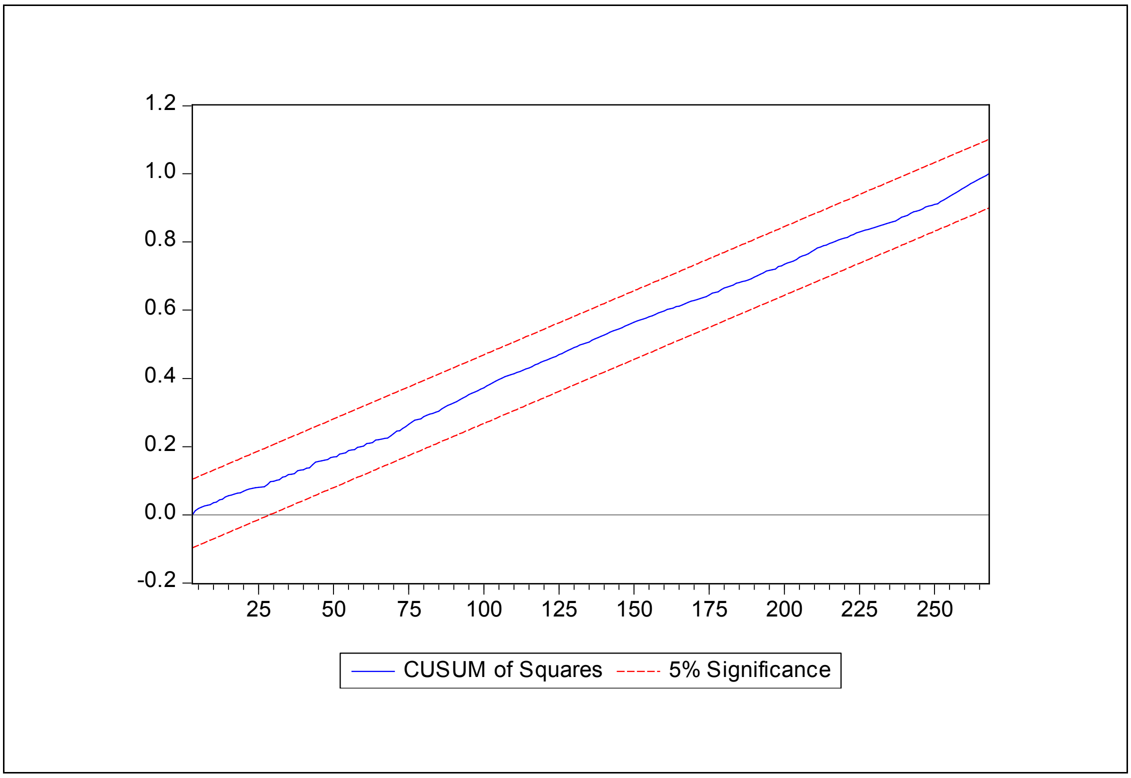



**Figure 2.10 CUSUMSQ Plot for Developing Countries**

These results imply that the conventional money demand specification is still feasible. Further, estimations that utilise data from the advanced OECD countries should consider testing the significance of various cost of holding money proxies (for example, inflation and exchange rates) to achieve robust estimates of income elasticity. The CUSUM and CUSUMSQ tests revealed that all estimated equations in Table 2.9 are stable. For convenience, I report only the CUSUMSQ tests for columns 1 and 4, see Figures 2.9 and 2.10.

## 2.5 Conclusions

In this chapter I have reviewed the empirical works on the demand for money for advanced OECD and developing countries. In the first part, the chapter summarised the major theoretical developments related to the topic. Keynes (1936) and Friedman (1956) are the ground breaking studies on the demand for money. Keynes proposed the liquidity preference theory, which highlighted the three motives for holding money i.e. transactionary, precautionary and speculative motives. Speculative motive is an important innovation in Keynes' analysis, which implies that the demand for money depends negatively on the rate of interest. Keynes criticised the classical quantity theorists for their assumption of a constant velocity and instead he argued that velocity is influenced by behavioural economic variables.

Friedman (1956) opposed the Keynesian perspective that money does not matter. Friedman presented the quantity theory as a theory of demand for money. Unlike Keynes, Friedman assumed that money is abstract purchasing power, implying that money is a durable good which yields a flow of nonobservable services. Utilising the portfolio choice theories, he suggested that the demand for money could be a function of permanent income and some opportunity cost variables (incentives for holding other assets relative to money). Friedman also suggested that the money demand function is highly stable and the velocity is predictable.

The recent developments in the theoretical literature tend to explore whether the demand for money has become irrelevant in the process of monetary policy. The use of monetary aggregates in the monetary policy procedures is supported by Poole (1970) and Goodfriend (1987). McCallum (1988) and Dotsey and Hornstein (2003) to some extent provide support for monetary base in the context of the US and the UK. Meltzer (2001) questioned the effectiveness of monetary policy transmission mechanism under the interest rate based policy. In contrast, Friedman (1975) argued that monetary aggregates play no direct role in the process of monetary policy. Perhaps, monetary aggregates could better serve as the intermediate targets. Other studies that support the interest rate based operating procedures are VanHoose (1989), Barro (1989), Taylor (1999), McCallum (2004), McCallum and Nelson (1999) and Nelson (2002).

The second part of this chapter reviewed the empirical literature of the demand for money. I noted that the empirical literature has looked at a number of specific issues. Amongst others, the issue of money demand instability has received vast interest. Establishing if the money demand function is stable is vital because it provides useful insights for the conduct of monetary policy. Since the 1980s, most empirical studies have focused on analysing the impact of financial reforms and liberalisation on the stability of demand for money. There appears to be no consensus on whether the money demand functions became unstable after the era of financial reforms in the 1980s. Controversy remains in the literature with the estimates of the income elasticities of money demand; for example above unity found by McNown and Wallace (1992) and below unity found by Ball (2001) for the USA. Anoruo (2002) found an income elasticity of around 5.7, while Owoye and Onafowora (2007) attained an income elasticity of nearly 2.1 for Nigeria.

Few other issues emerge from the earlier studies. First, the estimation methods used prior to the 1990s was largely on the basis of PAM approach, see Taylor (1994) for limitations of this method. Second, a number of the earlier studies have ignored the implications of the time series methods of estimation. Moreover, there is possibility of breaks in the unit roots as suggested by Perron (1989) and in such circumstances the conventional unit root test results will be biased. Finally, a relatively small number of studies have utilised the structural break tests to examine breaks in the cointegrating vector. The application of recently developed panel data estimation methods is also limited in the literature. To fill these gaps, this study employed the latest time series and panel data estimation techniques outlined in the next chapter.

To investigate the sources of variation in the results of individual money demand studies, I performed the meta-regression analysis detailed in the final part of this chapter. The procedure used so called the benckmark meta-regressions and is adopted from Knell and Stix (2005), however the analysis is extended to include a larger body of literature and examine characteristics for two sub-samples i.e. advanced OECD and developing countries. The results imply that income elasticities of money demand are significantly higher if broader definitions of the monetary aggregates are used. This effect is marginally higher in the advanced OECD than the developing countries. The inclusion of wealth and financial reforms seems to have reduced the estimates of the income elasticity slightly more in the advanced OECD than the developing countries. Moreover, different weighting schemes (such as number of observations, span of time and precision of estimates) yield estimates that are consistent with the benchmark meta-regression estimates. Further, it appears that the rate of interest is a significant proxy for the cost of holding money. The inflation and exchange rates were statistically significant only in the sample corresponding to the advanced OECD countries.

Finally, my earlier work (for example, see Kumar, 2011; Kumar and Webber, 2011; and Kumar et al., 2011) reviewed the empirical literature on the demand for money and also noted some of the above-mentioned limitations. Needless to say, this chapter has built on my existing work. The information presented in this literature survey should allow researchers to compare their own results and methods with those undertaken previously across a wide range of countries. In this era of financial crises/reforms and inflationary pressures, this study identifies some important factors that may be useful for monetary policy procedures in the advanced OECD and developing countries.

The next chapter describes the time series and panel data techniques that have been used in this study. These techniques include tests for unit roots, cointegration, causality, structural breaks and robustness. Actually, many researchers encounter the problem of selecting appropriate tests in cointegration analysis; therefore I developed flowcharts which illustrate when it is appropriate to apply various unit root and cointegration techniques. This could serve as a useful tool for practitioners working with non-stationary time series and panel data.

# CHAPTER 3: METHODS

## 3.1 Introduction

Many applied economists encounter the problem of selecting an appropriate estimation technique to estimate long and short run relationships. In other words, a methodological debate exists on the relative merits of the statistical techniques for the estimation of the time series and panel data models to test theoretical relationships. Although this new debate has more positive aspects, it appears that it is also difficult to evaluate their relative merits. This methodological debate is not new and it is difficult to achieve definite conclusions because empirical verifications seldom consistently favour one particular approach; see Rao (2007b, p. 1613). Often applied economists argue that multivariate cointegration techniques are relatively better than single-equation estimation techniques, while some follow a technique that is simple and easy to use.

Smith (2000) and Rao (2007b) detail the useful stages of the research programme. The distinction between the three stages of research are in terms of purpose (or objective), summary and interpretation of facts. Obviously, statistical techniques are seen as tools to develop credible summaries of the observed facts. The purpose and interpretation stages of research are more linked to the preferred economic theory. According to Rao (2007b), to evaluate the relative merits of the alternative statistical techniques, it is important to ask: how good a particular technique is for summarizing the observed facts? It is unlikely that alternative techniques will provide conflicting summaries, at least qualitatively, with the same set of observed facts. They may differ, however, in their precision and perhaps only marginally. If so, as Granger (1997) has observed, eventually a computationally simpler technique with an acceptable degree of precision will be widely used; see Rao (2007b, p. 1614). The more demanding and high precision techniques will probably be used in specialized applications.

The classical estimation methods of Ordinary Least Squares (OLS) or Partial Adjustment Models (PAM) were popular in the past, but recently the time series and panel data methods became increasingly popular in applied works. It is well known that the use of estimation techniques without verifying the integrated properties of the variables is inappropriate. This could result in spurious regression problems; see Engle and Granger (1987). In the context of money demand, developments in the time series and panel data methods has raised doubts on the earlier estimates that were achieved through the traditional methods.

The objective of this chapter is to describe the time series and panel data methods used in this study. It starts with unit root tests that are employed to examine the integrated properties of the variables i.e. conventional tests (Augmented Dickey Fuller, 1979 (ADF); Phillips and Perron, 1988 (PP); and Kwiatkowski et al. 1992, (KPSS)) and structural break tests (Zivot and Andrews, 1992; Lee and Strazicich, 2003 & 2004; and Bai and Perron, 1998 & 2003). Panel unit root tests (Levin, Lin and Chu, 2002; Im, Pesaran and Shin, 1997 & 2003; Maddala-Wu, 1999; Breitung, 2000; and Hadri, 2000) are also utilised. In order to determine and estimate cointgerating vectors, time series (panel data) techniques such as Hendry's (1995) General to Specific (GETS), Engle and Granger's (1987) two step procedure (EG) , Phillip and Hansen's (1990) fully modified OLS (FMOLS), Johansen's (1991) maximum likelihood (JML) and Pesaran et al.'s (2001) autoregressive distributed lag model (ARDL) (Pedroni, 2004; Mark and Sul, 2003; Breitung, 2005; and Westerlund, 2007) are employed. Further, to test for structural breaks in the cointegrating vectors, I preferred using the Gregory and Hansen (1996a & b) and Westerlund (2006) tests. Panel Granger causality (Hurlin, 2004 and Hurlin and Venet, 2001) and extreme bounds (Leamer, 1983 and 1985) tests are also performed.

As part of this chapter, I developed flowcharts which illustrate different unit root and cointegration methods and when it is appropriate to apply them. While it is a fairly complicated task to 'systemise' the application of unit root and cointegration tests in a flowchart, I have considered some decisions on the basis of what the data 'are' and some others on the basis of what the researcher 'prefers'. Obviously the choices depend on the wider context and usually applied economists employ tests that are relevant to the purpose of their exercise. The novelty of this statistical tool is that a comprehensive set of unit root and cointegration tests is structured in form of flowcharts which illustrate the possible instances in which they could be utilised. This could serve as a useful guide to applied economists who are working with non-stationary time series and panels. Further, I argue that alternative estimation methods give robust results if they are applied appropriately and if data is reliable.[98]

This chapter is organised as follows: Section 3.2 presents the flowcharts and briefly discusses the unit roots and cointegration in applied works. Sections 3.3 and 3.4 provide details on the alternative time series and panel data techniques, respectively. Section 3.5 gives a brief background of Granger causality tests and its extension in the panel data. Section 3.6 details the time series and panel data based structural break tests. The extreme bounds analysis is briefly discussed in Section 3.7, and finally, Section 3.8 concludes.

## 3.2 Unit Roots and Cointegration

In applied econometric work, the standard classical methods of estimation are based on the assumption that the means and variances of the variables are constant. However, applications of the unit root tests have shown that the means and variances of many macroeconomic variables are not constant or change over time and thus these assumptions are not satisfied; see Rao (2007a, p. 3). These variables are called non-stationary or unit root variables. It is obvious that spurious estimates will be attained when classical estimation methods, for example OLS, are used to estimate a cointegrating equation with unit root variables.[99] Moreover, conventional tests will equivocally reject the null of no relationship between the variables even if the null is true. There also seems to be some relationship between the Durbin-Watson (DW) statistic and non-stationarity; see Rao (2007a, p. 4). Phillips (1986) showed that when a regression is run between the unit root variables, DW statistic converges towards zero. To this end, a lower DW statistic implies that the variables in a

[98] This inference is based on my empirical results.
[99] These are well explained in Rao (2007a, p. 3). He argued that if the means and variances of the unit root variables change over time, all the computed summary statistics, in which these means and variances are used, are time dependent and fail to converge to their true values as the sample size increases.

regression are non-stationary. Thus in applied econometric work, it is vital to first determine the integrated properties of the variables.

The variables (real money stock, real income, nominal rate of interest, nominal exchange rate and inflation rate) that are frequently utilised in money demand analysis are generally non-stationary but the basic statistical concern is the appropriate representation of the nature of non-stationarity. There are two approaches to deal with this issue. In the first approach, variables are detrended by regressing the series on time. To this end, non-stationary time series are assumed to be trend-stationary. The second approach is well detailed in Nelson and Plosser (1982). In this set-up the series are better characterized as difference stationary i.e. differencing rather than detrending to attain stationarity. The second approach is more appealing and widely used in empirical works.[100]

Cointegration is observed as an equilibrium long run relationship between the non-stationary variables. According to Rao (2007a, p. 4) there are four main steps in applying unit root and cointegration techniques. First, integrated properties of the variables are determined through the application of various unit root tests. Second, if variables satisfy certain conditions then the cointegrating equations are estimated. These cointegrating equations should not be interpreted as causality relationship between the variables. To this end, theoretical considerations and appropriate empirical tests are mandatory to determine ‘what causes what’. Third, the short run dynamic adjustment equations are estimated. In this set-up, the ECM term captures the negative feedback mechanism. Finally, diagnostic tests are essential to evaluate the robustness of the results.

Useful economic implications emerge from the unit roots and cointegration literature. The mainsteam Keynesian and Neoclassical models regarded economic fluctuations as transitory deviations from a steady output growth. The two paradigms

[100] Trend (difference) stationary in aggregate income provides support for traditional (real) business cycle model in which income variations due to macroeconomic disturbances are transitory (permanent) variations from trend, see Serletis (2001, p. 114). More details on these will be given shortly.

provided varying inferences about economic fluctuations but assumed that economic fluctuations are due to aggregate demand shocks. These fluctuations will eventually diminish and the economy will return to its full employment equilibrium (Rao, 2007a, p. 6). To this end, income variations due to these aggregate demand shocks will have transitory impacts on the full employment equilibrium income. Alternatively, the real business cycle models examined the relationships between the aggregate supply shocks and economic fluctuations. It is argued that aggregate supply shocks will have permanent impacts on the full employment equilibrium income. Although it is difficult to evaluate these two theories; real business cycle models have received some immense interest in the time series literature; see Rao (2007a) and Nelson and Plosser (1982).

### *3.2.1 Flowchart for Application of Unit Roots and Cointegration Tests*

Smith (2000) argued that there are three vital stages of research in applied work viz. purpose, summary and interpretation. The purpose of research is established first and then appropriate empirical tests are employed to attain summaries of facts. Economic theory and results from these tests are useful for the interpretation stage. Since empirical tests play a crucial role within this threefold research programme, here I shall focus on how various tests could be utilised.

Controversy remains with the application of unit roots and cointegration methods in the applied econometrics literature. The pioneering works of Engle and Granger (1987) and Johansen (1988) have attracted many econometricians to extend their approaches or develop new tests for unit roots and cointegration. Consequently, there exist a large number of methods in the literature and each contributor argues that their methods are relatively better than others. From an application point of view, often researchers are uncertain on the set of tests that should be employed to ascertain answers to their questions. An incorrect choice of these methods can lead to attaining misleading results. The challenge to overcome this problem has given rise to comprehensive methodological surveys, for example see Pesaran and Smith (1995 & 1998), Rao (2007b) and Breitung and Pesaran (2008). This study adopted an alternative approach which offers to guide applied economists with the choices they need to make. I developed flowcharts which illustrate the application of various unit root and cointegration tests. To this end, it is specifically designed for practitioners who are working with non-stationary time series and panel data. In other words, laying out the manifold options would help to clarify the decisions that need to be made in such applied works.

It is a fairly complicated task to 'systemise' the application of unit root and cointegration tests in a flowchart. The choices depend on the wider context; in particular relevance to the purpose of the exercise, why you are doing it, and consistency with what else you know about the process. Pre-testing bias is a real problem and certainly no flowchart can take into account the complexity of real world, nor relieve the researcher from applying his own judgement and taking his responsibilities. This is in some way openly recognized in the flowcharts, because some decisions are taken on the basis of what the data 'are' (decisions with yellow colour) and some others on the basis of what the researcher 'prefers' (decisions with blue colour). These are certainly not the key decisions but instead are simple options that could help researchers in selecting among the various methods.

Let's now focus on Flowchart 3.1; see pages 139-140 below. The first choice is whether to pursue time series or panel estimation route. If T (time dimension) is large one might prefer to treat the data as N (cross section dimension) separate time series and follow the time series route. If T (N) is small (large) it would be preferable to pursue the panel route. In the next stage, researchers perform the unit root tests to avoid the problem of spurious regressions. There are several time series unit root tests developed, however, tests that consider non-linearities in the data series are limited, see Kapetanios et al. (2003) and Kruse (2011). On the other hand, tests that consider structural changes (Perron, 1989; Zivot and Andrews, 1992; Perron, 1997; Lumsdaine and Papell, 1997; Bai and Perron, 2003; and Lee and Strazicich, 2003 & 2004) in the data series are more demanding than the conventional tests (ADF, 1979; Elliot, Rothenberg and Stock, 1996 (ERS); PP, 1988; and KPSS, 1992). The presence of shifts in mean or trend will lead to equivocal rejection of the unit root null, even if the process is non-stationary around the shifting mean or trend. Perron (1997 & 2006) discusses the strengths of structural break unit root tests over the conventional tests. However, a number of other factors should also be considered in selecting the time series unit root tests, for instance, data span, treatment of intercept and trend, power of the tests and treatment of serial correlation. While it is difficult to consider all these factors in the flowchart, I preferred to utilise some of them.

Breitung and Pesaran (2008) distinguish between the first and second generation panel unit root tests. While the first generation tests (Maddala-Wu, 1999; Hadri, 2000; Breitung, 2000; Levin, Lin and Chu, 2002 (LLC); Im, Pesaran and Shin, 2003 (IPS)) are based on the incredible assumption that the cross-sectional units are independent, the second generation tests (Chang, 2002; Moon-Perron, 2004; Pesaran, 2007; Hadri-Kurozumi, 2008 and Cerrato et al., 2011) assume cross-section dependence; for a survey of these tests see Banerjee (1999), Baltagi and Kao (2000) and Baltagi (2005). Most empirical applications criticize the first generation tests because results can be misleading if the independence assumption is violated; for example see O'Connell (1998) and Banerjee et al. (2004).

In the first generation tests, the null of stationarity (non-stationarity) is tested against the homogenous alternative in the Hadri (2000) (Breitung, 2000; LLC, 2002) tests. Alternatively, tests such as Maddala and Wu (1999) and IPS (2003) tests the null of non-stationarity against the heterogenous alternative. Two characteristics emerge from the second generation panel unit root tests. The first set of tests imposes less or no restrictions on the residual covariance matrix or largely utilises the non-linear frameworks; for example Chang (2002) and Cerrato et al. (2011). The second set of tests adopts a factor structure approach, for instance, among others Pesaran (2007) utilises a single common factor while Moon and Perron (2004) and Hadri and Kurozumi (2008) relies on many common factors. Statistical software, for instance Eviews 7.0, RATS 8.0 and STATA 12.0 does contain routines for testing the time series and panel unit roots.

The analysis of cointegration in panel data is in early stages of development. Cointegration in the time series appears in a rather implicit way but panel cointegration does not. Flowchart 3.2 (see pages 141-142 below) illustrates when to apply various time series and panel data tests for cointegration. One of the crucial issues is whether the methods yield single or more than one cointegrating vectors. Cointegration in panels are based on two approximations viz. the residual-based and the system-based; see Carrion-i-Silvestre and Surdeanu (2009).[101] The residual-based tests are similar to single-equation tests. These methods either specify the null of no cointegration against the homogenous or heterogenous alternatives- see Pedroni (2004) and Kao (1999)- or the null of cointegration- see McCoskey and Kao (1998) and Westerlund (2005). According to McCoskey and Kao (1998), testing the null of cointegration can be very appealing in applications where cointegration is predicted a priori by economic theory. In such situations, Mark and Sul's (2003) DOLS estimator can be directly used to estimate the cointegrating vector. On the other hand, the system-based methods utilises the VAR framework, for example Larsson et al. (2001).

The most important characteristic of the above mentioned tests is that they are first generation panel cointegration tests i.e. observations are independent across individuals. Although these tests assume cross-section independence, but in application, one typically encounters some degree of cross-section dependence, for example, Pedroni (2004) and Mark and Sul (2003) permits a limited (negligible) degree of cross-section dependence through the presence of time-specific effects. Violation of the cross-section independence assumption implies that Central Limit Theorems cannot be utilised and, hence, the use of panel data statistics to determine the existence of cointegration can give misleading results. Consequently, the second generation panel cointegration tests tend to assume cross-section dependence to avoid this problem. These methods include Gengenbach et al. (2006) and Westerlund (2007) for the single-equation framework, and Groen and Kleinberger (2003), Breitung (2005) and Carrion-i-Silvestre and Surdeanu (2009) for the vector error correction (VECM) framework. Although these methods assume cross-section dependence, they differ in terms of their common factors, estimators and treatment of structural changes. The flowchart tends to utilise some of these features to distinguish between them. Some familiarity with GAUSS 11.0 is necessary to

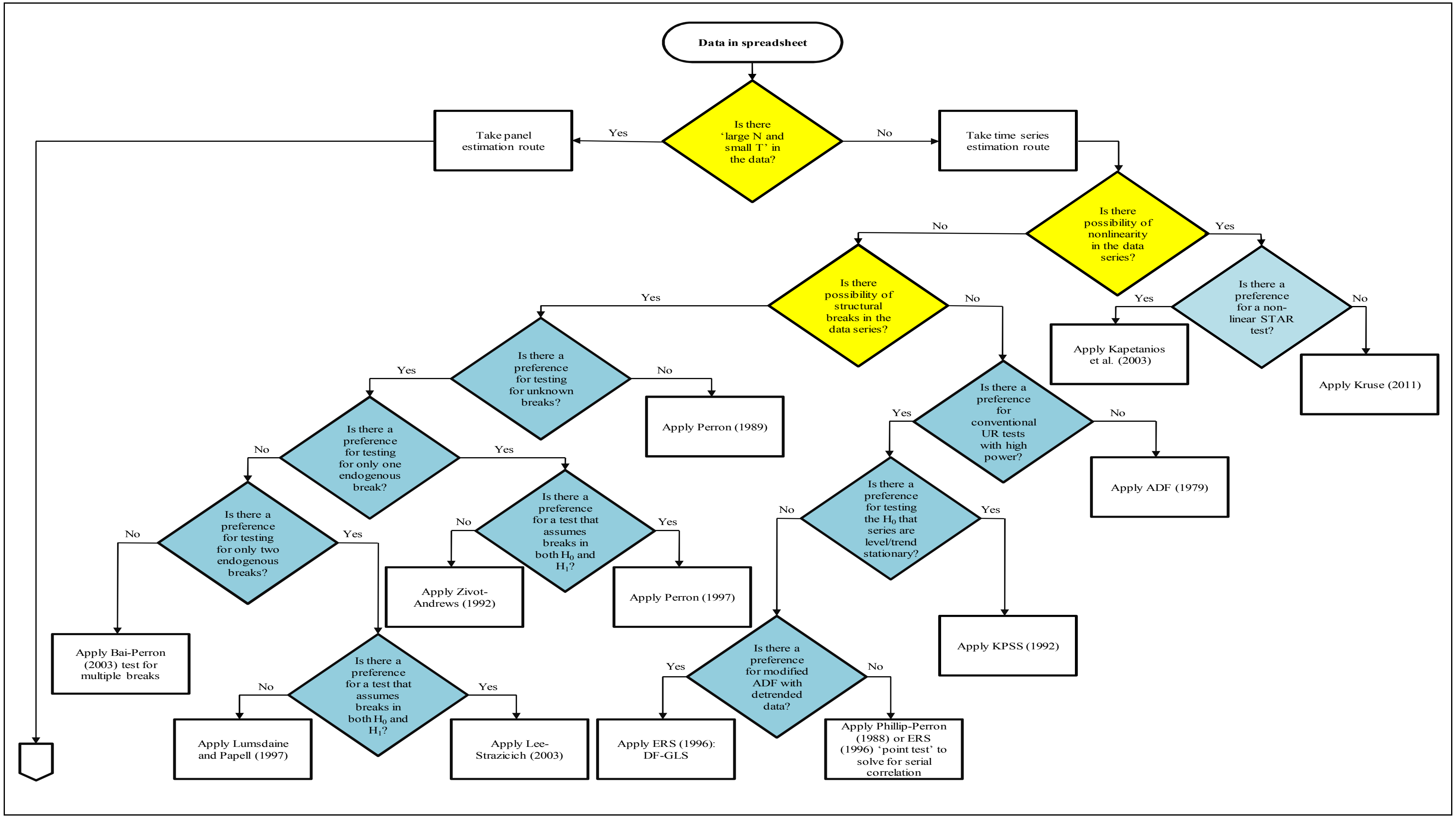
[101] The system-based methods offer more than one cointegrating vectors while the single-equation methods provide only one cointegrating vector.

perform these panel cointegration tests; nevertheless some tests are included in RATS 8.0 and STATA 12.0.

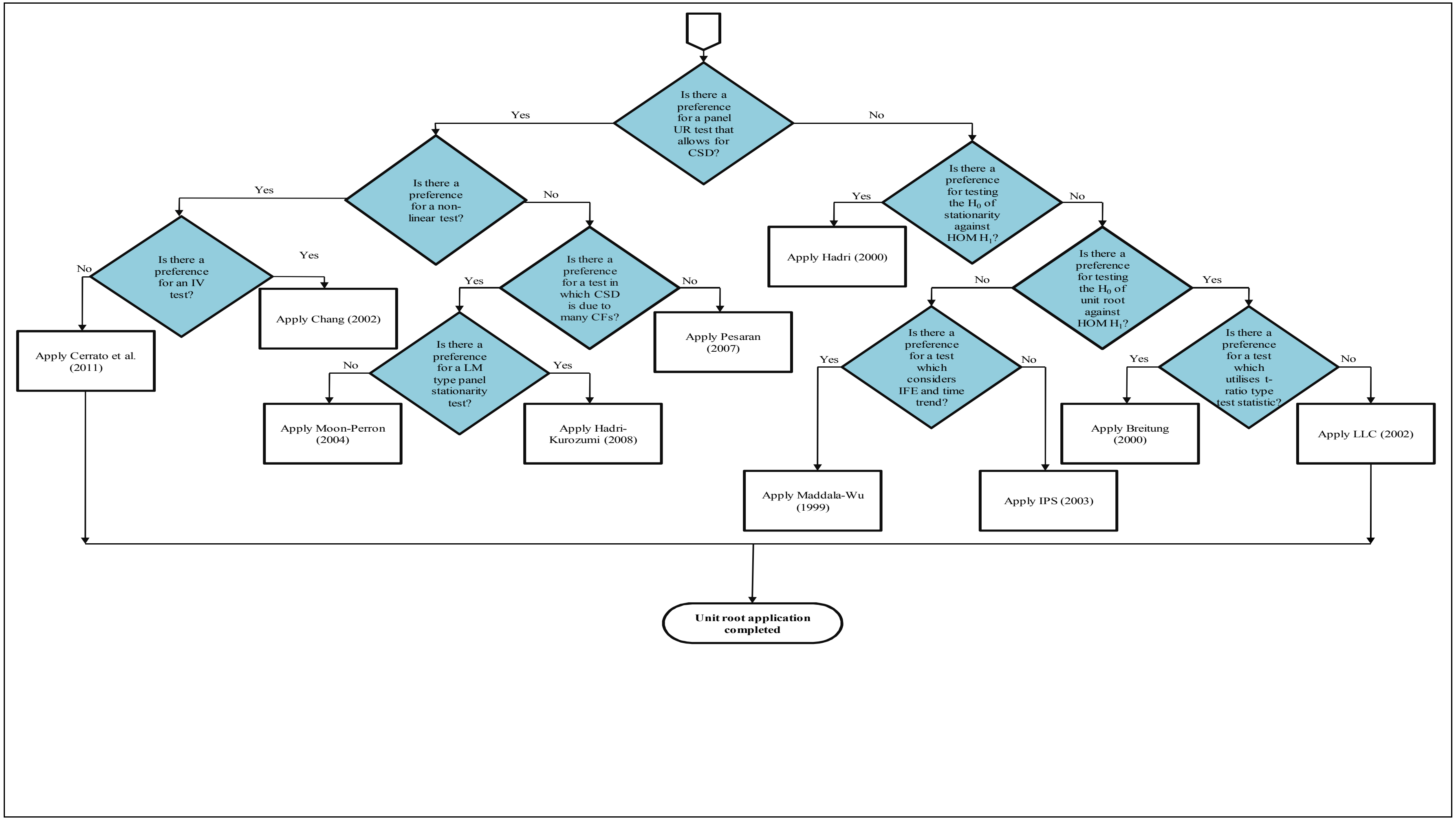
There are a few time series cointegration methods that generally do not entail testing for integrated order of the variables, for example Hendry's (1995) General to Specific (GETS) and Pesaran et al.'s (2001) autoregressive distributed lag (ARDL) methods. Ideally, these methods can be utilised regardless of whether the variables are I(1) or I(0) or combination of them. However, when the variables are I(1) in levels, single-equation (Engle and Granger, 1987 (EG); Phillip and Hansen, 1990 (FMOLS) fully modified OLS; Stock and Watson, 1993 (DOLS) dynamic OLS) and multivariate (Johansen, 1991 (JML)) methods are feasible.  Microfit 5.0 and RATS 8.0 does contain the routines to perform these tests.

If the cointegrating vector is known a priori, one can form the hypothesised I(0) linear combination and use a unit root test to establish whether they are actually I(0). If there is a single unknown cointegrating vector, this could be analysed through the application of time series tests which utilises error correction models (ECMs) or addresses endogeneity or short sample biases. In the multivariate context, JML is a fairly efficient estimator in dealing with identification and endogeneity issues, however it will not yield meaningful estimates if $T$ is small.

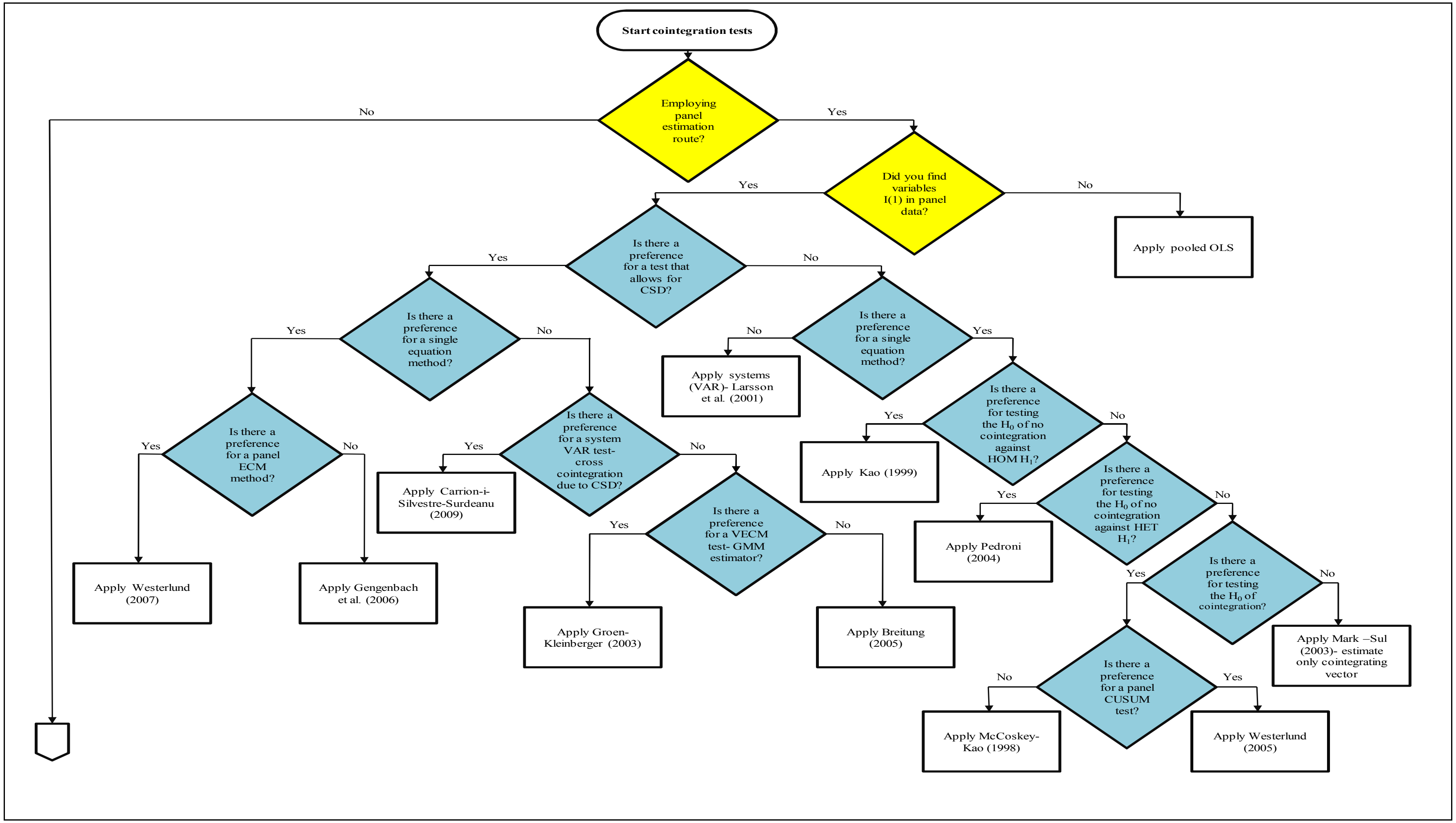
In the final stage, it is vital to check whether your preferred estimation methods gave meaningful results. Flowchart 3.3 (see page 143 below) illustrates that application of further tests would be necessary to examine robustness of the results, for example among others Leamer's (1983) extreme bounds analysis (EBA) and Brown et al.'s (1975) CUSUM (Cumulative Sum) and CUSUMSQ (CUSUM of Squares) of recursive residuals stability tests. Granger causality tests could also provide meaningful insights on the causality relationship between the variables. Further, the standard time series and panel methods can fail to yield robust results if there is



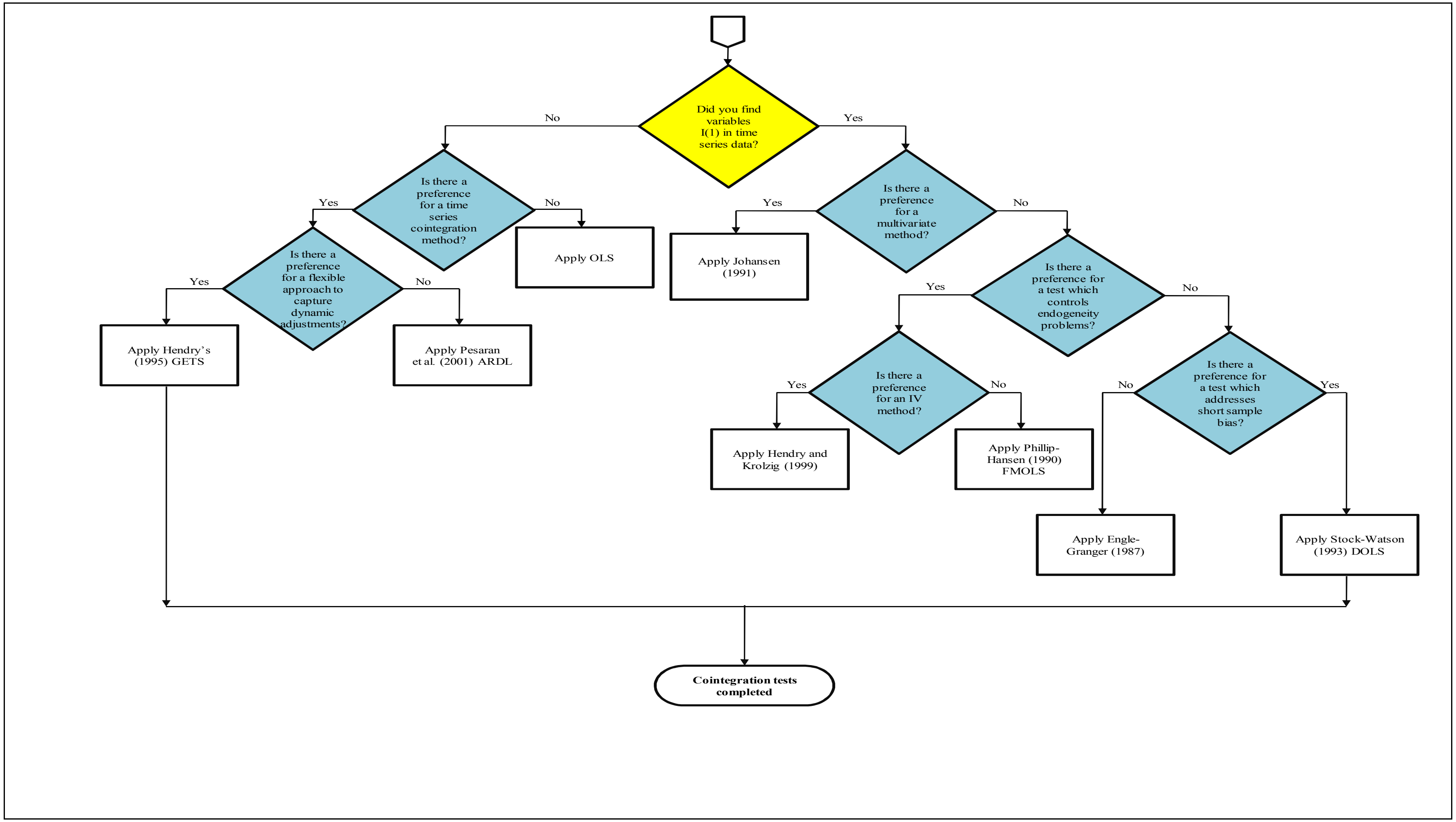

**Flowchart 3.1: Application of Unit Roots and Cointegration Tests**



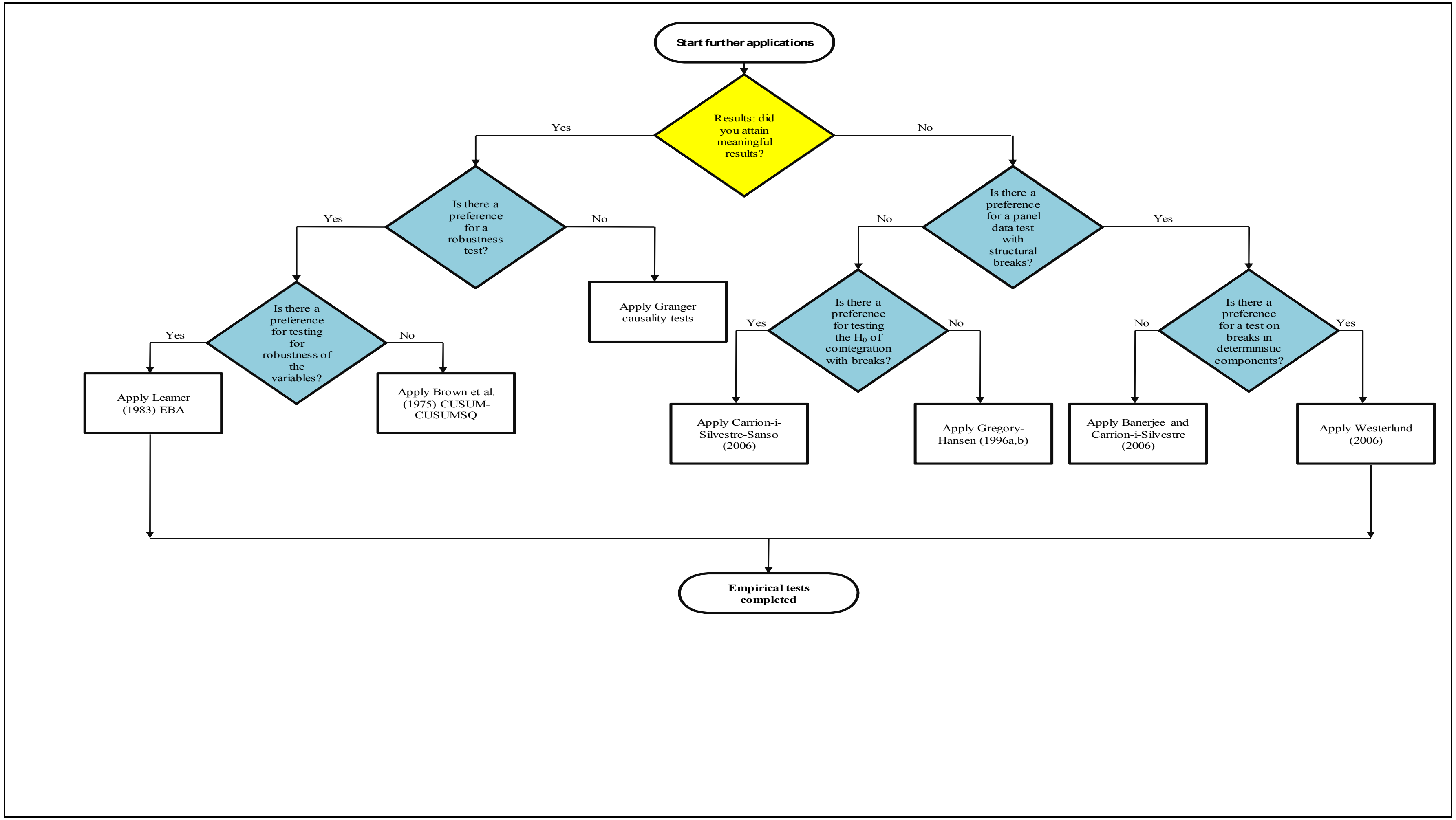

**Flowchart 3.1: Application of Unit Roots and Cointegration Tests**




**Flowchart 3.2: Application of Unit Roots and Cointegration Tests**




**Flowchart 3.2: Application of Unit Roots and Cointegration Tests**




**Flowchart 3.3: Application of Unit Roots and Cointegration Tests**

## Notes:

| | | |
|---|---|---|
| ADF | = | Augmented Dickey Fuller |
| ARDL | = | Autoregressive distributed lag model |
| CFs | = | Common factors |
| CSD | = | Cross section dependence |
| CUSUM | = | Cumulative sum of recursive residuals |
| CUSUMSQ | = | CUSUM of squares of recursive residuals |
| DF-GLS | = | Dickey-Fuller generalized least squares |
| DOLS | = | Dynamic OLS |
| EBA | = | Extreme bounds analysis |
| ECM | = | Error correction model |
| ERS | = | Elliot et al. (1996) |
| FMOLS | = | Fully modified OLS |
| GETS | = | General to Specific |
| GMM | = | Generealized method of moment |
| $H_0$ | = | Null hypothesis |
| $H_1$ | = | Alternative hypothesis |
| HET | = | Heterogeneous |
| HOM | = | Homogeneous |
| IFE | = | Individual fixed effects |
| IPS | = | Im et al. (2003) |
| IV | = | Instrumental variable |
| KPSS | = | Kwiatkowski et al. (1992) |
| LLC | = | Levin et al. (2002) |
| LM | = | Langrange multiplier |
| N | = | Cross-section units |
| OLS | = | Ordinary least squares |
| STAR | = | Smooth transition autoregressive |
| T | = | Time observations |
| UR | = | Unit root |
| VAR | = | Vector autoregression |
| VECM | = | Vector error correction model |

possibility of structural changes. In the time series context, this could be addressed through the application of the Gregory and Hansen (1996a & b) and Carrion-i-Silvestre and Sanso (2006) tests. Westerlund (2006) and Banerjee and Carrion-i-Silvestre (2006) tests could be utilised to test for multiple breaks in the panel data.[102]

Finally, I must restate that purpose of research is crucial in determining parameters of interest and appropriate estimators. Smith (2000) and Rao (2007b) provide excellent details on these aspects. Applied economists must consider not only the estimation theory and techniques but also the purpose of the activity and the economic context, which define the parameters of interest. To this end, different methods may be appropriate for different purposes, such as policy analysis or testing hypotheses or forecasting.

### *3.2.2 Conventional Tests for Unit Roots in Time Series*

The ADF (1979) tests can be generalized to allow for higher-order autoregressive dynamics, in the case that an AR(1) process is inadequate to render $\varepsilon_t$ white noise. The conventional ADF is a simple test that is used for models with or without a time trend. The ADF test is based on the following regressions:

$$\Delta y_t = k + \alpha y_{t-1} + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \qquad (3.1)$$

$$\Delta y_t = k + \alpha y_{t-1} + \beta t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \qquad (3.2)$$

The ADF auxiliary regression tests for non-stationarity in $y_t$, where $y$ denotes the variable in question, $t = 1, \ldots, T$ is an index of time, $\Delta y_{t-j}$ is the lagged first differences to accommodate serial correlation in the errors. Equation 3.1 (3.2) tests for the null of a unit root against a mean (trend) stationary alternative in $y_t$. Put

[102] Microfit 5.0 and RATS 8.0 can perform the CUSUM (CUSUMSQ) and Gregory and Hansen tests. However, GAUSS 11.0 is required to perform the EBA, Westerlund (2006), Carrion-i-Silvestre and Sanso (2006) and Banerjee and Carrion-i-Silvestre (2006) tests.

simply, the null and the alternative hypotheses (in both equations) for a unit root in $y_t$ are: $H_0$ $\alpha = 0$ and $H_1$ $\alpha < 0$. It is well known that ADF tests have low power against the unit root null and therefore it may be necessary to confirm the ADF results with some stronger tests; consequently PP and KPSS unit root tests are the alternatives applied in this study, these are discussed below. McNown and Wallace (1994) highlight the relative power of KPSS over the ADF test; this illustrated in Flowchart 3.1. However, in the presence of structural breaks and nonlinearity in the data, tests such as the ADF, PP and KPSS fail to yield robust results (see Henry and Shields, 2004).Consequently structural break unit roots tests are applied in this study; these are detailed below in Section 3.2.3.

Phillips (1987) and Phillips and Perron (1988) proposed a unit root test (referred as PP) that deals with potential serial correlation in the errors (see, Flowchart 3.1). The PP test is a more powerful test than the ADF but same critical values are used in both cases. This test employs a correction factor that estimates the long run variance of the error process with a variant of the Newey-West formula. Similar to the ADF test, the PP test requires specification of a lag order. Here the lag order is vital because it determines the number of lags to be included in the long run variance estimate. There is a choice whether to include a constant, a constant and trend or neither in the regression. The PP test allows for dependence among disturbances of either AR or MA form, but has been shown to exhibit serious size distortions in the presence of negative autocorrelations.

The KPSS test proposed by Kwiatkowski et al. (1992) tests the null hypothesis of stationarity against the alternative of a unit root. This test is performed under the null of trend stationarity or level stationarity, see Flowchart 3.1. Implications from this test are similar to that attained from those based on the Dickey-Fuller distribution. The KPSS test is usually utilised together with those tests that examine whether the series are fractionally integrated (that is, neither I(1) nor I(0)). Lee and Schmidt (1996) provide comprehensive details on this.

The series is detrended by regressing *y* on $z_t = (1,t)'(z_t = (1)')$, yielding residuals $e_t$. Let the partial sum series of $e_t$ be $s_t$. Then the zero order KPSS statistic is:

$$k_0 = T^{-2}\sum_{t=1}^{T} s^2{}_t / T^{-1}\sum_{t=1}^{T} e^2{}_t \qquad (3.3)$$

The approximate critical values for the KPSS test can be found in KPSS (1992). Hobijn et al. (1998) provide the updated routines for the KPSS test; particularly the automatic bandwidth selection routine. Hobijn et al. (1998) also introduced the Quadratic Spectral kernel to weight the empirical auto-covariance function. In such applications, the evaluation of the test statistics for various lags is not required.

Unit root tests provide important implications on cointegration. It is well known that if the variables are non-stationary in their levels, their means and variances violate the classical assumptions that they are constant. The estimated standard errors with the classical methods would be spurious and unreliable. Therefore, it is necessary to transform non-stationary variables into stationary by differencing and it is also vital to estimate the models taking into account the theoretical information on their levels. Time series methods have been developed for this purpose. In the money demand literature, there are a number of earlier studies that ignored the implications of the time series methods of estimation; examples are Diz (1970) for Argentina, Hossain (2006) for Bangladesh, Arize et al. (1990) for African countries and Brissimis and Leventakis (1981), Panayiotopoulos (1984) and Prodromidis (1984) for Greece. Therefore, this study investigated the integrated properties of the variables by employing both the conventional (ADF, PP and KPSS) and structural break (Zivot and Andrews, 1992; Lee and Strazicich, 2003; and Bai and Perron, 2003) unit root tests.

### *3.2.3 Structural Break Unit Root Tests in Time Series*

The influential study of Perron (1989) stimulated a number of other studies on unit roots and structural breaks. Perron (1989) criticized the conventional unit root tests like ADF, Generalized ADF, PP, etc., for ignoring the structural changes in the unit roots. Perron (1989) utilised the modified DF unit root test that included dummy variables to allow for an exogenous break. Subsequently, Zivot and Andrews (1992) (henceforth ZA) proposed the minimum unit root tests which selects the breakpoints on the basis of *t*-statistics. The single break point is endogenously determined, however the test assumes no break under the null hypothesis of unit root. The three models of ZA are as follows:[103]

Model A: $$\Delta Y_t = \mu_1^A + \gamma_1^A t + \mu_2^A DU_t(\lambda) + \alpha^A Y_{t-1} + \sum_{j=1}^{k-1} B_j \Delta Y_{t-j} + \varepsilon_t \qquad (3.4)$$

Model B: $$\Delta Y_t = \mu_1^B + \gamma_1^B t + \gamma_2^B DT_t^*(\lambda) + \alpha^B Y_{t-1} + \sum_{j=1}^{k-1} B_j \Delta Y_{t-j} + \varepsilon_t \qquad (3.5)$$

Model C: $$\Delta Y_t = \mu_1^c + \gamma_1^c t + \mu_2^c DU_t(\lambda) + \gamma_2^c DT_t^*(\lambda) + \alpha^c Y_{t-1} + \sum_{j=1}^{k-1} B_j \Delta Y_{t-j} + \varepsilon_t \qquad (3.6)$$

where $DU_t(\lambda)$ is a dummy variable which is equal to 1, and $DT_t^*(\lambda) = t - T\lambda$, 0 otherwise. Also, $\lambda = T_B / T$, and $T_B$ represents a possible break point, where $T$ is the sample size. ZA test allows both the break points and lag lengths to vary endogenously. The breakpoint is searched for over the range of the sample (0.15T, 0.85T). The three models of ZA are model A (allows for a change in the level of the series), model B (allows for a change in the slope of the trend of the series) and model C (combines both changes in the level and the slope of the trend). These three models were first proposed by Perron (1989). However, ZA questioned the exogeneity assumption made by Perron (1989) and instead treated the structural break as an endogenous occurrence. Later, Perron (1997) extended his earlier test (i.e. Perron, 1989) to accommodate a single endogenous break. Unlike ZA, Perron (1997) test does not require the end points of the sample to be trimmed. Further, Perron (1997) test allows for break under both the null and alternative hypotheses.

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[103] See, Lee and Chien (2008, p. 3189) for comprehensive details on ZA's model specifications and features.

Lumsdaine and Papell (1997) extended the ZA test to allow for two breaks. However, these tests were criticized for their treatment of breaks under the null hypothesis. Nunes et al. (1997) asserted that assuming no break under the null in endogenous break tests causes the test statistic to diverge and lead to significant rejections of the unit root null when the data generating process is a unit root with breaks, see Lee and Strazicich (2003, p. 1082). To address this problem, Lee and Strazicich (2003) proposed the langrange multiplier (*LM*) unit root tests that allows for two structural breaks. The two breaks in the *LM* unit root tests are endogenously determined and can be explained using two models viz., models A and C.[104] These models are based on alternative assumptions about structural breaks, for instance model A allows for two shifts in the intercept and model C includes two shifts in the intercept and trend (Lee and Strazicich, 2003, p. 1083). Models A and C with structural breaks is specified as follows:

Model A: $Z_t = [1, t, D_{1t}, D_{2t}]'$ (3.7)

($D_{jt} = 1$ for $t \geq T_{Bj} + 1, j = 1, 2,$ and 0 otherwise)

Model C: $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]'$ (3.8)

($DT_{jt} = t - T_{Bj}$ for $t \geq T_{Bj} + 1, j = 1, 2,$ and 0 otherwise)

The break date is denoted by $T_{Bj}$. The null and alternative hypothesis of models A and C, respectively, are given by equations (3.9) and (3.10) as follows:

$$H_0 : y_t = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + y_{t-1} + \nu_{1t} \quad (3.9)$$
$$H_1 : y_t = \mu_1 + \gamma t + d_1 D_{1t} + d_2 D_{2t} + \nu_{2t}$$

$$H_0 : y_t = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + d_3 D_{1t} + d_4 D_{2t} + y_{t-1} + \nu_{1t} \quad (3.10)$$
$$H_1 : y_t = \mu_1 + \gamma t + d_1 D_{1t} + d_2 D_{2t} + d_3 DT_{1t} + d_4 DT_{2t} + \nu_{2t}$$

---

[104] These models are similar to Perron (1989). Perron (1989) considered three structural break models viz., 'crash' model A (allows a change in intercept), 'changing growth' model B (allows for a change in trend) and model C (allows for a change in intercept and trend), for more details see (Lee and Strazicich, 2003, p. 1082). Model B is omitted because models A and C can adequately explain the time series properties of the variables.

where $B_{jt} = 1$ for $t = T_{Bj} + 1, j = 1, 2,$ and 0 otherwise. The stationary error terms are represented by $v_{1t}$ and $v_{2t}$. Note that the null in (3.9) and (3.10) includes dummy variables $B_{jt}$. Perron (1989, p. 1393) showed that including these dummy variables are important to ensure that the asymptotic distribution of the test statistic is invariant to the size of the breaks under the null. The *LM* unit root test statistic is attained by estimating the following regression:

$$\Delta y_t = \delta' \Delta Z_t + \phi \overline{S}_{t-1} + \mu_t \qquad (3.11)$$

where $\overline{S}_t = y_t - \overline{\psi}_x - Z_t \overline{\delta}$ , t=2,....,T; the regression of $\Delta y_t$ provides estimates of $\overline{\delta}$; $\overline{\psi}_x = y_1 - Z_t \overline{\delta}$ and the first observations of $y_t$ and $Z_t$ are $y_1$ and $Z_1$, respectively. The *LM* test statistics are given by $\overline{\tau}$ which is the test statistic for testing the unit root null hypothesis that $\phi$=0. The optimal lag length is selected by observing the significance of the *t*-statistic on the last lag. The break dates are determined where the *LM* test statistic is the minimum. Note that Lee and Strazicich (2004 & 2003) have tabulated the critical values for this test. My flowcharts illustrate the decisions through which these tests could be utilised.

Bai and Perron's (1998, 2003) (henceforth BP) model of multiple structural breaks is widely used in the cointegration analysis. BP's method assumes that potential structural break points are unknown. This method is similar to Lee and Strazicich (2003) and Lumsdaine and Papell (1997) tests, but has an advantage over these existing methods i.e. it offers multiple endogenous breaks in the data series (see, Flowchart 3.1). The existence of multiple structural breaks is pragmatic because various factors do influence the behaviour of tested data in different time periods (Lee and Chien, 2008). However, these methods might be of limited use if one intends to test for structural changes in the cointegrating vector of a long run relationship, hence for this purpose the Gregory and Hansen (1996a & b) tests might be appropriate.

The multiple linear regression system can be expressed in matrix form as:

$$Y = X\beta + \bar{Z}\delta + U \qquad (3.12)$$

where $Y = (y_1,...,y_T)'$, $X = (x_1,...,x_T)'$, $U = (u_1,...,u_T)'$, $\delta = (\delta'_1, \delta'_2, ..., \delta'_{m+1})'$, and $\bar{Z}$ is the matrix which diagonally partitions Z at the m-partition ($T_1$,..., $T_m$), i.e., $\bar{Z} = \text{diag}(Z_1, ..., Z_{m+1})$ with $Z_i = (z_{T_{i-1}+1}, ..., z_{T_i})'$ (Bai and Perron, 2003, p. 3). The model estimation is based on the least squares principle. For each m-partition ($T_1$,..., $T_m$) denoted $\{T_j\}$, the associated least squares estimates of $\beta$ and $\delta$ are attained by minimizing the sum of squared residual as follows:

$$SSR = \sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} [y_t - x_t'\beta - z_t'\delta_i]^2 \qquad (3.13)$$

The resulting coefficients are denoted by $\hat{\beta}(\{T_j\})$ and $\hat{\delta}(\{T_j\})$ and substituting them in the objective function gives the following break-point estimator:

$$(\hat{T}_1, ..., \hat{T}_m) = \arg\min_{T1,...,Tm} S_T(T_1, ..., T_m) \qquad (3.14)$$

where the sum of squared residuals and the estimated break points are $S_T(T_1, ..., T_m)$ and $(\hat{T}_1, ..., \hat{T}_m)$, respectively. The minimization is performed over all partitions $(T_1, ..., T_m)$ such that $T_i - T_{i-1} \geq q$. The regression parameter estimates at estimated *m*-partition $\{\hat{T}_j\}$ are $\hat{\beta} = \hat{\beta}(\{\hat{T}_j\})$ and $\hat{\delta} = \hat{\delta}(\{\hat{T}_j\})$. Note that the break point estimators are global minimizers and the break-points are estimated by using a dynamic programming algorithm (Bai and Perron, 2003, p. 5). BP (2003, p. 14) has suggested the following methods to determine the existence of structural breaks in the data series: (1) let the $\sup F_t(m)$ denote the F statistic for testing $H_0$: no breaks against $H_1$: *m* breaks, (2) UD max and WD max represents double maximum statistics and the weights double maximum statistic, respectively, and these are used for testing the

$H_0$: no breaks against $H_1$: $1 \leq m \leq M$ breaks[105] and (3) $\sup F_T(m+1|\text{m})$ denotes the *F* statistics for testing the $H_0$: *m* breaks against $H_1$: *m* + 1 breaks. Choi and Jung (2009) provide a good description of the BP method.

In this study, I found that all the variables are largely non-stationary in levels. The main purpose of applying the BP test is to compare the break dates with Zivot and Andrews (1992) and Lee and Strazicich (2003) tests. To this end, this study ignored most of the test statistics and confidence intervals which are proposed by BP.

### *3.2.4 Unit Roots in Panel Data*

Prior to using the panel cointegration techniques, it is essential to determine the order of integration of the variables in the panel. The first (second) generation panel unit root tests allow for cross-section independence (dependence) in the errors, see Flowchart 3.1. These tests are well discussed in Baltagi (2005), Baltagi and Kao (2000) and Banerjee (1999). Initially, I utilised both (first and second generation) set of panel unit root tests and have attained similar conclusions i.e. variables in the panels are I(1) in levels. Therefore, for convenience I only discuss the results based on the first generation tests.

The recently developed first generation panel unit root tests are LLC (2002), IPS (1997, 2003), Maddala-Wu (1999) (hereafter MW), Breitung (2000) and Hadri (2000).[106] In LLC, IPS, MW and Breitung tests the null hypothesis is non-stationary and where as in Hadri test, the null hypothesis is stationary, see Flowchart 3.1. Levin, Lin and Chu (2002) consider the following model of a variable with *N* cross sections and *T* periods with an exogenous term of individual effects:

$$\Delta Y_{it} = \alpha_i + \rho Y_{i,t-1} + \sum_{z=1}^{P_i} \beta_{i,z} \Delta Y_{i,t-z} + \varepsilon_{i,t} \qquad (3.15)$$

[105] *M* is the upper bound on the number of possible breaks.
[106] Examples of studies that used the first generation panel unit root tests in money demand analysis are Harb (2004), Dreger et al. (2007), Carrera (2008) and Rao and Kumar (2009b).

For $i = 1,\ldots, N$ and $t = 1,\ldots, T$. The errors are assumed to be distributed independently across the units included in the sample. Based on (3.15), the null hypothesis that each individual time series contains a unit root is tested against the alternative that each individual time series is stationary. Specifically, $H_0$: $\rho = 0$ and $H_1$ : $\rho_i < 0$ for $i =1,\ldots, N$. Alternatively, IPS (Im et al., 1997 & 2003) is based on a model similar to (3.15) which allows heterogeneity of $\rho$. In this case, the null hypothesis is $H_0$ : $\rho_i = 0$ for all $i =1,\ldots, N$, and the alternative hypothesis is $H_1$: $\rho$ for $i =N_1 + 1,\ldots, N$, with $0 < N_1 < N$. Explicitly, IPS null hypothesis states that each series in the panel contains a unit root, but the alternative hypothesis unlike in the case of the LLC test, maintains that some, but not all individual series might contain unit roots, see Murthy (2007) for more details. Testing for the existence of unit roots in heterogeneous cross-section panels, Im et al. (1997, 2003) have proposed the following test statistic, $t_{IPS}$

$$t_{IPS} = \frac{\sqrt{N}\left(\bar{t} - \frac{1}{N}\sum_{i=1}^{N} E\left[t_{iT} \middle| \rho_i = 0\right]\right)}{\sqrt{\frac{1}{N}\sum_{i=1}^{N} \mathrm{var}\left[t_{iT} \middle| \rho_i = 0\right]}} \Rightarrow N(0,1) \qquad (3.16)$$

where $N$ is the number of cross-section units, $t$ is the average of the computed ADF statistics, in the presence of serial correlation among $\varepsilon_{it}$, $\rho_i$ is the autoregressive root, $E[t_{iT}]$ and $\mathrm{Var}[t_{iT}]$ indicate respectively the moments of mean and variance attained from Monte Carlo simulation. The statistic $t_{IPS}$ approaches in probability a standard normal distribution as $N$ and $T$ tend to infinity.

The Fisher type (Fisher, 1932) panel unit root test was proposed by Maddala and Wu (1999). The MW test is a much more flexible and can be effectively applied on unbalanced panels. This test is also applicable for indi tests with different lag lengths and other unit root tests like PP. The MW test statistic,vidual ADF $\lambda$, which has a chi-square distribution with $2N$ degrees of freedom under the null hypothesis is expressed as:

$$\lambda = -2\sum_{i=1}^{N} \ell n P_i \qquad (3.17)$$

where, $P_i$ refers to the probability values from individual unit root tests. Brietung (2000) developed a panel unit root test, namely Breitung test, which improves the dramatic loss of power linked with the IPS test when individual ADF tests comprise a trend in the specification of the data generating process. Breitung test is, similar to the LLC test, a pooled unit root test against the homogeneous alternative. Ultimately, Hadri (2000) panel unit root test is a residual based *LM* test. Hadri (2000) proposed the null hypothesis as stationary in all panel units against the alternative hypothesis of a unit root in all cross-section units.

The unit roots in panel data is still in its early stages of development. These tests are important because they provide useful implications on the choice of estimation methods with panel data. If the variables in the panel are stationary, then panel SUR (seemingly unrelated regression) or pooled OLS methods could be utilised. Most panel cointegration methods are performed with I(1) variables to avoid spurious regression issues, see Flowchart 3.2. In the following section, I shall discuss the time series cointegration techniques that are utilised in this study.

### 3.3 Time Series Cointegration Techniques

It is difficult to argue that a particular time series method performs the best in empirical analysis. If data is reliable, all estimation methods may yield consistent and robust results. The system-based method of JML is widely used relative to the single-equation methods (GETS, EG, ARDL, FMOLS and DOLS).[107] Method selection largely depends on the purpose of the research and also how much the researcher understands about the processes involved. Smith (2000) argued that estimation methods are merely tools to summarize data and therefore they cannot answer difficult questions that need economic insights. To this end, he suggested that

[107] For an interesting methodological debate on the relative merits of alternative time series approaches, see Rao (2007b).

economic theory or context is important and these should guide the choice of the estimation method.

Often applied economists neglect the purpose of the research and instead give vast attention to the estimation methods. In this study I show that if these alternative methods are appropriately applied, they yield consistent summaries of data. Therefore, I take the view that while it is desirable to use a few alternative methods of estimation, adequate attention should also be paid to the purpose and their interpretations. The time series techniques that is used in this study are GETS, EG, FMOLS, JML and ARDL. The processes engrossed in these techniques are detailed in the following sections.

### *3.3.1 The General to Specific Technique*

The London School of Economics (LSE) Hendry's GETS approach is not new in time series econometrics. It is largely compared with the Cowles Commission approach or the Partial Adjustment Models (PAM), however GETS technique is flexible and hence more demanding because it offers dynamic specifications, see Flowchart 3.2. GETS is a single equation approach and thus assumes that there is only one cointegrating vector. The cointegrating vector is usually estimated with the OLS or Non Linear Least Squares (NLLS). There are three main steps involved in this method:

i. Specification of the underlying error correction model (ECM).
ii. Specification of a general (ARDL) dynamic scheme.
iii. Search for a parsimonious equation.

It is reasonable to start with a very general dynamic lag structure between the dependent and exogenous variables. PcGETS (software) of Hendry and Krolzig (2005) is useful for searching the optimal lag lengths. However, what is most important is the specification of the ECM term in the model. Essentially, this is the long run equilibrium relationship. The dependent and exogenous variables consisting of their lagged levels and first differences are estimated in one step with the OLS or

NLLS and through the application of the variable deletion tests, a parsimonious dynamic adjustment equation is attained.

The conventional long run specification of the demand for money is:

$$\ln m_t = \alpha_0 + \alpha_1 \ln y_t + \alpha_2 R_t + \epsilon_t \tag{3.18}$$

where *m* is real narrow money stock, *y* is real GDP, *R* is nominal rate of interest and $\epsilon_t$ is the *iid* error term. The above equation can be re-written as:

$$\begin{aligned}\Delta \ln m_t &= \beta_0 + \beta_1 \ln m_{t-1} + \beta_2 \ln y_{t-1} + \beta_3 R_{t-1} \\ &\quad + \beta_4 \Delta \ln m_{t-1} + \epsilon_t\end{aligned} \tag{3.19}$$

The general dynamic specification will have more lagged values of Δln*m*, Δln*y* and Δ*R*. The general dynamic equation can be specified as:

$$\begin{aligned}\Delta \ln m_t &= \beta_0 + \beta_1 \ln m_{t-1} + \beta_2 \ln y_{t-1} + \beta_3 R_{t-1} \\ &\quad + \sum_{i=0}^{n} \lambda_1 \Delta \ln y_{t-i} + \sum_{i=0}^{m} \gamma_1 \Delta R_{t-i} + \sum_{i=0}^{i} m_1 \Delta \ln m_{t-1} + \epsilon_t\end{aligned} \tag{3.20}$$

Note that $\beta_1$, $\beta_2$ and $\beta_3$ are the equilibrium long run estimates. I expect that the variables (ln*m*, ln*y* and *R*) in levels to contain unit roots and their first differences (Δln*m*, Δln*y* and Δ*R*) to be stationary. To this end, the error term will be stationary and this implies no violation of the classical assumptions.

Charemza and Deadman (1997) provides comprehensive details on the GETS method.[108] Although GETS is a simple method, it is computationally demanding because the general dynamic specification includes numerous lagged values of the variables especially when a large lag structure is utilised. Further, there is no guideline on how to reduce the long lag structure in order to achieve a parsimonious

[108] Davidson et al. (1978) and Hendry and Ericson (1991) are very interesting studies on the GETS method. Recent studies that used the GETS technique to estimate money demand are, for example, Kumar (2007) for Bangladesh, Rao and Singh (2005a & b) for Fiji and Singh and Kumar (2011) for a group of developing countries.

equation. The error correction part in GETS is given by the lagged level variables where the coefficients indicate the implied long run elasticities. From a methodological perspective, it could be argued that GETS is observationally equivalent to ARDL (perhaps also other methods), however it is difficult to argue that this or the other method is the best.

### *3.3.2 The Engle and Granger Technique*

Engle and Granger (1987) developed a two-step technique, so called EG, to estimate long- and short-run equations. Considerable number of studies in money demand literature used the EG technique, for instance see, Bundesbank (1995) for Germany, Nielson et al. (2004) for Italy, Ahumada (1992) for Argentina, Price and Insukindro (1994) for Indonesia and Kannapiran (2001) for Papua New Guinea. Among others, these studies were discussed in the preceding chapter. In EG, the first step is to estimate the cointegrating equation. For simplicity, I shall only focus on the conventional specification of the money demand. To determine if real narrow money is cointegrated with real income and nominal rate of interest, the residuals should be tested with an ADF type test, known as the cointegrating equation ADF type test or CRADF test. In other words, test if the residuals from the cointegrating equation are I(1) or I(0). To this end, the null hypothesis is that the variables are not cointegrated (i.e. residual are I(1)) and alternative hypothesis is that the variables are cointegrated (i.e. residuals are I(0)). MacKinnon (1991) test is usually employed to test for cointegration among the variables.

The identification problem exists in the EG technique. Like most other techniques, EG also indicates if there is a linear combination of I(1) variables. In other words, they do not provide information on what is the dependent variable and which variables are explanatory. One option to solve the identification problem is to perform the Granger causality tests. However, it should be noted that Granger causality tests are not 'cause and effect' tests, see Granger (1969). In this study we tackle the identification issue by testing for exogeneity. In the context of money demand, testing for weak exogeneity requires regressing $\Delta \ln m$, $\Delta \ln y$ and $\Delta R$ on the lagged residuals (ECM) of the EG cointegrating equation. According to Granger's

Representation Theorem, the lagged ECM term should be significant in at least one of the three equations, thus implying whether cointegrating vector should be normalised on money or income or the rate of interest. The second step of EG is that the residual from the cointegrating equation is used to estimate the short run dynamic model. In this second stage, GETS may be useful to attain an optimal short run dynamic model.

The fundamental difference between the EG and the commonly used JML technique is that the former is a single-equation technique that could estimate only one cointegrating vector, see Flowchart 3.2. To this end, it is similar to GETS, FMOLS, ARDL and DOLS methods.[109] In my view, the main strength of the EG technique is its simplicity and its intuitive interpretability. However, it has a number of disadvantages such as its inability to detect more than one cointegrating relationship and the impossibility of validly testing hypotheses about the cointegrating vector. It is also weak in terms of addressing the endogeneity problem. Despite of these limitations, I think that EG technique is useful.

### *3.3.3 The Phillip-Hansen technique*

The Fully Modified OLS estimator, namely FMOLS, was first proposed by Phillips and Hansen (1990) to provide optimal estimates of the cointegration regressions. This method uses kernal estimators of the nuisance parameters that influence the asymptotic distribution of the OLS estimator. It is well known that FMOLS achieves asymptotic efficiency. To this end, this technique transforms the least squares to account for serial correlation and tests for the endogeneity in the regressors that result from the existence of a cointegrating relationship. This feature is absent in the EG and GETS techniques.[110] Although this non-parametric approach is well-designed to deal with nuisance parameters, it may be problematic especially in fairly small samples.

[109] However, these single-equation methods differ in terms of their specifications and properties.
[110] Hendry and Krolzig's (1999) instrumental variable estimator is efficient in dealing with these issues.

When the asymptotic distribution of OLS is non-standard, the FMOLS estimator efficiently accounts for possible correlation between the regressors and residuals. Therefore, inferences based on the usual *t*-tests may be invalid without this adjustment. Similar to the EG and JML, the FMOLS is also a two step procedure. In the first stage, the cointegrating coefficients are estimated in levels of the I*(1)* variables. Thus, determining the integrated order of the variables is also required in FMOLS. In other words, to apply this estimator for estimating long run parameters, the condition that there exists a cointegrating relationship between the variables must be satisfied.

The standard econometrics software (for example, Eviews 7.0 and Microfit 5.0) has the routines for using this procedure. There is some flexibility in selecting the lag lengths of the VAR and the Microfit manual suggests the Parzen lag structure. Nevertheless, Bartlett lag window could also be utilised. A pragmatic approach in deciding the optimal lag length is to start with smaller lags and then increase systematically by keeping track of the estimated coefficients and thus stop varying the lags when there are no significant changes in the estimates.

The second stage entails developing the ECM term from the long run estimates and estimating a short run dynamic equation which should include the one period lagged residual. This dynamic equation is initially estimated with a large lag structure and later reduced to a manageable parsimonious version similar to GETS. Amano and Wirjanto (2000) provide good details on this method. Using the FMOLS technique, they found an income elasticity of *M2* demand around 1.5 for Japan.

Thus, the FMOLS estimator (among other single-equation methods) is preferable when one or more explanatory variables seem to be endogenous. However, it is less flexible than the GETS and JML when the cointegration equations are to be estimated with restricted intercept and trend. Further, it is difficult to include the I(0) variables, for example shift dummies, in the cointegrating equation although it is possible to include them in the dynamic adjustment equations. For more details on the FMOLS method, see Microfit manual.

### *3.3.4 The Johansen Maximum Likelihood Technique*

Johansen (1988, 1991) and Johansen and Juselius (1990) proposed a maximum likelihood technique to determine the presence of cointegrating vectors. This technique is a variant of the VAR approach and usually referred as JML, ECM or VECM in the literature.[111] However, unlike VAR, all the parameters are identified and estimated on the basis of the underlying economic theory. Before the JML technique is applied, pre-testing of variables for unit roots is important. JML is based on the following VAR model:

$$\Delta y_t = \alpha + \sum_{i=1}^{k} \Gamma_i \Delta y_{t-i} + \Pi y_{t-1} + \varepsilon_t \qquad (3.21)$$

where $y_t$ is non-stationary in level form and a vector of I(1) variables and $\alpha$ is a constant. Johansen and Juselius (1990, p. 170) formulated the hypothesis of cointegration as the hypothesis of reduced rank of the long run impact matrix $\Pi = \gamma\delta'$, where $\gamma$ and $\delta$ are weights and cointegrating vectors, respectively. The main objective of Johansen and Juselius (1990) was to investigate whether the coefficient matrix $\Pi$ contains information about long run relationships between the variables in the data vector.

Prior to performing the JML test for cointegration, it is necessary to investigate the order of the VAR. In other words, it is vital to determine the number of lags in the VAR model. Using the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC), the optimal order of the VAR can be easily identified. The test for the existence of the cointegrating vector(s) is conducted with a procedure that allows for (un)restricted intercept and restricted/no trend options for the VAR. For this purpose, Microfit software provides five options i.e. no intercepts or trends, restricted intercepts no trends, unrestricted intercepts no trends, unrestricted intercepts restricted trends, and unrestricted intercepts unrestricted trends. The choice of intercepts/trends is very crucial in testing for cointegration. A simple

[111] Literature search (in EconLit database) shows that most studies on money demand have utilized the JML technique. See the literature review chapter for details of these studies.

approach to deal with this is to attempt all options and then choose the ones that give meaningful estimates. If the underlying variables are trended (they move together), this does not imply that trend should be used in the cointegration analysis, see Pesaran and Pesaran (1997).

The test for cointegration is performed through eigenvalue and trace tests. The null of no cointegration can be rejected or not rejected with the computed eigenvalue and trace test statistics which are detailed in standard econometric texts or software manuals. Specifically, the null of no cointegration is rejected when the computed eigenvalue and trace test statistics are greater than the corresponding critical values (usually 5% or 10% levels). The alternative hypothesis of one or more cointegrating vectors is accepted if the computed eigenvalue and trace test statistics are less than the corresponding critical values.

Further, the exogeneity tests for block Granger Non-Causality with the null that the coefficients of the lagged values of dependent variables are insignificant in the equations of independent variables are performed. The computed LAR test indicates if there is endogeneity bias, i.e. whether the dependent variable Granger causes the independent variable(s).[112] Identification is tested by regressing the first difference of each variable on the one period lagged residuals normalized on respective variables. This is confirmed if respective ECM term is significant with correct negative sign in their own equation. These tests are necessary to examine the endogeneity problems.

The justification for the JML technique is that identification and testing for the significance of the structural coefficients, underlying the theoretical relationships, is important. The simple VAR models do not identify structural coefficients nor do they take seriously the relevance of unit root tests. In GETS, although there is some awareness of the unit root characteristics of the variables, the crucial theoretical relationship, in the error correction part, is specified in the levels of the variables. The justification is that the underlying theory should be taken seriously. This does

[112] As explained in Rao (2007b, p. 1615), the Granger causality test is not a 'cause and effect' test but a test of precedence and in itself does not indicate causality used in more common sense.

not mean that theory should be accepted. In JML, both theory and integrated properties of the variables play important roles. In comparison to the single-equation methods (GETS, EG, FMOLS and DOLS), JML accounts for more than one cointegrating vector, see Flowchart 3.2. In addressing the endogeneity problem, both FMOLS and JML are efficient.

### *3.3.5 The Autoregressive Distributed Lag Technique*

Pesaran et al. (2001) proposed the ARDL method also known as the bounds test technique. This technique has some advantages in comparison to other single-equation methods: first unlike ARDL, there are no formal tests for cointegration in GETS, EG and FMOLS.[113] Second, when compared to GETS and EG, ARDL minimizes the endogeneity problems and all the variables are assumed to be endogenous.[114] Third, the long run and short run variables are estimated simultaneously, removing problems associated with omitted variables and autocorrelation. Fourth, the ARDL does not generally require a knowledge of the order of integration of variables, which is necessary in the EG and FMOLS and also in the JML technique, see Flowchart 3.2. These techniques require that the variables have the same order of integration.[115] However, problem arises when the variables have different orders of integration. To overcome this problem, Pesaran et al. (1996, 2001) proposed the ARDL technique that does not require the classification of variables into I(0) or I(1) (Pesaran et al. 2001, p. 290). Pesaran and Shin (1999) argued that the ARDL technique can be reliably used in small samples to estimate and test hypotheses on the long run coefficient in both cases where the underlying regressors are I(1) or I(0). For the reasons above, I shall also use the ARDL technique to estimate the demand for money functions.[116]

[113] Usually MacKinnon's (1991) cointegration test is used in the EG method.
[114] However, note that GETS instrumental variable method is adequate in solving the endogeneity problem.
[115] Pesaran and Pesaran (1997, p. 291) points out that the residual-based cointegration tests are inefficient and can lead to misleading results, especially when there are more than two I(1) variables under consideration.
[116] Examples of studies that used the ARDL technique in modelling money demand are Bahmani-Oskooee (2001) for Japan, Siddiki (2000) for Bangladesh, Sanchez-Fung (2007) for Chile, Bahmani-Oskooee and Rehman (2005) for Asian countries and Nair et al. (2008) for Malaysia. Literature review chapter provides more details on these studies.

Following Pesaran et al. (2001, p. 292), the ARDL bounds test entails estimating the following unrestricted error correction models:

$$\begin{aligned}\Delta \ln m_t = a_{om} + \sum_{i=1}^{n} b_{im} \Delta \ln m_{t-i} + \sum_{i=1}^{n} c_{im} \Delta \ln y_{t-i} + \sum_{i=1}^{n} d_{im} \Delta R_{t-i} \\ + \sigma_{1m} \ln m_{t-1} + \sigma_{2m} \ln y_{t-1} + \sigma_{3m} R_{t-1} + \varepsilon_{1t}\end{aligned} \tag{3.22}$$

$$\begin{aligned}\Delta \ln y_t = a_{oY} + \sum_{i=1}^{n} b_{iY} \Delta \ln y_{t-i} + \sum_{i=1}^{n} c_{iY} \Delta \ln m_{t-i} + \sum_{i=1}^{n} d_{iY} \Delta R_{t-i} \\ + \varpi_{1Y} \ln y_{t-1} + \varpi_{2Y} \ln m_{t-1} + \varpi_{3Y} R_{t-1} + \varepsilon_{1t}\end{aligned} \tag{3.23}$$

$$\begin{aligned}\Delta \ln R_t = a_{oR} + \sum_{i=1}^{n} b_{iR} \Delta R_{t-i} + \sum_{i=1}^{n} c_{iR} \Delta \ln m_{t-i} + \sum_{i=1}^{n} d_{iR} \Delta \ln y_{t-i} \\ + \sigma_{1R} R_{t-1} + \sigma_{2R} \ln y_{t-1} + \sigma_{3R} \ln m_{t-1} + \varepsilon_{1t}\end{aligned} \tag{3.24}$$

As stated in Pesaran and Pesaran (1997, p. 304), the ARDL procedure contains two steps. First, the existence of the long run relation between the variables in the system is tested. The *F* tests are used for testing the existence of long run relationships. When such relationships are seen to exist, the *F* test dictates which variable should be normalized. In other words, the null hypothesis of no cointegration amongst the variables in equation (3.22) is $(H_0 : \sigma_{1m} = \sigma_{2m} = \sigma_{3m} = 0)$ tested against its alternative hypothesis $(H_1 : \sigma_{1m} \neq \sigma_{2m} \neq \sigma_{3m} \neq 0)$ which is referred to as $F_m(m|y,R)$. In equation (3.23), where real income is the endogenous variable, the null hypothesis of no cointegration is $(H_0 : \varpi_{1Y} = \varpi_{2Y} = \varpi_{3Y} = 0)$ against the alternative $(H_1 : \varpi_{1Y} \neq \varpi_{2Y} \neq \varpi_{3Y} \neq 0)$, which is referred to as $F_Y(y|m,R)$. Similarly, in equation (3.24) where *R* represents nominal rate of interest, the null hypothesis of no cointegration amongst the variables is $(H_0 : \sigma_{1R} = \sigma_{2R} = \sigma_{3R} = 0)$ against the alternative hypothesis $(H_1 : \sigma_{1R} \neq \sigma_{2R} \neq \sigma_{3R} \neq 0)$. This is denoted as $F_R(R|m,y)$.

The *F* test has a non-standard distribution which depends upon: i) whether variables included in the ARDL model are to be *I*(0) or *I*(1), ii) the number of regressors and

iii) whether the ARDL model contains an intercept and/or a trend. Two sets of critical values (CVs) are reported in Pesaran and Pesaran (1997): one set is calculated assuming that all variables included in the ARDL model are $I(1)$ and the other is estimated assuming the variables are $I(0)$. If the computed $F$ values fall outside the inclusive band, a conclusive decision could be drawn without knowing the order of integration of the variables. More precisely, if the empirical analyses show that the estimated $F_m(.)$ is higher than the upper bound of the CV while $F_Y(.)$ and $F_R(.)$ are lower than the lower bound of the CV then there exists a unique and stable long run relationship.

When the results of $F$-statistics in the first step support the evidence of the existence of cointegration between variables, then I proceed to the second step of this approach. In the second stage, a further two-step procedure to estimate the model is carried out. In the first step of the second stage, the orders of the lags in the ARDL model are selected by AIC or SBC criteria. Following Pesaran and Pesaran (1997, p. 353), the optimal lag order is chosen based on the highest value of AIC or SBC. This step of selecting the lag orders of variables is very important because the appropriate lag selection enables us to identify the true dynamics of the models. In the second step, the selected model is estimated by OLS to attain the long run coefficients. It also provides estimates of the error correction model (ECM) which corresponds to the selected ARDL model. The next section discusses the panel cointegration techniques used in this study.

### 3.4 Panel Cointegration Techniques

Panel data estimation methods are increasingly popular in testing growth and other macroeconomic models. Among other developments in the estimation theory, a reason for the increased interest in the panel data methods is due to the availability of longer periods of data for many countries. These panel data studies can be divided into two types, viz. those in which the variables are stationary and those that assume the variables are non-stationary. Many earlier studies assume that the variables are stationary and use techniques like the OLS, SUR or the General Method of Moments (GMM). However, the importance of non-stationary panels has been emphasized by a number of econometricians (for example, Pedroni, 1999 & 2001; Chang, 2002; Banerjee et al., 2004; and Moon and Perron, 2004), see Flowchart 3.1 and 3.2 for their contributions.

Subsequently, the controversy on testing for cointegration with or without structural breaks has also made its impact on the estimation with panel data. A few econometricians have followed the trend set by the seminal paper of Perron (1989) and developed cointegration tests with breaks for panel data, for example see Banerjee and Carrion-i-Silvestre (2006) and Westerlund (2006). The controversy on whether macroeconomic variables in the panels are stationary or non-stationary is still in its early stages. Nevertheless, the tests have important implications for the estimation with panel data. If the variables in the panels are stationary, then classical methods of estimation (for example, SUR or OLS) could be used. Otherwise, one should adopt a non-stationary panel approach (Flowchart 3.2 illustrates a number of non-stationary panel tests). However, with the exception of Carrion-i-Silvestre et al. (2005) there do not seem to be any test for structural breaks in the panel unit roots. To this end, it is necessary for further theoretical developments with endogenous structural breaks in the panel unit roots. In this thesis I utilise four panel cointegration techniques viz. Pedroni (2004), Mark and Sul (2003), Breitung (2005) and Westerlund (2007). The following sections discuss these four methods.

### *3.4.1 The Pedroni FMOLS technique*

Pedroni (1995, 1999, 2001 and 2004) proposed a single equation method to be used in the panel data. This method does not allow for cross-section dependence in the errors and to this end it is similar to McCoskey and Kao (1998), Kao (1999) and Larsson et al. (2001), see Flowchart 3.2. From this perspective, it may be a less attractive technique, however in applications this method might permit some limited degree of cross-section dependence through the presence of time-specific effects. Despite of this limitation, I employ the Pedroni (2004) method because it is computationally convenient and standard statistical software (for example Eviews 7.0, RATS 8.0 and STATA 12.0) contains the routines. Most methods that utilise the cross-section dependence are difficult to use because their statistical codes are not readily available.

Prior to applying a panel cointegration test, it is necessary to determine the integrated properties of variables in the panels. If each variable is integrated of order one I(1), then the Pedroni (1995, 1999, 2001 and 2004) panel cointegration tests could be used to investigate whether the variables are cointegrated in the panel under investigation, given the existence of heterogeneity in the panels. This method allows consistent and efficient estimation of cointegration vector and also addresses the problem of non-stationary regressors, as well as the problem of simultaneity biases. Initially, Pedroni test requires the estimation of the following panel cointegration regression model:[117]

$$\ln m_{i,t} = \alpha_i + \beta_i \ln y_{i,t} + \theta_i R_{i,t} + \epsilon_{i,t} \qquad (3.25)$$

for $t = 1, \ldots, T$; $i = 1 \ldots, N$, where $T$ denotes to the number of observations over time and $N$ denotes to the number of countries in the panel. There are several steps in Pedroni method. First, the residuals are saved from the estimated cointegrating equation i.e. $\hat{\epsilon}_{i,t}$ . Second, I difference the original data series for each country and calculate the residuals for the differenced regression:

$$\Delta \ln m_{i,t} = \alpha_i + \beta_i \Delta \ln y_{i,t} + \theta_i \Delta R_{i,t} + \eta_{i,t} \qquad (3.26)$$

Third, $\hat{L}^2_{11i}$ is computed as the long run variance of $\hat{\eta}_{i,t}$ utilising the kernel estimator. Fourth, the residual $\epsilon_{i,t}$ from the original cointegrating equation is used to estimate the appropriate autoregressive model.

The null hypothesis of no cointegration against the alternative of cointegration is tested using the seven test statistics, which consist of four panel and three group statistics, respectively, panel v–statistic, panel $\rho$-statistic, panel $\rho\rho$-statistic, panel

[117] For simplicity, I shall consider only the case of conventional specification of the demand for money.

ADF-statistic, group $\rho$-statistic, group $\rho\rho$-statistic and group ADF-statistic, proposed by Pedroni, see Flowchart 3.2. The first group of tests are termed 'within dimension' (panel tests) and the second group of tests are 'between dimension' (group tests). The 'within dimension' tests consider the common time factors and allows for heterogeneity across countries. The 'between dimension' tests are called 'group mean cointegration tests' and these also allow for heterogeneity of parameters across countries.[118]

Each of these seven panel cointegration test statistics under appropriate standardization is asymptotically normally distributed and is expressed as follows:

$$\frac{\theta_{NT} - \mu\sqrt{N}}{\sqrt{\nu}} \Rightarrow N(0,1) \qquad (3.27)$$

where, $\theta_{NT}$ is the corresponding form of the cointegration test statistic of each test, $\mu$ and $\nu$ are the mean and variance simulated and provided by Pedroni (1999, 2001) and their numerical values depend upon the presence of a constant, time trend, and the number of regressors in the cointegration test regression. The rejection of the null hypothesis of no cointegration for the seven tests requires that the absolute value of the observed or computed test statistic exceed appropriate critical values. For comprehensive discussion on this, see Murthy (2007).

Pedroni (2000) suggests the FMOLS estimator which is simply the average of the individual FMOLS for each country. The technique therefore deals with the endogeneity of the regressors and corrects for serial correlation. The FMOLS estimator depends on the between-dimension estimation which allows for heterogeneity of the cointegrating vectors in that it presents a common cointegrating vector under the null hypothesis while under the alternative the cointegrating vector need not be common.

[118] Pedroni (1999, pp. 667-8) argues that the panel-*v* statistic differs from the other six tests insofar as it diverges to positive infinity, and consequently the right tail of the normal distribution is used to reject the non-cointegration null. This means that large positive values for panel-*v* imply that non-cointegration can be rejected.

In this study, I utilise the between-dimension or group-mean test statistics to test for cointegration between the variables. Pedroni's (2004) FMOLS estimator is employed to estimate the cointegrating vectors in the panel. Recently, a number of studies have used the Pedroni FMOLS technique to estimate the demand for money, for instance see, Rao and Kumar (2009b) for Asian countries, Dreger et al. (2007) and Hamori and Hamori (2008) for EU countries, Garcia-Hiernaux and Cerno (2006) for a group of advanced and developing countries, Harb (2004) for GCC countries and Carrera (2008) for Latin American countries.[119]

### *3.4.2 Panel DOLS Technique*

Mark and Sul (2003) proposed the panel DOLS estimator of a homogeneous cointegration vector for a balanced panel of $N$ individuals observed over $T$ time periods. This technique allows for heterogeneity across individuals and these include individual-specific time trends, individual-specific fixed effects and time-specific effects (Mark and Sul, 2003, p. 656). The estimator is entirely parametric and more precise than the panel FMOLS estimator proposed by Pedroni (2000 & 2004) and Phillips and Moon (1999). The asymptotic distribution theory employed by Mark and Sul (2003) requires that observations are independent across individuals, however they did allow a limited degree of cross-section dependence through the presence of time-specific effects. With this negligible degree of cross-section dependence, it is difficult to treat this technique as a second generation panel method, see Flowchart 3.2.

Mark and Sul (2003, p. 656) showed that for fixed $N$ as $T \rightarrow \infty$, the estimator converges to a function of Brownian motions and the Wald statistic for testing a set of $s$ linear constraints has a limiting $X^2(s)$ distribution. The estimator also has a Gaussian sequential limit distribution that is obtained first by letting $T \rightarrow \infty$, and then letting $N \rightarrow \infty$. In a series of Monte-Carlo experiments, Mark and Sul find that

[119] See literature review chapter for details on these studies.

the asymptotic distribution theory provides a reasonably close approximation to the exact finite sample distribution.

The panel DOLS technique allows the long run regression to be augmented by lead and lagged differences of the explanatory variables to control for endogeneous feedback. Lead and lagged differences of the dependent variable can be incorporated to account for serial correlation (for more details, see Saikkonen 1991, Stock and Watson 1993, Dreger et al. 2007). Equation (3.28) is estimated for the *i*-th panel member, where the appropriate choice of leads and lags is based on data-dependent criteria.

$$y_{it} = a_i + B_i x_{it} + \sum_{J=-P1}^{P2} \delta_j \Delta y_{it-j} + \sum_{J=-q1}^{q2} \lambda_j \Delta x_{it-j} + u_{it} \tag{3.28}$$

Note that standard errors are calculated using the long run variance of the cointegration residuals. According to Mark and Sul (2003), a panel DOLS estimator is obtained in the following ways. First, individual dynamic and deterministic components are regressed out separately for the panel members. Then, the residuals are stacked and a pooled regression is run.

Recently, Dreger et al. (2007) and Rao and Kumar (2009b) used the Mark and Sul's DOLS technique to estimate money demand for 10 EU and 14 Asian countries, respectively. While Dreger et al. (2007) raised doubts on the stability of *M2* demand in the EU countries, Rao and Kumar (2009b) found that *M1* demand is stable in the Asian countries.

### *3.4.3 Breitung Technique*

Breitung (2005) proposed a parametric approach for estimation and inference in cointegrated panel data models. This is an asymptotically efficient estimator, where all individual specific short run parameters are estimated in the first step and the long run parameters are estimated from a pooled regression in the second step. This method is comparable to Groen and Kleinberger (2003) and Carrion-i-Silvestre and Surdeanu (2009). These methods are so called second generation panel methods because they allow for cross-section dependence. Unlike Gengenbach et al. (2006) and Westerlund (2007) methods, Breitung's (2005) method allows us to estimate more than one cointegrating vector, see Flowchart 3.2.

Using Monte Carlo simulations, Breitung showed that this parametric test has good sample properties compared to Pedroni (1995, 2000) and Phillips and Moon's (1999) FMOLS or Kao and Chiang's (2000) DOLS. Further, the estimated standard errors from this test could be easily adjusted to account for heteroscedasticity and contemporaneous correlation of the errors.

Mark and Sul's (2003) DOLS and Breitung's (2005) two-step method differ in their treatment of the intercept, trend and variables that influence dynamic adjustments in estimating the cointegrating equations (see Rao and Kumar, 2009b, p. 1014). Collectively these variables are called nuisance variables. However, the common objective of these methods is to estimate unbiased and efficient parameters, especially in finite samples. There is no difference in their asymptotic properties. Although Mark and Sul (2003) and Breitung (2005) claim that their methods are more efficient in finite samples, I take the view that when the real world data is used it is difficult to argue that one is unequivocally better than the other. Therefore, it seems better to use all these methods in applied work because, in finite samples, efficiency may also depend on the estimated relationships, their specifications and the quality of data. Rao and Kumar (2009b) and Dreger et al. (2007) briefly discuss, from an applied perspective, the relative merits of these methods. Both studies found consistent estimates of money demand across the three techniques (Pedroni, Mark and Sul and Breitung).

### *3.4.4 Westerlund's Panel ECM Method*

Westerlund (2007) proposed the error correction based cointegration test for panel data. Four (two panel and two group) tests based on structural dynamics are used to test the null hypothesis of no cointegration. These tests are extensions of Banerjee et al. (1998) and they test the null by inferring whether the error correction term in a conditional error correction model is equal to zero. If the null of no error correction is rejected, then the null of no cointegration is also rejected. The four tests accommodates individual-specific short run dynamics, including serially correlated errors, non-strictly exogenous regressors, individual-specific intercept and trend terms and individual specific slope parameters. This method has good sample properties and high power relative to other residual-based panel tests like McCoskey and Kao (1998), Kao (1999) and Pedroni (2004). Further, cross-sectional dependence is well addressed through bootstrapping; due to this process the test could be included in the second generation category, see Flowchart 3.2. The data generating process used here is observed as a restricted version of the one used by Larsson, et al. (2001) (see Westerlund, 2007, p. 713). The restriction being that the cointegration rank is at most one. To this end, Larsson et al. (2001) test is more attractive if one suspects that there is more than one cointegrating vector.

To adequately understand the Westerlund (2007) method, let us consider the following data generating process:[120]

$$y_{it} = \phi_{1i} + \phi_{2i}t + z_{it} \tag{3.29}$$

$$x_{it} = x_{it-1} + \upsilon_{it} \tag{3.30}$$

where $t = 1,...,T$ and $i = 1,...,N$ index the time series and cross sectional units, respectively. The $K$-dimensional vector $x_{it}$ is treated as a pure random walk while the scalar $y_{it}$ comprises a deterministic and stochastic terms. This can be further modelled as:

$$\alpha_i(L)\Delta z_{it} = \alpha_i(z_{it-1} - \beta'_i x_{it-1}) + \gamma_i(L)'\upsilon_{it} + e_{it} \tag{3.31}$$

where the scalar is:

$$\alpha_i(L) = 1 - \sum_{j=1}^{pi} \alpha_{ij} L^j \text{ and } \gamma_i(L) = \sum_{j=0}^{pi} \gamma_{ij} L^j$$

[120] See Westerlund (2007, p. 711).

$L$ is the lag operator. Substituting (3.29) into (3.31) gives the following conditional error correction model for $y_{it}$.

$$\alpha_i(L)\Delta y_{it} = \delta_{1i} + \delta_{2i}t + \alpha_i(\mathrm{y}_{it-1}\text{-}\beta'_i x_{it-1}) + \gamma_i(L)'\upsilon_{it} + e_{it} \qquad (3.32)$$

where $\delta_{1i}$ and $\delta_{2i}$ denotes the deterministic components (intercept and trend, respectively). The *ECM* model in (3.32) can only be stable if the variables it includes are stationary. More explicitly, $(L)\Delta y_{it}$ and $\mathrm{y}_{it-1}\text{-}\beta'_i x_{it-1}$ must be stationary together with $\upsilon_{it}$ and $e_{it}$. The departures from the equilibrium will be corrected by a proportion -2 < $\alpha_i \leq 0$, which is the error correction parameter. If $y_{it}$ and $x_{it}$ are cointegrated then $\alpha_i$ < 0. However if $\alpha_i$ = 0 then there exists no cointegration between $y_{it}$ and $x_{it}$. This implies that the null hypothesis of no cointegration for cross-sectional unit *i* can be implemented as a test of $H_0 : \alpha_i = 0$ and $H_1 : \alpha_i < 0$. The two group statistics are computed to determine the existence of cointegration as follows:

$$G_\tau = \frac{1}{N}\sum_{i-1}^{N}\frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \text{ and } G_\alpha = \frac{1}{N}\sum_{i-1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \qquad (3.33)$$

where $SE(\hat{\alpha}_i)$ is the conventional standard error of $\hat{\alpha}_i$. Alternatively, the panel statistics are computed as:

$$P_\tau = \frac{\hat{\alpha}}{SE(\hat{\alpha}\ )} \text{ and } P_\alpha = T\hat{\alpha} \qquad (3.34)$$

For the group statistics, the null and alternative hypothesis are formulated as $H_0 : \alpha_i = 0$ for all *i* and $H_1^g : \alpha_i < 0$ for at least some *i* which suggests that rejection of the null should be taken as evidence of cointegration for at least one of the cross-sectional units. In contrast, the panel statistics specifies the null and alternative hypothesis as $H_0 : \alpha_i = 0$ and $H_1^p : \alpha_i = \alpha < 0$ for all *i*, suggesting that rejection of the null hypothesis should be taken as evidence of cointegration for the panel as a whole. In the following section, I discuss the panel Granger causality tests.

### 3.5 Granger Causality Tests

Clive Granger gets all the credit for proposing causality in time series analysis. Conceptually, Granger causality provides useful inferences related to temporality, exogeneity and independence. Temporality exists only if past values of a variable (*X*) can cause another variable (*Y*). Sims (1972) asserted that a necessary condition for *X* to be exogenous of *Y* is that *X* fails to Granger cause *Y*. Similarly, variables are independent if there is no causality between them. The 'ARIMA or cross correlation' approach can be used for determining Granger causality. Although this approach is simple to implement, it has a few limitations such as the failure to detect the direction of causality and the statistical power of these are low.

The 'direct Granger causality' method is widely used in empirical works. As illustrated in Flowchart 3.3, causality tests could be applied once cointegration between the variables is established. It is worth noting that the existence of cointegration implies Granger causality but does not indicate the direction of causality. Further, it is vital to note that Granger causality testing should be applied on a fully-specified model. If the model is not well specified, 'spurious' relationships may be found, despite the fact of no or conditional relationship between the variables.

To test the direction of causality among the variables, econometricians have followed the trend set by Granger (1969) and developed alternative causality tests for time series data, for example among others are Hsiao (1981) and Johansen's (1991) VECM tests. However, there do not seem to be many causality tests for panel data with the exception of Hurlin (2004), Hurlin and Venet (2001) and Konya (2006). In this study, I employed the Granger non-causality tests proposed by Hurlin (2004) and Hurlin and Venet (2001).

Hurlin (2004) and Hurlin and Venet's (2001) procedure is applicable for homogenous or heterogeneous panel data models. I adapt the Granger causality panel data approach with fixed coefficients in which the following two models are examined.

$$\Delta \ln y_{i,t} = \upsilon + \sum_{a=1}^{n} \theta_a \Delta \ln y_{i,t-a} + \sum_{a=0}^{n} k_a \Delta \ln x_{i,t-a} + u_{i,t} \qquad (3.35)$$

$$\Delta \ln x_{i,t} = \upsilon + \sum_{a=1}^{n} \theta_a \Delta \ln x_{i,t-a} + \sum_{a=0}^{n} k_a \Delta \ln y_{i,t-a} + u_{i,t} \qquad (3.36)$$

where $i$ is individual of the panel ($i$ = 1,...,$N$), $t$ is time period ($t$ = 0,...,$T$) and $n$ is the maximum number of considered lags. It is assumed that there are balanced panels and identical lag orders ($a$) for all cross section units. The $F$-tests are utilised to formulate inferences related to Granger non-causality. In doing so, I tested the following hypotheses:

$$\begin{aligned} H_0 &: k_i^a = 0 \quad \forall i \in [1,N], \quad \forall a \in [0,n], \\ H_1 &: k_i^a \neq 0 \quad \forall i \in [1,N], \quad \forall a \in [0,n], \end{aligned} \qquad (3.37)$$

If the null hypothesis is not rejected, this means that there exists no causality between the variables. According to Hurlin and Venet (2001), analysis of causality for panel data sets should consider the different sources of heterogeneity of the data-generating process. To this end, I only test the heterogeneous non-causality hypothesis based on the fixed effects model. Structural change techniques are discussed in the next section.

### 3.6 Structural Change Tests

Given that a number of major financial reforms were implemented by many developing and OECD countries to enhance the efficiency of the financial sector, it is likely that structural changes might have taken place in the demand for money. However, most studies have failed to apply the formal tests for structural breaks in the money demand relationship. This study attempts to fill this gap by applying the newly developed structural change tests of Gregory and Hansen (1996a & b) and Westerlund (2006). These methods are discussed in the following two sections.

### *3.6.1 The Gregory and Hansen Technique*

Gregory and Hansen (1996a & b) (GH henceforth) proposed tests for cointegration with an endogenous structural break in the time series data. The GH approach is an extension of similar tests for unit root tests with structural breaks, for example, by Zivot and Andrews (1992) and Perron (1997). Strictly speaking, GH tests should only be used when standard methods fail to yield robust estimates, see Flowchart 3.3. GH proposed the cointegration tests which accommodates a single endogenous break in the underlying cointegrating relationship. The four models of GH with assumptions about structural breaks and their specifications with two variables, for simplicity, are as follows (see Rao and Kumar, 2009a, p.1279 and Rao and Kumar, 2007, p. 54):

GH-1: Level shift

$$Y_t = \mu_1 + \mu_2\varphi_{tk} + \alpha_1 X_t + \varepsilon_t \tag{3.38}$$

GH-2: Level shift with trend

$$Y_t = \mu_1 + \mu_2\varphi_{tk} + \beta_1 t + \alpha_1 X_t + \varepsilon_t \tag{3.39}$$

GH-3: Regime shift where intercept and slope coefficients change

$$Y_t = \mu_1 + \mu_2\varphi_{tk} + \beta_1 t + \alpha_1 X_t + \alpha_2 X_t\varphi_{tk} + \varepsilon_t \tag{3.40}$$

GH-4: Regime shift where intercept, slope coefficients and trend change

$$Y_t = \mu_1 + \mu_2\varphi_{tk} + \beta_1 t + \beta_2 t\varphi_{tk} + \alpha_1 X_t + \alpha_2 X_t\varphi_{tk} + \varepsilon_t \tag{3.41}$$

where $Y$ is the dependent and $X$ is the independent variable, $t$ is time subscript, $\varepsilon$ is an error term, $k$ is the break date and $\varphi$ is a dummy variable such that:

$$\varphi_{tk} = 0 \text{ if } t < k \text{ and } \varphi_{tk} = 1 \text{ if } t > k \tag{3.42}$$

The null hypothesis of no cointegration with structural breaks is tested against the alternative of cointegration by the GH approach. The single break date in these models is endogenously determined. In most of the previous studies on demand for money in developing and in fact in many developed countries, an important issue that was not addressed was that the cointegration relationship may have a structural break during the sample period. Few studies have accounted for structural breaks in the cointegrating vector of money demand, for example see, Felmingham and Zhang (2001) for Australia, Breuer and Lippert (1996) for USA, Rao and Kumar (2007 & 2009a) respectively for Fiji and Bangladesh and Nair et al. (2008) for Malaysia. The money demand specifications for the aforesaid four models, with structural breaks, are as follows:

GH-1: Level shift

$$\ln m_t = \mu_1 + \mu_2 \varphi_{tk} + \alpha_1 \ln y_t - \alpha_2 R_t + \varepsilon_t \tag{3.43}$$

GH-2: Level shift with trend

$$\ln m_t = \mu_1 + \mu_2 \varphi_{tk} + \beta_1 t + \alpha_1 \ln y_t - \alpha_2 R_t + \varepsilon_t \tag{3.44}$$

GH-3: Regime shift where intercept and slope coefficients change

$$\ln m_t = \mu_1 + \mu_2 \varphi_{tk} + \beta_1 t + \alpha_1 \ln y_t + \alpha_{11} \ln y_t \varphi_{tk} - \alpha_2 R_t - \alpha_{22} R_t \varphi_{tk} + \varepsilon_t \tag{3.45}$$

GH-4: Regime shift where intercept, slope coefficients and trend change

$$\ln m_t = \mu_1 + \mu_2 \varphi_{tk} + \beta_1 t + \beta_2 t \varphi_{tk} + \alpha_1 \ln y_t + \alpha_{11} \ln y_t \varphi_{tk} - \alpha_2 R_t - \alpha_{22} R_t \varphi_{tk} + \varepsilon_t \tag{3.46}$$

The break date is found by estimating the cointegration equations for all possible break dates in the sample. We select a break date where the test statistic is the minimum or in other words the absolute ADF test statistic is at its maximum. GH have tabulated the critical values by modifying the MacKinnon (1991) procedure for testing cointegration in the EG method for unknown breaks.

For the purpose of determining break dates in the cointegrating vector, I will use the GH tests. There is lot of controversy in the time series literature on the use of alternative structural break tests. Rao and Kumar (2009a, 2009b & 2007) criticised Bai and Perron (2003) multiple break tests because their approach does not estimate cointegrating equations with break dates. To estimate breaks within a cointegrating framework, Rao and Kumar suggested the application of Gregory and Hansen (1996a & b) break tests.

### *3.6.2 Westerlund Structural Break Tests*

Westerlund (2006) proposed a simple test for the null hypothesis of cointegration that accommodate for structural change in the deterministic component of a cointegrating panel regression. The test is based on the *LM* cointegration test of McCoskey and Kao (1998) to allow for structural breaks in both intercept and trend, which may be located at different dates for different individuals. To this end, it is different to the structural break tests proposed by Banerjee and Carrion-i-Silvestre (2006), see Flowchart 3.3. This method also allows for endogenous regressors and serial correlation and addresses the short sample biases. Westerlund performed the Monte Carlo simulations to investigate the finite sample properties.

Westerlund method presents two ways to examine breaks in the data: first, when the breaks are known and second, when the breaks are determined endogenously. In the latter case, Bai and Perron (1998 & 2003) tests are useful to ascertain the location of the breaks. Here the sum of squared residuals are minimised as follows:

$$\hat{T}_i = \arg \min_{T_i} \sum_{j=1}^{M_i+1} \sum_{t=T_{ij-1+1}=1}^{T_{ij}} (y_{ij} - z'_{it}\hat{\gamma}_{ij} - x'_{it}\hat{\beta}_i)^2 \tag{3.47}$$

where $\hat{T}_i = (\hat{T}_{i1},...,\hat{T}_{iMi})'$ is the vector of estimated break points, $\hat{\gamma}_{ij}$ and $\hat{\beta}_i$ are the estimates of the cointegration parameters based on the partition $T_i = (T_{i1},...,T_{iMi})'$ and $\tau$ is a trimming parameter such that $\gamma_{ij} - \gamma_{ij-1} > \tau$, which imposes a minimum length for each sub-sample (Westerlund, 2006, p. 114). There are two steps involved to perform the estimation. The first step entails estimating the global minimizers (break point estimators) of the sum of squared residuals. These are placed together with the associated optimal break partitions for each possible number of breaks $M_i = 1, ..., J$, where $J$ is some predetermined upper boundary. The rationale here is to estimate the unknown parameters of the regression together with the unknown break points given that each individual have $T$ observations.

Since the dynamic programming algorithm cannot be used directly, therefore the minimization of the sum of squared residuals must be performed iteratively. The iterative procedure is detailed in Westerlund (2006, p. 114) as follows. Given an initial value for $\beta_i$ , initiate the procedure by minimising the objective function with respect to $\gamma_{ij}$ and $T_i$ while keeping $\beta_i$ constant. This entails an evaluation of the optimal break partition for all sub-samples that show the possibility of $M_i$ breaks. Subsequently, the objective function is minimized with respect to $\gamma_{ij}$ and $\beta_i$ simultaneously while keeping $T_i$ constant. In this process the marginal decline in the objective function converges or the number of iterations acquires some predetermined upper boundary. The second step estimates the number of breaks utilising an information criterion. Explicitly, the sum of squared residuals is used to estimate the number of breaks to incorporate in the cointegrating vector. To this end, the SBC criterion can be used. These two steps are repeated $N$ times, which provides a vector of estimated break points for each individual in the sample. The $LM$ statistic can then be constructed using $\hat{T}_i$ in place of $T_i$ for each individual. The following section provides a brief background of the extreme bounds analysis.

### 3.7 Extreme Bounds Analysis

Flowchart 3.3 illustrates that extreme bounds analysis (EBA henceforth) could be applied to test the robustness of the determinants of a long run relationship. I have used the EBA suggested by Leamer (1983, 1985) and an extension of EBA postulated by Sala-i-Martin (1997) to investigate robustness of the variables that capture the cost of holding money. This analysis is performed using panel data instead of cross section because panel regressions allow for unobservable variations in money demand function across countries through individual effects, but also considers within country variation.

Essentially, EBA estimates regressions with all possible combinations of three explanatory variables at a time. In these estimates, one or two variables, usually included in many regressions, are retained as MUST variables in all combinations of the estimates. In this study I used the log of GDP, which is a scale variable in most money demand specifications as the MUST variable. Leamer (1985) and Levine and Renelt (1992) have treated a variable as robust if its coefficient did not change sign in the estimates with all combinations of the three explanatory variables.

The traditional EBA does provide useful insights on model specifications, however it is likely that at times the extreme bounds may be based on models that are unreasonable. To this end, it is necessary to compare the results with a reasonable EBA test. Granger and Uhlig (1990) refined the traditional EBA to allow a condition on the level of goodness of fit such that models with a very low $R^2$ compared to $R^2_{\max}$ are eliminated for the estimation of extreme bounds. This approach is usually referred as reasonable or restricted EBA test. Similarly, Sala-i-Martin (1997) argued that the traditional EBA is too stringent because a variable becomes fragile even if it changes sign only once. Therefore, he used the cumulative distribution functions (CDF) of the estimated coefficients to determine the robustness of the variable. He selected the 95% probability level as the critical value. Therefore, a variable becomes fragile only if its coefficient changes sign in more than 5% of the estimates. In this study, I followed Levine and Renelt (1992) and Sala-i-Martin (1997) to perform the EBA test with GAUSS 11.0 software.

**3.8 Conclusions**

While attempting to accomplish its objective this chapter from a pedagogical perspective also demonstrates empirically, first, how to perform some well-known unit root tests with time series and panel data, second, how to test and estimate the cointegrating equations by employing alternative time series and panel data estimation techniques, third, how to apply the structural change tests to determine breaks in the cointegrating equations, and finally, how to apply the Granger causality and extreme bounds tests in the panel data.

There exist a large number of methods for unit roots and cointegration in the literature, yet there is no clear direction on when to apply these tests. While the time series methods are somewhat implicit, methods utilising the panel data are not. Each contributor generally argues that their methods are relatively better than others. However, what is most important is the purpose of research. Smith (2000) argued that statistical techniques are merely tools to summarise data and therefore they cannot answer difficult questions that require economic insights. To this end, one must not lose sight of the purpose of research and interpretation of results. Economic theory or context should guide the choice of the methods.

To help researchers navigate through the issues of model selection and its application, I developed flowcharts which illustrate different unit root and cointegration methods and when it is appropriate to apply them. In doing so, I have considered some decisions on the basis of what the data 'are' and some others on the basis of what the researcher 'prefers'. Obviously the choices depend on the wider context and usually applied economists employ tests that are relevant to the purpose of their exercise. The flowcharts cover a comprehensive set of unit root and cointegration tests and perhaps this could serve as a useful guide to applied economists working with non-stationary time series and panel data. Further, I argue that alternative estimation methods should give consistent and robust results if they are applied appropriately and if data is reliable.

Regardless of which estimation technique is used, it is vital to test for the non-stationarity properties of the variables. Since the ADF tests have low power against the unit root null, hence it is appropriate to utilise relatively stronger tests for example, ERS, PP or KPSS. Perron (1989) criticized the conventional unit root tests for not taking account of structural changes and instead extended the DF test to allow for an exogenous break. Later, the endogenous break unit root tests emerged in the literature, notably, Zivot and Andrews (1992), Perron (1997), Lumsdaine and Papell (1997), Bai and Perron (2003) and Lee and Strazicich (2003). Therefore, this study attempts to examine the non-stationarity properties of the variables using three conventional (ADF, PP and KPSS) and three structural break (Zivot and Andrews, Lee and Strazicich and Bai and Perron) unit root tests.

For testing unit roots in the panel data, the recently developed panel unit root tests of LLC, IPS, MW, Breitung and Hadri are used in this study. In LLC, IPS, MW and Breitung tests the null hypothesis is non-stationary and where as in Hadri test, the null hypothesis is stationary. These are so called the first generation panel unit root tests because they assume cross-section independence in the errors. Initially, I applied the second generation panel unit root tests and derived consistent results with the above. To this end, I infer that the first generation panel unit root tests are adequate in explaining the non-stationarity properties of the variables in the panels. For convenience, I discussed only the results on the first generation tests in the next chapter.

For the purpose of testing for cointegration and estimating the cointegrating vectors in the money demand relationship, I applied five alternative time series techniques viz. GETS, EG, FMOLS, ARDL and JML. With the exception of the JML method, others are chracterised as the single-equation methods. The recently developed panel data techniques such as Pedroni (2004), Mark and Sul (2003), Breitung (2005) and Westerlund (2007) are also employed. Further the determination of structural breaks in the cointegrating equations is examined with the Gregory and Hansen (1996a & b) and Westerlund (2006) structural break tests. In the final stage of the cointegration analysis, I applied the Hurlin (2004) and Hurlin and Venet’s (2001) panel Granger causality and Leamer’s (1983 & 1985) extreme bounds analysis. The latter is a robustness test suitable for panel data models.

The next chapter is perhaps the most significant component of the thesis. It utilises the above mentioned tests to derive results and draw inferences on the demand for money in advanced OECD and developing countries. I shall follow the flowcharts developed in this chapter in the application of these empirical tests. Given that most countries have switched from using money supply to the rate of interest as their instrument of monetary policy, it is therefore important to assess this new policy stance in light of money demand stability. It appears that most central banks pay less attention to the stability of the money demand functions. This study therefore identifies that the money demand stability is useful for policy and it requires strong empirical investigations.

# CHAPTER 4: EMPIRICAL RESULTS

## 4.1 Introduction

Empirical works on the demand for money are numerous. Therefore, it is necessary to offer a justification for yet another applied study on this relationship. There are two reasons for this. First, although this thesis estimates a standard specification of the demand for narrow money using time series and panel data methods, it applies recent developments in econometric techniques and second, it offers useful and new methodological guidelines to estimate other relationships. To this end, the flowcharts detailed in Chapter 3 illustrate the relevance of these methods. They not only portray the step-by-step processes in cointegration analysis, but help to facilitate understanding of the process and where the process can be improved.

The objective of this chapter is to re-examine the *M1* demand for selected advanced OECD and developing (Pacific Islands, Asian, African and Latin American) countries using a comprehensive set of time series and panel data estimation methods. First, I test for the integrated properties of the variables using conventional (Augmented Dickey Fuller, Phillips Perron and Kwiatkowski-Phillips-Schmidt-Shin) and structural break (Zivot-Andrews, 1992; Lee and Strazicich, 2003 and 2004; and Bai and Perron, 1998 and 2003) unit root tests. Second, the tests for cointegration among the variables are performed using the Johansen (1991), Pedroni (2004) and Westerlund (2007) methods. Note that the latter two methods utilises panel data. Third, the cointegrating equations of *M1* demand are estimated through the application of five time series (Pesaran et al.'s, 2001 autogressive distributed lag model; Hendry's, 1995 General to Specific; Engle and Granger, 1987; Phillip and Hansen's, 1990 fully modified ordinary least squares; Johansen's, 1991 maximum likelihood) and three panel data (Pedroni, 2004; Breitung, 2005; Mark and Sul, 2003) estimation methods. Fourth, stability of *M1* demand is analysed with the CUSUM (Cumulative Sum) and CUSUMSQ (CUSUM of Squares) of recursive residuals tests. Further, I also conduct the structural change (Gregory and Hansen, 1996a & b and Westerlund, 2006), panel Granger causality (Hurlin, 2004 and Hurlin and Venet, 2001) and extreme bounds (Leamer, 1983 and 1985) tests.

Estimates of the demand for money and its stability became controversial after the 1970s due to the instability caused by financial reforms that improved efficiency of the financial markets. A variety of money substitutes for transactions such as credit and debit cards and electronic money transfers etc., were introduced. Reforms enhanced competition and improved international capital mobility. It is now a stylized fact that the demand for various monetary aggregates became unstable in advanced countries following the 1970s reforms. Consequently, central banks in many advanced countries switched from using money supply to the rate of interest as their instrument of monetary policy since it is not possible to accurately forecast the target given unstable and unreliable estimates of the demand for money.[121] This is also consistent with Poole's (1970) conjecture that money supply should be targeted when the demand for money is stable and the rate of interest when this relationship is unstable. In essence, the use of an incorrect instrument will only accentuate instability in output.

The monetary policy frameworks in the Pacific Island countries (henceforth PICs) aim to promote monetary stability and a sound financial structure, foster credit and exchange conditions conducive to balanced economic development. While adjustments to the bank rate play a crucial role in stabilising the inflation rate, fluctuations in world commodity prices and domestic supply conditions, mainly in agriculture, often play a dominant role in determining inflation outcomes in the PICs. Recently a few researchers have questioned the effectiveness of interest rate targeting procedure in maintaining price and output stability and instead argued that other policy instruments should be explored, for instance see Rao and Singh (2005a & b), Kumar and Manoka (2008) and Singh and Kumar (2010 & 2011).

[121] Some studies support the Taylor rule based interest rate targeting; see Orden and Fisher (1993) for Australia, McPhail (1991) and Haug (1999) for Canada, Maki and Kitasaka (2006) and Nagayasu (2003) for Japan, Papadopoulos and Zis (1997) for Greece, Vega (1995; 1998) for Spain, Caporale and Gil-Alana (2005) and Oxley (1983) for UK and Breuer and Lippert (1996) for USA.

Financial market liberalisation in most Asian countries has started from the early 1980s and by end of the 1990s most central banks in Asia had formally or informally abandoned monetary targeting in favour of a more eclectic approach i.e., interest rate targeting. Several Asian countries consider that their money demand functions have become unstable, indeed findings of some empirical studies (for example see Narayan, 2007; Katafono, 2001) support this while a few claim that there is a lack of evidence of instability in money demand for Asian countries (for example see Bahmani-Oskooe and Rehman, 2005; Yu and Gan, 2009).

Most African countries underwent financial reforms during the 1990s, for instance, Nigeria privatised its state owned banks in 1992, Kenya pursued economic liberalisation policies from 1993 and Malawi adopted floating exchange system in 1994. Although the central banks in Africa aim for price stability through adjusting the monetary aggregates; some also use the short-term interest rates, for example South Africa. Central banks in Latin American countries also place more emphasis on inflation targeting. Here adjustments to the bank rate seem to be a prime strategy.

The advanced OECD countries have liberalized their financial markets during the 1970s and the 1980s. The main objective of monetary policy in advanced OECD countries is attaining inflation and financial stability. In achieving these goals, central banks have switched from monetary aggregates to the bank rate, and such policy selection is based on the belief that money demand functions are unstable. Further, the European Central Bank (ECB) has facilitated the ability to use cross country monetary aggregates and money play a crucial role within ECB's monetary policy framework. For example, French *M3* is an indicator of French aggregate demand conditions and it may also be a valuable indicator of potential inflationary pressures in Germany. To this end, it might be appropriate if some importance to French *M3* is given when formulating German monetary policy.

Central banks in many developing economies including the PICs, Asian, African and Latin American, have followed suit and switched towards monetary policies directed at the bank rate. A major part of this policy switching is grounded on the view that their own financial market reforms and liberalisations might have contributed to the instability in their own money demand functions. However, my earlier work (Kumar, 2011; Singh and Kumar, 2011; Singh and Kumar, 2010; Rao and Kumar, 2009a; Rao and Kumar, 2009b; Kumar and Manoka, 2008; Rao and Kumar, 2007; Kumar, 2007) raised doubts about the validity and strength of central bank interest rate targeting in developing economies. In these studies I found that money demand functions are stable in developing countries over the 1970-2007 time period and continued use of the money supply as the monetary policy instrument by the respective central banks is feasible. Bahmani-Oskooee and Rehman (2005) and Rao et al. (2009) also made similar observations.

The outline of this chapter is stated as follows. Section 4.2 provides the specification and a brief description of data. The variables are tested for unit roots in Section 4.3. Sections 4.4 and 4.5, respectively, present estimates with alternative time series and panel data methods with structural breaks for *M1* demand for selected advanced OECD and developing countries. The Granger causality results are reported in Section 4.6. Section 4.7 applies the extreme bounds analysis to confirm the robust explanatory variables in the demand for *M1* relationship. *M1* stability is tested and implications on monetary policy are detailed in Section 4.8. Finally, Section 4.9 concludes.

## 4.2 Specification and Data Description

Many empirical studies have used canonical specification of the demand for money, however to capture the true cost of holding money we specify the demand for money in its canonical form and its extended versions, such that:[122]

$$\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t \qquad (4.1)$$

$$\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t \qquad (4.2)$$

[122] We present here the time series specifications of the demand for money, where subscript *t* denotes the time period.

where $\theta_0$ = intercept, $m$ = real narrow money stock, $y$ = real output, $R$ = cost of holding money proxied with the nominal short term interest rate, $E$ = cost of holding money proxied with the nominal effective exchange rate, $\pi$ = cost of holding money proxied with the inflation rate and $\varepsilon \approx N(0,\sigma)$. Real money balances are defined as the narrow monetary aggregate, *M1*, deflated by the GDP deflator. Real output, or income, is constructed using nominal GDP deflated by GDP deflator and the 3 month deposit rate is our proxy for the nominal interest rate. Inflation rate is computed as the change in the GDP deflator. The expected sign of real output or income is positive. Ball (2001) pointed out that a lower (< 1) income elasticity would imply that the Friedman rule is not optimal and the money supply should grow more sluggishly than income to attain price stability. Friedman (1969) presents his famous rule for optimal monetary policy. 'Our final rule for the optimum quantity of money is that it will be attained by a rate of price deflation that makes the nominal rate of interest equal to zero' (p.34). Friedman also suggests that this rule can be implemented by steadily contracting the money supply at the representative household's rate of time preference.

The income elasticity in developing countries is expected to be around unity (or slightly higher). The underdeveloped financial markets in many developing countries generally lack the features like diversified financial sector and payments technology. Most transactions involve the use of narrow money as opposed to other forms of monetary aggregates. Alternatively, the income elasticity in advanced countries is expected to be much lower than unity due to improved and developed financial system, see Figure 2.1 (p. 36). For a comprehensive survey of income elasticities for developed and less developed countries, see Sriram (1999).

The nominal rate of interest represents the opportunity cost of holding money and its coefficient is expected to be negative. The holding of foreign currency is a practical option in many countries and therefore justifies the inclusion of nominal effective exchange rate. Mundell (1963) conjectured that in addition to the interest rates and the level of real income, the determinants of the demand for money should be augmented by the exchange rate. The expected sign for the exchange rate can be either negative or positive. Measured as a number of units of foreign currency per unit of domestic currency, if depreciation of the domestic currency (a reduction in $E$) is to increase the demand for cash balances, hence the estimate of ln$E$ should be negative. However, the estimate of ln$E$ could be positive if depreciation induces the expectation of additional depreciation which results in a decrease in the demand for the domestic currency. We have used the rate of inflation as a proxy to measure the return on holdings of goods (example, real estate and shares). These goods are an alternative to holding domestic currency and therefore the inflation rate is expected to be negative. A number of studies have used the inflation rate in money demand analysis, for instance see Adam (1992), Arize (1994) and Bahmani-Oskooee and Rehman (2005).[123]

The annual data used in this study consists of 53 countries i.e., 5 Pacific Island countries (1970-2009 period), 18 Asian countries (1965-2009 period), 10 African countries (1970-2009 period), 10 Latin American countries (1970-2009 period) and 10 advanced OECD countries (1960-2009 period).[124] The data is extracted from the International Financial Statistics (IFS 2010) and the World Development Indicators (WDI 2010) which is published by the International Monetary Fund and The World Bank, respectively. The next section discusses the unit root test results.

## 4.3 Unit Root Tests

### *4.3.1 Conventional Unit Root Tests*

The first step in cointegration analysis is to establish the order of integration of the series under consideration; Flowchart 3.1 (p. 137) constructed in Chapter 3 detailed when it is appropriate to apply various unit root tests. There are many controversies

[123] See literature review chapter for discussion of these studies.

[124] These countries are Fiji (FJI), Samoa (WSM), Solomon (SLB), Vanuatu (VUT), Papua New Guinea (PNG), Bangladesh (BGD), Myanmar (MMR), India (IND), Indonesia (IDN), Iran (IRN), Israel (ISR), Jordon (JOR), Korea (KOR), Kuwait (KWT), Malaysia (MYS), Nepal (NPL), Pakistan (PAK), Oman (OMN), the Philippines (PHL), Singapore (SGP), Sri Lanka (LKA), Syria (SYR), Thailand (THA), Kenya (KEN), Cameroon (CMR), South Africa (ZAF), Rwanda (RWA), Egypt (EGY), Ethiopia (ETH), Ivory Coast (CIV), Malawi (MWI), Nigeria (NGA), Uganda (UGA), Argentina (ARG), Brazil (BRA), Bolivia (BOL), Chile (CHL), Colombia (COL), Ecuador (ECU), Peru (PER), Uruguay (URY), Venezuela (VEN), Mexico (MEX), Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Greece (GRC), Japan (JPN), Norway (NOR), New Zealand (NZL), Switzerland (CHE) and the United States (USA).

surrounding the conventional unit root tests, our strategy is to compare results obtained from three tests viz. Augmented Dickey Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS). My earlier work (Kumar, 2007; Rao and Kumar, 2007; Kumar and Manoka, 2008; Rao and Kumar, 2009a; Kumar, 2010b; Kumar, 2011) have mainly utilised the ADF tests however it is well known that ADF tests have low power against the unit root null and therefore it may be important to confirm the ADF results with other tests like for instance, PP and KPSS, see Flowchart 3.1. Tables A1-A8 (see Appendix 2) presents the unit root test results for the variables real *M1*, real income, nominal interest rate, nominal exchange rate and inflation rate. The ADF tests have been applied for both levels and their first differences with an intercept and trend. The unit root null hypothesis is accepted when the ADF and PP statistics for the level variables do not exceed the critical values (in absolute terms). Similarly, time series variables are first difference stationary when the ADF and PP statistics are higher than the respective critical values (in absolute terms).

Tables A1 and A2 (see Appendix 2) reports the ADF unit root results. The ADF statistic suggests that all variables are integrated of order one, I(1), whereas the first differences are integrated of order zero, I(0), except for ln*m* for Kuwait and Mexico, ln*y* for Chile and Greece and inflation rate for Fiji, Israel, Sri Lanka and Columbia. These variables are found to be stationary in levels for these countries. However, the hypothesis that the time series contain an autoregressive unit root is accepted for majority of the countries. Applying the PP test provides different lag lengths for the various time series variables, the main conclusion is qualitatively the same as reported by the ADF tests, except that the PP test confirmed the non-stationarity hypothesis in ln*m* for Kuwait and Mexico (ln*y* for Chile and Greece and inflation rate for Fiji, Israel, Sri Lanka and Columbia remains stationary in levels). Tables A3 and A4 (see Appendix 2) reports the PP unit root results. More explicitly, both tests are in favor of the unit root hypothesis in majority of the cases.

The null hypothesis of stationarity is tested against the alternative of a unit root in the KPSS tests. The test may be conducted under the null of either trend stationarity or level stationarity. Tables A5-A8 (see Appendix 2) reports the results for KPSS unit root tests. The KPSS statistics test for lag-truncation parameters ($\iota$) one and four since it is unknown how many lagged residuals should be employed to construct a consistent estimator of the residual variance. The KPSS statistics are known to be sensitive to the choice of truncation parameter $\iota$ and tend to decline monotonically as $\iota$ increases.[125] The crucial KPSS statistics are $\eta_\mu$ and $\eta_\tau$ for testing the null hypothesis that the series are I(0) when the residuals are computed from a regression equation with only an intercept and intercept and time trend, respectively. The critical values for this test is tabulated in Kwiatkowski et al. (1992).

Tables A5-A8 (see Appendix 2) report the KPSS results for truncation parameter $\iota$ = 1.[126] The KPSS test rejects the null hypothesis of level and trend stationarity in all cases, except the inflation rate for Israel and Columbia. The KPSS statistics do not reject the I(0) hypothesis for the first differences of the variables at conventional statistical levels. Therefore, the combined results from all the tests (ADF, PP and KPSS) suggest that all the variables appear to be I(1) processes, except the inflation rate for Israel and Columbia where all tests confirmed they are I(0). However, if there are structural breaks in the data series, these findings become equivocal. Flowchart 3.1 constructed in Chapter 3 illustrates that standard unit root tests should not be applied if there is any possibility of breaks in the data series. Perron (1989) criticized the conventional unit root tests for ignoring the structural changes in the unit roots and argued that the unit root null can be equivocally accepted or rejected if there are breaks in the data series. On a similar front, Hendry (1996) argued that a structural break essentially corresponds to an intermittent shock with a permanent effect on the series. This issue is addressed in the next section.

#### *4.3.2 Unit Root Tests with Structural Breaks*

The Zivot and Andrews (1992) (henceforth ZA) unit root test is utilised to test the order of variables in the presence of structural breaks. Following the suggested method in Flowchart 3.1, if there is possibility of a single break, ZA tests can be

[125] A good description of KPSS test can be found in Hondroyiannis (2004).
[126] The results for KPSS with $\iota$ = 4 are consistent with $\iota$ = 1 and therefore I report only the first set of results in Tables 3 and 4.

utilised. The ZA unit root test is a transformation of Perron's (1989) test and this method determines the presence of any possible break in the data series endogenously. Note that here the break points are 'unknown' and this is the advantage over Perron's unit root test, i.e. the ZA unit root test allows both the break points and lag lengths to vary endogenously. The breakpoint is searched for over the range of the sample (0.15T, 0.85T). The three models of ZA are models A, B and C where model A allows for a change in the level of the series, model B allows for a change in the slope of the trend of the series, while model C combines both changes in the level and the slope of the trend. In this study, I used model C because it considers breaks in the two parameters of a regression, viz. intercept and trend. The null hypothesis is that the variables follow a random walk process with no structural change, while the alternative is that the variables are trend stationary with one-time break with the precise timing unknown. Tables 4.1 and 4.2 reports the results for ZA unit root tests. The minimum t-statistics for testing the non-stationarity assumes a shift in the level and slope of the trend of real *M1*, real income, nominal rate of interest, nominal exchange and inflation rates. The null is not rejected in all cases because the minimum t-statistics (absolute value) are lower than the 5% critical value (absolute value), except for the inflation rate for Israel. The results suggest that none of the tested variables are stationary at 5% level of significance[127], while their first difference is I(0).[128]

For most countries, there seems to be a structural break in the series during the 1980s and 1990s. The single break dates of Zivot and Andrews are reasonable because these countries have undergone a continuing economic liberalisation since the 1980s. Other factors could also cause structural breaks in the data series for instance, oil price shocks, financial crises, natural disasters, political instabilities etc, and hence it is vital to account for these structural changes. Following the method outlined in Flowchart 3.1, I tested for the possibility of two structural breaks in unit roots. To do this I applied the Lee and Strazicich (2003 & 2004) (henceforth LS) endogenous two

[127] Except for inflation rate in Israel.
[128] The first difference results are not reported, however, in all cases the variables are found to be first difference stationary.

## Table 4.1 Zivot Andrews (ZA) Tests- African and Asian Countries

| *Country* | $\ln m_t$ | | $\ln y_t$ | | $R_t$ | | $\ln E_t$ | | $\pi_t$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *t*-statistic | break date | *t*-statistic | break date | *t*-statistic | break date | *t*-statistic | break date | *t*-statistic | break date |
| *African* | | | | | | | | | | |
| CMR | 1.068 | 2002 | 3.420 | 1997 | 0.512 | 1990 | 0.248 | 1991 | 1.224 | 2002 |
| KEN | 2.669 | 1987 | 3.476 | 1989 | 1.448 | 1992 | 4.157 | 2001 | 4.510 | 1992 |
| ZAF | 2.345 | 1994 | 1.571 | 1996 | 1.460 | 1987 | 3.423 | 1994 | 0.704 | 2001 |
| RWA | 3.201 | 1996 | 1.156 | 1978 | 4.022 | 2002 | 0.229 | 1995 | 1.199 | 2002 |
| EGY | 4.310 | 2002 | 2.594 | 1988 | 2.389 | 2001 | 1.345 | 1997 | 3.194 | 1983 |
| ETH | 1.530 | 2003 | 2.881 | 1977 | 4.838 | 2002 | 4.117 | 2001 | 4.397 | 1979 |
| CIV | 0.722 | 1999 | 4.641 | 1989 | 3.283 | 1995 | 3.360 | 2002 | 2.187 | 2000 |
| MWI | 1.788 | 1999 | 2.447 | 2000 | 1.222 | 1984 | 4.252 | 1996 | 2.476 | 1998 |
| NGA | 2.821 | 1988 | 2.179 | 1989 | 0.161 | 1978 | 3.484 | 1992 | 4.488 | 1992 |
| UGA | 3.903 | 2001 | 1.920 | 2002 | 5.022 | 1980 | 1.129 | 1995 | 1.932 | 1983 |
| *Asian* | | | | | | | | | | |
| BGD | 3.484 | 1988 | 1.852 | 1987 | 1.206 | 1999 | 0.126 | 2001 | 2.322 | 1989 |
| MMR | 2.439 | 1978 | 2.566 | 2002 | 1.510 | 2001 | 0.231 | 1984 | 1.175 | 2002 |
| IND | 2.362 | 1985 | 2.607 | 1994 | 4.916 | 1987 | 1.272 | 1982 | 4.362 | 1996 |
| IDN | 2.296 | 1984 | 4.611 | 1985 | 1.435 | 2002 | 4.100 | 1990 | 2.300 | 1986 |
| IRN | 3.196 | 2002 | 3.625 | 2002 | 3.554 | 1987 | 2.457 | 2000 | 3.122 | 1997 |
| ISR | 0.191 | 1976 | 3.649 | 1980 | 3.274 | 2000 | 1.141 | 1984 | 5.621 | 2001 |
| JOR | 3.752 | 1992 | 0.723 | 1985 | 1.466 | 1996 | 1.457 | 1977 | 0.420 | 1979 |
| KOR | 4.130 | 1982 | 1.248 | 1998 | 2.858 | 2002 | 3.202 | 1988 | 0.309 | 1997 |
| KWT | 1.346 | 2002 | 1.871 | 2001 | 2.454 | 1987 | 3.141 | 1995 | 2.345 | 2001 |
| MYS | 4.425 | 1995 | 4.836 | 1995 | 1.040 | 1982 | 3.478 | 1981 | 4.504 | 1999 |
| NPL | 1.614 | 1997 | 5.004 | 1996 | 4.310 | 1989 | 4.232 | 2002 | 3.003 | 1982 |
| PAK | 2.947 | 1986 | 1.786 | 1985 | 3.778 | 2002 | 1.293 | 1997 | 2.980 | 1980 |
| OMN | 2.125 | 2002 | 2.730 | 1996 | 3.502 | 2001 | 2.335 | 2002 | 3.373 | 1991 |
| PHL | 5.061 | 1987 | 0.612 | 2000 | 1.542 | 1987 | 0.195 | 1998 | 1.259 | 2002 |
| SGP | 4.648 | 1998 | 1.500 | 1999 | 2.088 | 1988 | 1.252 | 2001 | 1.406 | 1998 |
| LKA | 4.331 | 2000 | 0.793 | 1995 | 4.029 | 2002 | 2.378 | 1981 | 0.850 | 1990 |
| SYR | 2.130 | 1993 | 4.160 | 1994 | 0.646 | 1988 | 4.212 | 2002 | 5.043 | 1997 |
| THA | 3.547 | 1997 | 1.293 | 2002 | 2.175 | 1978 | 4.103 | 1998 | 0.344 | 1999 |

Notes: All t-statistics estimated from a break in intercept and trend model. Critical values are attained from Zivot and Andrews (1992). 1% and 5% critical values are 5.57 and 5.08, respectively. African and Asian represents African and Asian developing countries.

**Table 4.2 Zivot Andrews (ZA) Tests- Pacific Islands, Latin American and Advanced OECD Countries**

| *Country* | $\ln m_t$ | | $\ln y_t$ | | $R_t$ | | $\ln E_t$ | | $\pi_t$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *t*-statistic | break date | *t*-statistic | break date | *t*-statistic | break date | *t*-statistic | break date | *t*-statistic | break date |
| *PICs* | | | | | | | | | | |
| FJI | 3.264 | 1987 | 2.119 | 1988 | 1.989 | 2002 | 1.301 | 1985 | 4.201 | 1994 |
| PNG | 1.980 | 1988 | 3.071 | 1997 | 4.179 | 1977 | 0.212 | 1982 | 0.233 | 2001 |
| WSM | 4.704 | 1996 | 2.000 | 2002 | 3.067 | 1995 | 4.430 | 1995 | 1.400 | 1996 |
| SLB | 2.605 | 2001 | 1.948 | 1982 | 1.894 | 1989 | 2.492 | 2001 | 4.389 | 2000 |
| VUT | 4.493 | 2002 | 4.903 | 1991 | 2.005 | 1995 | 3.093 | 1988 | 2.741 | 1990 |
| *LACs* | | | | | | | | | | |
| ARG | 1.314 | 1988 | 3.668 | 1984 | 1.097 | 1993 | 2.068 | 2003 | 2.171 | 2001 |
| BRA | 1.275 | 1990 | 1.449 | 1993 | 0.872 | 1978 | 2.374 | 2001 | 4.355 | 1978 |
| BOL | 0.252 | 1995 | 2.324 | 1985 | 1.255 | 2002 | 3.187 | 1980 | 3.156 | 1981 |
| CHL | 4.219 | 1979 | 1.251 | 1982 | 2.042 | 1995 | 1.117 | 1997 | 2.050 | 2002 |
| COL | 4.148 | 1988 | 4.179 | 1990 | 3.231 | 2002 | 4.143 | 2002 | 1.459 | 1980 |
| ECU | 5.044 | 1989 | 1.135 | 1990 | 0.117 | 1982 | 0.345 | 2000 | 1.105 | 1991 |
| PER | 3.973 | 2002 | 3.103 | 2003 | 1.005 | 1981 | 2.287 | 1994 | 0.460 | 2002 |
| URY | 1.450 | 1977 | 1.074 | 1997 | 1.542 | 2000 | 1.199 | 1996 | 3.133 | 1994 |
| VEN | 4.622 | 1980 | 4.041 | 1987 | 1.251 | 1999 | 3.396 | 2003 | 2.008 | 2002 |
| MEX | 3.627 | 1993 | 5.011 | 1979 | 0.161 | 2000 | 4.135 | 1980 | 4.127 | 1983 |
| *OECD* | | | | | | | | | | |
| AUS | 2.754 | 1983 | 3.903 | 1984 | 1.222 | 1976 | 2.179 | 1979 | 1.005 | 2002 |
| AUT | 1.905 | 1976 | 3.668 | 2002 | 4.376 | 2001 | 5.022 | 1982 | 3.538 | 1979 |
| CAN | 5.000 | 1980 | 2.179 | 1977 | 1.265 | 1985 | 1.267 | 1996 | 0.287 | 1992 |
| DNK | 2.126 | 1978 | 0.287 | 2001 | 1.920 | 2001 | 1.905 | 1993 | 3.973 | 1988 |
| GRC | 1.381 | 1981 | 1.256 | 1986 | 4.916 | 1990 | 4.219 | 1978 | 0.872 | 2002 |
| JPN | 3.491 | 1999 | 4.219 | 1998 | 0.277 | 2001 | 0.268 | 1995 | 2.374 | 1981 |
| NOR | 1.267 | 1984 | 2.821 | 1993 | 2.353 | 1980 | 1.554 | 2002 | 1.277 | 1997 |
| NZL | 1.780 | 1985 | 0.278 | 2001 | 1.223 | 1989 | 3.271 | 1994 | 2.050 | 1995 |
| CHE | 2.333 | 1977 | 1.248 | 1979 | 4.032 | 2002 | 0.923 | 1980 | 4.001 | 2002 |
| USA | 4.280 | 1979 | 0.277 | 1981 | 2.341 | 1993 | 4.388 | 2000 | 2.126 | 2001 |

Notes: All t-statistics estimated from a break in intercept and trend model. Critical values are attained from Zivot and Andrews (1992). 1% and 5% critical values are 5.57 and 5.08, respectively. PICs, LACs and OECD represents Pacific Islands, Latin American and advanced OECD countries.

break minimum *LM* unit root tests to assess the order of integration of the variables. Tables 4.3 and 4.4 reports the results for *LM* unit root tests based on model C which represents two breaks in the intercept and trend.[129] The test statistics of the *LM* unit root tests for the five variables (ln$m$, ln$y$, $R$, ln$E$ and $\pi$) does not exceed the critical values in absolute terms and therefore the unit root null cannot be rejected at 5% level. The $t$-statistics for break dates are significant at conventional levels, except for Vanuatu (2002 for ln$m$), the Philippines (1979 and 1999 for $R$ and ln$E$, respectively), Venezuela (1991 for ln$m$), Kenya (2003 and 1986 for ln$y$ and $\pi$, respectively), Uganda (1978 and 1980 for $R$), Ethiopia (2000 for $\pi$), Bolivia (1993 and 1979 for ln$m$ and ln$y$, respectively), Peru (1994 for ln$E$), Brazil (1990 for ln$m$), Pakistan (2002 for $R$), Norway (2001 for ln$y$), Greece (1981 and 2002 for ln$E$) and Denmark (1988 for $\pi$).[130] The break dates are fairly consistent with the ZA test and as discussed earlier, it is probable that structural breaks in the data series could be caused by economic reforms or crises, rapid expansion, external shocks etc,.

There is also possibility of multiple structural breaks in the series. The ZA and LS tests fail to detect multiple structural breaks and therefore following the suggested method in Flowchart 3.1, I also employ the Bai and Perron (1998, 2003) (henceforth BP) tests to investigate the unknown multiple breaks in the series. Application of BP tests to the data of Solomon, Vanuatu, Myanmar, Iran, Kuwait, Nepal, Sri Lanka, Syria, Cameroon, Egypt, Ethiopia, Kenya, Malawi, Bolivia, Ecuador, Chile, Colombia, Peru, Uruguay, Venezuela, Austria, Norway and Switzerland revealed the existence of two breaks for the five series. We first look at the double maximum tests of *UDmax* and *WDmax* that reject the null of no breaks against the unknown number of breaks given the upper bound of five breaks. It is well known that the significance of these tests does not give much information about the exact number of breaks, but implies that one break is at least present, see Choi and Jung (2009, p. 1253) and Bai and Perron (2003, p. 16). In my case, both the *UDmax* and *WDmax* tests provide

[129] I also estimated model A and found that the results are not notably different from model C. The break dates are fairly consistent and the five variables are confirmed to be non-stationary in levels and first difference stationary.
[130] The t-statistics are not reported in the table.

**Table 4.3 Lee and Strazicich (LS) Tests- African and Asian Countries**

| *Country* | $\ln m_t$ | $\ln y_t$ | $R_t$ | $\ln E_t$ | $\pi_t$ |
|---|---|---|---|---|---|
| | *t*-statistic [break dates] | *t*-statistic [break dates] | *t*-statistic [break dates] | *t*-statistic [break dates] | *t*-statistic [break dates] |
| *African* | | | | | |
| CMR | 4.223 [1984; 1994] | 0.573 [1989; 1990] | 0.576 [1990; 1995] | 1.554 [1992; 2003] | 1.968 [2001; 2003] |
| KEN | 0.043 [1987; 1990] | 4.818 [1990; 2003] | 2.955 [1992; 2003] | 4.635 [1986; 2002] | 2.784 [1984; 1986] |
| ZAF | 1.615 [1994; 1996] | 4.085 [1988; 1996] | 5.004 [1987; 2000] | 3.629 [1999; 2000] | 4.636 [1995; 2001] |
| RWA | 5.078 [1984; 1996] | 1.367 [2001; 2002] | 2.912 [1989; 1993] | 2.995 [1979; 1995] | 1.462 [1989; 2003] |
| EGY | 2.725 [2000; 2002] | 4.748 [1996; 2001] | 1.273 [1988; 1990] | 2.143 [1986; 1997] | 1.834 [1983; 1987] |
| ETH | 4.620 [1976; 1988] | 2.476 [1977; 1986] | 4.521 [1996; 2002] | 4.762 [1994; 2001] | 0.747 [1976; 2000] |
| CIV | 1.573 [1982; 1999] | 3.677 [2000; 2001] | 3.765 [1990; 1995] | 3.961 [1999; 2003] | 2.814 [1976; 1980] |
| MWI | 3.489 [1999; 2003] | 1.132 [1998; 2000] | 3.971 [1980; 1985] | 3.083 [2001; 2001] | 4.030 [1998; 2000] |
| NGA | 3.973 [1983; 1988] | 4.831 [1987; 1990] | 4.125 [2000; 2002] | 1.190 [1989; 1992] | 3.477 [1990; 1992] |
| UGA | 1.826 [1996; 1999] | 5.001 [2001; 2002] | 1.320 [1978; 1980] | 4.298 [1994; 1995] | 5.075 [1980; 1983] |
| *Asian* | | | | | |
| BGD | 2.947 [1984; 1988] | 4.407 [1987; 1990] | 5.004 [2000; 2002] | 4.274 [2000; 2001] | 3.248 [1989; 1990] |
| MMR | 1.376 [1980; 1997] | 1.052 [1987; 2001] | 3.628 [1994; 2001] | 5.005 [1984; 1993] | 2.616 [2000; 2002] |
| IND | 4.778 [1985; 1987] | 2.178 [1990; 1994] | 2.157 [1985; 2002] | 1.383 [1976; 1985] | 1.013 [1997; 2002] |
| IDN | 3.151 [1985; 2002] | 1.533 [1985; 2001] | 4.380 [1978; 1996] | 2.545 [1990; 1992] | 0.972 [1979; 1986] |
| IRN | 3.553 [1980; 2001] | 4.604 [1975; 2002] | 4.213 [1987; 1995] | 4.427 [1993; 2001] | 0.897 [1997; 2001] |
| ISR | 0.948 [1976; 1986] | 1.078 [1981; 1997] | 1.054 [1995; 2000] | 1.625 [1984; 2002] | 4.209 [1988; 2000] |
| JOR | 1.882 [1992; 2002] | 4.520 [1976, 1985] | 2.818 [1995; 1996] | 4.731 [1976; 1990] | 2.675 [1979; 1991] |
| KOR | 4.332 [1980; 1982] | 4.833 [1998; 2001] | 3.989 [2000; 2001] | 2.075 [1988; 1997] | 1.048 [1997; 2001] |
| KWT | 2.347 [1979; 2000] | 1.974 [1996; 2001] | 2.491 [1980; 1987] | 2.860 [1978; 1995] | 3.451 [1989; 2001] |
| MYS | 3.688 [1984; 1995] | 2.039 [1990; 2002] | 1.615 [1982; 2001] | 3.918 [1979; 1981] | 4.246 [1999; 2002] |
| NPL | 0.437 [1997; 2001] | 3.144 [1980; 1996] | 1.753 [1974; 1989] | 1.321 [2001; 2002] | 2.983 [1982; 1999] |
| PAK | 1.340 [1985; 1997] | 2.283 [1985; 2002] | 0.891 [1984; 2002] | 4.986 [1990; 1998] | 3.097 [1978; 1980] |
| OMN | 1.069 [1982; 2002] | 1.492 [1996; 2001] | 5.017 [1979; 2000] | 2.091 [1985; 2002] | 3.291 [1991; 1999] |
| PHL | 2.027 [1981; 1987] | 0.629 [1994; 2000] | 3.185 [1979; 1995] | 1.211 [1998; 1999] | 1.900 [2000; 2002] |
| SGP | 4.875 [1988; 1998] | 4.742 [1999; 2000] | 2.473 [1975; 1988] | 0.300 [1999; 2002] | 0.712 [1986; 1998] |
| LKA | 0.825 [1974; 1980] | 3.871 [2001; 2002] | 2.805 [1981; 1992] | 1.196 [1981; 1989] | 4.479 [1990; 1997] |
| SYR | 1.999 [1983; 2000] | 3.062 [1994; 1996] | 4.020 [1988; 1995] | 2.313 [2000; 2001] | 3.153 [1997; 1999] |
| THA | 2.264 [1980; 1998] | 1.309 [1974; 1980] | 1.275 [1979; 1985] | 3.420 [1996; 1998] | 3.297 [1999; 2001] |

Notes: The 5% critical value for LS is -5.286. The critical value is taken from Lee and Strazicich (2004 and 2003). African and Asian represents African and Asian developing countries.

**Table 4.4 Lee and Strazicich (LS) Tests- Pacific Islands, Latin American and Advanced OECD Countries**

| *Country* | $\ln m_t$ | $\ln y_t$ | $R_t$ | $\ln E_t$ | $\pi_t$ |
|---|---|---|---|---|---|
| | *t*-statistic [break dates] | *t*-statistic [break dates] | *t*-statistic [break dates] | *t*-statistic [break dates] | *t*-statistic [break dates] |
| *PICs* | | | | | |
| FJI | 1.267 [1988;2002] | 2.045 [1995; 1997] | 3.015 [2000;2001] | 0.894 [1985;1995] | 3.228 [1992;2002] |
| PNG | 0.287 [1982;1988] | 4.880 [2001;2003] | 1.271 [1977;1989] | 1.769 [1985;2001] | 4.255 [1998; 2002] |
| WSM | 2.356 [1996; 1997] | 1.202 [1997; 2002] | 3.288 [1995; 1997] | 0.166 [1978; 2000] | 3.214 [1996; 1999] |
| SLB | 1.272 [2000; 2001] | 3.467 [1985;1998] | 4.538 [1989;2000] | 4.329 [2001;2003] | 2.024 [1998; 2000] |
| VUT | 2.005 [1981;2002] | 3.265 [1990;1991] | 1.316 [1998;2003] | 0.762 [1988; 1994] | 1.054 [1991; 1995] |
| *LACs* | | | | | |
| ARG | 4.672 [1980; 1988] | 1.245 [1983; 1988] | 2.569 [1993; 2002] | 2.434 [2000; 2002] | 5.156 [1996; 2001] |
| BRA | 2.114 [1986; 1990] | 3.886 [1978; 2001] | 4.856 [1980; 1986] | 4.556 [1995; 2001] | 0.259 [1975; 2003] |
| BOL | 4.510 [1993; 1995] | 5.098 [1979; 1985] | 3.159 [2001; 2003] | 1.323 [1981; 1989] | 3.052 [1982;1998] |
| CHL | 1.409 [1980; 2001] | 1.980 [1982; 1990] | 4.444 [1990; 1995] | 0.616 [1991;1998] | 4.308 [2002; 2003] |
| COL | 3.460 [1988; 2003] | 2.833 [1976; 1990] | 4.639 [1996; 2003] | 5.005 [2000; 2003] | 1.969 [1980; 1988] |
| ECU | 5.019 [1989; 1997] | 2.531 [1985; 1990] | 2.838 [1982; 1988] | 0.837 [1997; 2001] | 2.792 [1989; 1991] |
| PER | 4.270 [1997; 2003] | 3.671 [2000; 2002] | 3.026 [1980; 1981] | 1.991 [1994; 1998] | 4.959 [2001; 2002] |
| URY | 1.513 [1978; 1988] | 4.516 [1994; 1997] | 0.211 [1995; 2000] | 1.091 [1996; 2003] | 2.185 [1994; 2000] |
| VEN | 2.024 [1980; 1991] | 1.211 [1987; 2002] | 1.385 [1978;1986] | 2.242 [2000; 2002] | 1.304 [1980; 2003] |
| MEX | 5.070 [1993; 1996] | 0.159 [1976; 1980] | 1.541 [2000; 2002] | 4.433 [1980; 1986] | 0.661 [1983; 1992] |
| *OECD* | | | | | |
| AUS | 4.819 [1978; 1983] | 2.305 [1982; 1984] | 0.647 [1976; 2002] | 3.618 [1980; 2001] | 4.496 [2001; 2002] |
| AUT | 4.658 [1976; 1985] | 3.484 [1984; 2002] | 3.787 [1997; 2001] | 2.823 [1979; 1982] | 2.269 [1979; 1980] |
| CAN | 3.839 [1980; 1991] | 4.251 [1977; 2001] | 1.060 [1980; 1985] | 5.010 [1991; 1996] | 5.100 [1989; 1992] |
| DNK | 3.452 [1979; 1982] | 1.882 [2000; 2001] | 1.244 [2000; 2001] | 5.032 [1985; 1993] | 2.035 [1980; 1988] |
| GRC | 2.613 [1980; 1981] | 3.136 [1976; 1986] | 4.419 [1990; 1999] | 2.118 [1981; 2002] | 1.101 [2000; 2002] |
| JPN | 1.010 [1995; 1999] | 1.712 [1997; 2000] | 2.640 [1998; 2001] | 3.249 [1984; 1995] | 3.860 [1979; 1981] |
| NOR | 0.373 [1984; 1991] | 4.176 [1992; 2001] | 0.946 [1978; 1980] | 1.436 [2001; 2000] | 2.767 [1997; 2001] |
| NZL | 3.152 [1985; 1997] | 2.361 [1998; 2001] | 0.303 [1984; 1989] | 1.597 [1994; 2001] | 0.532 [1978; 1995] |
| CHE | 4.722 [1976; 1980] | 2.904 [1980; 2002] | 4.668 [1976; 1985] | 0.753 [1981; 1986] | 1.703 [1986; 2002] |
| USA | 2.410 [1979; 2002] | 5.097 [1981; 1985] | 3.982 [1990; 1999] | 3.869 [2000; 2002] | 0.647 [1987; 2001] |

Notes: The 5% critical value for LS is -5.286. The critical value is taken from Lee and Strazicich (2004 and 2003). PICs, LACs and OECD represents Pacific Islands, Latin American and advanced OECD countries.

evidence of multiple structural breaks at the 5% level. It is not surprising that *Sup F*(2|1) tests were rejected for the null of 1 break against the alternative of 2 breaks. However, the null cannot be rejected for *Sup F*(3|2) tests. The two break points for each series are consistent with the LS break dates for a number of the above countries.[131] Countries with different break points for some series are Vanuatu (1990 and 2000 for ln*m*), Korea (1999 for ln*E*), Nepal (1997 and 1995 for ln*y* and $\pi$, respectively), Syria (1984 and 1996 for ln*m* and 1998 for ln*E*), Sri Lanka (1987 for *R*), Egypt (1995 for $\pi$), Ethiopia (1979 and 2000 for ln*m* and ln*y*, respectively), Kenya (1995 for ln*m*, and 1988 and 2000 for ln*E*), Malawi (2001 for ln*m*, 1988 for ln*y* and 1986 and 1993 for ln*E*), Columbia (1998 for *R*), Ecuador (1987 for ln*y*), Peru (1990 and 1996 for ln*y*), Mexico (1985 and 1978 for ln*m*, 1995 for ln*y* and 2001 for $\pi$), Venezuela (1994 and 1988 for ln*E* and $\pi$, respectively), Austria (1989 for ln*m*, 1991 for *R* and 1995 for $\pi$), Canada (1987 for ln*y*, 1995 for *R* and 1990 for $\pi$), Japan (2000 for *R*) and New Zealand (1999 for ln*m*, 1994 for *R* and 1998 for $\pi$). Countries for which the BP break dates did not match the LS break dates for all series are PNG, Uruguay, Bolivia, Israel, Jordon, Uganda, Norway, Switzerland and the USA.

BP test results for countries that had three or four break points are reported in Table 4.5. It is found that three break points exists for Fiji, Samoa, PNG, India, Indonesia, Israel, Jordon, Korea, Malaysia, the Philippines, Pakistan, Oman, Ivory Coast, South Africa, Rwanda, Nigeria, Uganda, Argentina, Brazil, Mexico, Canada, Denmark, Greece and New Zealand. For all cases, the *UDmax* and *WDmax* tests reveal the existence of multiple structural breaks at the 5% level. The *Sup F*(3|2) tests were rejected for the null of 2 breaks against the alternative of 3 breaks. However, the null was not rejected for *Sup F*(4|3) tests. For six countries (Bangladesh, Singapore, Thailand, Australia, Japan and the USA) the *UDmax* and *WDmax* tests reject the null of no breaks against an unknown number of changes given the upper bound of five breaks. The *Sup F*(4|3) tests reject the null and confirms that four break points exists for these countries. These break points for each series are also comparable with the LS break dates.

[131] These results are not tabulated but detailed below.

**Table 4.5 Bai and Perron (BP) Tests**

| Country/ Variable | *UDmax* | *WDmax* | *SupF*(1\|0) | *SupF*(2\|1) | *SupF*(3\|2) | *SupF*(4\|3) | *SupF*(5\|4) | Break Dates |
|---|---|---|---|---|---|---|---|---|
| *FJI* | | | | | | | | |
| ln*m* | 129.250 | 126.604 | 24.156 | 62.678 | 23.963 | 6.634 | 1.109 | 1988; 1990;2002 |
| ln*y* | 237.432 | 247.020 | 38.284 | 43.858 | 54.110 | 9.012 | 9.726 | 1980; 1995; 1998 |
| *R* | 332.007 | 136.996 | 65.349 | 37.024 | 103.625 | 10.132 | 2.124 | 1997; 2000; 2003 |
| ln*E* | 198.263 | 161.274 | 39.476 | 85.193 | 44.221 | 10.078 | 2.048 | 1985; 1991; 1995 |
| $\pi$ | 203.326 | 297.842 | 95.504 | 93.390 | 42.124 | 10.136 | 14.159 | 1992; 1995; 2002 |
| *WSM* | | | | | | | | |
| ln*m* | 159.122 | 230.765 | 102.676 | 93.099 | 25.355 | 10.409 | 3.559 | 1988; 1996; 1997 |
| ln*y* | 237.955 | 348.013 | 87.259 | 82.649 | 96.219 | 3.221 | 4.079 | 1997; 1999; 2001 |
| *R* | 162.270 | 277.943 | 29.322 | 75.418 | 100.233 | 10.510 | 15.036 | 1990; 1997; 2000 |
| ln*E* | 342.240 | 292.208 | 33.378 | 92.154 | 84.032 | 7.943 | 2.730 | 1978; 1990; 2001 |
| $\pi$ | 158.160 | 464.216 | 35.408 | 27.866 | 26.631 | 6.740 | 6.523 | 1986; 1996; 1999 |
| *PNG* | | | | | | | | |
| ln*m* | 119.119 | 347.405 | 90.456 | 39.556 | 29.965 | 7.986 | 8.985 | 1982;1990;1995 |
| ln*y* | 260.134 | 468.594 | 27.492 | 23.501 | 75.430 | 9.251 | 3.829 | 1994; 2001; 2002 |
| *R* | 250.006 | 132.569 | 34.708 | 85.710 | 61.277 | 11.358 | 3.149 | 1976; 1989;1990 |
| ln*E* | 148.535 | 196.598 | 51.749 | 23.813 | 94.176 | 1.039 | 6.305 | 1980;1985; 2001 |
| $\pi$ | 279.162 | 208.534 | 78.838 | 30.432 | 93.257 | 4.526 | 9.371 | 1989; 1998; 2002 |
| *BGD* | | | | | | | | |
| ln*m* | 213.105 | 452.678 | 56.874 | 23.250 | 25.546 | 28.559 | 4.566 | 1984;1988;1996;2001 |
| ln*y* | 166.366 | 196.040 | 21.939 | 35.510 | 47.738 | 45.470 | 1.161 | 1979;1985;1987;1990 |
| *R* | 268.685 | 314.126 | 27.007 | 77.855 | 100.660 | 27.952 | 7.872 | 1981;1990;2001;2002 |
| ln*E* | 371.264 | 259.302 | 76.020 | 41.635 | 22.724 | 46.200 | 5.900 | 1977;2000;2001;2002 |
| $\pi$ | 475.418 | 263.300 | 91.028 | 55.828 | 50.157 | 92.947 | 4.365 | 1989;1990;1994;1999 |
| *IND* | | | | | | | | |
| ln*m* | 128.974 | 279.457 | 65.059 | 25.072 | 21.808 | 4.594 | 9.235 | 1981;1985; 2002 |
| ln*y* | 141.415 | 338.977 | 76.073 | 58.065 | 94.144 | 3.527 | 2.590 | 1990;1994; 1998 |
| *R* | 139.632 | 120.046 | 34.118 | 86.969 | 88.138 | - | - | 1985; 1997; 2001 |
| ln*E* | 262.216 | 242.337 | 26.149 | 61.833 | 24.570 | 10.892 | 1.685 | 1976; 2001; 2000 |
| $\pi$ | 174.452 | 111.305 | 22.240 | 69.706 | 39.833 | 1.024 | 6.605 | 1980;1997; 2001 |

**Table 4.5 Bai and Perron (BP) Tests**

| Country/ Variable | *UDmax* | *WDmax* | *SupF*(1\|0) | *SupF*(2\|1) | *SupF*(3\|2) | *SupF*(4\|3) | *SupF*(5\|4) | Break Dates |
|---|---|---|---|---|---|---|---|---|
| *IDN* | | | | | | | | |
| ln*m* | 184.481 | 482.701 | 79.296 | 25.631 | 23.700 | 10.136 | 6.632 | 1985; 1999;2002 |
| ln*y* | 190.097 | 323.617 | 54.519 | 72.794 | 41.688 | 2.807 | 1.903 | 1985;1999; 2001 |
| *R* | 220.985 | 256.716 | 23.586 | 42.105 | 92.073 | 9.863 | 4.301 | 1978; 1990;1995 |
| ln*E* | 193.754 | 634.765 | 71.589 | 77.324 | 30.540 | 10.378 | 7.295 | 1986; 1990;1992 |
| $\pi$ | 137.880 | 104.132 | 29.649 | 96.344 | 28.189 | 3.654 | 10.097 | 1979; 1980;1986 |
| *ISR* | | | | | | | | |
| ln*m* | 275.401 | 221.149 | 163.253 | 82.385 | 22.618 | 2.549 | 5.881 | 1976;1979;1987 |
| ln*y* | 107.654 | 527.808 | 28.761 | 48.201 | 85.126 | 6.163 | 5.878 | 1980;1981;1997 |
| *R* | 174.323 | 340.749 | 92.349 | 31.530 | 28.207 | 8.588 | 8.001 | 1991;1995;2002 |
| ln*E* | 138.646 | 221.009 | 27.319 | 90.536 | 41.449 | 7.599 | 7.803 | 1981; 1997;2000 |
| $\pi$ | 104.580 | 226.040 | 23.294 | 26.174 | 103.058 | - | - | 1988; 1997; 2001 |
| *JOR* | | | | | | | | |
| ln*m* | 198.978 | 121.381 | 68.530 | 89.099 | 28.102 | 8.860 | 2.820 | 1990;1992;1999 |
| ln*y* | 236.301 | 219.271 | 85.612 | 29.133 | 55.988 | 11.149 | 4.492 | 1976;1985;1991 |
| *R* | 137.992 | 136.011 | 36.844 | 81.327 | 79.439 | 7.489 | 5.773 | 1988;1995;1996 |
| ln*E* | 134.068 | 122.214 | 35.000 | 34.271 | 93.292 | 9.535 | 1.747 | 1976;1990;1991 |
| $\pi$ | 171.297 | 341.607 | 75.881 | 97.108 | 26.489 | 3.543 | 10.001 | 1979;1991;2001 |
| *KOR* | | | | | | | | |
| ln*m* | 148.947 | 328.414 | 79.550 | 102.238 | 29.048 | 3.013 | 10.700 | 1980;1982;1998 |
| ln*y* | 269.967 | 128.272 | 43.454 | 26.097 | 20.149 | 11.370 | 7.000 | 1998; 2001; 2000 |
| *R* | 109.993 | 130.085 | 68.570 | 40.561 | 54.995 | 2.112 | 3.221 | 1987;2000;2001 |
| ln*E* | 127.345 | 155.287 | 56.123 | 65.983 | 32.259 | 7.327 | 3.207 | 1985;1988;1997 |
| $\pi$ | 136.866 | 380.250 | 64.015 | 21.230 | 82.013 | 10.029 | 5.449 | 1994;1997;2001 |
| *MYS* | | | | | | | | |
| ln*m* | 324.280 | 123.206 | 81.542 | 27.377 | 23.387 | 9.019 | 1.130 | 1980;1984;1995 |
| ln*y* | 122.787 | 230.101 | 78.871 | 66.004 | 39.025 | 10.277 | 6.309 | 1991; 1997; 2001 |
| *R* | 137.202 | 324.294 | 50.250 | 101.283 | 165.290 | 1.029 | 4.337 | 1986; 1999; 2001 |
| ln*E* | 263.341 | 129.029 | 118.730 | 20.005 | 25.551 | 10.232 | 1.024 | 1979; 1981; 1998 |
| $\pi$ | 120.290 | 228.398 | 21.720 | 77.204 | 30.039 | 4.330 | 2.203 | 1998; 1999; 2002 |

**Table 4.5 Bai and Perron (BP) Tests**

| Country/ Variable | *UDmax* | *WDmax* | *SupF*(1\|0) | *SupF*(2\|1) | *SupF*(3\|2) | *SupF*(4\|3) | *SupF*(5\|4) | Break Dates |
|---|---|---|---|---|---|---|---|---|
| *PHL* | | | | | | | | |
| ln*m* | 216.137 | 372.082 | 26.436 | 34.642 | 31.525 | 6.057 | 11.685 | 1978;1981;1987 |
| ln*y* | 227.561 | 413.883 | 23.169 | 26.950 | 24.622 | 3.744 | 3.157 | 1988;1994;2002 |
| *R* | 129.038 | 874.904 | 47.586 | 50.165 | 41.240 | 9.581 | 7.561 | 1979;1994;1998 |
| ln*E* | 121.218 | 116.291 | 54.885 | 24.341 | 25.132 | - | - | 1980;1998;2000 |
| $\pi$ | 480.137 | 127.750 | 27.081 | 56.792 | 42.849 | 10.486 | 4.028 | 1995;2000;2002 |
| *PAK* | | | | | | | | |
| ln*m* | 374.550 | 234.203 | 39.449 | 52.303 | 36.349 | 1.803 | 3.773 | 1981;1985;1990 |
| ln*y* | 127.639 | 546.314 | 21.477 | 41.942 | 27.231 | 6.094 | 10.260 | 1985; 1990;2002 |
| *R* | 330.977 | 138.201 | 77.812 | 25.122 | 38.808 | 2.435 | 3.959 | 1979;1984;2000 |
| ln*E* | 173.890 | 248.039 | 93.109 | 26.298 | 29.573 | 4.795 | - | 1990;1998;1999 |
| $\pi$ | 145.323 | 243.134 | 28.936 | 46.400 | 50.369 | - | - | 1978;1980;2001 |
| *OMN* | | | | | | | | |
| ln*m* | 171.299 | 148.101 | 31.249 | 36.195 | 21.477 | 4.451 | 1.169 | 1982;1998;2000 |
| ln*y* | 180.797 | 254.291 | 85.383 | 27.130 | 23.007 | 5.122 | 6.253 | 1987;1996;2001 |
| *R* | 231.857 | 165.583 | 93.452 | 82.793 | 57.781 | 2.750 | 10.146 | 1979;1990;2002 |
| ln*E* | 403.860 | 470.628 | 24.189 | 21.253 | 92.238 | 8.578 | 6.177 | 1981;1985;2002 |
| $\pi$ | 156.179 | 175.695 | 26.129 | 37.391 | 26.761 | 1.617 | 4.272 | 1991;1998;1999 |
| *SGP* | | | | | | | | |
| ln*m* | 151.053 | 183.938 | 44.245 | 28.590 | 39.561 | 35.289 | 4.313 | 1981;1988;1998;2001 |
| ln*y* | 222.908 | 265.489 | 58.441 | 20.268 | 51.270 | 28.337 | 2.024 | 1976;1984; 1999;2000 |
| *R* | 355.141 | 191.628 | 26.682 | 52.313 | 34.458 | 22.664 | 9.003 | 1977;1988;1998;1999 |
| ln*E* | 164.014 | 204.350 | 30.662 | 23.203 | 21.956 | 66.769 | 4.525 | 1987;1999;2001;2002 |
| $\pi$ | 158.753 | 185.802 | 23.453 | 22.858 | 64.322 | 38.652 | 3.166 | 1986;1998;1999;2001 |
| *THA* | | | | | | | | |
| ln*m* | 165.257 | 128.888 | 47.291 | 45.582 | 28.081 | 52.090 | 1.637 | 1979;1980;1998;1999 |
| ln*y* | 167.127 | 199.504 | 65.461 | 23.472 | 31.063 | 33.466 | 8.742 | 1974;1980;1989;1998 |
| *R* | 352.836 | 433.232 | 51.588 | 68.260 | 24.512 | 25.095 | 4.819 | 1979;1985;1995;1999 |
| ln*E* | 174.908 | 131.555 | 63.986 | 22.970 | 88.185 | 27.238 | 1.872 | 1996;1998;2000;2001 |
| $\pi$ | 200.880 | 281.528 | 26.179 | 30.035 | 40.760 | 99.981 | 0.929 | 1981;1993;1999;2001 |

### Table 4.5 Bai and Perron (BP) Tests

| Country/ Variable | *UDmax* | *WDmax* | *SupF*(1\|0) | *SupF*(2\|1) | *SupF*(3\|2) | *SupF*(4\|3) | *SupF*(5\|4) | Break Dates |
|---|---|---|---|---|---|---|---|---|
| *CIV* | | | | | | | | |
| ln*m* | 112.076 | 205.291 | 74.400 | 29.868 | 38.671 | 6.445 | 8.823 | 1982;1990;1995 |
| ln*y* | 179.854 | 138.419 | 25.734 | 73.784 | 71.531 | 1.113 | 5.770 | 1997;2000;2002 |
| *R* | 302.948 | 260.261 | 36.391 | 26.517 | 24.692 | 5.106 | 1.092 | 1983;1990;1996 |
| ln*E* | 287.737 | 411.000 | 41.028 | 82.127 | 29.361 | 6.526 | 2.121 | 1980;1999;2000 |
| $\pi$ | 170.352 | 102.528 | 39.418 | 26.823 | 44.803 | 1.238 | 2.155 | 1979;1980;1997 |
| *ZAF* | | | | | | | | |
| ln*m* | 142.195 | 129.507 | 22.915 | 25.126 | 72.564 | 4.773 | 5.217 | 1994;1996;2001 |
| ln*y* | 439.185 | 310.192 | 24.349 | 34.354 | 37.590 | 10.225 | 1.167 | 1988;1991;2001 |
| *R* | 191.169 | 281.346 | 35.020 | 21.383 | 74.002 | 2.779 | 4.315 | 1987;2000;2002 |
| ln*E* | 203.755 | 128.789 | 81.473 | 46.379 | 80.015 | 2.297 | 3.355 | 1994;1999;2001 |
| $\pi$ | 476.903 | 896.928 | 28.196 | 51.310 | 23.471 | 6.843 | 5.437 | 1994;1995;2002 |
| *RWA* | | | | | | | | |
| ln*m* | 115.523 | 524.010 | 39.427 | 93.502 | 91.946 | 3.109 | 1.491 | 1980;1984;1997 |
| ln*y* | 198.122 | 132.300 | 25.530 | 26.600 | 26.194 | 9.425 | 10.510 | 1991;2001;2003 |
| *R* | 130.000 | 101.223 | 30.078 | 42.280 | 104.038 | 9.350 | 3.522 | 1989;1993;1998 |
| ln*E* | 102.033 | 118.000 | 28.100 | 65.934 | 45.179 | 10.000 | 5.570 | 1979;1995;2003 |
| $\pi$ | 154.364 | 199.108 | 114.000 | 41.781 | 70.549 | 1.857 | 4.492 | 1989;2000;2001 |
| *NGA* | | | | | | | | |
| ln*m* | 143.640 | 298.506 | 27.596 | 24.347 | 113.007 | 1.934 | 5.499 | 1983;1988;1996 |
| ln*y* | 127.299 | 132.035 | 40.453 | 23.290 | 34.550 | 2.366 | 1.230 | 1987;1990;1994 |
| *R* | 103.005 | 148.995 | 65.461 | 54.297 | 21.291 | 9.031 | 3.012 | 1990;2000;2003 |
| ln*E* | 450.122 | 231.298 | 28.023 | 28.196 | 48.116 | 6.749 | 1.287 | 1989;1992;2000 |
| $\pi$ | 371.229 | 227.123 | 31.227 | 51.310 | 70.202 | - | - | 1983;1990;2000 |
| *UGA* | | | | | | | | |
| ln*m* | 342.334 | 134.027 | 42.399 | 23.291 | 20.067 | 3.109 | 1.220 | 1979;1996;1999 |
| ln*y* | 102.973 | 237.331 | 28.936 | 76.275 | 25.530 | 2.297 | 4.328 | 1995;2001;2002 |
| *R* | 150.115 | 349.228 | 26.436 | 74.400 | 28.100 | 1.241 | 10.936 | 1978;1980;1995 |
| ln*E* | 165.251 | 101.262 | 38.004 | 34.632 | 49.239 | 8.270 | 3.234 | 1994;1999;2001 |
| $\pi$ | 250.147 | 134.036 | 81.473 | 52.303 | 42.280 | 6.843 | 5.570 | 1980;1999;2001 |

**Table 4.5 Bai and Perron (BP) Tests**

| Country/ Variable | *UDmax* | *WDmax* | *SupF*(1\|0) | *SupF*(2\|1) | *SupF*(3\|2) | *SupF*(4\|3) | *SupF*(5\|4) | Break Dates |
|---|---|---|---|---|---|---|---|---|
| *ARG* | | | | | | | | |
| ln*m* | 129.204 | 375.994 | 27.700 | 23.087 | 37.106 | 5.149 | 2.413 | 1980;1988;1996 |
| ln*y* | 462.252 | 216.006 | 29.122 | 45.714 | 40.206 | 4.727 | 2.934 | 1983;1990;2002 |
| *R* | 906.738 | 127.684 | 86.288 | 39.545 | 22.125 | 1.660 | 4.125 | 1980;1993;2000 |
| ln*E* | 128.66 | 429.373 | 23.721 | 23.801 | 54.318 | 3.289 | 5.249 | 1990;2000;2002 |
| $\pi$ | 267.978 | 231.190 | 84.040 | 26.111 | 26.577 | 4.112 | 1.063 | 1985;1997;2001 |
| *BRA* | | | | | | | | |
| ln*m* | 133.228 | 201.329 | 56.563 | 29.315 | 29.162 | 4.164 | 3.451 | 1982;1986;1995 |
| ln*y* | 286.831 | 774.431 | 24.865 | 38.603 | 50.637 | 10.063 | 1.218 | 1978;1980;2001 |
| *R* | 142.403 | 174.114 | 77.625 | 23.721 | 32.010 | 5.409 | 2.703 | 1980;1986;2001 |
| ln*E* | 146.166 | 436.513 | 27.263 | 32.143 | 55.454 | 2.240 | 5.249 | 1987;1995;2001 |
| $\pi$ | 256.892 | 457.870 | 30.681 | 37.047 | 58.180 | 3.062 | 4.791 | 1979;1991;2003 |
| *MEX* | | | | | | | | |
| ln*m* | 129.745 | 870.548 | 39.605 | 26.108 | 23.628 | 6.681 | 6.774 | 1992;1997;2000 |
| ln*y* | 264.613 | 193.428 | 40.140 | 20.541 | 25.249 | 1.367 | 8.113 | 1978;1980;1992 |
| *R* | 266.575 | 565.215 | 23.888 | 42.722 | 26.102 | 3.554 | 3.697 | 1992;2000;2002 |
| ln*E* | 170.009 | 125.974 | 45.127 | 65.809 | 31.144 | 8.167 | 1.023 | 1980;1986;1995 |
| $\pi$ | 671.172 | 326.043 | 30.865 | 78.376 | 46.434 | 4.144 | 4.661 | 1983;1991;2000 |
| *AUS* | | | | | | | | |
| ln*m* | 803.66 | 459.742 | 64.044 | 49.087 | 43.257 | 28.306 | 4.128 | 1978;1983;1993;2001 |
| ln*y* | 171.834 | 255.197 | 21.718 | 21.698 | 24.808 | 29.859 | 2.348 | 1982;1984;1992;1993 |
| *R* | 201.783 | 107.654 | 33.602 | 52.747 | 67.429 | 49.054 | 7.244 | 1976;1991;2000;2001 |
| ln*E* | 179.861 | 132.235 | 61.383 | 39.605 | 28.743 | 30.176 | 4.137 | 1980;1990;1992;2001 |
| $\pi$ | 178.319 | 291.123 | 74.122 | 61.282 | 37.042 | 25.527 | 4.309 | 1993;1999;2000;2002 |
| *CAN* | | | | | | | | |
| ln*m* | 332.784 | 102.818 | 22.552 | 68.111 | 20.530 | 7.883 | 2.182 | 1980;1988;1991 |
| ln*y* | 112.282 | 188.700 | 20.818 | 20.672 | 22.914 | 2.646 | 4.234 | 1977;1986;2002 |
| *R* | 820.323 | 155.468 | 62.376 | 32.207 | 33.602 | 4.110 | 5.114 | 1980;1985;2001 |
| ln*E* | 105.098 | 260.165 | 97.241 | 74.430 | 75.446 | 9.264 | 2.008 | 1986;1991;2000 |
| $\pi$ | 113.545 | 441.259 | 23.190 | 26.104 | 27.919 | 8.118 | 6.405 | 1989;1992;2001 |

## Table 4.5 Bai and Perron (BP) Tests

| Country/ Variable | *UDmax* | *WDmax* | *SupF*(1\|0) | *SupF*(2\|1) | *SupF*(3\|2) | *SupF*(4\|3) | *SupF*(5\|4) | Break Dates |
|---|---|---|---|---|---|---|---|---|
| *DNK* | | | | | | | | |
| ln*m* | 154.439 | 501.384 | 30.069 | 80.953 | 34.281 | 2.589 | 6.719 | 1979;1980;1982 |
| ln*y* | 216.136 | 160.676 | 28.678 | 24.009 | 33.183 | 8.215 | 4.012 | 1990;2001;2001 |
| *R* | 723.034 | 340.285 | 21.908 | 29.256 | 40.992 | 8.852 | 5.226 | 1984;1993;2000 |
| ln*E* | 127.687 | 165.126 | 26.784 | 41.060 | 29.256 | 1.007 | 2.483 | 1985;1994;2000 |
| $\pi$ | 242.943 | 378.892 | 41.242 | 93.228 | 34.745 | 4.137 | 10.195 | 1976;1980;1988 |
| *GRC* | | | | | | | | |
| ln*m* | 275.089 | 143.806 | 109.169 | 43.102 | 25.233 | 9.376 | 4.225 | 1980;1981;2002 |
| ln*y* | 184.806 | 905.258 | 40.435 | 25.285 | 47.002 | 10.967 | 1.302 | 1976;1986;1998 |
| *R* | 210.88 | 176.173 | 52.149 | 49.161 | 39.298 | 4.908 | 1.267 | 1990;1993;2001 |
| ln*E* | 369.618 | 420.004 | 24.573 | 45.037 | 20.619 | 3.711 | 5.995 | 1981;1996;1998 |
| $\pi$ | 167.155 | 182.584 | 60.089 | 36.023 | 33.709 | 4.413 | 8.225 | 1979;2000;2001 |
| *JPN* | | | | | | | | |
| ln*m* | 474.834 | 129.376 | 31.450 | 27.882 | 25.209 | 99.988 | 1.412 | 1985;1995;1998;2002 |
| ln*y* | 108.873 | 294.136 | 27.300 | 98.310 | 21.021 | 105.395 | 3.697 | 1990;1997;1998;2000 |
| *R* | 187.125 | 197.547 | 23.224 | 102.125 | 84.040 | 32.217 | 7.036 | 1984;1997;1998;2001 |
| ln*E* | 184.21 | 107.200 | 47.503 | 21.892 | 110.340 | 34.120 | 1.278 | 1984;1995;1997;1998 |
| $\pi$ | 500.165 | 812.926 | 20.672 | 20.140 | 23.130 | 38.818 | 2.173 | 1979;1997;2000;2001 |
| *NZL* | | | | | | | | |
| ln*m* | 227.311 | 173.515 | 87.825 | 34.239 | 29.277 | 1.901 | 5.331 | 1980;1985;1998 |
| ln*y* | 142.195 | 279.203 | 34.310 | 106.506 | 46.447 | - | - | 1991;1998;2002 |
| *R* | 242.943 | 124.332 | 33.175 | 25.850 | 23.305 | 8.005 | 4.364 | 1984;1990;1995 |
| ln*E* | 260.112 | 104.221 | 21.227 | 23.335 | 28.203 | 3.299 | 2.387 | 1987;1994;2000 |
| $\pi$ | 198.122 | 452.376 | 30.060 | 31.270 | 34.481 | 1.231 | 1.204 | 1978;1995;1999 |
| *USA* | | | | | | | | |
| ln*m* | 145.123 | 110.203 | 34.376 | 35.312 | 21.430 | 33.209 | 7.288 | 1979;1984;1987;2000 |
| ln*y* | 101.223 | 723.034 | 21.082 | 23.190 | 98.310 | 22.363 | 1.278 | 1981;1990;1996;2001 |
| *R* | 329.304 | 326.043 | 21.257 | 27.281 | 34.049 | 87.825 | 2.348 | 1990;1995;2000;2002 |
| ln*E* | 167.155 | 286.831 | 34.351 | 21.227 | 25.372 | 25.850 | 3.402 | 1987;1991;1995;2002 |
| $\pi$ | 995.124 | 265.370 | 27.391 | 30.280 | 32.039 | 20.311 | 9.283 | 1975;1992;2001;2002 |

Notes: '–' indicates that there are no more places to insert an additional break given the minimal length requirement. The upper bound is set to be 5 and the trimming percentage is chosen to be 15% in all cases.

The multiple break points seems to be related to economic and financial incidents of these countries, for instance oil price shocks, adoption of flexible exchange rate regimes, advances in computer technology, market-oriented reforms, etc. Some countries had more break dates than others because they had a number of economic and financial incidents; see Section 4.4.6 for a more specific justification for the break dates. Although the break tests of ZA, LS and BP are important in unit root testing, these tests do not offer information for breaks in the cointegrating equations.

To this end, the Gregory and Hansen test for structural breaks are useful, although it renders only single endogenous break points. My earlier work (Rao and Kumar, 2007; Kumar, 2007; Kumar and Manoka, 2008; Kumar, 2010a; Rao and Kumar, 2009a; Kumar, 2011) did not utilise unit root tests that accommodate for structural breaks but applied mainly the ADF tests. The ADF test results could be biased if there are structural breaks in the series and in such cases the ZA, LS and BP tests are necessary.

There are only a few empirical studies that have used structural break unit root tests in money demand analysis. Using the ZA and BP tests, Lee and Chien (2008) found that economic and financial deregulation did affect the stability of the demand for money (*M1* and *M2*) in China over the period 1977 to 2002. The structural break points are mainly 1980 and 1993. Choi and Jung (2009) attained stable *M1* demand functions for each of the sub-samples (1959-74,1974-86, 1986-2000) for the USA. The BP test revealed two break points i.e. 1974 and 1986. The country-specific time series results are discussed in the following section.

**4.4 Country-Specific Time Series Results**

The tests for cointegration among the variables in the canonical and extended specifications of money demand are performed with the Johansen's maximum likelihood (JML) method, which is a widely used cointegration approach. Following Flowchart 3.2 (p. 139), this method is applied to test for cointegration relationships in the context of error correction models (ECMs) and to address endogeneity bias. In JML, the first stage is to determine the order of the VAR, and then to test for the existence of cointegrating vector(s). Rejection or acceptance of the null of no cointegration is based on the eigenvalue and trace test statistics.[132] Further, it is useful to perform the identification and endogeneity tests in this procedure.

### *4.4.1 Estimates for Pacific Island Countries*

Since the level variables contain unit root and their first differences are stationary, we proceed with estimating the *M1* demand for PICs with the JML approach. The optimum lag lengths of the vector auto-regressions (VARs) were tested with a 4$^{th}$ order model. A constant and a trend term were included for all the countries. For Fiji, a dummy variable was developed to capture the effects of the two political instabilities (military coups) of 1987 and 2000.[133] The coup dummy is expected to have a positive coefficient because coup is likely to increase holdings of precautionary balances. A dummy variable was also created for Vanuatu to represent the financial sector reforms which is also expected to have a positive impact because better and efficient financial system permits to improve the availability of credit.[134] Similar dummy variables were tried for Samoa, PNG and Solomons but they were statistically insignificant at conventional levels.

The Akaike Information Criteria (AIC) and Schwartz Bayesian Criteria (SBC) criteria were used to select the lag lengths of the VARs. The AIC and SBC indicated the lag length of 1 period for Samoa (both specifications) and PNG (canonical specification) and 2 periods for Fiji (both specifications), PNG (extended specification) and Vanuatu (both specifications). For the Solomon Islands, 2$^{nd}$ and 3$^{rd}$ order VARs were optimal for canonical and extended specifications, respectively. Both the Trace and Eigenvalues rejected the null of no cointegration at 95% level, thus implying there exists one long run relationship. Specifically, the null of no

[132] Statistical software like Eviews 7.0, Microfit 5.0, STATA 11 and RATS 7.2 has the routines for estimating the JML cointegrating equations. I used Microfit 5.0 in this study.
[133] The COUP dummy for Fiji was constructed as 1 in 1987 and 2000 and zero in other periods.
[134] The reform dummy for Vanuatu was constructed as 1 in 1985 to 2000 and zero in other periods.

**Table 4.6. JML Cointegration Tests-PICs**

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvalue | | | Trace | | | Eigenvalue | | | Trace | | |
| | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% |
| *FJI* | | | | | | | | | | | | |
| r = 0 | 12.270 | 10.713 | 9.550 | 24.369 | 13.423 | 18.247 | 26.370 | 11.030 | 9.280 | 18.251 | 15.870 | 13.810 |
| r <= 1 | 7.530 | 9.160 | 10.135 | 12.663 | 15.021 | 17.880 | 2.871 | 4.160 | 3.040 | 20.377 | 31.226 | 35.250 |
| *PNG* | | | | | | | | | | | | |
| r = 0 | 41.270 | 32.461 | 40.275 | 17.642 | 10.240 | 12.311 | 17.262 | 9.270 | 7.341 | 28.760 | 21.346 | 22.350 |
| r <= 1 | 20.450 | 26.556 | 28.048 | 16.284 | 28.910 | 29.850 | 5.340 | 16.005 | 14.540 | 5.565 | 13.480 | 17.743 |
| *WSM* | | | | | | | | | | | | |
| r = 0 | 34.670 | 20.225 | 30.260 | 21.760 | 10.280 | 13.259 | 41.230 | 24.562 | 28.390 | 24.369 | 13.423 | 18.247 |
| r <= 1 | 12.540 | 13.480 | 17.743 | 20.970 | 30.245 | 32.350 | 15.520 | 18.730 | 20.281 | 12.663 | 15.021 | 17.880 |
| *SLB* | | | | | | | | | | | | |
| r = 0 | 12.340 | 4.355 | 5.360 | 25.360 | 17.780 | 15.540 | 22.990 | 18.210 | 15.630 | 15.070 | 24.360 | 28.024 |
| r <= 1 | 4.375 | 10.270 | 13.544 | 12.640 | 13.110 | 17.230 | 4.520 | 13.245 | 12.300 | 2.342 | 5.630 | 7.460 |
| *VUT* | | | | | | | | | | | | |
| r = 0 | 45.560 | 36.710 | 38.755 | 13.456 | 8.790 | 6.755 | 18.958 | 14.450 | 12.340 | 24.367 | 21.225 | 18.200 |
| r <= 1 | 24.463 | 27.650 | 28.365 | 3.400 | 12.324 | 15.550 | 14.450 | 23.432 | 24.480 | 26.556 | 28.048 | 28.284 |

Note: r is the number of cointegrating vectors.

**Table 4.7 Alternative Estimates-PICs**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *FJI* | | | | | | | | | | |
| ln*y* | 1.025 | 0.925 | 1.127 | 1.044 | 1.120 | 0.926 | 1.135 | 0.988 | 1.002 | 1.027 |
| | (2.37)* | (3.35)* | (6.20)* | (3.22)* | (4.36)* | (1.98)* | (7.32)* | (4.45)* | (3.00)* | (4.06)* |
| *R* | -0.021 | -0.009 | -0.028 | -0.012 | -0.020 | -0.046 | -0.013 | -0.046 | -0.008 | -0.016 |
| | (4.11)* | (2.87)* | (3.27)* | (2.02)* | (3.35)* | (1.79)** | (2.89)* | (2.46)* | (4.53)* | (2.36)* |
| ln*E* | | | | | | 0.059 | 0.286 | 0.199 | 0.036 | 0.174 |
| | | | | | | (2.78)* | (1.24) | (0.70) | (1.21) | (1.68)** |
| $\pi$ | | | | | | -0.371 | -0.127 | -0.025 | -0.113 | -0.102 |
| | | | | | | (0.35) | (1.41) | (1.26) | (1.70)** | (1.17) |
| *PNG* | | | | | | | | | | |
| ln*y* | 1.325 | 1.401 | 1.420 | 1.384 | 1.403 | 1.417 | 1.465 | 1.348 | 1.402 | 1.325 |
| | (3.46)* | (2.36)* | (1.88)** | (2.36)* | (4.50)* | (2.56)* | (4.50)* | (2.31)* | (0.87) | (2.35)* |
| *R* | -0.076 | -0.102 | -0.086 | -0.022 | -0.080 | -0.103 | -0.045 | -0.128 | -0.077 | -0.109 |
| | (4.50)* | (2.36)* | (3.49)* | (2.10)* | (4.52)* | (1.33) | (1.67)** | (3.46)* | (1.70)** | (1.20) |
| ln*E* | | | | | | 0.137 | 0.088 | 0.127 | 0.023 | 0.079 |
| | | | | | | (2.35)* | (0.41) | (1.42) | (1.37) | (1.65)** |
| $\pi$ | | | | | | -0.276 | -0.106 | -0.089 | -0.125 | -0.104 |
| | | | | | | (1.50) | (1.27) | (0.57) | (1.33) | (1.74)** |
| *WSM* | | | | | | | | | | |
| ln*y* | 1.128 | 0.967 | 1.105 | 1.006 | 1.149 | 1.240 | 0.890 | 1.027 | 1.252 | 0.901 |
| | (3.47)* | (3.40)* | (7.84)* | (5.56)* | (3.42)* | (2.90)* | (4.52)* | (2.04)* | (1.77)** | (2.50)* |
| *R* | -0.025 | -0.074 | -0.058 | -0.103 | -0.024 | -0.012 | -0.037 | -0.070 | -0.153 | -0.026 |
| | (3.20)* | (2.01)* | (4.57)* | (2.31)* | (3.11)* | (1.37) | (1.46) | (1.68)** | (1.84)** | (2.21)* |
| ln*E* | | | | | | 0.136 | 0.084 | 0.195 | 0.039 | 0.274 |
| | | | | | | (0.32) | (1.67)** | (1.24) | (0.96) | (1.39) |
| $\pi$ | | | | | | -0.228 | -0.127 | -0.088 | -0.146 | -0.145 |
| | | | | | | (1.70)** | (1.85)** | (1.03) | (1.80)** | (1.28) |

Notes: Absolute *t* - ratios are reported below the coefficients in parentheses. Significance at 5% and 10% levels are indicated by * and **, respectively.

**Table 4.7 Alternative Estimates-PICs**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *SLB* | | | | | | | | | | |
| ln*y* | 1.126 | 1.133 | 1.259 | 1.184 | 1.145 | 1.280 | 0.962 | 1.277 | 1.204 | 1.199 |
| | (5.62)* | (2.46)* | (3.40)* | (4.32)* | (2.58)* | (5.37)* | (2.35)* | (3.41)* | (2.60)* | (3.21)* |
| *R* | -0.120 | -0.065 | -0.101 | -0.037 | -0.108 | -0.006 | -0.125 | -0.036 | -0.080 | -0.103 |
| | (2.46)* | (2.57)* | (3.41)* | (3.45)* | (2.42)* | (8.88)* | (4.57)* | (6.35)* | (4.50)* | (4.57)* |
| ln*E* | | | | | | 0.221 | 0.570 | 0.326 | 0.227 | 0.132 |
| | | | | | | (1.54) | (0.52) | (1.38) | (1.50) | (1.36) |
| $\pi$ | | | | | | -0.023 | -0.165 | -0.211 | -0.128 | -0.086 |
| | | | | | | (1.14) | (1.32) | (0.68) | (1.30) | (1.25) |
| *VUT* | | | | | | | | | | |
| ln*y* | 1.279 | 1.146 | 1.260 | 1.251 | 1.176 | 1.405 | 0.966 | 1.250 | 1.328 | 1.422 |
| | (3.46)* | (2.47)* | (5.63)* | (3.48)* | (5.54)* | (2.11)* | (1.80)** | (1.65)** | (2.45)* | (1.46) |
| *R* | -0.042 | -0.112 | -0.068 | -0.105 | -0.069 | -0.125 | -0.081 | -0.126 | -0.057 | -0.126 |
| | (4.50)* | (3.47)* | (2.31)* | (6.74)* | (3.41)* | (2.44)* | (1.23) | (1.54) | (1.81)** | (1.72)** |
| ln*E* | | | | | | 1.368 | 0.472 | 0.480 | 1.129 | 0.355 |
| | | | | | | (0.40) | (1.32) | (1.90)** | (0.84) | (1.10) |
| $\pi$ | | | | | | -0.114 | -0.064 | -0.171 | -0.045 | -0.156 |
| | | | | | | (1.70)** | (1.35) | (1.73)** | (0.60) | (1.32) |

Notes: Absolute *t* - ratios are reported below the coefficients in parentheses. Significance at 5% and 10% levels are indicated by * and **, respectively.

cointegration is rejected when the test statistic is greater than the 95% or 90% critical values and the alternative hypothesis of one cointegrating vector is accepted when the test statistic is less than the critical values. The Trace and Eigenvalues test results are reported in Table 4.6.

Table 4.7 reports the results of autoregressive distributed lag model (ARDL), General to Specific (GETS), Engle and Granger (EG), fully modified ordinary least squares (FMOLS) and JML cointegration estimates for both specifications. While the first four are single-equation methods, JML is a system- based estimator as illustrated in Flowchart 3.2. The consistent and stable results obtained across the five estimation techniques provide support for the canonical specification of money demand in which real income and nominal rate of interest are the crucial determinants of *M1* demand in the PICs. The extended specification did not yield meaningful results. The income elasticities are around unity and the semi-rate of interest elasticities has the expected negative sign, except PNG where the estimated income elasticity is around 1.4. These crucial estimates are statistically significant at the 95 percent confidence level. When I tested for the constraint of unit income elasticity, the Wald test computed $\chi^2(1)$ test statistic was insignificant and the constraint could not be rejected for all countries, except for PNG. The unit income elasticity implies that an increase in the real income leads to a proportionate increase in the demand for *M1*. These results suggest that the quantity theory of money is valid for the PICs, see Figure 2.1 in Chapter 2. Moreover, these results are comparable to Jayaraman and Ward (2003) for Samoa, Rao and Singh (2005a & b) for Fiji and Singh and Kumar (2010) for five PICs.[135]

Further, the cointegration equations in Table 4.7 were subjected to identification and endogeinity tests. It is found that the dis-equilibrium in the respective money markets do not significantly contribute to the explanation of ln$y$ and $R$ in all cases. Therefore, ln$y$ and $R$ can be treated as being weakly exogenous variables in all the money demand equations. In my view, consistent results across the five time series estimation methods also seems to imply that short sample and endogeneity issues are

[135] The five countries examined by Singh and Kumar (2010) were Fiji, Samoa, Solomons, PNG and Vanuatu.

minimal. Kumar (2011) also addressed these issues by observing the consistency in the results across alternative estimation methods (JML and GETS). This is a pragmatic way, however, the Monte Carlo simulations would be useful to further evaluate the appropriateness of these methods.

### *4.4.2 Estimates for Asian Developing Countries*

Application of the JML method revealed some thought provoking results for the Asian developing countries. The findings for six countries (Korea, Malaysia, Pakistan, the Philippines, Singapore and Thailand) are less robust. Using the AIC and SBC criteria to select the lag lengths of the VARs, I found the optimal lag lengths as 4 for Korea (both specifications) and Malaysia (extended specification), 2 for Pakistan (canonical specification), the Philippines (both specifications), Malaysia (canonical specification) and Singapore (both specifications) and 1 for Thailand (both specifications) and Pakistan (extended specification).

For all countries a dummy variable was created to capture the impact of the 1998 Asian financial crises.[136] Surprisingly, the null of no cointegration was not rejected by the Trace and Eigenvalue tests at the 95% level.[137] For the null of no cointegration the test statistics are less than the 95% critical values implying that at this confidence level there exists no cointegrating relationship of the demand for *M1* in Korea, Malaysia, Pakistan, the Philippines, Singapore and Thailand. However, the null of no cointegration is rejected for canonical specification for Malaysia, Pakistan, the Philippines and Thailand at the 10% level. Therefore, one may hypothesize that the weak evidence of cointegration in the money demand relationship implies that the long run demand for money has become unstable may be due to the financial reforms. However, this inference should be made cautiously because the distortion in the cointegrating relationship of money demand may be due to the presence of structural breaks or limitations in the data. Flowchart 3.3 (p. 141) illustrates that unexpected results in cointegration analysis may be due to the structural breaks and therefore cointegration tests that considers structural breaks should be used.

[136] Dummy variable was developed as 1 in 1998 and 0 otherwise.
[137] For these six countries, the Trace and Eigenvalue results are not reported.

My existing work (Rao and Kumar (2007 and 2009a) showed that if there are structural breaks in the cointegration relationship of money demand, it is unlikely that the standard cointegration methods will yield cointegration among the variables or the estimates of the cointegrating parameters will be less robust. Therefore, the relationship of money demand in these six countries should be analysed with a structural break method, for instance Gregory and Hansen (1996a & b).

Recently, Arrau et al. (1995), Nair et al. (2008) and Rao and Kumar (2009b) attempted to address the issue of structural breaks in money demand however their empirical approaches were different. While Arrau et al. (1995) analysed the impact of financial innovations with a deterministic drift and stochastic process, Nair et al. (2008) tested for cointegration with the Gregory and Hansen method but did not estimate the cointegrating vectors as suggested by Gregory and Hansen. In contrast, Rao and Kumar (2009b) tackled this issue by utilising the standard panel methods of estimation.

The JML tests provide evidence of a cointegrating relationship of money demand for the remaining 12 Asian countries viz. Bangladesh, Myanmar, India, Indonesia, Iran, Israel, Jordon, Kuwait, Nepal, Oman, Sri Lanka and Syria. Significantly different lag lengths were selected for these countries through the application of the AIC and SBC criteria. With the maximal lag order of 6, the AIC and SBC criteria indicated lag lengths of 5 periods for Bangladesh, 4 periods for Myanmar, Syria and Nepal, 3 periods for India and Kuwait, 2 periods for Indonesia, Iran and Oman and 1 period for Israel, Jordon and Sri Lanka.  In all cases, the Trace and Eigenvalues rejected the null of no cointegration at 95%, except for Jordon and Sri Lanka where the null was rejected at the 90% level for extended specification. However, the null of one long run relationship was not rejected for all countries implying that a long run cointegrating relationship of money demand exists for these countries. The Trace and Eigenvalue test results are reported in Table 4.8.

The cointegration estimates for both specifications are reported in Table 4.9. The estimates of ARDL, GETS, EG, FMOLS and JML seem to support only the

## Table 4.8 JML Cointegration Tests-Asian Developing Countries

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvalue | | | Trace | | | Eigenvalue | | | Trace | | |
| | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% |
| *BGD* | | | | | | | | | | | | |
| r = 0 | 25.140 | 12.823 | 18.261 | 27.112 | 20.980 | 18.473 | 32.500 | 21.750 | 30.240 | 18.251 | 15.870 | 13.810 |
| r <= 1 | 8.103 | 12.554 | 13.205 | 10.325 | 25.290 | 22.120 | 8.230 | 12.380 | 16.100 | 2.340 | 10.232 | 15.330 |
| *MMR* | | | | | | | | | | | | |
| r = 0 | 22.180 | 7.150 | 10.540 | 30.580 | 23.200 | 22.350 | 20.240 | 17.300 | 17.870 | 30.240 | 26.248 | 25.240 |
| r <= 1 | 6.150 | 16.490 | 8.140 | 7.235 | 18.430 | 19.850 | 13.270 | 21.100 | 24.230 | 14.500 | 24.230 | 19.780 |
| *IND* | | | | | | | | | | | | |
| r = 0 | 14.360 | 8.200 | 12.460 | 29.150 | 20.070 | 22.240 | 18.958 | 14.450 | 12.340 | 24.367 | 21.225 | 18.200 |
| r <= 1 | 7.530 | 9.160 | 10.135 | 6.270 | 10.315 | 12.720 | 15.120 | 18.730 | 20.281 | 22.474 | 25.250 | 27.380 |
| *IDN* | | | | | | | | | | | | |
| r = 0 | 40.450 | 30.300 | 35.180 | 25.360 | 17.780 | 15.540 | 20.100 | 15.250 | 15.600 | 22.310 | 15.870 | 13.810 |
| r <= 1 | 34.120 | 40.170 | 43.500 | 22.650 | 33.000 | 34.460 | 5.340 | 16.005 | 14.540 | 5.565 | 13.480 | 17.743 |
| *IRN* | | | | | | | | | | | | |
| r = 0 | 12.270 | 10.713 | 9.550 | 10.300 | 3.450 | 6.230 | 20.100 | 15.250 | 15.600 | 19.286 | 17.770 | 16.010 |
| r <= 1 | 7.530 | 9.160 | 10.135 | 3.640 | 5.900 | 9.150 | 12.390 | 14.870 | 13.540 | 2.590 | 7.600 | 5.150 |
| *ISR* | | | | | | | | | | | | |
| r = 0 | 31.230 | 22.120 | 24.890 | 33.140 | 20.330 | 32.900 | 10.660 | 9.870 | 7.350 | 17.463 | 13.350 | 12.550 |
| r <= 1 | 22.495 | 26.500 | 26.550 | 22.200 | 27.342 | 28.365 | 7.140 | 11.105 | 12.128 | 8.025 | 10.246 | 11.300 |

## Table 4.8 JML Cointegration Tests-Asian Developing Countries

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvalue | | | Trace | | | Eigenvalue | | | Trace | | |
| | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% |
| *JOR* | | | | | | | | | | | | |
| r = 0 | 24.369 | 13.423 | 18.247 | 21.760 | 10.280 | 13.259 | 9.457 | 14.501 | 8.240 | 24.369 | 13.423 | 18.247 |
| r <= 1 | 15.240 | 21.104 | 18.795 | 20.970 | 30.245 | 32.350 | 5.120 | 8.430 | 9.281 | 12.663 | 15.021 | 17.880 |
| *KWT* | | | | | | | | | | | | |
| r = 0 | 32.540 | 24.960 | 25.542 | 12.480 | 7.300 | 5.326 | 42.750 | 38.356 | 35.045 | 35.070 | 24.360 | 28.024 |
| r <= 1 | 12.652 | 16.470 | 13.187 | 9.224 | 12.340 | 10.420 | 24.980 | 33.650 | 32.265 | 2.342 | 5.630 | 7.460 |
| *NPL* | | | | | | | | | | | | |
| r = 0 | 29.141 | 26.264 | 28.652 | 23.454 | 18.790 | 6.755 | 18.958 | 14.450 | 12.340 | 14.746 | 11.340 | 13.230 |
| r <= 1 | 12.450 | 17.600 | 18.343 | 10.420 | 12.387 | 15.550 | 14.450 | 23.432 | 24.480 | 26.556 | 28.048 | 27.550 |
| *OMN* | | | | | | | | | | | | |
| r = 0 | 22.569 | 14.364 | 15.740 | 25.360 | 17.780 | 15.540 | 29.537 | 28.435 | 25.103 | 25.120 | 17.460 | 18.120 |
| r <= 1 | 14.395 | 20.340 | 16.764 | 18.746 | 23.428 | 25.486 | 18.220 | 23.500 | 22.134 | 12.322 | 15.380 | 17.266 |
| *LKA* | | | | | | | | | | | | |
| r = 0 | 26.130 | 16.442 | 15.763 | 13.456 | 8.790 | 6.755 | 36.671 | 37.260 | 32.200 | 9.310 | 3.554 | 8.200 |
| r <= 1 | 24.463 | 27.650 | 28.365 | 3.400 | 12.324 | 15.550 | 24.006 | 30.125 | 24.480 | 6.127 | 8.348 | 6.784 |
| *SYR* | | | | | | | | | | | | |
| r = 0 | 25.260 | 24.750 | 18.452 | 17.642 | 10.240 | 12.311 | 21.458 | 15.650 | 15.300 | 14.677 | 10.185 | 8.250 |
| r <= 1 | 4.273 | 7.230 | 8.550 | 16.284 | 28.910 | 29.850 | 18.350 | 20.340 | 21.464 | 16.502 | 18.205 | 18.284 |

Note: r is the number of cointegrating vectors.

**Table 4.9 Alternative Estimates-Asian Developing Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *BGD* | | | | | | | | | | |
| ln*y* | 1.134 | 1.130 | 0.988 | 1.201 | 1.031 | 1.141 | 1.501 | 1.123 | 1.002 | 1.387 |
| | (2.42)* | (2.40)* | (4.12)* | (5.56)* | (3.25)* | (2.01)* | (0.69) | (4.20)* | (2.07)* | (1.86)** |
| *R* | -0.015 | -0.023 | -0.012 | -0.024 | -0.056 | -0.127 | -0.213 | -0.053 | -0.151 | -0.072 |
| | (2.67)* | (2.63)* | (2.28)* | (2.47)* | (3.00)* | (3.70)* | (2.22)* | (1.04) | (2.54)* | (1.35) |
| ln*E* | | | | | | 0.042 | 0.148 | 0.640 | 0.166 | 0.025 |
| | | | | | | (1.30) | (1.44) | (1.68)** | (1.53) | (1.64)** |
| $\pi$ | | | | | | -0.001 | -0.189 | -0.117 | -0.035 | -0.232 |
| | | | | | | (1.02) | (0.76) | (1.35) | (1.50) | (1.64)** |
| *MMR* | | | | | | | | | | |
| ln*y* | 1.204 | 1.161 | 1.020 | 1.212 | 1.203 | 1.034 | 0.820 | 1.273 | 1.152 | 1.141 |
| | (3.64)* | (3.58)* | (2.81)* | (3.25)* | (4.49)* | (2.34)* | (2.56)* | (3.41)* | (1.82)** | (2.80)* |
| *R* | -0.077 | -0.113 | -0.106 | -0.047 | -0.082 | -0.063 | -0.137 | -0.024 | -0.367 | -0.249 |
| | (6.12)* | (4.05)* | (2.74)* | (4.49)* | (3.03)* | (1.82)** | (1.24) | (2.05)* | (1.67)** | (1.26) |
| ln*E* | | | | | | 0.874 | 0.308 | 0.309 | 0.530 | 0.742 |
| | | | | | | (1.37) | (1.08) | (1.72)** | (1.46) | (1.33) |
| $\pi$ | | | | | | -0.025 | -0.121 | -0.454 | -0.067 | -0.420 |
| | | | | | | (1.70)** | (1.56) | (0.99) | (1.28) | (1.85)** |
| *IND* | | | | | | | | | | |
| ln*y* | 0.895 | 1.107 | 1.123 | 0.918 | 1.163 | 1.021 | 0.946 | 1.124 | 0.956 | 1.005 |
| | (6.01)* | (4.25)* | (2.80)* | (5.42)* | (3.45)* | (2.43)* | (6.02)* | (3.55)* | (2.07)* | (2.62)* |
| *R* | -0.116 | -0.089 | -0.138 | -0.113 | -0.101 | -0.016 | -0.097 | -0.047 | -0.013 | -0.034 |
| | (3.74)* | (3.42)* | (2.55)* | (3.46)* | (4.35)* | (4.10)* | (2.06)* | (2.03)* | (4.80)* | (2.91)* |
| ln*E* | | | | | | 0.046 | 0.124 | 0.095 | 0.133 | 0.213 |
| | | | | | | (2.34)* | (3.39)* | (2.16)* | (2.91)* | (2.54)* |
| $\pi$ | | | | | | -0.083 | -0.101 | -0.191 | -0.120 | -0.145 |
| | | | | | | (2.74)* | (1.82)** | (2.36)* | (2.04)* | (3.11)* |

**Table 4.9 Alternative Estimates-Asian Developing Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *IDN* | | | | | | | | | | |
| ln*y* | 0.904 | 1.026 | 0.838 | 1.114 | 1.040 | 1.003 | 1.251 | 0.876 | 1.213 | 1.124 |
| | (3.02)* | (8.06)* | (2.10)* | (6.24)* | (3.15)* | (4.07)* | (2.81)* | (7.01)* | (2.54)* | (2.62)* |
| *R* | -0.127 | -0.025 | -0.069 | -0.131 | -0.139 | -0.136 | -0.153 | -0.024 | -0.187 | -0.104 |
| | (2.75)* | (4.19)* | (3.27)* | (3.54)* | (3.62)* | (1.83)** | (3.07)* | (1.25) | (3.56)* | (3.27)* |
| ln*E* | | | | | | 0.017 | 0.180 | 0.022 | 1.327 | 0.191 |
| | | | | | | (1.60) | (1.48) | (2.01)* | (1.22) | (1.03) |
| *π* | | | | | | -0.143 | -0.035 | -0.062 | -0.398 | -0.021 |
| | | | | | | (1.30) | (1.81)** | (1.68)** | (1.35) | (1.69)** |
| *IRN* | | | | | | | | | | |
| ln*y* | 1.301 | 1.246 | 1.303 | 1.274 | 1.199 | 1.428 | 0.994 | 1.301 | 1.025 | 1.222 |
| | (4.16)* | (3.40)* | (4.23)* | (7.08)* | (5.41)* | (5.28)* | (2.84)* | (4.54)* | (2.30)* | (6.06)* |
| *R* | -0.013 | -0.009 | -0.054 | -0.135 | -0.061 | -0.103 | -0.114 | -0.086 | -0.117 | -0.188 |
| | (4.53)* | (5.15)* | (3.20)* | (2.44)* | (3.75)* | (3.47)* | (3.03)* | (2.18)* | (2.71)* | (1.67)** |
| ln*E* | | | | | | 0.125 | 0.042 | 0.090 | 0.049 | 0.301 |
| | | | | | | (1.45) | (1.55) | (1.10) | (1.76)** | (0.54) |
| *π* | | | | | | -0.102 | -0.200 | -0.075 | -0.144 | -0.150 |
| | | | | | | (1.26) | (1.06) | (1.84)** | (0.31) | (1.29) |
| *ISR* | | | | | | | | | | |
| ln*y* | 0.945 | 1.115 | 1.104 | 1.351 | 1.202 | 1.320 | 0.901 | 1.181 | 1.150 | 0.742 |
| | (8.06)* | (5.42)* | (7.64)* | (7.72)* | (6.22)* | (1.90)** | (2.32)* | (3.14)* | (8.25)* | (2.31)* |
| *R* | -0.024 | -0.036 | -0.053 | -0.085 | -0.106 | -0.003 | -0.018 | -0.200 | -0.921 | -0.052 |
| | (4.06)* | (5.32)* | (4.51)* | (3.20)* | (4.24)* | (2.04)* | (3.27)* | (1.51) | (1.72)** | (2.38)* |
| ln*E* | | | | | | 0.065 | 0.007 | 0.012 | 0.126 | 0.020 |
| | | | | | | (1.75)** | (1.34) | (1.43) | (1.69)** | (1.22) |
| *π* | | | | | | -0.032 | -0.001 | -0.024 | -0.005 | -0.653 |
| | | | | | | (1.61) | (0.60) | (1.44) | (1.01) | (1.90)** |

**Table 4.9 Alternative Estimates-Asian Developing Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *JOR* | | | | | | | | | | |
| ln*y* | 1.241 | 1.171 | 1.038 | 1.233 | 1.162 | 1.201 | 1.285 | 1.327 | 0.972 | 1.514 |
| | (6.58)* | (5.58)* | (6.80)* | (4.25)* | (7.36)* | (1.97)* | (3.04)* | (5.28)* | (3.47)* | (2.14)* |
| *R* | -0.283 | -0.078 | -0.235 | -0.015 | -0.049 | -0.043 | -0.046 | -0.262 | -0.005 | -0.137 |
| | (4.51)* | (2.06)* | (3.47)* | (4.24)* | (5.02)* | (2.10)* | (1.89)** | (1.68)** | (2.95)* | (1.35) |
| ln*E* | | | | | | 0.084 | 1.340 | 0.732 | 1.027 | 0.669 |
| | | | | | | (1.23) | (0.36) | (1.54) | (0.99) | (1.64)** |
| $\pi$ | | | | | | -0.548 | -0.153 | -0.309 | -0.608 | -0.008 |
| | | | | | | (1.71)** | (1.21) | (1.40) | (1.75)** | (1.52) |
| *KWT* | | | | | | | | | | |
| ln*y* | 1.301 | 0.996 | 1.140 | 1.202 | 1.324 | 1.120 | 1.387 | 1.155 | 1.501 | 1.435 |
| | (5.96)* | (7.21)* | (6.58)* | (4.15)* | (3.54)* | (2.53)* | (4.26)* | (4.03)* | (1.80)** | (3.17)* |
| *R* | -0.114 | -0.093 | -0.185 | -0.059 | -0.077 | -0.274 | -0.113 | -0.095 | -0.126 | -0.276 |
| | (3.32)* | (4.30)* | (2.07)* | (4.42)* | (4.61)* | (4.23)* | (2.54)* | (1.78)** | (1.53) | (1.80)** |
| ln*E* | | | | | | 0.328 | 0.021 | 1.022 | 0.164 | 0.133 |
| | | | | | | (1.70)** | (1.36) | (1.71)** | (1.71)** | (1.71)** |
| $\pi$ | | | | | | -0.322 | -0.690 | -0.105 | -0.673 | -0.125 |
| | | | | | | (1.61) | (0.87) | (1.54) | (1.76)** | (0.58) |
| *NPL* | | | | | | | | | | |
| ln*y* | 1.202 | 1.166 | 1.223 | 1.140 | 1.193 | 1.207 | 1.009 | 1.241 | 1.202 | 1.381 |
| | (3.17)* | (5.84)* | (3.63)* | (4.10)* | (4.55)* | (2.74)* | (1.50) | (3.82)* | (1.89)** | (4.75)* |
| *R* | -0.136 | -0.075 | -0.032 | -0.192 | -0.174 | -0.154 | -0.382 | -0.098 | -0.075 | -0.029 |
| | (2.52)* | (3.47)* | (1.75)** | (3.12)* | (2.02)* | (1.94)** | (1.77)** | (2.25)* | (1.71)** | (2.46)* |
| ln*E* | | | | | | 0.007 | 0.121 | 0.258 | 0.723 | 1.129 |
| | | | | | | (1.35) | (2.41)* | (2.32)* | (0.50) | (1.73)** |
| $\pi$ | | | | | | -0.016 | -1.003 | -0.054 | -0.355 | -0.005 |
| | | | | | | (1.41) | (1.15) | (1.32) | (3.30)* | (1.34) |

**Table 4.9 Alternative Estimates-Asian Developing Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *OMN* | | | | | | | | | | |
| ln*y* | 1.421 | 1.507 | 1.435 | 1.506 | 1.449 | 1.441 | 1.892 | 1.325 | 1.301 | 1.622 |
| | (4.58)* | (5.28)* | (5.04)* | (2.50)* | (3.44)* | (2.53)* | (2.51)* | (3.24)* | (4.07)* | (1.72)** |
| *R* | -0.037 | -0.104 | -0.151 | -0.083 | -0.104 | -0.482 | -0.064 | -0.176 | -1.143 | -0.426 |
| | (3.26)* | (2.35)* | (3.07)* | (4.33)* | (3.57)* | (1.99)* | (1.57) | (1.72)** | (2.14)* | (2.01)* |
| ln*E* | | | | | | 0.100 | 0.381 | 1.135 | 0.738 | 0.574 |
| | | | | | | (1.67)** | (0.90) | (1.52) | (0.52) | (2.34)* |
| $\pi$ | | | | | | -2.210 | -1.027 | -1.908 | -0.846 | -1.149 |
| | | | | | | (0.95) | (3.84)* | (1.04) | (1.83)** | (1.30) |
| *LKA* | | | | | | | | | | |
| ln*y* | 1.241 | 1.135 | 1.288 | 0.954 | 1.122 | 1.089 | 1.162 | 1.307 | 1.256 | 1.391 |
| | (7.14)* | (5.28)* | (3.52)* | (5.37)* | (3.08)* | (4.07)* | (5.05)* | (4.22)* | (1.69)** | (4.51)* |
| *R* | -0.127 | -0.079 | -0.047 | -0.132 | -0.105 | -0.103 | -0.147 | -0.039 | -1.261 | -0.743 |
| | (3.28)* | (3.53)* | (2.47)* | (3.05)* | (2.52)* | (1.23) | (2.54)* | (1.35) | (2.51)* | (1.77)** |
| ln*E* | | | | | | 1.231 | 0.112 | 0.826 | 0.227 | 0.992 |
| | | | | | | (1.06) | (1.72)** | (1.51) | (0.73) | (1.04) |
| $\pi$ | | | | | | -0.323 | -1.063 | -0.618 | -0.125 | -0.127 |
| | | | | | | (1.74)** | (1.51) | (1.68)** | (1.45) | (1.05) |
| *SYR* | | | | | | | | | | |
| ln*y* | 1.171 | 0.926 | 1.100 | 1.249 | 1.106 | 1.326 | 0.823 | 1.150 | 1.224 | 1.220 |
| | (4.06)* | (4.42)* | (4.23)* | (4.78)* | (4.54)* | (3.58)* | (4.85)* | (2.65)* | (2.85)* | (3.16)* |
| *R* | -0.142 | -0.112 | -0.024 | -0.145 | -0.029 | -0.005 | -0.384 | -0.226 | -0.153 | -0.023 |
| | (3.54)* | (3.03)* | (1.83)** | (2.75)* | (2.01)* | (2.39)* | (2.20)* | (3.04)* | (1.81)** | (3.72)* |
| ln*E* | | | | | | 0.738 | 0.012 | 0.181 | 0.124 | 0.115 |
| | | | | | | (1.42) | (1.52) | (1.71)** | (1.84)** | (1.14) |
| $\pi$ | | | | | | -0.154 | -0.165 | -0.276 | -0.145 | -0.256 |
| | | | | | | (3.74)* | (1.55) | (1.33) | (1.60) | (0.82) |

Notes: Absolute *t* - ratios are reported below the coefficients in parentheses. Significance at 5% and 10% levels are indicated by * and **, respectively.

canonical specification of money demand for these twelve Asian countries, except for India where the extended specification also yields meaningful estimates. The income elasticities are around unity and when I tested for the constraint of unit income elasticity, the Wald test computed $\chi^2(1)$ test statistic was insignificant and the constraint could not be rejected for all countries, except Oman. The income elasticity in Oman is slightly high at around 1.4 and 1.5. The quantity theory predicts the income elasticity should be 1 (Friedman, 1956) and the often found income elasticity above unity is explained within the standard portfolio approach by the neglect of a wealth variable in the cointegrating vector, see Figure 2.1. Since income is proportional to wealth and the fact that wealth is difficult to measure, many researchers use income as the scale variable and extend the simple money demand function with other variables that capture the cost of holding money. The demand for *M1* responds negatively to interest rate changes, albeit by small amount. Both the income and semi-interest elasticities are significant at the 5% level, except for FMOLS estimates of interest rate for Nepal and Syria which are significant at the 10% level. Further, the identification and endogeneity tests showed that income and interest rate are weakly exogenous variables in the money demand equations. Similar to the PICs, these results support the quantity theory of money because a change in income induces a proportionate change in *M1* demand.

The less robust estimates of the extended specification imply that foreign exchange holdings may be inadequate and thus challenges the fundamental proposition of Mundell (1963) that in addition to the interest rates and the level of real income, the determinants of the demand for money should be augmented by the exchange rate. While the exchange rate seems to influence the demand for *M1* in India, this effect does not ensue for other countries. Further, a number of empiricists use the inflation rate as an explanatory variable in the money demand specification. Theoretically this is justified on the basis of Friedman's postulations that as inflation uncertainty increases, it may affect the demand for money in opposite directions. Put simply, it will increase the precautionary demand and it is also plausible that as uncertainty increases, the risk of holding real money balances rises relative to other assets, inducing changes in portfolio composition and substitution away from real balances. However, results suggest inflation is not a significant determinant of *M1* demand in the Asian developing countries. These results are comparable to the findings of my earlier work, for instance see Kumar (2007 & 2011), Rao and Kumar (2009a & b) and Singh and Kumar (2010 & 2011). Alternatively, Bahmani-Oskooee and Rehman (2005), Tang (2007) and Yu and Gan (2009) support the use of additional proxies for cost of holding money other than the nominal rate of interest.

### *4.4.3 Estimates for African Countries*

Despite the relative paucity of African countries economic data in many areas, there are some countries for which, reliable economic data, in particular the money stock, income and nominal rate of interest are provided by their central banks. Limitations in the data have resulted in only a limited number of empirical studies that have investigated the long run relationship of money demand, for example Arize et al. (1990), Adam (1992), Fielding (1994), Ghartey (1998a), Nachega (2001) and Bahmani-Oskooee and Gelan (2009), among others. Using the extended specification of money demand, some of these studies found stable money demand functions for African countries.[138]

The null of no cointegration could not be rejected if there exists structural breaks in the cointegrating relationship. The acceptance of the null could also be due to other reasons such as short-sample bias, data limitations, endogeneity problems etc. It is also vital to check the results with more than one cointegration method or use a method that effectively addresses these issues. If alternative estimation methods give consistent elasticities, this signifies that short-sample and endogeneity issues are minimal, see Rao (2007b). Nevertheless, as illustrated in Flowchart 3.2, JML is efficient in addressing the endogeneity issues.

The JML cointegration tests provided evidence of cointegration between the variables at 5% level, except for South Africa at the 10% level. The existence of a weak cointegrating relationship of money demand in South Africa is not unexpected

[138] See literature review chapter for specific details on these studies.

## Table 4.10 JML Cointegration Tests-African Countries

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvalue | | | Trace | | | Eigenvalue | | | Trace | | |
| | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% |
| *CMR* | | | | | | | | | | | | |
| r = 0 | 18.040 | 12.823 | 18.261 | 20.100 | 10.960 | 18.400 | 37.548 | 31.540 | 34.210 | 10.200 | 7.857 | 8.803 |
| r <= 1 | 4.276 | 8.550 | 6.200 | 10.350 | 5.295 | 7.250 | 18.230 | 22.175 | 22.100 | 10.353 | 12.250 | 15.302 |
| *KEN* | | | | | | | | | | | | |
| r = 0 | 25.137 | 17.230 | 14.210 | 13.210 | 14.200 | 13.150 | 20.240 | 17.300 | 17.870 | 45.236 | 36.248 | 35.140 |
| r <= 1 | 6.150 | 16.490 | 8.140 | 17.045 | 18.430 | 19.850 | 14.500 | 24.230 | 19.780 | 34.540 | 44.200 | 29.710 |
| *RWA* | | | | | | | | | | | | |
| r = 0 | 24.252 | 18.267 | 22.460 | 19.487 | 13.170 | 16.274 | 18.936 | 15.250 | 12.340 | 14.493 | 11.226 | 13.236 |
| r <= 1 | 17.580 | 19.000 | 20.345 | 16.255 | 20.345 | 23.700 | 15.120 | 18.730 | 20.281 | 20.468 | 21.268 | 15.190 |
| *EGY* | | | | | | | | | | | | |
| r = 0 | 19.476 | 13.374 | 15.100 | 25.360 | 17.780 | 15.540 | 24.153 | 21.290 | 23.610 | 22.310 | 15.870 | 13.810 |
| r <= 1 | 14.130 | 20.168 | 15.550 | 12.140 | 13.430 | 14.060 | 15.367 | 16.005 | 16.230 | 12.126 | 13.480 | 19.850 |
| *ETH* | | | | | | | | | | | | |
| r = 0 | 18.160 | 12.705 | 18.010 | 20.462 | 23.130 | 24.400 | 25.130 | 18.548 | 19.630 | 19.436 | 20.340 | 18.110 |
| r <= 1 | 17.550 | 21.065 | 20.170 | 13.540 | 15.355 | 19.356 | 22.151 | 16.070 | 17.524 | 12.360 | 17.258 | 20.359 |
| *CIV* | | | | | | | | | | | | |
| r = 0 | 14.260 | 12.870 | 14.000 | 16.253 | 10.548 | 12.934 | 20.156 | 19.330 | 17.150 | 14.435 | 13.350 | 12.550 |
| r <= 1 | 12.135 | 8.547 | 9.483 | 20.230 | 23.152 | 24.306 | 16.130 | 14.265 | 12.128 | 8.025 | 10.246 | 11.300 |
| *MWI* | | | | | | | | | | | | |
| r = 0 | 25.127 | 23.120 | 20.200 | 21.760 | 10.280 | 13.259 | 19.004 | 14.550 | 18.240 | 14.353 | 17.850 | 12.236 |
| r <= 1 | 15.240 | 21.104 | 18.795 | 20.970 | 30.245 | 32.350 | 15.324 | 18.426 | 10.341 | 10.015 | 11.420 | 13.845 |
| *NGA* | | | | | | | | | | | | |
| r = 0 | 16.547 | 14.112 | 15.530 | 12.480 | 7.300 | 5.326 | 17.546 | 13.336 | 15.345 | 25.252 | 22.110 | 18.324 |
| r <= 1 | 8.250 | 12.110 | 13.187 | 9.224 | 12.340 | 10.420 | 14.480 | 20.050 | 22.254 | 2.342 | 5.630 | 7.460 |
| *UGA* | | | | | | | | | | | | |
| r = 0 | 19.145 | 16.247 | 18.092 | 20.013 | 19.240 | 16.340 | 28.220 | 24.150 | 22.740 | 10.345 | 12.300 | 9.264 |
| r <= 1 | 11.160 | 12.268 | 13.847 | 12.325 | 10.354 | 11.556 | 14.450 | 23.432 | 24.480 | 6.136 | 8.440 | 7.530 |

Note: r is the number of cointegrating vectors.

**Table 4.11 Alternative Estimates-African Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *CMR* | | | | | | | | | | |
| ln*y* | 1.564 | 1.632 | 1.608 | 1.551 | 1.639 | 1.842 | 1.581 | 1.429 | 1.695 | 1.507 |
| | (6.41)* | (3.46)* | (4.54)* | (3.56)* | (3.20)* | (1.71)** | (2.69)* | (4.25)* | (2.42)* | (1.76)** |
| *R* | -0.030 | -0.039 | -0.172 | -0.087 | -0.106 | -0.105 | -0.013 | -0.256 | -0.051 | -0.034 |
| | (3.07)* | (1.80)** | (3.25)* | (1.81)** | (3.42)* | (1.78)** | (1.26) | (1.54) | (2.20)* | (3.45)* |
| ln*E* | | | | | | 0.173 | 0.018 | 0.141 | 0.576 | 0.738 |
| | | | | | | (1.35) | (1.74)** | (2.58)* | (1.24) | (1.83)** |
| $\pi$ | | | | | | -0.341 | -0.177 | -1.013 | -0.133 | -0.132 |
| | | | | | | (0.68) | (1.30) | (1.05) | (0.76) | (1.44) |
| *KEN* | | | | | | | | | | |
| ln*y* | 1.213 | 1.289 | 1.325 | 1.423 | 1.274 | 1.450 | 1.220 | 1.203 | 1.352 | 1.147 |
| | (5.14)* | (3.88)* | (3.85)* | (4.26)* | (5.05)* | (2.84)* | (3.16)* | (2.48)* | (1.72)** | (2.81)* |
| *R* | -0.036 | -0.043 | -0.156 | -0.107 | -0.032 | -0.041 | -0.107 | -0.120 | -0.065 | -0.049 |
| | (4.62)* | (5.27)* | (2.54)* | (4.30)* | (3.47)* | (1.52) | (2.04)* | (2.35)* | (1.52) | (2.25)* |
| ln*E* | | | | | | 0.005 | 0.018 | 0.009 | 0.134 | 1.046 |
| | | | | | | (1.83)** | (1.28) | (1.22) | (2.06)* | (1.06) |
| $\pi$ | | | | | | -0.164 | -0.022 | -0.054 | -1.461 | -0.170 |
| | | | | | | (1.67)** | (1.40) | (1.29) | (1.68)** | (1.55) |
| *RWA* | | | | | | | | | | |
| ln*y* | 1.513 | 1.488 | 1.501 | 1.412 | 1.514 | 1.621 | 1.706 | 1.427 | 1.556 | 1.505 |
| | (6.38)* | (4.45)* | (3.84)* | (4.02)* | (5.15)* | (2.41)* | (1.24) | (3.27)* | (1.87)** | (2.32)* |
| *R* | -0.086 | -0.302 | -0.221 | -0.023 | -0.041 | -0.236 | -0.692 | -0.148 | -0.413 | -0.062 |
| | (3.36)* | (3.40)* | (3.02)* | (3.80)* | (4.01)* | (2.10)* | (2.01)* | (1.43) | (1.83)** | (2.81)* |
| ln*E* | | | | | | 1.541 | 1.624 | 0.491 | 0.430 | 0.813 |
| | | | | | | (1.34) | (1.69)** | (2.35)* | (1.92)** | (1.54) |
| $\pi$ | | | | | | -0.383 | -0.147 | -1.191 | -1.120 | -0.175 |
| | | | | | | (1.74)** | (1.52) | (0.66) | (1.34) | (1.11) |

## Table 4.11 Alternative Estimates-African Countries

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *EGY* | | | | | | | | | | |
| ln*y* | 0.974 | 1.004 | 0.988 | 1.134 | 0.946 | 1.023 | 0.851 | 1.071 | 1.103 | 1.124 |
| | (7.82)* | (8.36)* | (4.14)* | (3.54)* | (4.45)* | (4.57)* | (2.84)* | (4.31)* | (2.54)* | (2.62)* |
| *R* | -0.027 | -0.065 | -0.042 | -0.031 | -0.039 | -0.032 | -0.054 | -0.120 | -0.187 | -0.104 |
| | (4.75)* | (3.29)* | (5.26)* | (3.84)* | (5.02)* | (2.13)* | (2.07)* | (1.70)** | (3.56)* | (3.27)* |
| ln*E* | | | | | | 0.037 | 0.083 | 0.245 | 1.327 | 0.191 |
| | | | | | | (1.43) | (1.78) | (2.61)* | (1.22) | (1.03) |
| $\pi$ | | | | | | -0.383 | -0.136 | -0.262 | -0.398 | -0.021 |
| | | | | | | (1.39) | (1.89)** | (1.40) | (1.35) | (1.69)** |
| *ETH* | | | | | | | | | | |
| ln*y* | 1.464 | 1.532 | 1.513 | 1.485 | 1.502 | 1.347 | 1.621 | 1.572 | 1.705 | 1.547 |
| | (4.81)* | (4.70)* | (7.50)* | (4.16)* | (2.29)* | (3.51)* | (2.50)* | (3.25)* | (3.12)* | (2.86)* |
| *R* | -0.130 | -0.081 | -0.049 | -0.147 | -0.046 | -0.275 | -0.133 | -0.076 | -0.171 | -0.334 |
| | (3.27)* | (2.35)* | (1.76)** | (2.54)* | (2.02)* | (1.99)* | (2.06)* | (2.84)* | (1.90)** | (2.05)* |
| ln*E* | | | | | | 0.337 | 0.818 | 1.041 | 0.172 | 0.031 |
| | | | | | | (1.46) | (1.68)** | (1.28) | (3.64)* | (1.53) |
| $\pi$ | | | | | | -0.041 | -0.027 | -0.043 | -0.003 | -0.522 |
| | | | | | | (1.88)** | (1.25) | (1.46) | (1.35) | (1.67)** |
| *CIV* | | | | | | | | | | |
| ln*y* | 1.647 | 1.580 | 1.555 | 1.617 | 1.574 | 1.457 | 1.620 | 1.714 | 1.452 | 1.528 |
| | (5.54)* | (3.58)* | (2.80)* | (5.19)* | (3.45)* | (3.14)* | (5.90)* | (1.88)** | (2.12)* | (1.81)** |
| *R* | -0.106 | -0.093 | -0.107 | -0.077 | -0.112 | -0.028 | -0.017 | -0.034 | -0.055 | -0.109 |
| | (4.91)* | (3.87)* | (3.14)* | (3.35)* | (4.07)* | (2.12)* | (2.24)* | (4.04)* | (2.32)* | (3.65)* |
| ln*E* | | | | | | 0.259 | 0.430 | 0.159 | 0.054 | 0.026 |
| | | | | | | (2.53)* | (1.05) | (1.54) | (1.36) | (1.17) |
| $\pi$ | | | | | | -0.084 | -0.226 | -1.034 | -0.821 | -0.087 |
| | | | | | | (0.97) | (1.60) | (1.79)** | (1.35) | (1.74)** |

**Table 4.11 Alternative Estimates-African Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *MWI* | | | | | | | | | | |
| ln*y* | 1.543 | 1.508 | 1.479 | 1.514 | 1.487 | 1.320 | 1.616 | 1.551 | 1.350 | 1.415 |
| | (3.04)* | (5.28)* | (4.14)* | (5.62)* | (3.36)* | (2.24)* | (3.27)* | (4.07)* | (2.87)* | (2.04)* |
| *R* | -0.041 | -0.092 | -0.051 | -0.094 | -0.121 | -0.036 | -0.092 | -0.045 | -0.053 | -0.202 |
| | (3.26)* | (2.75)* | (3.32)* | (2.84)* | (2.62)* | (2.86)* | (2.71)* | (3.44)* | (3.93)* | (2.45)* |
| ln*E* | | | | | | 0.043 | 0.025 | 0.092 | 0.004 | 0.047 |
| | | | | | | (1.52) | (0.49) | (1.34) | (0.86) | (1.32) |
| $\pi$ | | | | | | -0.003 | -0.160 | -0.152 | -0.020 | -0.071 |
| | | | | | | (1.24) | (2.62)* | (0.86) | (1.40) | (1.53) |
| *NGA* | | | | | | | | | | |
| ln*y* | 1.044 | 0.894 | 1.187 | 1.035 | 1.148 | 1.105 | 1.357 | 1.221 | 1.124 | 1.026 |
| | (4.52)* | (4.16)* | (4.52)* | (3.57)* | (4.36)* | (4.49)* | (2.30)* | (2.34)* | (2.49)* | (2.58)* |
| *R* | -0.107 | -0.095 | -0.039 | -0.076 | -0.132 | -0.061 | -0.163 | -0.144 | -0.280 | -0.147 |
| | (3.16)* | (2.74)* | (3.17)* | (3.42)* | (2.64)* | (3.37)* | (2.97)* | (2.65)* | (1.86)** | (2.52)* |
| ln*E* | | | | | | 0.129 | 0.183 | 1.048 | 0.567 | 0.295 |
| | | | | | | (2.44)* | (1.42) | (1.42) | (1.38) | (0.67) |
| $\pi$ | | | | | | -0.086 | -0.486 | -0.064 | -0.193 | -0.227 |
| | | | | | | (1.26) | (1.69)** | (1.71)** | (0.69) | (1.30) |
| *UGA* | | | | | | | | | | |
| ln*y* | 1.536 | 1.454 | 1.489 | 1.531 | 1.466 | 1.604 | 1.350 | 1.463 | 1.323 | 1.527 |
| | (7.12)* | (2.36)* | (4.47)* | (3.34)* | (4.15)* | (2.17)* | (2.51)* | (3.35)* | (2.67)* | (2.53)* |
| *R* | -0.030 | -0.014 | -0.043 | -0.032 | -0.016 | -0.136 | -0.177 | -0.025 | -0.307 | -0.008 |
| | (3.74)* | (4.27)* | (5.07)* | (3.27)* | (2.12)* | (2.05)* | (2.36)* | (2.36)* | (3.25)* | (2.25)* |
| ln*E* | | | | | | 0.932 | 0.013 | 0.046 | 1.971 | 0.092 |
| | | | | | | (1.73)** | (1.01) | (1.32) | (1.37) | (1.23) |
| $\pi$ | | | | | | -0.085 | -0.126 | -0.066 | -0.314 | -0.021 |
| | | | | | | (1.42) | (2.09)* | (1.26) | (1.66)** | (1.29) |

Notes: Absolute *t* - ratios are reported below the coefficients in parentheses. Significance at 5% and 10% levels are indicated by * and **, respectively.

because a number of reforms were implemented since the establishment of democracy in 1994; therefore this relationship should be tested for structural breaks. However, for 9 African countries (Kenya, Cameroon, Rwanda, Egypt, Ethiopia, Ivory Coast, Malawi, Nigeria and Uganda) there seems to be no, or insignificant, structural breaks because a long run relationship of money demand exists. This implies that for these countries standard time series methods will give robust estimates. In a $4^{th}$ order model AIC and SBC gave fairly different lag lengths, however I used the ones that gave plausible results for cointegration tests. To this end, the selected lag lengths are 4 for Rwanda (both specifications) and Nigeria (canonical specification), 3 for the Ivory Coast (both specifications), Malawi (extended specifications) and Uganda (canonical specification), 2 for Egypt (both specifications), Ethiopia (both specifications) and Nigeria (extended specification), and 1 for Kenya (both specifications), Cameroon (both specifications), Malawi (canonical specification) and Uganda (extended specification). I did attempt to use the country-specific dummies but this did not change the original results except for Nigeria. Reforms dummy for Nigeria was statistically significant at the conventional levels.[139]The Eigenvalues and Trace tests rejected the null of no cointegration at 95%, except for extended specifications for Malawi, Ethiopia and Uganda where Trace test rejected at the 90% level. Table 4.10 report these results.

Table 4.11 reports the cointegration estimates of GETS, EG, ARDL, FMOLS and JML and they are consistent across the five methods. Similar to PICs and Asian countries the canonical specification performs better than the extended version, however the income elasticities are slightly above unity for some of the countries. The unit income elasticity constraint was not rejected by the Wald tests in the case of Kenya, Egypt and Nigeria, and thus supports the quantity theory of money. In contrast, Cameroon and the Ivory Coast has income elasticity of around 1.6, Rwanda, Ethiopia, Malawi and Uganda's income elasticity is around 1.5, implying that progress in the financial system is enormously slow and these countries are yet to implement significant financial reforms. The income and semi-interest elasticities have the correct signs and are statistically significant at conventional levels, except

[139] For Nigeria, reforms dummy was developed as 1 in 1984 and 1985, 0 otherwise.

for semi-interest elasticities for Ethiopia (FMOLS) and Cameroon (EG and ARDL). The identification and endogeneity tests were also within expected parameters.

The implied income elasticity estimates are comparable to Adam (1992) and Karanja (2006) for Kenya, Fielding (1994) for four African countries,[140] Akinlo (2006) for Nigeria, Nachega (2001) for Cameroon and Sterken (2004) for Ethiopia. However, our results contrast with those provided by Arize et al. (1990) for seven African countries[141] and Anoruo (2002) and Owoye and Onafowora (2007) for Nigeria; these studies found implausibly high income elasticities.

### *4.4.4 Estimates for Latin American Countries*

Following the Keynesian and Monetarist theories of the demand for money, a number of empiricists have attempted to test these theories using time series methods. Several attempts have been made with data from Latin American countries (henceforth LAC). The well-known Cambridge and Keynesian approaches emphasized that the liaison between real money demand and real income (interest or inflation rates) is positive (negative). Friedman (1956) assumed that there exists a stationary relationship of real money demand and its determinants (real income and opportunity cost of holding money variables).

Similar to PICs, Asian and African countries, studies related to LACs have employed various additional variables other than the nominal rate of interest to capture the cost of holding money, for example among others Choudhry (1995a) and Ahumada (1992) used inflation rate for Argentina and Bjørnland (2005) used domestic and foreign interest rates and nominal exchange rate for Venezuela. My findings for 10 LACs (Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Peru, Uruguay, Venezuela and Mexico) revealed that extended equations of money demand are reliable only for Mexico. On the other hand, results for Argentina and Venezuela provide support for the use of inflation rate.

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[140] Cameroon, Nigeria, Ivory Coast and Kenya.
[141] Egypt, Gambia, Mauritania, Morocco, Niger, Nigeria and Somalia.

## Table 4.12 JML Cointegration Tests-Latin American Countries

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvalue | | | Trace | | | Eigenvalue | | | Trace | | |
| | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% |
| *ARG* | | | | | | | | | | | | |
| r = 0 | 12.140 | 10.268 | 17.235 | 21.540 | 16.375 | 18.230 | 27.487 | 22.740 | 24.256 | 10.200 | 7.857 | 8.803 |
| r <= 1 | 14.275 | 9.470 | 9.224 | 10.580 | 7.117 | 8.554 | 24.754 | 22.175 | 22.100 | 14.653 | 12.250 | 11.267 |
| r <= 2 | 4.360 | 14.550 | 7.252 | 19.231 | 25.560 | 20.342 | 27.026 | 32.538 | 28.440 | 16.271 | 18.260 | 17.600 |
| *BOL* | | | | | | | | | | | | |
| r = 0 | 12.034 | 11.930 | 10.672 | 23.260 | 18.250 | 14.360 | 23.717 | 20.480 | 19.270 | 45.236 | 36.248 | 35.140 |
| r <= 1 | 8.270 | 12.425 | 10.280 | 27.872 | 31.280 | 29.050 | 11.230 | 14.980 | 13.645 | 14.260 | 15.248 | 19.230 |
| *CHL* | | | | | | | | | | | | |
| r = 0 | 25.154 | 16.037 | 22.460 | 18.117 | 15.370 | 16.338 | 10.230 | 7.120 | 9.240 | 28.113 | 21.376 | 24.676 |
| r <= 1 | 16.470 | 19.369 | 21.225 | 12.127 | 14.348 | 15.720 | 11.762 | 13.450 | 15.364 | 10.268 | 14.758 | 15.190 |
| *COL* | | | | | | | | | | | | |
| r = 0 | 35.176 | 33.980 | 30.130 | 15.870 | 13.220 | 14.010 | 14.336 | 11.570 | 13.550 | 22.310 | 15.870 | 13.810 |
| r <= 1 | 24.370 | 30.278 | 25.457 | 10.470 | 11.450 | 12.458 | 18.220 | 21.685 | 26.340 | 12.126 | 13.480 | 19.850 |
| *ECU* | | | | | | | | | | | | |
| r = 0 | 34.730 | 32.285 | 29.510 | 21.232 | 16.850 | 19.270 | 35.730 | 27.374 | 34.190 | 22.360 | 16.250 | 18.275 |
| r <= 1 | 27.150 | 31.275 | 30.837 | 13.540 | 15.355 | 19.356 | 32.354 | 36.221 | 37.401 | 14.784 | 17.258 | 15.218 |
| *PER* | | | | | | | | | | | | |
| r = 0 | 16.270 | 13.127 | 14.360 | 27.773 | 20.348 | 25.444 | 23.250 | 22.950 | 20.270 | 14.435 | 13.350 | 12.550 |
| r <= 1 | 22.475 | 18.487 | 19.380 | 16.760 | 13.260 | 14.118 | 14.370 | 12.280 | 13.345 | 16.335 | 10.246 | 11.300 |
| r <= 2 | 8.995 | 12.461 | 14.448 | 10.325 | 12.360 | 19.362 | 11.460 | 13.495 | 12.554 | 7.256 | 9.240 | 11.247 |
| *VEN* | | | | | | | | | | | | |
| r = 0 | 21.547 | 16.120 | 20.200 | 34.890 | 30.750 | 33.284 | 29.234 | 25.260 | 25.630 | 20.113 | 17.850 | 16.204 |
| r <= 1 | 15.240 | 21.104 | 18.795 | 30.126 | 33.255 | 32.350 | 18.224 | 19.326 | 20.178 | 19.315 | 21.460 | 23.045 |
| *MEX* | | | | | | | | | | | | |
| r = 0 | 18.128 | 16.742 | 15.180 | 13.750 | 10.247 | 11.016 | 23.150 | 17.735 | 20.874 | 21.542 | 22.398 | 26.390 |
| r <= 1 | 10.470 | 13.420 | 11.280 | 8.264 | 11.280 | 13.470 | 14.970 | 20.050 | 22.254 | 12.365 | 15.340 | 17.109 |

Note: r is the number of cointegrating vectors.

**Table 4.13 Alternative Estimates-Latin American Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *ARG* | | | | | | | | | | |
| ln*y* | 1.062 | 0.835 | 0.968 | 0.831 | 0.909 | 1.102 | 0.934 | 0.925 | 1.025 | 0.837 |
| | (3.45)* | (5.43)* | (3.55)* | (4.01)* | (3.26)* | (2.74)* | (2.26)* | (3.28)* | (2.47)* | (3.38)* |
| *R* | -0.027 | -0.101 | -0.074 | -0.020 | -0.146 | -0.045 | -0.048 | -0.056 | -0.025 | -0.041 |
| | (2.38)* | (2.24)* | (2.86)* | (3.84)* | (2.46)* | (3.28)* | (2.26)* | (3.12)* | (5.24)* | (2.58)* |
| ln*E* | | | | | | 0.041 | 0.618 | 0.045 | 0.066 | 0.038 |
| | | | | | | (1.46) | (1.54) | (1.58) | (1.84)** | (1.23) |
| $\pi$ | | | | | | -0.044 | -0.017 | -0.080 | -0.101 | -0.062 |
| | | | | | | (2.41)* | (3.26)* | (2.17)* | (3.06)* | (2.46)* |
| *BOL* | | | | | | | | | | |
| ln*y* | 1.510 | 1.483 | 1.524 | 1.503 | 1.484 | 1.152 | 1.420 | 1.553 | 1.358 | 1.500 |
| | (5.44)* | (3.51)* | (4.04)* | (3.15)* | (4.25)* | (2.10)* | (3.46)* | (3.42)* | (4.72)* | (3.84)* |
| *R* | -0.182 | -0.052 | -0.057 | -0.122 | -0.027 | -0.142 | -0.037 | -0.024 | -0.035 | -0.011 |
| | (3.22)* | (4.28)* | (2.37)* | (2.65)* | (3.64)* | (2.56)* | (2.54)* | (3.04)* | (3.02)* | (2.33)* |
| ln*E* | | | | | | 0.315 | 0.017 | 0.140 | 0.034 | 0.146 |
| | | | | | | (0.39) | (2.18)* | (1.62) | (1.26) | (1.27) |
| $\pi$ | | | | | | -0.166 | -0.036 | -0.023 | -1.064 | -0.040 |
| | | | | | | (0.79) | (1.72) | (1.50) | (1.46) | (1.35) |
| *CHL* | | | | | | | | | | |
| ln*y* | 1.171 | 1.076 | 1.105 | 1.145 | 1.222 | 1.171 | 1.226 | 1.114 | 1.232 | 1.321 |
| | (6.40)* | (4.36)* | (3.34)* | (4.42)* | (3.73)* | (2.59)* | (2.24)* | (4.68)* | (2.47)* | (3.32)* |
| *R* | -0.013 | -0.042 | -0.024 | -0.176 | -0.057 | -0.034 | -0.097 | -0.043 | -0.013 | -0.047 |
| | (4.06)* | (5.45)* | (2.67)* | (3.30)* | (4.12)* | (2.37)* | (3.61)* | (2.33)* | (2.87)* | (2.48)* |
| ln*E* | | | | | | 0.043 | 0.025 | 0.092 | 0.100 | 0.003 |
| | | | | | | (1.22) | (1.50) | (1.57) | (1.74)** | (1.20) |
| $\pi$ | | | | | | -0.051 | -0.043 | -0.091 | -0.020 | -0.035 |
| | | | | | | (1.85)** | (1.91)** | (1.63) | (1.56) | (1.52) |

**Table 4.13 Alternative Estimates-Latin American Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *COL* | | | | | | | | | | |
| ln*y* | 0.899 | 1.105 | 1.208 | 1.036 | 1.047 | 1.124 | 1.255 | 1.171 | 1.067 | 0.928 |
| | (4.86)* | (5.16)* | (4.37)* | (4.55)* | (4.59)* | (3.59)* | (3.87)* | (2.34)* | (3.04)* | (2.74)* |
| *R* | -0.035 | -0.097 | -0.010 | -0.057 | -0.036 | -0.044 | -0.070 | -0.024 | -0.082 | -0.134 |
| | (4.83)* | (3.86)* | (3.65)* | (3.15)* | (3.58)* | (2.88)* | (1.77)** | (4.73)* | (3.11)* | (4.32)* |
| ln*E* | | | | | | 0.080 | 0.005 | 0.042 | 0.023 | 0.041 |
| | | | | | | (1.30) | (1.90)** | (1.68)** | (1.35) | (1.46) |
| $\pi$ | | | | | | -0.031 | -0.067 | -0.062 | -0.058 | -0.037 |
| | | | | | | (4.69)* | (1.30) | (1.53) | (2.35)* | (1.75)** |
| *ECU* | | | | | | | | | | |
| ln*y* | 1.478 | 1.514 | 1.482 | 1.530 | 1.446 | 1.320 | 1.554 | 1.570 | 1.443 | 1.627 |
| | (5.02)* | (4.56)* | (4.56)* | (4.51)* | (2.36)* | (3.52)* | (3.60)* | (4.44)* | (2.34)* | (2.52)* |
| *R* | -0.130 | -0.080 | -0.074 | -0.046 | -0.015 | -0.022 | -0.024 | -0.870 | -0.085 | -0.004 |
| | (4.33)* | (3.59)* | (3.16)* | (3.11)* | (3.62)* | (2.83)* | (2.46)* | (2.73)* | (3.34)* | (3.83)* |
| ln*E* | | | | | | 1.064 | 0.043 | 0.015 | 0.028 | 0.031 |
| | | | | | | (1.73)** | (1.50) | (1.42) | (0.68) | (1.43) |
| $\pi$ | | | | | | -0.047 | -0.122 | -0.063 | -0.045 | -0.028 |
| | | | | | | (1.52) | (1.83)** | (1.46) | (3.05)* | (1.43) |
| *PER* | | | | | | | | | | |
| ln*y* | 1.148 | 1.231 | 1.260 | 1.101 | 1.246 | 1.126 | 1.037 | 1.321 | 1.120 | 0.969 |
| | (4.05)* | (5.33)* | (3.32)* | (2.41)* | (3.45)* | (4.04)* | (3.58)* | (2.25)* | (1.87)** | (2.18)* |
| *R* | -0.125 | -0.041 | -0.023 | -0.124 | -0.096 | -0.025 | -0.101 | -0.048 | -0.013 | -0.033 |
| | (2.67)* | (2.75)* | (3.59)* | (2.85)* | (3.36)* | (3.09)* | (1.68)** | (2.14)* | (2.54)* | (2.02)* |
| ln*E* | | | | | | 1.210 | 1.018 | 0.642 | 0.396 | 0.171 |
| | | | | | | (0.75) | (1.74)** | (1.28) | (3.04)* | (1.58) |
| $\pi$ | | | | | | -0.136 | -0.117 | -0.083 | -0.003 | -0.273 |
| | | | | | | (1.43) | (1.24) | (1.40) | (1.16) | (1.53) |

## Table 4.13 Alternative Estimates-Latin American Countries

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *VEN* | | | | | | | | | | |
| ln*y* | 1.210 | 1.100 | 1.301 | 1.103 | 1.124 | 1.133 | 1.020 | 1.250 | 1.058 | 1.240 |
| | (2.69)* | (4.52)* | (2.04)* | (4.55)* | (3.42)* | (2.67)* | (3.65)* | (5.77)* | (4.72)* | (2.70)* |
| *R* | -0.003 | -0.021 | -0.016 | -0.122 | -0.038 | -0.032 | -0.177 | -0.121 | -0.032 | -0.380 |
| | (2.27)* | (4.48)* | (3.77)* | (2.45)* | (2.80)* | (2.16)* | (2.66)* | (2.48)* | (3.75)* | (2.32)* |
| ln*E* | | | | | | 0.026 | 0.983 | 0.008 | 0.864 | 0.006 |
| | | | | | | (1.25) | (1.54) | (1.74) | (1.62) | (1.45) |
| $\pi$ | | | | | | -0.056 | -0.025 | -0.030 | -0.124 | -0.036 |
| | | | | | | (2.71)* | (2.02)* | (3.52)* | (2.76)* | (2.52)* |
| *MEX* | | | | | | | | | | |
| ln*y* | 1.074 | 1.170 | 1.131 | 1.245 | 0.922 | 1.101 | 0.938 | 1.245 | 1.035 | 1.126 |
| | (5.42)* | (3.71)* | (2.36)* | (2.53)* | (2.76)* | (4.19)* | (3.53)* | (2.18)* | (2.57)* | (3.42)* |
| *R* | -0.044 | -0.121 | -0.043 | -0.079 | -0.024 | -0.049 | -0.022 | -0.128 | -0.038 | -0.028 |
| | (4.37)* | (2.64)* | (2.95)* | (2.41)* | (3.48)* | (3.56)* | (2.81)* | (3.47)* | (3.17)* | (2.29)* |
| ln*E* | | | | | | 0.123 | 0.146 | 0.102 | 0.193 | 0.243 |
| | | | | | | (2.26)* | (3.27)* | (2.06)* | (2.75)* | (3.57)* |
| $\pi$ | | | | | | -0.021 | -0.090 | -0.033 | -0.054 | -0.104 |
| | | | | | | (3.05)* | (2.03)* | (2.64)* | (2.54)* | (2.40)* |

Notes: Absolute *t* - ratios are reported below the coefficients in parentheses. Significance at 5% and 10% levels are indicated by * and **, respectively.

Application of the JML method provided evidence of no cointegration in both specifications for Uruguay and Brazil which I presume is due to the structural breaks. However, for remaining 8 countries there seems to be no or negligible structural breaks because a long run relationship of money demand exists.

Using 4th order models for AIC and SBC, lag lengths were selected that gave plausible results for cointegration tests. The selected lag lengths are 3 for Columbia (both specifications), Chile (canonical specification) and Bolivia (both specifications), 2 for Argentina (extended specification), Ecuador (canonical specification), Venezuela (both specifications) and Chile (extended specification) and 1 for Argentina (canonical specification), Ecuador (extended specification), Peru (both specifications) and Mexico (both specifications). For these 8 countries, Eigenvalues and Trace tests rejected the null of no cointegration at the 95% level implying that one cointegrating vector of *M1* demand exists in these countries, except for Argentina (extended specification) and Peru (both specifications) where two cointegrating vectors are confirmed. In a system-based method like JML, multiple cointegration vectors can be attained as illustrated in Flowchart 3.2; these results are presented in Table 4.12.

The cointegration estimates of GETS, EG, ARDL, FMOLS and JML are reported in Table 4.13. The five methods seem to produce consistent and reasonable estimates with the canonical specification.[142] The Wald tests confirmed unit income elasticity for all countries, except Bolivia and Ecuador. The income elasticity in both Bolivia and Ecuador is around 1.5. Further, the demand for money responds negatively to changes in the rate of interest, however this adjustment is very small. In all cases the income and semi-interest elasticities are statistically significant at the 5% level. Further, no issues of identification and endogeneity were revealed.

[142] Only one cointegrating vector out of two for Argentina and Peru produced good results.

### *4.4.5 Estimates for Advanced OECD Countries*

The European Monetary Union came into existence in 1999 and since then one of the most controversial issues for the European Central Bank (ECB) is whether to target a monetary aggregate or the rate of interest. While the former is strongly supported by the German Bundesbank, the latter has been adopted by a number of countries including the UK since 1993. However, adopting a policy tool requires reliable estimates of the demand for money. If money demand vastly fluctuates, the transmission mechanism of monetary policy becomes enormously complicated and the potential of the central bank to manage the supply of money and thereby inflation is compromised; for more details see Hayo (1999). Because it is difficult to control inflation directly, most central banks use the short-term rate of interest or supply of money. There exists a huge array of studies on money demand for advanced OECD countries, however there seems to be no consensus with respect to their findings.

The JML method provided somewhat mixed results for 10 advanced OECD countries viz. Australia, Austria, Canada, Denmark, Greece, Japan, Norway, New Zealand, Switzerland and the USA. Results suggest no cointegration among the variables in canonical and extended specifications for Canada and the USA while for Australia and Japan cointegration exists at the 10% level in extended specification. This outcome is not unexpected because these latter countries have continually liberalised their financial markets since the 1980s, and therefore the *M1* demand relationship especially for these four countries must be tested for structural breaks.

Results for six advanced OECD countries (Austria, Denmark, Greece, Norway, New Zealand and Switzerland) reveal existence of a long run relationship of *M1* demand. Using the $5^{th}$ order models for AIC and SBC, I determined optimal lag lengths of 4 for Denmark (extended specification), 3 for Austria (both specifications), Greece (canonical specification), Switzerland (both specifications), 2 for Denmark (canonical specification), New Zealand (extended specification) and 1 for Greece (extended specification), Norway (both specifications) and New Zealand (canonical specification). In both specifications the null of no cointegration was rejected by the

## Table 4.14 JML Cointegration Tests-Advanced OECD Countries

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvalue | | | Trace | | | Eigenvalue | | | Trace | | |
| | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% | Test Statistic | 95% | 90% |
| *AUT* | | | | | | | | | | | | |
| r = 0 | 31.320 | 25.482 | 30.320 | 23.420 | 19.434 | 19.200 | 19.473 | 14.266 | 15.870 | 27.100 | 22.550 | 23.165 |
| r <= 1 | 23.104 | 24.120 | 25.665 | 10.291 | 12.046 | 14.770 | 6.120 | 10.384 | 8.845 | 15.455 | 17.150 | 21.135 |
| *DNK* | | | | | | | | | | | | |
| r = 0 | 24.744 | 20.362 | 23.150 | 17.668 | 15.230 | 14.993 | 41.460 | 37.470 | 40.105 | 45.236 | 36.248 | 35.140 |
| r <= 1 | 14.470 | 15.380 | 18.240 | 8.124 | 9.380 | 11.320 | 34.261 | 37.446 | 39.670 | 24.340 | 27.720 | 30.210 |
| *GRC* | | | | | | | | | | | | |
| r = 0 | 42.640 | 38.165 | 35.720 | 38.531 | 32.860 | 35.224 | 30.116 | 26.480 | 29.005 | 28.223 | 32.250 | 33.544 |
| r <= 1 | 25.370 | 28.440 | 30.128 | 28.165 | 34.737 | 32.253 | 18.420 | 19.290 | 22.462 | 8.118 | 14.788 | 15.190 |
| *NOR* | | | | | | | | | | | | |
| r = 0 | 10.536 | 8.024 | 10.150 | 17.450 | 12.430 | 16.780 | 38.553 | 34.890 | 37.314 | 24.770 | 22.530 | 23.100 |
| r <= 1 | 7.280 | 10.521 | 8.390 | 9.550 | 11.237 | 13.268 | 21.520 | 28.275 | 23.020 | 18.338 | 20.185 | 22.640 |
| *NZL* | | | | | | | | | | | | |
| r = 0 | 29.260 | 25.185 | 27.410 | 18.352 | 16.990 | 16.150 | 34.239 | 29.331 | 32.070 | 30.120 | 26.290 | 28.532 |
| r <= 1 | 27.642 | 32.983 | 31.360 | 13.540 | 15.355 | 19.356 | 23.657 | 25.875 | 27.284 | 10.268 | 14.758 | 15.190 |
| *CHE* | | | | | | | | | | | | |
| r = 0 | 25.164 | 22.173 | 24.780 | 25.360 | 17.780 | 15.540 | 35.070 | 24.360 | 28.024 | 38.135 | 33.780 | 32.160 |
| r <= 1 | 15.430 | 18.117 | 19.023 | 22.650 | 33.000 | 34.460 | 2.342 | 5.630 | 7.460 | 18.725 | 20.581 | 21.425 |

Note: r is the number of cointegrating vectors.

**Table 4.15 Alternative Estimates-Advanced OECD Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *AUT* | | | | | | | | | | |
| ln*y* | 0.614 | 0.630 | 0.823 | 0.786 | 0.613 | 0.602 | 0.805 | 0.822 | 0.761 | 0.846 |
| | (7.51)* | (4.37)* | (3.25)* | (4.28)* | (4.86)* | (2.57)* | (4.74)* | (4.31)* | (2.16)* | (2.02)* |
| *R* | -0.098 | -0.122 | -0.011 | -0.049 | -0.034 | -0.077 | -0.036 | -0.025 | -0.026 | -0.037 |
| | (4.33)* | (3.27)* | (3.36)* | (3.52)* | (2.36)* | (3.19)* | (1.70)** | (1.83)** | (2.00)* | (1.90)** |
| ln*E* | | | | | | 0.038 | 0.031 | 0.047 | 0.103 | 0.034 |
| | | | | | | (2.47)* | (1.38) | (2.05)* | (1.44) | (2.57)* |
| $\pi$ | | | | | | -0.167 | -0.164 | -0.443 | -0.083 | -0.128 |
| | | | | | | (1.34) | (1.50) | (1.27) | (2.35)* | (1.54) |
| *DNK* | | | | | | | | | | |
| ln*y* | 0.446 | 0.525 | 0.538 | 0.669 | 0.402 | 0.424 | 0.635 | 0.463 | 0.422 | 0.524 |
| | (5.03)* | (4.57)* | (3.01)* | (2.28)* | (3.06)* | (4.24)* | (4.61)* | (5.24)* | (3.65)* | (4.63)* |
| *R* | -0.036 | -0.020 | -0.048 | -0.012 | -0.043 | -0.150 | -0.281 | -0.069 | -0.146 | -0.059 |
| | (2.37)* | (1.07) | (1.66)** | (1.50) | (1.25) | (2.26)* | (3.14)* | (2.23)* | (3.37)* | (2.14)* |
| ln*E* | | | | | | 0.053 | 0.067 | 0.129 | 0.031 | 0.033 |
| | | | | | | (3.01)* | (3.15)* | (2.10)* | (4.37)* | (2.13)* |
| $\pi$ | | | | | | -0.054 | -0.027 | -0.184 | -0.025 | -0.012 |
| | | | | | | (2.99)* | (2.75)* | (2.39)* | (2.65)* | (2.74)* |
| *GRC* | | | | | | | | | | |
| ln*y* | 0.703 | 0.644 | 0.619 | 0.634 | 0.627 | 0.701 | 0.649 | 0.530 | 0.713 | 0.635 |
| | (3.54)* | (1.89)** | (5.84)* | (6.32)* | (3.66)* | (2.24)* | (4.28)* | (2.67)* | (3.28)* | (2.56)* |
| *R* | -0.145 | -0.096 | -0.097 | -0.046 | -0.025 | -0.084 | -0.033 | -0.050 | -0.013 | -0.132 |
| | (1.70)** | (3.15)* | (1.82)** | (1.24) | (1.41) | (2.11)* | (2.48)* | (2.19)* | (4.99)* | (2.34)* |
| ln*E* | | | | | | 0.003 | 0.018 | 0.041 | 0.144 | 0.068 |
| | | | | | | (3.02)* | (3.19)* | (2.74)* | (2.76)* | (3.02)* |
| $\pi$ | | | | | | -0.224 | -0.067 | -0.032 | -0.024 | -0.121 |
| | | | | | | (4.25)* | (2.00)* | (2.71)* | (2.45)* | (3.57)* |

**Table 4.15 Alternative Estimates-Advanced OECD Countries**

| Country | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GETS | EG | FMOLS | ARDL | JML | GETS | EG | FMOLS | ARDL | JML |
| *NOR* | | | | | | | | | | |
| ln*y* | 0.710 | 0.654 | 0.729 | 0.701 | 0.568 | 0.722 | 0.670 | 0.762 | 0.527 | 0.718 |
| | (6.32)* | (2.36)* | (2.45)* | (4.04)* | (2.35)* | (3.46)* | (4.54)* | (3.46)* | (2.07)* | (3.22)* |
| *R* | -0.079 | -0.214 | -0.123 | -0.171 | -0.217 | -0.086 | -0.072 | -0.147 | -0.027 | -0.148 |
| | (3.82)* | (1.25) | (1.57) | (1.77)** | (1.46) | (2.37)* | (2.01)* | (4.37)* | (3.11)* | (2.47)* |
| ln*E* | | | | | | 0.132 | 0.203 | 0.148 | 0.576 | 0.013 |
| | | | | | | (3.74)* | (3.21)* | (2.69)* | (2.08)* | (3.03)* |
| $\pi$ | | | | | | -0.186 | -0.320 | -0.231 | -0.342 | -0.224 |
| | | | | | | (3.43)* | (2.35)* | (4.30)* | (2.64)* | (3.38)* |
| *NZL* | | | | | | | | | | |
| ln*y* | 0.721 | 0.629 | 0.701 | 0.711 | 0.730 | 0.654 | 0.721 | 0.762 | 0.682 | 0.734 |
| | (6.62)* | (4.16)* | (2.45)* | (1.84)** | (3.25)* | (2.17)* | (4.53)* | (4.28)* | (3.65)* | (3.86)* |
| *R* | -0.132 | -0.016 | -0.145 | -0.068 | -0.113 | -0.136 | -0.074 | -0.081 | -0.127 | -0.228 |
| | (1.74)** | (1.48) | (1.57) | (1.89)** | (1.72)** | (2.05)* | (3.01)* | (2.74)* | (2.36)* | (4.76)* |
| ln*E* | | | | | | 0.137 | 0.074 | 0.105 | 0.272 | 0.221 |
| | | | | | | (2.70)* | (2.41)* | (3.26)* | (2.97)* | (2.82)* |
| $\pi$ | | | | | | -0.049 | -0.136 | -0.154 | -0.013 | -0.120 |
| | | | | | | (2.46)* | (2.25)* | (2.02)* | (4.91)* | (3.09)* |
| *CHE* | | | | | | | | | | |
| ln*y* | 0.634 | 0.712 | 0.685 | 0.632 | 0.667 | 0.725 | 0.521 | 0.670 | 0.727 | 0.602 |
| | (4.52)* | (3.33)* | (4.86)* | (5.28)* | (5.22)* | (3.57)* | (3.48)* | (2.34)* | (2.18)* | (2.44)* |
| *R* | -0.131 | -0.087 | -0.140 | -0.112 | -0.131 | -0.037 | -0.079 | -0.038 | -0.067 | -0.278 |
| | (3.24)* | (2.29)* | (3.16)* | (3.65)* | (2.54)* | (2.36)* | (1.76)** | (2.01)* | (1.29) | (2.13)* |
| ln*E* | | | | | | 0.002 | 0.125 | 0.044 | 0.072 | 0.182 |
| | | | | | | (1.63) | (1.71)** | (2.31)* | (1.87)** | (1.46) |
| $\pi$ | | | | | | -0.036 | -0.102 | -0.027 | -0.015 | -0.124 |
| | | | | | | (1.34) | (1.53) | (1.50) | (1.70)** | (3.41)* |

Notes: Absolute *t* - ratios are reported below the coefficients in parentheses. Significance at 5% and 10% levels are indicated by * and **, respectively.

Eigenvalues and Trace tests implying that there exists one long run relationship of the demand for money, see Table 4.14 for the results. Several other studies have also found a cointegration relationship of money demand for these countries using the JML method, for example Hayo (1999 and 2000) for Austria, Juselius (1998) for Denmark, Loizos and Thompson (2001) and Bahmani-Oskooee and Economidou (2005) for Greece, Bahmani–Oskooee and Chomsisengphet (2002) for Norway, Siklos (1995a & b) and Choi and Oxley (2004) for New Zealand and Baltensperger et al. (2001) for Switzerland, among others. Most of these studies estimated the extended equation of the demand for money.

Table 4.15 reports the cointegration estimates of ARDL, GETS, EG, FMOLS and JML. I obtained consistent results across the five methods for both specifications. In terms of statistical significance, the extended specification seems to perform better than canonical specification for all countries, except for Austria and Switzerland. The income elasticities are less than unity and this was also confirmed through the application of Wald tests. The elasticities with respect to interest rate, exchange and inflation rates are statistically significant with expected signs. Moreover, the identification and endogeneity tests are satisfactory, indicating that income, interest rate, exchange and inflation rates are weakly exogenous variables in the money demand equations.

Further, the implied income elasticities are comparable to Loizos and Thompson (2001) for Greece, Bahmani-Oskooee and Shabsigh (1996) and Maki and Kitasaka (2006) for Japan, Orden and Fisher (1993) and Kumar and Webber (2011) for New Zealand and Chowdhury (1995) for Switzerland. Hayo's (2000) estimate for income elasticity of Austrian *M1* demand was constraint to unity and Bond et al. (2007) attained an income elasticity of around 0.9 which I presume is close to unity if tested with the Wald test. My earlier findings (see Kumar et al., 2011) suggest that income elasticity is around 0.8 in the advanced OECD countries and this is fairly consistent with the results of this study using more recent techniques and up-to-date data.

### *4.4.6 Gregory and Hansen Tests*

At the outset of this section it should be noted that there are only a handful of empirical studies that have used the Gregory and Hansen (1996a & b) (henceforth GH) techniques. As illustrated in Flowchart 3.3, the development of the GH method have raised doubts on the validity of earlier estimates that have used the standard time series estimation methods such as GETS, EG, FMOLS, DOLS, JML and TSLS because these methods fail to address structural breaks in the cointegration equations. The GH approach accommodates a single endogenous break in an underlying cointegrating relationship. The four models proposed by GH are based on alternative assumptions about structural breaks: i) level shift; ii) level shift with trend; iii) regime shift where both the intercept and the slope coefficients change and iv) regime shift where intercept, trend and slope coefficients change, see Grgeory and Hansen (1996a & b) for more details. This method tests the null hypothesis of no cointegration with structural breaks against the alternative of cointegration. The single endogenous break date is found by estimating the cointegration equations for all possible break dates in the sample. The selection of a break date takes place when the test statistic is the minimum or in other words the absolute ADF test statistic is at its maximum.  The GH cointegrating equations are estimated with the Engle-Granger method.

GH tests are applied to data of those countries for which JML cointegration tests failed to reject the null of no cointegration or cointegration exists at the 10% level; applied economists usually follow this procedure. These countries are Korea, Malaysia, Pakistan, the Philippines, Singapore, Thailand, South Africa, Uruguay, Brazil, Canada, Australia, Japan and the USA, Table 4.16 present the results for GH cointegration tests. Results imply that in at least one of the four models with structural breaks, there is cointegration between the variables in canonical and extended equations. For most cases, the break points occur in the 1980s and 1990s. Essentially these structural break points relate to the crucial economic and financial incidents that took place in these countries. These can be summarised as follows.

1) The South Korean economy continued to achieve a stable economic growth since early 1960s, however some uncertainty in growth was experienced in 1997 with the Asian Financial crisis. Consequently, the Korean Won was heavily depreciated in the 1997. Strong growth thereafter was mainly due to subsequent financial reforms.
2) From 1988 to 1997, Malaysia experienced a period of broad diversification and sustained rapid growth averaging 9 percent annually. Rapid growth was achieved partly through privatisation of inefficient state owned enterprises, foreign direct investment (FDI) and financial reforms. The 1997 Asian financial crises also affected Malaysia in a number of ways, for instance, speculative short-selling of the Malaysian currency, high capital outflows, reduction in FDI, etc. As a result, growth suffered a sharp 7.5 percent contraction in 1998 although it dramatically improved thereafter.
3) The Pakistan economy suffered from decades of internal political disputes and economic instabilities. The oil price shocks, devaluations of Pakistani rupee, natural disasters etc. have also created drawbacks to the macroeconomic performance of the economy. Pakistan deregulated her financial market during the 1980s, and later in 1997 the Asian financial crises slowed down the economic activity.
4) The Philippines experienced a severe recession in 1984-85. The reforms implemented since 1985 helped improve the growth rates, however economy deteriorated again as a result of spill-over from the Asian financial crisis in 1998, although not as much as other Asian countries. Natural disasters and political turmoil also resulted in negative impacts on economic activity. The government effort to continue the reforms made significant progress in the domestic sectors.
5) Singapore's economic reforms of the 1980s proved a success, producing real growth that averaged more than 5 percent from 1980 to 1997. The economic slowdown due to the 1997 Asian financial crises was temporary and the economy picked up again from 1999. A structural break date in the 1980s and late 1990s is not unexpected for this economy.
6) Thailand underwent substantial financial market reforms during the 1980s and this allowed them to gain an average growth rate of 9.4 percent from

1985 to 1996. The military government in power from 1980 to 1988 encouraged policies that boosted Thailand's international trade. However, the 1997-1998 Asian financial crises had an adverse impact on the domestic economy, for example the loss of jobs and investor confidence. Economic activity also slowed down in 2005 due to rising oil prices, trade deficits and severe droughts and floods.

7) In light of the developments in the South African economy, a break in 1994 is expected because this may highlight the advent of democracy which improved general economic performance in many ways, for instance, enhanced competitiveness in the markets, increased job creation, development of trade promotion policies, etc. I would expect a break in the 1980s for two reasons. First, to capture the impact of the gold market boom in 1980 and second to highlight the liberalisation of financial markets.
8) Major economic reforms were implemented during the 1970s by the Uruguay military government (1973-85), however it was at the cost of high fiscal deficits and extensive borrowing. During the late 1970s the government eliminated price controls and slashed tariffs and provided subsidies to exporters. These reform benefits were realised for only the very short-term and in early 1980s the country faced both a recession and a domestic debt crisis.
9) Brazil took important steps during the 1990s toward fiscal sustainability, as well as measures taken to liberalize their financial markets. These reform policies have improved the banking system and have significantly boosted private sector competition. Between 1996 and 1998, Brazil's foreign exchange reserves dropped by nearly 40 percent and in 1999 the central bank devalued the currency by 8 percent. This led to a drastic adjustment in Brazil's current account from 2003 to 2006.
10) Canada implemented some major financial reforms during the 1960s and 1970s. This gave boost to the payments technology and raised competitiveness and productivity in the banking sector. The 1989 free trade agreement signed with the USA formed the basis for the North American Free Trade Agreement (NAFTA) between the United States, Canada and Mexico in 1994. In the early 1980s and 1990s, they experienced economic

recession which led to massive government deficits and high unemployment. Since the 1996, Canadian economy has improved markedly in its economic performance, for example high foreign investment and boom in the housing market.

11) Some major events that took place in the USA during the 1970s: the collapse of the Bretton Woods system, the 1973 oil crisis, 1973-74 stock market crash and the 1970s recession. Deregulation policies were employed during the period 1974-1992 which further enhanced the USA's financial system. In 2000, the economy experienced a bubble in stock valuations and experienced recession in the following year, although this is often blamed on the September 11, 2001 terrorist attacks.
12) In Australia, the mid-1980s saw financial deregulation and floating of the Australian dollar. In 2000, the introduction of a goods and services tax (*GST*) sought to encourage savings amongst low income earners. The formation of the Australian Stock Exchange Limited in 1987 and microeconomic reforms in the manufacturing sector both boosted private investment. Australia also experienced a recession in 1992 due to the stock market collapse in the USA.
13) During the 1980s, the Japanese economy shifted its emphasis away from primary and secondary to technology based production (telecommunications and information technology). Some major events related to this economy were 1989 asset price bubble, economic expansion of the late 1980s, 1992 recession and 1997 Asian financial crises. Furthermore, the Bank of Japan adopted a quantitative easing strategy in post 2000 period.

The GH cointegrating equations are reported in Table 4.17. These equations are estimated with the Engle and Granger method. The canonical specification provided better results for all countries, however for Canada, Australia and the USA both canonical and extended equations are preferred. GH-1 (level shift) gave plausible elasticities for Malaysia, Pakistan, Thailand, Brazil and Australia. For Korea and Uruguay, GH-2 (level shift with trend) estimates are preferred. GH-3 (GH-4) which is a regime shift model gave plausible estimates for Singapore, South Africa, Canada, Japan and the USA (Australia, Canada and the Philippines). The estimates

## Table 4.16 Cointegration Tests with Structural Breaks

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | |
|---|---|---|---|---|---|---|---|---|
| Country/GH Model | Break Date | GH Test Statistic | 5% Critical Value | Is there CIV? | Break Date | GH Test Statistic | 5% Critical Value | Is there CIV? |
| *KOR* | | | | | | | | |
| GH-1 | 1968 | -4.238 | -5.50 | No | 1975 | -2.340 | -3.19 | No |
| GH-2 | 1997 | -6.351 | -5.97 | Yes | 1999 | -3.782 | -4.34 | No |
| GH-3 | 1998 | -2.600 | -3.60 | No | 2001 | -4.110 | -4.34 | No |
| GH-4 | 1971 | 5.235 | -5.50 | No | 1997 | -8.364 | -3.19 | Yes |
| *MYS* | | | | | | | | |
| GH-1 | 1988 | -7.365 | -6.00 | Yes | 2003 | -8.395 | -5.20 | Yes |
| GH-2 | 2003 | -3.470 | -4.34 | No | 2001 | -4.382 | -6.51 | No |
| GH-3 | 1998 | -5.274 | -6.51 | No | 1998 | -3.450 | -3.60 | No |
| GH-4 | 1998 | -6.883 | -6.51 | Yes | 1997 | -4.170 | -5.50 | No |
| *PAK* | | | | | | | | |
| GH-1 | 1985 | -6.390 | -5.50 | Yes | 2002 | -3.357 | -6.00 | No |
| GH-2 | 1997 | -2.100 | -5.96 | No | 1997 | -5.310 | -6.51 | No |
| GH-3 | 1997 | -7.015 | -4.34 | Yes | 1983 | -8.765 | -5.50 | Yes |
| GH-4 | 1984 | -6.320 | -5.50 | Yes | 2002 | -5.853 | -5.50 | Yes |
| *PHL* | | | | | | | | |
| GH-1 | 2000 | -1.377 | -3.65 | No | 1985 | -3.402 | -5.97 | No |
| GH-2 | 1984 | -2.320 | -4.34 | No | 2000 | -5.228 | -4.50 | Yes |
| GH-3 | 1985 | -1.648 | -6.78 | No | 2003 | -4.324 | -3.19 | No |
| GH-4 | 1998 | -7.425 | -6.51 | Yes | 1998 | -2.471 | -3.60 | No |

**Table 4.16 Cointegration Tests with Structural Breaks**

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | |
|---|---|---|---|---|---|---|---|---|
| Country/GH Model | Break Date | GH Test Statistic | 5% Critical Value | Is there CIV? | Break Date | GH Test Statistic | 5% Critical Value | Is there CIV? |
| *SGP* | | | | | | | | |
| GH-1 | 2001 | -2.746 | -3.60 | No | 2000 | -5.341 | -4.50 | Yes |
| GH-2 | 1983 | -5.439 | -7.32 | No | 2001 | -1.878 | -3.74 | No |
| GH-3 | 1997 | -7.470 | -6.51 | Yes | 1998 | -2.505 | -3.60 | No |
| GH-4 | 1985 | -5.300 | -3.60 | Yes | 1978 | -6.864 | -5.50 | Yes |
| *THA* | | | | | | | | |
| GH-1 | 1986 | -7.499 | -4.96 | Yes | 1999 | -4.334 | -6.00 | No |
| GH-2 | 2001 | -1.220 | -3.65 | No | 1997 | -6.210 | -4.35 | Yes |
| GH-3 | 1998 | -1.037 | -5.84 | No | 1985 | -2.362 | -3.40 | No |
| GH-4 | 1985 | -3.400 | -5.50 | No | 1977 | -1.038 | -5.23 | No |
| *ZAF* | | | | | | | | |
| GH-1 | 1987 | -1.367 | -3.44 | No | 2002 | -2.764 | -4.20 | No |
| GH-2 | 1984 | -10.220 | -7.10 | Yes | 1994 | -6.590 | -5.50 | Yes |
| GH-3 | 1994 | -7.459 | -6.00 | Yes | 1988 | -2.458 | -3.65 | No |
| GH-4 | 1978 | -2.380 | -3.65 | No | 1985 | -4.021 | -4.20 | No |
| *URY* | | | | | | | | |
| GH-1 | 1981 | -3.124 | -5.50 | No | 1978 | -4.380 | -3.24 | Yes |
| GH-2 | 1976 | -4.500 | -3.15 | Yes | 2000 | -4.376 | -5.88 | No |
| GH-3 | 1978 | -2.480 | -3.40 | No | 1993 | -5.300 | -6.00 | No |
| GH-4 | 1982 | -8.476 | -5.75 | Yes | 1981 | -7.874 | -6.00 | Yes |

## Table 4.16 Cointegration Tests with Structural Breaks

| | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | |
|---|---|---|---|---|---|---|---|---|
| Country/GH Model | Break Date | GH Test Statistic | 5% Critical Value | Is there CIV? | Break Date | GH Test Statistic | 5% Critical Value | Is there CIV? |
| *BRA* | | | | | | | | |
| GH-1 | 1999 | -5.200 | -3.60 | Yes | 2003 | -3.468 | -6.00 | No |
| GH-2 | 1996 | -4.104 | -4.96 | No | 1998 | -6.330 | -3.60 | Yes |
| GH-3 | 2003 | -3.990 | -3.60 | Yes | 2001 | -2.600 | -4.25 | No |
| GH-4 | 1998 | -7.361 | -5.00 | Yes | 1999 | -4.385 | -3.60 | Yes |
| *CAN* | | | | | | | | |
| GH-1 | 2001 | -3.102 | -4.34 | No | 1994 | -3.286 | -7.10 | No |
| GH-2 | 1989 | -5.470 | -3.85 | Yes | 2002 | -6.480 | -5.50 | Yes |
| GH-3 | 1982 | -9.001 | -6.47 | Yes | 1989 | -8.239 | -6.15 | Yes |
| GH-4 | 1993 | -7.863 | -5.00 | Yes | 2000 | -1.244 | -3.40 | No |
| *USA* | | | | | | | | |
| GH-1 | 1976 | -3.220 | -4.34 | No | 2001 | -3.127 | -5.50 | No |
| GH-2 | 1972 | -1.298 | -5.72 | No | 1973 | -6.500 | -6.00 | Yes |
| GH-3 | 1985 | -6.346 | -6.00 | Yes | 1985 | -6.981 | -5.00 | Yes |
| GH-4 | 1987 | -5.011 | -3.24 | Yes | 1974 | -2.355 | -4.34 | No |
| *AUS* | | | | | | | | |
| GH-1 | 1985 | -5.380 | -3.60 | Yes | 1987 | -3.228 | -4.82 | No |
| GH-2 | 1987 | -5.000 | -4.00 | Yes | 2002 | -7.325 | -5.00 | Yes |
| GH-3 | 2001 | -1.871 | -3.60 | No | 2000 | -2.030 | -3.60 | No |
| GH-4 | 1992 | -4.239 | -6.25 | No | 1987 | -6.255 | -4.34 | Yes |

Note: CIV indicates cointegration.

**Table 4.17 Gregory-Hansen Cointegrating Equations**

| Country/GH Model | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | |
|---|---|---|---|---|---|---|
| | ln*y* | *R* | ln*y* | *R* | ln*E* | $\pi$ |
| *KOR* | | | | | | |
| GH-2 | 0.961 | -0.040 | - | - | - | - |
| | (7.28)* | (4.37)* | | | | |
| GH-4 | - | - | 1.173 | -0.161 | 0.022 | -0.235 |
| | | | (3.86)* | (2.38)* | (1.45) | (1.67)** |
| *MYS* | | | | | | |
| GH-1 | 1.246 | -0.182 | 1.304 | -0.096 | -0.127 | -0.186 |
| | (8.50)* | (4.36)* | (3.42)* | (2.70)* | (1.58) | (1.43) |
| GH-4 | 1.147 | -0.201 | - | - | - | - |
| | (2.36)* | (1.35) | | | | |
| *PAK* | | | | | | |
| GH-1 | 1.114 | -0.060 | - | - | - | - |
| | (4.38)* | (3.24)* | | | | |
| GH-3 | 0.943 | -0.033 | 1.377 | -0.274 | 0.095 | -0.126 |
| | (6.34)* | (1.50) | (2.36)* | (2.11)* | (1.40) | (1.70)** |
| GH-4 | 1.862 | -0.835 | 1.200 | -0.081 | 0.124 | -0.742 |
| | (1.52) | (1.38) | (4.62)* | (3.47)* | (0.89) | (1.46) |
| *PHL* | | | | | | |
| GH-2 | - | - | 1.274 | -0.091 | 0.267 | -0.163 |
| | | | (5.27)* | (2.43)* | (1.56) | (1.61) |
| GH-4 | 1.145 | -0.078 | 1.320 | -0.789 | -0.234 | -0.340 |
| | (3.75)* | (5.50)* | (1.89)** | (2.01)* | (1.28) | (1.90)** |
| *SGP* | | | | | | |
| GH-1 | - | - | 1.483 | -0.483 | 0.136 | -0.820 |
| | | | (2.37)* | (1.71)** | (1.58) | (1.42) |
| GH-3 | 0.964 | -0.218 | - | - | - | - |
| | (4.50)* | (2.41)* | | | | |
| GH-4 | 1.027 | -0.174 | 0.921 | -0.411 | 0.132 | -1.283 |
| | (2.43)* | (1.36) | (6.74)* | (2.35)* | (1.56) | (0.85) |

**Table 4.17 Gregory-Hansen Cointegrating Equations**

| Country/GH Model | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | |
|---|---|---|---|---|---|---|
| | ln*y* | *R* | ln*y* | *R* | ln*E* | $\pi$ |
| *THA* | | | | | | |
| GH-1 | 1.266 | -0.110 | - | - | - | - |
| | (6.82)* | (4.35)* | | | | |
| GH-2 | - | - | 1.678 | -0.281 | 0.112 | -0.024 |
| | | | (1.75)** | (1.42) | (2.16)* | (1.58) |
| *ZAF* | | | | | | |
| GH-2 | 1.755 | -0.076 | 1.164 | -0.139 | 0.264 | -0.264 |
| | (2.30)* | (1.36) | (3.48)* | (2.00)* | (1.49) | (1.68)** |
| GH-3 | 1.203 | -0.084 | - | - | - | - |
| | (3.47)* | (4.92)* | | | | |
| *URY* | | | | | | |
| GH-1 | - | - | 1.340 | -0.368 | 0.754 | -0.008 |
| | | | (2.35)* | (1.32) | (1.57) | (1.82)** |
| GH-2 | 1.106 | -0.064 | - | - | - | - |
| | (4.36)* | (3.20)* | | | | |
| GH-4 | 1.299 | -0.179 | 0.826 | -0.017 | 0.253 | -0.268 |
| | (1.52) | (1.66)** | (1.28) | (2.11)* | (1.04) | (1.62) |
| *BRA* | | | | | | |
| GH-1 | 0.920 | -0.088 | - | - | - | - |
| | (9.26)* | (5.20)* | | | | |
| GH-2 | - | - | 1.141 | -0.003 | -0.195 | -0.035 |
| | | | (3.46)* | (5.23)* | (0.47) | (1.39) |
| GH-3 | 1.037 | -0.063 | - | - | - | - |
| | (5.38)* | (1.49) | | | | |
| GH-4 | 0.821 | -0.120 | 1.300 | -0.084 | -0.157 | -0.136 |
| | (1.55) | (1.04) | (10.47)* | (1.53) | (1.80)** | (1.61) |

**Table 4.17 Gregory-Hansen Cointegrating Equations**

| Country/GH Model | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \varepsilon_t$ | | $\ln m_t = \theta_0 + \theta_y \ln(y_t) + \theta_R R_t + \theta_E \ln E_t + \theta_\pi \pi_t + \varepsilon_t$ | | | |
|---|---|---|---|---|---|---|
| | ln*y* | *R* | ln*y* | *R* | ln*E* | $\pi$ |
| *CAN* | | | | | | |
| GH-2 | 0.860 | -0.054 | 0.701 | -0.103 | 0.125 | -0.018 |
| | (1.27) | (3.26)* | (1.54) | (2.34)* | (3.28)* | (1.35) |
| GH-3 | 0.672 | -0.016 | 0.711 | -0.074 | 0.006 | -0.743 |
| | (12.48)* | (5.20)* | (9.26)* | (4.58)* | (7.30)* | (3.44)* |
| GH-4 | 0.835 | -0.200 | - | - | - | - |
| | (6.30)* | (3.49)* | | | | |
| *USA* | | | | | | |
| GH-2 | - | - | 0.611 | -0.074 | 0.670 | -0.125 |
| | | | (6.22)* | (4.32)* | (1.30) | (2.20)* |
| GH-3 | 0.527 | -0.055 | 0.528 | -0.093 | 0.215 | -0.067 |
| | (12.35)* | (7.21)* | (10.21)* | (3.66)* | (4.64)* | (2.17)* |
| GH-4 | 0.531 | -0.146 | - | - | - | - |
| | (11.26)* | (1.74)** | | | | |
| *AUS* | | | | | | |
| GH-1 | 0.674 | -0.049 | - | - | - | - |
| | (8.24)* | (6.31)* | | | | |
| GH-2 | 0.588 | -0.091 | 0.601 | -0.012 | 0.320 | -0.274 |
| | (13.22)* | (1.89)** | (6.36)* | (3.00)* | (4.35)* | (1.46) |
| GH-4 | - | - | 0.615 | -0.184 | 0.029 | -0.142 |
| | | | (12.06)* | (6.73)* | (3.21)* | (6.83)* |
| *JPN* | | | | | | |
| GH-1 | 0.736 | -0.130 | - | - | - | - |
| | (4.26)* | (1.50) | | | | |
| GH-2 | 1.895 | -0.216 | - | - | - | - |
| | (1.94)** | (3.20)* | | | | |
| GH-3 | 0.701 | -0.086 | - | - | - | - |
| | (9.25)* | (5.32)* | | | | |
| GH-4 | - | - | 0.726 | -0.263 | 1.328 | -0.217 |
| | | | (7.28)* | (2.40)* | (1.53) | (1.60) |

Notes: Absolute *t* - ratios are reported below the coefficients in parentheses. Significance at 5% and 10% levels are indicated by * and **, respectively.

in these models are statistically significant at the 5 percent level.

With the exception of Australia, Canada, Japan and the USA, the income elasticity in other countries is around unity. The interest rate coefficients are negative and highly significant. The unit income elasticity constraint was not rejected by the Wald test. For Australia, Canada, Japan and the USA, income elasticity is less than unity; this result is not unexpected for advanced countries. Further, all the cost of holding money estimates (interest rate, exchange and inflation rates) are statistically significant at the 5% level for Australia, Canada and the USA. The income elasticity estimates for advanced OECD countries are consistent with the Baumol-Tobin model. These results are comparable to my earlier findings; see Kumar et al. (2011) for OECD countries and Kumar and Webber (2011) for Australia and New Zealand. The next section details the results of panel unit roots and cointegration tests.

## 4.5 Panel Data Results

### *4.5.1 Panel Unit Root Tests*

The panel data used in this study consists of 53 countries $(N = 1....53)$ for the period 1970 to 2009 ($T$ = 1.....39). I first tested for the order of the variables viz. ln$m$, ln$y$, $R$, $\ln E$ and $\pi$ using the panel unit root tests of Levin, Lin and Chu (2002, LLC), Breitung (2000), Im, Pesaran and Shin (2003, IPS), ADF Fisher $\chi^2$ (ADF), PP Fisher $\chi^2$ (PP) and Hadri (2000). It is well known that the LLC and Breitung tests does not allow for heterogeneity in the autoregressive coefficient. Therefore, I shall also apply IPS, PP and Hadri tests which are less restrictive and more powerful. The IPS test is efficient in solving serial correlation by assuming heterogeneity between units in a dynamic panel framework. Flowchart 3.1 constructed in Chapter 3 provides insights on selecting relevant panel unit root tests. More comprehensive details on panel unit root tests are available in Banerjee (1999) and Hurlin and Mignon (2005). The panel unit root test results are displayed in Table 4.18.

These tests gave fairly unambiguous results for ln$m$ and ln$y$. The LLC, IPS, ADF, PP and Breitung tests in which the null is that the variable is non-stationary is not rejected at the 5% level. In the Hadri test the null that the variable is stationary is also rejected for these two variables at the 5% level. For ln*E* and *R*, all the tests show that they are non-stationary variables at the 5% level, except in the IPS and Breitung test at the 1% level. For $\pi$ all the tests show that it is non-stationary, except the LLC, Breitung and IPS. With the exception of the Hadri test, all other tests show that the first differences of all the variables are stationary. Therefore, it is reasonable to infer that these variables are *I(1)* in levels.[143] Flowchart 3.2 illustrated that if variables in a panel data are non-stationary then panel cointegration methods like Pedroni (2004), Mark and Sul (2003), Breitung (2005) etc. can be employed.

**Table 4.18 Panel Unit Root Tests 1970-2009**

| Series | LLC | Breitung | IPS | ADF | PP | Hadri |
|---|---|---|---|---|---|---|
| ln*m* | 0.289 | 0.437 | 1.672 | 9.247 | 8.253 | 5.509 |
| | (0.127) | (0.297) | (0.953) | (0.980) | (0.990) | (0.00)* |
| ln*y* | 2.408 | 2.404 | 3.664 | 9.780 | 6.945 | 8.281 |
| | (0.992) | (0.992) | (1.000) | (0.972) | (0.997) | (0.000)* |
| *R* | -0.414 | -2.280 | -1.977 | 4.920 | 10.552 | 10.303 |
| | (0.340) | (0.007)* | (0.010)* | (0.381) | (0.957) | (0.000)* |
| ln*E* | 3.320 | -2.269 | -2.462 | -0.082 | 19.745 | 7.711 |
| | (0.999) | (0.008)* | (0.007)* | (0.47) | (0.474) | (0.00)* |
| $\pi$ | -1.746 | -1.222 | -0.282 | 32.296 | 71.085 | 6.584 |
| | (0.000)* | (0.000)* | (0.000)* | (0.760) | (0.635) | (0.000)* |
| $\Delta$ln*m* | -18.520 | -8.368 | -24.554 | 78.964 | 12.814 | 2.800 |
| | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.003)* |
| $\Delta$ln*y* | -12.960 | -47.029 | -40.009 | 125.701 | 206.323 | 296.527 |
| | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.000)* |
| $\Delta R$ | -12.003 | -12.419 | -15.569 | 22.349 | 206.323 | 296.527 |
| | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.000)* |
| $\Delta$ln*E* | -26.047 | -27.844 | -18.273 | 14.484 | 98.690 | 5.041 |
| | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.000)* |
| $\Delta\pi$ | -14.334 | -24.202 | -34.734 | 28.387 | 761.325 | 2.800 |
| | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.000)* | (0.003)* |

Notes: Probability values are reported in the parentheses. * denotes the rejection of the null at the 5% level. Baltagi (2005) and Pesaran and Breitung (2005) provide detailed discussion of these tests.

[143] Since LLC, Breitung, IPS, ADF, PP and Hadri are first generation panel unit root tests, they restrict cross-section dependence in the errors. To address this issue, I applied the recently developed panel unit root test by Pesaran (2007); this is a second generation panel unit root test, see Flowchart 3.1. These results are not reported but briefly discussed here. It is found that the null of non-stationarity cannot be rejected at 5% level for ln*m*, ln*y*, *R* and ln*E*. For $\pi$, the null is rejected at 10% level. The results imply that cross-section dependence is not an issue in this dataset.

### *4.5.2 Pedroni Cointegration Tests*

The Pedroni cointegration tests are employed to test for cointegration between the variables in canonical and extended equations. Tables 4.19 and 4.20 display the results from Pedroni cointegration tests. The majority of the reported 7 tests are significant and show that there is cointegration among the variables at the 5% level. For canonical equation the panel $\sigma$ statistic is insignificant at conventional levels for PICs and Advanced OECD countries and the panel $\rho\rho$ test is significant at only 10% level for African countries. Only the panel $v$ and panel $\rho\rho$ test statistics in the extended equation (African countries) are insignificant at the conventional levels. Of these 7 tests the two *ADF* tests have more power against the null and they conclusively reject the null of no cointegration. Therefore, it can be concluded that the variables in canonical and extended equations are cointegrated and a long run money demand function exists for the group as a whole and the members of the panel.

**Table 4.19 Panel Cointegration Tests for Canonical Equation-1970-2009**

| | $\ln m_{it} = \theta_0 + \theta_y \ln(y_{it}) + \theta_R R_{it} + \varepsilon_{it}$ | | | | |
|---|---|---|---|---|---|
| Test Statistic | PICs | Asian | African | LACs | OECD |
| Panel $v$ - statistic | -3.147* | -5.100* | -3.846* | -7.460* | -4.164* |
| Panel $\sigma$ - statistic | -1.436 | -4.096* | -2.042* | -1.988* | -0.648 |
| Panel $\rho\rho$ - statistic | -10.230* | -3.633* | -1.673** | -5.132* | -3.275* |
| Panel ADF-statistic | -6.002* | -3.274* | -2.176* | -3.075* | -2.278* |
| Group $\sigma$ - statistic | -3.338* | -2.028* | -3.128* | -2.523* | -3.902* |
| Group $\rho\rho$ - statistic | -3.015* | -5.638* | -3.140* | -2.244* | -2.011* |
| Group ADF- statistic | -6.989* | -4.009* | -4.931* | -2.001* | -2.205* |

Pedroni cointegration test includes common time dummies. The test statistics are distributed as $N(0,1)$. * and ** denotes significance at 5% and 10% levels, respectively.

**Table 4.20 Panel Cointegration Tests for Extended Equation 1970-2009**

$$\ln m_{it} = \theta_0 + \theta_y \ln(y_{it}) + \theta_R R_{it} + \theta_E \ln E_{it} + \theta_\pi \pi_{it} + \varepsilon_{it}$$

| Test Statistic | PICs | Asian | African | LACs | OECD |
|---|---|---|---|---|---|
| Panel $\nu$ - statistic | -2.558* | -1.830** | -1.342 | -1.700** | -2.944* |
| Panel $\sigma$ - statistic | -4.116* | -2.276* | -2.145* | -2.216* | -2.375* |
| Panel $\rho\rho$ - statistic | -1.810** | -4.023* | -2.003* | -3.362* | -2.026* |
| Panel ADF-statistic | -4.691* | -3.679* | -1.676** | -2.176* | -3.118* |
| Group $\sigma$ - statistic | -2.542* | -1.728** | -2.220* | -4.890* | -5.921* |
| Group $\rho\rho$ - statistic | -1.915** | -2.004* | -3.731* | -1.984* | -2.637* |
| Group ADF- statistic | -3.109* | -2.741* | -2.951* | -1.842* | -4.835* |

Pedroni cointegration test includes common time dummies. The test statistics are distributed as $N(0,1)$.* and ** denotes significance at 5% and 10% levels, respectively.

Few others in the money demand literature, notably Dreger et al. (2007), Harb (2004), Carerra (2008) and Hamori (2008) have employed the Pedroni method to test for cointegration. My earlier work (Rao and Kumar, 2009b; Kumar, 2010a; and Kumar et al., 2011) related to *M1* demand for PICs, Asian and advanced OECD countries also utilised this method and the findings are consistent. In the next section, I shall compare the findings with a powerful panel method recently developed by Westerlund (2007).

### *4.5.3 Westerlund Cointegration Tests*

Flowchart 3.2 illustrates that if panel cointegration equations are to be estimated within an error correction framework then the Westerlund (2007) panel cointegration method is suitable. Following the flowchart, I shall apply Westerlund's (2007) panel cointegration tests. The number of lags and leads for each time series in the panel and the Bartlett kernel window width is set to one. Changing these parameters did not show any significant changes in the results.

To test the null hypothesis of no cointegration, Westerlund (2007) developed two group-mean tests viz. $G_\tau$ and $G_\alpha$, and two analogous panel results tests, $P_\tau$ and $P_\alpha$. These four test statistics are normally distributed. The first of these two tests ($G_\tau, P_\tau$) are computed with the standard errors of intercept, estimated in a standard way. The second set of tests ($G_\alpha, P_\alpha$) are based on the Newey and West (1994) adjusted standard errors for heteroscedasticity. To overcome possible finite sample bias, bootstrap values of these four test statistics are also generated and used. In the two group-mean based tests, the alternative hypothesis is that there is cointegration at least in one cross-section unit. Therefore, the adjustment to equilibrium estimate may be heterogeneous across the cross-section units. Alternatively, in the two panel data based tests, the alternative hypothesis is that adjustment to equilibrium is homogenous across cross-section units.

Cointegration test results for canonical and extended equations of money demand are presented in Table 4.21. It can be seen from the results that the four tests reject the null of no cointegration at the 5% level for canonical equations. The p-values and robust p-values are significant at the 5% level. For extended equations, the null is rejected by $G_\tau$ (PICs and Asian), $G_\alpha$ (African) and $P_\alpha$ (Asian and Latin American) at the 10% level. The reported boot-strapped robust *p*-values are based on 800 replications. These results indicate that there is cointegration among the variables in canonical and extended equations of money demand for both advanced OECD and developing countries. These cointegration results are consistent with the Pedroni results. Recently, Rao and Kumar (2011b) employed the Westerlund method to estimate *M1* demand for 18 Asian countries.[144] Their results support cointegration among the variables in both canonical and extended equations. Given the existence of cointegration among the variables, in the next section I shall present the estimates of associated cointegration equations.

[144] These countries are Bangladesh, Myanmar, India, Indonesia, Iran, Israel, Jordon, Korea, Kuwait, Malaysia, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka, Syria and Thailand.

**Table 4.21 Westerlund Cointegration Tests 1970-2009**

| | $\ln m_{it} = \theta_0 + \theta_y \ln(y_{it}) + \theta_R R_{it}$ | | | | $\ln m_{it} = \theta_0 + \theta_y \ln(y_{it}) + \theta_R R_{it} + \theta_E \ln E_{it} + \theta_\pi \pi_{it}$ | | | |
|---|---|---|---|---|---|---|---|---|
| Stats | Value | Z-value | P-value | Robust P-value | Value | Z-value | P-value | Robust P-value |
| *PICs* | | | | | | | | |
| $G_\tau$ | -2.931 | -4.370 | 0.027 | 0.043 | -10.264 | -3.762 | 0.065 | 0.097 |
| $G_\alpha$ | -12.358 | -6.271 | 0.000 | 0.000 | -7.900 | -2.366 | 0.031 | 0.000 |
| $P_\tau$ | -15.334 | -6.465 | 0.000 | 0.000 | -18.401 | -8.104 | 0.000 | 0.007 |
| $P_\alpha$ | -8.275 | -5.483 | 0.026 | 0.030 | -10.307 | -4.566 | 0.000 | 0.000 |
| *Asian* | | | | | | | | |
| $G_\tau$ | -4.699 | -2.845 | 0.042 | 0.050 | -8.300 | -1.424 | 0.080 | 0.097 |
| $G_\alpha$ | -12.273 | -4.615 | 0.002 | 0.010 | -15.213 | -4.301 | 0.000 | 0.000 |
| $P_\tau$ | -9.350 | -6.271 | 0.049 | 0.037 | -8.587 | -2.184 | 0.031 | 0.040 |
| $P_\alpha$ | -11.572 | -2.489 | 0.000 | 0.000 | -5.311 | -0.382 | 0.104 | 0.075 |
| *African* | | | | | | | | |
| $G_\tau$ | -9.371 | -1.210 | 0.032 | 0.045 | -10.621 | -4.390 | 0.021 | 0.016 |
| $G_\alpha$ | -16.288 | -5.483 | 0.030 | 0.026 | -7.370 | -1.236 | 0.102 | 0.085 |
| $P_\tau$ | -6.303 | -2.328 | 0.042 | 0.051 | -4.280 | -1.254 | 0.052 | 0.045 |
| $P_\alpha$ | -12.475 | -6.432 | 0.000 | 0.000 | -13.255 | -3.002 | 0.014 | 0.003 |
| *LACs* | | | | | | | | |
| $G_\tau$ | -2.104 | -3.280 | 0.016 | 0.005 | -12.432 | -7.360 | 0.000 | 0.000 |
| $G_\alpha$ | -7.641 | -4.328 | 0.000 | 0.000 | -9.211 | -2.384 | 0.022 | 0.050 |
| $P_\tau$ | -10.376 | -3.271 | 0.008 | 0.000 | -18.263 | -5.479 | 0.000 | 0.000 |
| $P_\alpha$ | -14.742 | -3.232 | 0.000 | 0.000 | -5.302 | -1.200 | 0.096 | 0.091 |
| *OECD* | | | | | | | | |
| $G_\tau$ | -2.178 | -1.838 | 0.033 | 0.022 | -10.240 | -6.216 | 0.000 | 0.000 |
| $G_\alpha$ | -8.448 | -1.437 | 0.104 | 0.032 | -7.266 | -2.819 | 0.002 | 0.024 |
| $P_\tau$ | -10.649 | -3.041 | 0.010 | 0.006 | -9.426 | -1.211 | 0.047 | 0.032 |
| $P_\alpha$ | -9.320 | -1.217 | 0.048 | 0.035 | -16.438 | -7.390 | 0.000 | 0.000 |

Note: The column 'Stats' contains country group names and panel cointegration statistics.

### *4.5.4 Alternative Estimates*

Panel cointegrating equations of fixed and random effects are estimated with the Pedroni (2004), Mark and Sul (2003) and Breitung (2005) methods. The Pedroni method uses the Phillips-Hansen's FMOLS, while Mark and Sul used the Stock-Watson's DOLS. Breitung's method uses the JML method in the first stage and the second stage equation is estimated with OLS with the pooled results from the first stage with the constraint that the parameters of the cointegrating equation are the same in all the countries. Dreger et al. (2007) and Rao and Kumar (2009b) utilised these three estimators to estimate money demand for EU and Asian countries, respectively. While Dreger et al.'s (2007) estimate of the panel income elasticity was between 1.73 and 1.94, Rao and Kumar (2009b) found near unit income elasticity. Both studies confirmed that the interest rate elasticity is negative and significant.

**Table 4.22 Estimates of the Canonical Equation 1970-2009**

**Dependent Variable: ln*m***

| Country group/ Method | Fixed Effects | | Random Effects | |
|---|---|---|---|---|
| | ln*y* | *R* | ln*y* | *R* |
| *PICs* | | | | |
| Pedroni | 1.071 | -0.014 | 1.097 | -0.019 |
| | (14.86)* | (6.85)* | ( 32.91)* | ( 7.64)* |
| Mark and Sul | 0.925 | -0.022 | 0.937 | -0.038 |
| | (16.00)* | (4.45)* | (24.47)* | (3.95)* |
| Breitung | 1.124 | -0.032 | | |
| | (23.73)* | (7.31)* | | |
| *Asian* | | | | |
| Pedroni | 1.100 | -0.023 | 0.994 | -0.011 |
| | (16.32)* | (4.70)* | ( 22.53)* | ( 3.54)* |
| Mark and Sul | 1.029 | -0.031 | 1.030 | -0.076 |
| | (10.28)* | (9.98)* | (14.35)* | (7.35)* |
| Breitung | 0.922 | -0.009 | | |
| | (13.55)* | (4.36)* | | |
| *African* | | | | |
| Pedroni | 1.270 | -0.095 | 1.099 | -0.073 |
| | (19.52)* | (6.04)* | ( 32.78)* | (5.27)* |
| Mark and Sul | 1.126 | -0.024 | 1.148 | -0.014 |
| | (25.00)* | (4.11)* | (21.44)* | (8.06)* |
| Breitung | 1.320 | -0.014 | | |
| | (12.25)* | (7.52)* | | |
| *LACs* | | | | |
| Pedroni | 0.890 | -0.102 | 1.174 | -0.042 |
| | (14.45)* | (7.78)* | (18.05)* | (5.04)* |
| Mark and Sul | 1.003 | -0.093 | 1.046 | -0.104 |
| | (12.87)* | (6.36)* | (20.86)* | (4.72)* |
| Breitung | 0.962 | -0.115 | | |
| | (26.01)* | (3.57)* | | |
| *OECD* | | | | |
| Pedroni | 0.521 | -0.088 | 0.602 | -0.079 |
| | (28.15)* | (6.03)* | (27.25)* | (9.32)* |
| Mark and Sul | 0.670 | -0.074 | 0.712 | -0.094 |
| | (32.04)* | (3.18)* | (16.66)* | (7.74)* |
| Breitung | 0.665 | -0.016 | | |
| | (24.54)* | (4.59)* | | |

Notes: Absolute t-ratios are in the parentheses and * indicates significance at the 5% level.

**Table 4.23 Estimates of the Extended Equation 1970-2009**

**Dependent Variable: ln*m***

| Country group/ Method | Fixed Effects | | | | Random Effects | | | |
|---|---|---|---|---|---|---|---|---|
| | ln*y* | *R* | ln*E* | $\pi$ | ln*y* | *R* | ln*E* | $\pi$ |
| *PICs* | | | | | | | | |
| Pedroni | 1.237 | -0.039 | 0.113 | -0.059 | 1.370 | -0.174 | 0.321 | -0.025 |
| | (23.26)* | (12.21)* | (0.74) | (1.47) | (10.42)* | (1.49) | (1.68)** | (1.36) |
| Mark and Sul | 0.858 | -0.021 | 0.030 | -0.132 | 1.200 | -0.055 | 0.493 | -0.122 |
| | (18.93)* | (8.20)* | (1.78)** | (1.25) | (8.50)* | (2.47)* | (1.30) | (1.71)** |
| Breitung | 0.923 | -0.126 | 0.328 | -0.054 | | | | |
| | (9.07)* | (3.45)* | (0.69) | (1.82)** | | | | |
| *Asian* | | | | | | | | |
| Pedroni | 0.985 | -0.120 | 0.054 | -0.113 | 1.144 | -0.048 | 0.327 | -0.040 |
| | (32.56)* | (12.57)* | (4.52)* | (1.36) | (16.53)* | (3.64)* | (1.26) | (1.32) |
| Mark and Sul | 1.061 | -0.058 | 1.320 | -0.004 | 0.931 | -0.007 | 0.121 | -0.093 |
| | (13.40)* | (6.42)* | (0.64) | (0.91) | (8.53)* | (1.72)** | (1.84)** | (1.20) |
| Breitung | 1.047 | -0.036 | 0.400 | -0.031 | | | | |
| | (9.37)* | (1.58) | (1.43) | (1.85)** | | | | |
| *African* | | | | | | | | |
| Pedroni | 1.205 | -0.037 | 0.144 | -0.007 | 1.144 | -0.048 | 0.327 | -0.040 |
| | (22.10)* | (5.00)* | (0.93) | (1.48) | (16.53)* | (3.64)* | (1.26) | (1.32) |
| Mark and Sul | 1.327 | -0.008 | 0.372 | -0.134 | 0.995 | -0.137 | 0.024 | -0.046 |
| | (16.58)* | (2.12)* | (1.66)** | (1.82)** | (10.33)* | (4.02)* | (1.35) | (1.29) |
| Breitung | 1.248 | -0.167 | 0.001 | -0.239 | | | | |
| | (16.74)* | (4.28)* | (1.05) | (1.43) | | | | |

## Table 4.23 Estimates of the Extended Equation 1970-2009

**Dependent Variable: ln*m***

| Country group/ Method | Fixed Effects | | | | Random Effects | | | |
|---|---|---|---|---|---|---|---|---|
| | ln*y* | *R* | ln*E* | $\pi$ | ln*y* | *R* | ln*E* | $\pi$ |
| *LACs* | | | | | | | | |
| Pedroni | 1.529 | -0.060 | 0.052 | -0.100 | 1.144 | -0.048 | 0.327 | -0.040 |
| | (13.18)* | (2.53)* | (1.23) | (0.78) | (16.53)* | (3.64)* | (1.26) | (1.32) |
| Mark and Sul | 1.028 | -0.168 | 0.070 | -0.042 | 0.995 | -0.137 | 0.024 | -0.046 |
| | (13.02)* | (1.62) | (2.06)* | (1.53) | (10.33)* | (4.02)* | (1.35) | (1.29) |
| Breitung | 0.840 | -0.064 | 0.480 | -0.035 | | | | |
| | (12.54)* | (1.88)** | (1.54) | (1.83)** | | | | |
| *OECD* | | | | | | | | |
| Pedroni | 0.711 | -0.162 | 0.041 | -0.131 | 0.540 | -0.011 | 0.021 | -0.101 |
| | (26.84)* | (3.05)* | (1.98)* | (2.00)* | (18.50)* | (2.53)* | (1.86)** | (3.39)* |
| Mark and Sul | 0.520 | -0.042 | 0.003 | -0.035 | 0.627 | -0.039 | 0.050 | -0.087 |
| | (18.73)* | (5.72)* | (1.68)** | (2.52)* | (17.84)* | (3.52)* | (2.38)* | (4.25)* |
| Breitung | 0.600 | -0.068 | 0.102 | -0.047 | | | | |
| | (22.64)* | (7.75)* | (2.01)* | (5.82)* | | | | |

Notes: Absolute t-ratios are in the parentheses and * indicates significance at the 5% level. PICs, Asian, African, LAC and OECD represents Pacific Islands, Asian developing, African, Latin American and advanced OECD countries.

Tables 4.22 and 4.23 provide the estimated panel group cointegrating estimates for canonical and extended equations with these three methods. Since the panel group estimates are vital for our main discussion, estimates of the individual country cointegrating parameters are not reported. It is also not unlikely that some of these individual estimates will have unexpected magnitudes and signs. However, I found that for most countries the long run elasticities are plausible.

Based on the results attained from the three methods, it can be inferred that canonical specification performs better than extended specification for developing countries (PICs, Asian, African and Latin American countries). Estimates of income elasticity and semi-interest elasticity vary only marginally in these three methods and both parameters are statistically significant at the 5% level. The income elasticity is very close to unity and the rate of interest coefficient has the expected negative signs. For advanced OECD countries, both canonical and extended specifications yield plausible estimates. The income elasticity is less than unity and the estimates of the cost of holding money variables have expected signs and magnitudes. All estimates are statistically significant at the 5% level.

Observing the significance level of the estimates it is difficult to admit that the Mark-Sul and Breitung methods are conclusively more efficient than the Pedroni method. However, in comparison to the Pedroni and Mark and Sul methods that assume a single cointegration equation, Breitung is a system method and allows for the existence of multiple cointegrating equations, see Flowchart 3.2. While these alternative methods may be theoretically more efficient in finite samples, each method may perform differently depending on the estimated relationship and data. On the basis of the above estimates I may conclude that income elasticity is about unity in developing countries and less than unity in advanced OECD countries. The panel income elasticities are comparable to what is attained in the country-specific results and most importantly the theoretical implications that quantity theory of money and Baumol-Tobin model is valid, respectively, for developing and advanced OECD countries.

### *4.5.5 Structural Breaks and Sub-Sample Estimates*

It is likely that financial reforms may have caused structural breaks in the money demand relationship and therefore it is envisage examining the impact of these financial reforms. Financial reforms have been implemented in many countries from the early 1980s to the late 1990s but it is hard to argue that all these countries have undergone reforms process at the same time. Indeed it is difficult to select a common break date for all these countries. Flowchart 3.3 illustrates that if structural breaks are to be investigated in a panel framework then Westerlund (2006) or Banerjee and Carrion-i-Silvestre (2006) tests could be used. Therefore I utilise the recently developed Westerlund (2006) structural break tests to investigate the break dates in the sample. Table 4.24 reports the single endogenous break results in the intercepts and trends.[145]

**Table 4.24 Westerlund Tests for Structural Breaks 1970-2009**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | *FJI* | *PNG* | *WSM* | *SLB* | *VUT* | *BGD* | *MMR* | *IND* | *IDN* | *IRN* | *ISR* |
| Break Date | 1988 | 1996 | 1989 | 2001 | 1984 | 1985 | 1996 | 1979 | 1984 | 1987 | 1994 |
| Country | *JOR* | *KOR* | *KWT* | *MYS* | *NPL* | *PAK* | *OMN* | *PHL* | *SGP* | *LKA* | *SYR* |
| Break Date | 1992 | 1994 | 1978 | 1999 | 1980 | 1986 | 2002 | 1994 | 1990 | 2000 | 1995 |
| Country | *THA* | *CMR* | *KEN* | *ZAF* | *RWA* | *EGY* | *ETH* | *CIV* | *MWI* | *NGA* | *UGA* |
| Break Date | 1980 | 1983 | 1986 | 1995 | 1999 | 1982 | 1988 | 2001 | 2002 | 1980 | 1991 |
| Country | *ARG* | *BRA* | *BOL* | *CHL* | *COL* | *ECU* | *PER* | *URY* | *VEN* | *MEX* | *AUS* |
| Break Date | 1981 | 1988 | 2003 | 1979 | 1984 | 1992 | 1985 | 1987 | 1980 | 1993 | 1984 |
| Country | *AUT* | *CAN* | *DNK* | *GRC* | *JPN* | *NOR* | *NZL* | *CHE* | *USA* | | |
| Break Date | 1995 | 1977 | 1984 | 1999 | 2000 | 1987 | 1986 | 1996 | 1981 | | |

Note: Single endogenous break dates are reported.

Although it is difficult to develop sub-samples based on different break dates, we adopt the following pragmatic approach to analyse the impact of financial reforms. Respectively the developing and advanced OECD countries are grouped into two types i.e., countries that had an early break date and those that had a late break date.

[145] Although it is also possible to test for multiple breaks I decided to test for one dominant break because the data covers relatively short period of about 40 years. Multiple breaks may also give conflicting break dates and dramatically increase the number of sub-samples. Therefore, testing for a single dominant break is a pragmatic option.

1985 and 1995 are selected as early and late break dates, respectively. It is observed that majority of the countries have undergone structural changes which I assume is due to financial reforms at different, but close time periods. For developing countries, there are twenty three countries (Fiji, Samoa, Vanuatu, Bangladesh, India, Indonesia, Iran, Kuwait, Nepal, Pakistan, Thailand, Cameroon, Kenya, Egypt, Ethiopia, Nigeria, Argentina, Brazil, Chile, Columbia, Peru, Uruguay and Venezuela) with early break dates sometime during the 1970s and 1980s. However, twenty developing countries (PNG, Solomons, Myanmar, Israel, Jordon, Korea, Malaysia, Oman, the Philippines, Singapore, Sri Lanka, Syria, South Africa, Rwanda, Ivory Coast, Malawi, Uganda, Bolivia, Ecuador and Mexico) have late break dates occurring in the 1990s and 2000s, which may be due to a late start of financial reforms. For advanced OECD economies, six countries (Australia, Canada, Denmark, Norway, New Zealand and the USA) had early break dates and four countries (Austria, Greece, Japan and Switzerland) had late break dates. Consequently the pre-reform sub-samples are 1970-1984 and 1970-1994 and the post-reform sub-samples are 1985-2009 and 1995-2009.

So what is expected from the sub-sample results? If financial reforms have been effective, it is to be expected that there will be support for some economies of scale in the use of *M1* and the response to the rate of interest will improve because of more market dominated interest rate policies. Consequently, it is to be expected in the second set of sub-samples income elasticity will show a decline and the absolute value of the interest rate coefficient will increase. The instability in the demand for money may also be observed if reforms have generated considerable quantity of near monies. This should be reflected in the second set of sub-samples as lack of a well defined long run relationship between money and its determinants, i.e. cointegration tests might show that there is no cointegration among the variables. The results for cointegration tests for the sub-samples are reported in Tables A9 and A10 (see Appendix 2).

The sub-sample results reveal that the null of no cointegration is rejected by the majority of the cointegration tests at the 5% level. The more powerful ADF test statistics are significant at the conventional level in all cases. This provides strong evidence that there is cointegration in the two sets of sub-samples for developing and advanced OECD countries.

**Table 4.25 Pedroni Estimates of the Sub-period Cointegration Coefficients-Developing Countries (Dependent Variable: log*m*)**

| | Sub-sample periods | ln*y* Canonical eq | ln*y* Extended eq | *R* Canonical eq | *R* Extended eq | ln*E* Extended eq | $\pi$ Extended eq |
|---|---|---|---|---|---|---|---|
| Early Break Countries | 1970-1984 | 1.202 | 1.260 | -0.012 | -0.009 | 0.037 | -0.011 |
| | | (10.03)* | (14.04)* | (14.48)* | (11.12)* | (1.26) | (1.44) |
| | 1985-2009 | 1.110 | 1.201 | -0.026 | -0.010 | 0.040 | -0.022 |
| | | (9.85)* | (12.02)* | (8.40)* | (8.54)* | (1.57) | (1.81)** |
| Late Break Countries | 1970-1994 | 1.106 | 1.203 | -0.027 | -0.027 | 0.122 | -0.008 |
| | | (20.01)* | (23.10)* | (4.45)* | (9.82)* | (1.67)** | (1.38) |
| | 1995-2009 | 1.019 | 1.119 | -0.029 | -0.034 | 0.210 | -0.016 |
| | | (17.35)* | (12.39)* | (7.70)* | (3.02)* | (1.32) | (1.44) |

Notes: Reported are the Pedroni FMOLS estimates with trend (fixed effects). Fiji, Samoa, Vanuatu, Bangladesh, India, Indonesia, Iran, Kuwait, Nepal, Pakistan, Thailand, Cameroon, Kenya, Egypt, Ethiopia, Nigeria, Argentina, Brazil, Chile, Columbia, Peru, Uruguay and Venezuela are the countries that have an early break. Countries that have a late break are PNG, Solomons, Myanmar, Israel, Jordon, Korea, Malaysia, Oman, Philippines, Singapore, Sri Lanka, Syria, South Africa, Rwanda, Ivory Coast, Malawi, Uganda, Bolivia, Ecuador and Mexico. The absolute t-ratios are in the parentheses and * and ** indicates significance at the 5% and 10% levels, respectively.

**Table 4.26 Pedroni Estimates of the Sub-period Cointegration Coefficients-Advanced OECD Countries (Dependent Variable: log*m*)**

| | Sub-sample periods | ln*y* Canonical eq | ln*y* Extended eq | *R* Canonical eq | *R* Extended eq | ln*E* Extended eq | $\pi$ Extended eq |
|---|---|---|---|---|---|---|---|
| Early Break Countries | 1970-1984 | 0.932 | 0.960 | -0.045 | -0.009 | 0.103 | -0.031 |
| | | (7.42)* | (8.63)* | (11.35)* | (11.12)* | (3.40)* | (4.93)* |
| | 1985-2009 | 0.539 | 0.600 | -0.108 | -0.044 | 0.126 | -0.057 |
| | | (12.37)* | (9.41)* | (7.38)* | (7.17)* | (2.18)* | (2.41)* |
| Late Break Countries | 1970-1994 | 0.726 | 0.684 | -0.058 | -0.145 | 0.122 | -0.018 |
| | | (10.45)* | (8.16)* | (2.63)* | (2.89)* | (4.57)* | (2.36)* |
| | 1995-2009 | 0.708 | 0.527 | -0.120 | -0.235 | 0.128 | -0.022 |
| | | (11.40)* | (6.59)* | (3.00)* | (3.47)* | (2.35)* | (2.16)* |

Notes: Reported are the Pedroni FMOLS estimates with trend (fixed effects). Australia, Canada, Denmark, Norway, New Zealand and USA are the countries that have an early break. Countries that have a late break are Austria, Greece, Japan and Switzerland. The absolute t-ratios are in the parentheses and * and ** indicates significance at the 5% and 10% levels, respectively.

The cointegrating coefficients for two sets of sub-samples for developing and advanced OECD countries are reported in Tables 4.25 and 4.26. All the estimated coefficients have the expected signs and are statistically significant at the 5% level, except the estimates of exchange and inflation rates in extended equation of developing countries. For developing countries the estimates of canonical equation show that in the post-reforms periods the income elasticity has slightly declined and the rate of interest coefficient has slightly increased in absolute value. The income elasticity is around unity and the magnitude of the rate of interest is plausible.

Estimates of canonical and extended equations for advanced OECD countries show that in post-reforms period the income elasticity has decreased and the coefficient of rate of interest (absolute value) has increased. For countries with early break income elasticity in canonical equation has declined from 0.93 to 0.54 and for the late break countries from 0.73 to 0.71. The absolute value of the coefficient of the rate of interest has increased from 0.01 to 0.03 and from 0.06 to 0.12 for the early and late break countries, respectively. Fairly similar change in elasticities is observed for the extended equation. These results imply that in the post-reforms period scale economies have improved although this is more in advanced countries that had an early break. On the basis of these results it can be concluded that reforms did improve the expected scale and rate of interest effects. Importantly, there is no evidence that a well-defined long run demand for money function does not exist. This finding is consistent with my earlier findings, for example see Kumar (2010a), Kumar et al. (2011) and Rao and Kumar (2009b).

**4.6 Panel Granger Causality Tests**

Testing for causality can provide useful insights on the relationship between the money demand and its determinants. Flowchart 3.3 illustrates that once meaningful estimates from cointegration are attained then causality can be tested between the variables. In this study, Hurlin (2004) and Hurlin and Venet's (2001) Granger non-causality tests are applied to test for causality between real income, real *M1* and inflation rate. This test is suitable for heterogeneous panel data models and assumes that there are balanced panels and identical lag orders for all cross section units. The *F*-tests are utilised to formulate inferences related to Granger non-causality. If the null hypothesis is not rejected, this means that there exists no causality between the variables. According to Hurlin and Venet (2001), analysis of causality for panel data sets should consider the different sources of heterogeneity of the data-generating process. In this study I only test the heterogeneous non-causality hypothesis based on the fixed effects models for advanced OECD and developing countries. These results are tabulated in Table 4.27.

The lag lengths are selected using the AIC criteria. The maximum lag length used is three, however in most cases lag lengths of one or two are applied. In all cases the *F*-test rejected the null hypothesis at conventional levels, except between i) ln*m* and ln*y* and ii) ln*m* and Δln*y* for developing countries. This implies that there exists uni-directional causality from real *M1* to real income in developing countries. The results largely support bi-directional causality between i) real income and inflation rate and ii) real *M1* and inflation rate for developing countries. For advanced OECD countries there exists a bi-directional causality between real *M1*, real income and inflation rate.

**Table 4.27 Panel Granger Causality Tests- 1970-2009**

| Dependent Variable | Explanatory Variable | Advanced OECD Countries *F Tests* | Developing Countries *F-Tests* |
|---|---|---|---|
| ln*m* | ln*y* | 14.630 (0.00)* | 1.236 (0.27) |
| ln*y* | ln*m* | 11.263 (0.00)* | 8.201 (0.00)* |
| ln*m* | Δln*y* | 8.399 (0.00)* | 2.759 (0.18) |
| ln*y* | Δln*m* | 15.559 (0.00)* | 5.294 (0.03)* |
| ln*m* | $\pi$ | 3.911 (0.07)** | 12.370 (0.00)* |
| $\pi$ | ln*m* | 9.473 (0.00)* | 9.047 (0.01)* |
| ln*m* | $\Delta\pi$ | 13.434 (0.00)* | 4.114 (0.03)* |
| $\pi$ | Δln*m* | 9.229 (0.00)* | 14.209 (0.00)* |
| ln*y* | $\pi$ | 10.404 (0.00)* | 4.004 (0.06)** |
| $\pi$ | ln*y* | 12.005 (0.00)* | 3.925 (0.07)** |
| ln*y* | $\Delta\pi$ | 10.324 (0.00)* | 10.104 (0.00)* |
| $\pi$ | Δln*y* | 4.037 (0.06)** | 6.738 (0.02)* |

Notes: The *p* values are reported below the *F*-statistics. Significance at 5% and 10% levels are denoted by * and **.

Since Granger causality and economic causality are not the same, it is difficult to make any policy recommendations. However, Granger causality results may be helpful for forecasting purposes.

### 4.7 Extreme Bounds Analysis

To check the robustness of the variables used in cointegration analysis, I perform the Leamer's (1983 & 1985) extreme bounds analysis (*EBA*). This provides justification for the specifications of money demand I have used; Flowchart 3.3 illustrates the relevance of this test.[146] Essentially, *EBA* estimates regressions with all likely combinations of three independent variables at a time. In these estimates, one or two variables, usually included in many regressions, are retained as MUST variables in all combinations of the estimates. In this study, I used GDP as the MUST variable. In most money demand specifications, GDP is the scale variable, for example among others see Laidler (1977) where real GDP is treated as the scale variable for narrow and broad definitions of money.

Leamer (1983), and Levine and Renelt (1992) have treated a variable as robust if its coefficient did not change sign in the estimates with all combinations of the three independent variables. Recently, Sala-i-Martin (1997a & b) modified the traditional EBA because at times the traditional criterion becomes too stringent in the sense that a variable is deemed fragile even if it changes sign only once. Sala-i-Martin suggested utilising the cumulative distribution functions (CDF) of the estimated coefficients to determine the robustness of the variable. Here the 95% probability level as the critical value is used. According to this new criterion a variable becomes fragile only if its coefficient changes sign in more than 5% of the estimates.

Tables 4.28 and 4.29 provides the *EBA* results for the robustness of five variables viz. short-term rate of interest ($R$), rate of inflation ($\pi$), tightness of credit conditions ($CC$) (measured with the difference between the short-term rate of interest and the long-term rates of interest), long-term rate of interest ($RL$) and the log of the

[146] EBA is well explained by Levine and Renelt (1992) and Sala-i-Martin (1997a & b).

exchange rate (ln$E$). These are proxies for the cost of holding money which are often included in the specifications of the demand for money functions. Although the short-term nominal rate of interest is widely used as a proxy for the cost of holding money, in many empirical studies its estimates are statistically insignificant at conventional levels, for instance see Bahmani-Oskooee and Economidou (2005) for Greece and Nielson et al. (2004) for Italy. This is not unexpected because the rate of interest is often set by the central banks (financial repression) and it does not show much variation. Therefore some researchers have used other proxies such as exchange rates, inflation rate, credit availability etc. to capture the impacts of cost of holding money.[147]

**Table 4.28 Extreme Bounds Analysis-Developing Countries 1970 to 2009**

| Variable | LR CV | Average Estimated Coefficient | S-I-M CV |
|---|---|---|---|
| $R$ | 1 | -0.003 | 1 |
| $RL$ | 0 | -0.013 | 0 |
| $CC$ | 0.11 | -0.001 | 0.32 |
| $\pi$ | 0 | -0.102 | 0 |
| ln$E$ | 0 | 0.018 | 0 |

Notes: LR CV is Levine and Renelt (1992) critical value. If it is equal to one, the variable is robust and when it is zero, the variable is fragile. S-I-M CV is Sala-i-Martin's (1997a & b) critical value. When it is $\geq 0.95$ the variable is robust. CDF is the cumulative distribution of the estimates of the coefficients.

**Table 4.29 Extreme Bounds Analysis-Advanced OECD Countries 1970 to 2009**

| Variable | LR CV | Average Estimated Coefficient | S-I-M CV |
|---|---|---|---|
| $R$ | 1 | -0.025 | 1 |
| $RL$ | 0 | -0.106 | 0 |
| $CC$ | 0 | -0.421 | 0 |
| $\pi$ | 1 | -0.079 | 1 |
| ln$E$ | 1 | 0.084 | 1 |

Notes: LR CV is Levine and Renelt (1992) critical value. If it is equal to one, the variable is robust and when it is zero, the variable is fragile. S-I-M CV is Sala-i-Martin's (1997a & b) critical value. When it is $\geq 0.95$ the variable is robust. CDF is the cumulative distribution of the estimates of the coefficients.

The credit conditions variable is expected to have a negative coefficient because when credit conditions are tight, the short-term rate increases relative to the long-

[147] For instance see, Bahmani-Oskooee and Rehman (2005) for Asian countries, Choi and Oxley (2004) for New Zealand, Juselius (1998) for Denmark, Ghartey (1998b) for Jamaica, Bahmani-Oskooee and Shabsigh (1996) for Japan, Drake and Crystal (1994) and Baba et al. (1992) for USA, Fielding (1994) for African countries and Orden and Fisher (1993) for Australia and New Zealand.

term rate and individuals hold less money. The justification for including the exchange rate is based on currency substitution. If it is expected that the domestic currency will depreciate, individuals hold more foreign currency and less domestic currency. It can also be argued that exchange rate movements are used as a proxy for the expected rate of inflation. If the domestic currency depreciates, given that it takes time for the completion of the exchange rate pass-through effects, the inflation rate will increase. Since the exchange rate is measured as foreign currency per unit of domestic currency, the sign of the coefficient of this variable is expected to be positive.

These results indicate that for developing countries only the short-term rate of interest is the robust explanatory variable. Here other proxies for the cost of holding money ($RL$, $CC$, $\pi$, $\ln E$) are fragile explanatory variables. With the exception of the long-term interest rate ($RL$) and credit conditions ($CC$), other proxies such as the short-term rate of interest, inflation and exchange rates are all robust determinants of the demand for money in advanced OECD countries. These results corroborate the earlier findings from the cointegration analysis that the canonical specification (extended specification) performs better for developing countries (advanced OECD countries). The following section tests for the stability of *M1* demand and provides discussion on monetary policy.

## 4.8 Financial Reforms, *M1* Stability and Implications on Monetary Policy

### *4.8.1 Pacific Island Countries*

The Pacific Island countries that have their own currency are Fiji, PNG, Tonga, Samoa, Solomons and Vanuatu. These island nations do have common monetary policy objectives, for instance maintaining price stability, preserving international reserves, ensuring financial sector stability and promoting growth and development. Adjustments to the bank rate are mostly made to stabilize the price levels, however other instruments are also utilised for example open market operations, reserve and liquidity asset requirements, credit limits etc. The monetary targeting framework was abandoned in the late 1990s by many countries due to the belief that economic reforms may have created significant instabilities in money demand. For example, Fiji switched to interest rate targeting in 1997. The unit income elasticity of *M1* demand in PICs implies that the long run focus should be on financial market development which will strengthen the monetary policy transmission. Many operating under fixed exchange rate regimes, the role of alternative exchange rate policies should be explored.

### *4.8.2 Asian Countries*

While many East Asian countries have liberalized their financial markets from the early 1980s, the South Asian countries were late starters and delayed reforms until the early 1990s. For instance, initiatives to reform the financial sector in Bangladesh had started in the late 1980s with the denationalisation of the *Uttara Bank* and *Pubali Bank.* Also a few new private commercial banks were given licences.[148] Similarly the Philippine economy commenced their reforms since the mid 1980s with rehabilitation of the financial system and liberalisation of the foreign exchange market. Consequently, in most Asian countries for instance, Thailand, Singapore, China, Indonesia, India and the Philippines, the central banks are using bank rate as the tool for monetary policy. Furthermore, reforms seem to have been introduced without considering the adequacy of the existing banking laws. Consequently the East Asian countries had a major financial crisis during 1997-1998. On the other hand in countries like India several non-bank financial intermediaries, known as chit-funds, were established. They have mobilized large amounts of deposits but many have become insolvent and bankrupt due to the inadequacies in the Indian banking laws.[149]

Many Asian countries are self-proclaimed inflation targeters.[150] In 2005, Bank Indonesia launched a new monetary policy framework in which inflation targeting is the major objective. The bank rate is used to achieve an inflation target. Similarly, Korea and the Philippines pursued inflation targeting regimes in 1999 and 2002, respectively, in which the central bank announces an explicit inflation target and

[148] Kumar (2011) provides details about reforms in developing countries, especially Asia and Africa.
[149] See Rao and Kumar (2009b) for more details.
[150] Comprehensive review of reform policies and monetary policy in the Asia-Pacific region can be found in Filardo and Genberg (2010), Cavoli and Rajan (2008) and Goodfriend (2007).

achieves its target directly. Malaysia shifted from fixed to floating exchange rate regimes in 2005 and since then the *ringgit* exchange rate is largely determined by *ringgit* demand and supply in the foreign exchange market. Thailand also budged from fixed to floating exchange rate system in 1997. Currently under the inflation targeting framework, the Bank of Thailand implements its monetary policy by altering short-term money market rates via the selected key policy rate, currently set at the 14-day re-purchase rate.

China has already taken a number of financial reforms to modernize its banking system. Low inflation is the main objective of monetary policy and the short-term rate of interest is influential in maintaining the inflation target. China has allowed deposit and lending rates to be more responsive to the interbank rate; although there continues to be a ceiling on deposit rates and a floor on lending rates. Similar to China, Singapore also aims for low inflation as a sound basis for sustainable economic growth. Early reforms (during the 1980s) in Singapore did improve competition and productivity in its banking sector. The monetary policy is centered on the management of exchange rate instead of the short-term rate of interest or supply of money.

Since the beginning of 1990s, liberalisation of financial exchange control has progressed apace, and Israeli economy has benefited from this in a number of ways. Israel central bank has set an inflation target as part of its monetary policy and this was first implemented in 1992. It does so by influencing the short-term rate of interest on its loans to the banks and deposits from them, and thus, via the financial markets, affects the supply of money. There are ongoing debates on whether the monetary policy for Iran and Nepal should focus on short-term interest rates. Both utilise banking profit rates, credit ceilings, exchange rates and open market operations to maintain price and financial stability. Pakistan treats monetary policy as a short-term instrument with which emerging risks can be managed. It seems that fiscal policy plays a major role in Pakistan. However, the policy (bank) rate is adjusted to maintain inflation rate within the target.

### *4.8.3 African Countries*

Many African countries delayed their financial reforms until the early 1990s. For example, the privatisation of state owned banks in Nigeria commenced in 1992. In 1993, Kenya began a major program of economic liberalisation. As part of this program, government eliminated the price controls and import licensing, removed foreign exchange controls and advanced the banking system. Ethiopia nationalised and subsequently re-organised private banks and insurance companies. Other African countries also implemented financial reforms during the 1990s but the effects have been minimal. South Africa, the economic powerhouse of Africa, has boosted its banking sector by allowing continued financial reforms. An inflation target was set by the central bank for the first time in 2000 with an average inflation rate of between 3 and 6 percent was to be achieved for 2002. Since then the short-term interest rates are used to achieve similar targets. The central banks of Egypt also meet its inflation objectives by steering the short-term interest rates.

Malawi adopted a floating exchange rate regime in 1994 and experienced a growth of nearly 13% in 1995. Economic reforms were implemented to raise the productivity, however natural disasters, rising oil prices, high interest rates, high domestic borrowing and excess liquidity, wiped away the gains recorded in previous years, led the economy into an economic crisis. The Reserve Bank of Malawi uses a combination of tools to attain its objectives of monetary policy, for instance bank rate, liquidity reserve requirements, open market operations and sales and purchases of foreign exchange. Rwanda and Uganda also liberalized their financial markets in the early 1990s. Both countries do seem to focus on monetary aggregates to achieve price and exchange rate stability.

### *4.8.4 Latin American Countries*

During the last two decades, the central banks of Latin American countries have transformed their monetary policy procedures. Most countries in the region have provided their central banks more sovereignty and placed more emphasis on inflation targeting. The monetary policy procedures have shifted towards market-based frameworks. Argentina's reform policy 'Austral Plan 1985' was significant that it increased the real holdings of money balances. It was followed by demonetization period with partial recoveries in 1987 and 1988. Monetary policy in Argentina aims to stabilize inflation rate through various policy instruments like bank rates, exchange rates etc. Ecuador and Peru also use similar monetary policy instruments.

After abandoning the fixed exchange rate regime in 1999, the Brazilian Central Bank chose to pursue floating exchange rate and opted to target inflation rate. Greater openness and liberalisation has strengthened Brazil's private sector. Bolivia implemented a number of important reforms during the 1980s, for instance, deregulation of financial sector, legalizing currency black markets, floating exchange rates etc.

From the early 1990s, Chile focused on inflation targeting scheme together with a floating exchange rate regime. Some macroeconomic stability was achieved due to these changes. Mexico experienced currency crises during 1994 and 1995 which made her to adopt floating exchange rate as the only viable option. Devaluation of the *peso* and return of high inflation in 1995 resulted in other economic shortcomings.

### *4.8.5 Advanced OECD Countries*

The advanced OECD countries have implemented a number of financial reforms throughout the 1970s and 1980s, however the process of these reforms was not uniform. A few countries, particularly Germany, Canada and the Netherlands, eliminated the bank interest rate and capital controls during the 1960s and 1970s. In some countries, for instance Australia, the USA, New Zealand and the UK, the direct price and quantity controls were accomplished by the mid-1980s. Some continental European countries and Japan deregulated their financial markets over a span of time and these depended on the nature of reforms.

Since 1989, the Reserve Bank of Australia and New Zealand started to set the official cash rate in the money market. Inflation targeting is a monetary policy framework employed in Australia and New Zealand, and such policy selection may be based on either the Taylor rule or a belief that money demand functions are unstable. Although it appears that they have been relatively successful in achieving price stability their policies have guaranteed neither balanced growth nor macroeconomic stability; this may be due to the added complexities attributable to the liberalisation of their financial markets in the 1980s. The Reserve Bank of New Zealand is also using the bank rate to attain inflation and financial stability. From the early 1980s, European countries underwent continuing economic liberalisation. The formation of the ECB in 1999 has further enhanced the ability to use cross country monetary aggregates. Money plays an important role within the ECB's monetary policy framework. The reference value of monetary growth is observed as a benchmark for assessing monetary developments in the euro area.

#### *4.8.6 M1 Stability and Policy Implications*

To examine whether these financial reforms had any significant impacts on *M1* demand, I apply structural stability tests including the *CUSUM* and the *CUSUMSQ* procedures developed by Brown et al. (1975). The *CUSUM* procedure is based on the cumulative recursive sum of recursive residuals. However, the *CUSUMSQ* framework is based on the cumulative sum of squares of recursive residuals. To draw inferences relative to the stability of the parameters and the model in particular, the *CUSUM* and *CUSUMSQ* procedures are updated recursively and are plotted against the break points. The null hypothesis of instability is rejected when the plots of the *CUSUM* and *CUSUMSQ* stay within the 5 percent significance level. However, the model is unstable when the plots of the *CUSUM* and *CUSUMSQ* move outside the 5 percent critical levels.

The *CUSUM* and *CUSUMSQ* stability tests were performed on the short run dynamic adjustment equations. The estimated short run dynamic equations are not reported but their results are discussed briefly here. The JML and GH cointegrating equations were utilised to form the *ECM* terms. The Hendry's *GETS* approach was used to estimate the short run equations; where the dependent variable is regressed on its lagged values, the current and lagged values of explanatory variables and the one period lagged residuals from the respective *JML* or *GH* cointegrating equation. For countries where both the canonical and extended equations gave plausible long run results, the estimates of extended equations are selected, however there are no significant differences in the short run results of either case. In all cases the short run dynamic estimates are statistically significant at the 5% level and the lagged error correction term has the expected negative sign; this implies a negative feedback mechanism which suggests that if there are departures from equilibrium in the previous period then this departure is reduced in the current period. The summary statistics and diagnostic test results are reasonable.

The stability of *M1* demand functions are assessed for whole-and sub-sample periods. The *CUSUMSQ* tests for sub-periods are reported in Figures A1 to A28 (see Appendix 3).[151] These stability tests illustrate that *M1* demand functions were unstable in nine countries (Israel, Korea, Singapore, South Africa, Australia, Canada, Denmark, Japan and New Zealand) over the 1984-1998 period. For Argentina, Greece and Thailand the stability of *M1* is rejected over the 1980-1995 period. These results imply that the 1980s reforms did have a significant impact on the demand for money in these countries. However this impact on stability was temporary, as stability of *M1* demand is not rejected after 1995 or 1998. Further, some instability in *M1* is observed for Switzerland and the USA during 2003 and 2005, respectively.

The observed instability in money demand functions for these countries implies that it would have been appropriate monetary policy stance for their central banks to target the rate of interest. However, there is lack of evidence to support instability in the money demand functions after 1998, except Switzerland and the USA, and therefore it would not be unreasonable if these central banks chose to switch policies and target the money supply as their instrument of monetary policy. As emphasized by Poole (1970), the money supply (rate of interest) should be targeted if money demand is stable (unstable) and targeting the rate of interest when money demand is

[151] Results for other sub-sample periods (1960-1979, 1960-1983, 1996-2009 and 1998-2009) and entire sample periods show that *M1* demand functions are largely stable. These results are not reported.

stable will accentuate instability in income. Under these circumstances, monetary targeting is the feasible policy stance for these countries.

In 1988, Switzerland introduced new liquidity prescriptions and the Swiss Interbank Clearing system (Fischer, 2005). These reforms boosted technology of the payments system, reduced the reserve requirements for banks and improved the financial management of bank assets. A more concentrated banking system was also followed in Switzerland, for example market segmentations. The US dollar has maintained its position as the world's primary reserve currency but it is gradually being challenged in that role which could have caused some instability in *M1* demand. Nevertheless the USA economy in 1990s implemented a number of financial reforms and experienced technical innovation and bubble in stock valuations. Perhaps these changes in Switzerland and the USA have resulted in large shifts in the narrow monetary aggregates in 2003 and 2005, respectively.

### 4.9 Conclusions

In this chapter, I have applied alternative time series and panel data methods to estimate demand for *M1* for developing Asian, African, Latin American, Pacific and advanced OECD countries. The flowcharts constructed in Chapter 3 are used as a guide to perform the cointegration analysis. I made the following observations from the results. First, all the empirical approaches yielded similar cointegrating coefficients although their dynamic adjustment lags are somewhat different. From this finding it can be inferred that when alternative time series and panel methods are implemented properly, it is likely they will give robust results. To this end, following the flowcharts are helpful as they illustrate the step-by-step process in applying unit root and cointegration methods and if appropriately followed robust results should be attained. Regardless of which estimation method is used, one must not lose sight of the purpose of the research and subsequent interpretation of the results.

Our results show that the canonical specification performs better for developing countries. Additional proxies for the cost of holding money such as inflation and the exchange rates are useful for advanced OECD countries. The income elasticity is around unity in developing countries and less than unity in advanced OECD countries. Low income elasticity is expected for advanced OECD countries because of their sophisticated financial systems. The estimates of the cost of holding money variables ($R$, ln$E$ and $\pi$) are statistically significant with the expected signs. There were no significant differences between the income elasticities of large and smaller developing countries or advanced OECD countries.

Due to the financial reforms of the 1980s the demand for money was unstable in many countries however, in general, the impact was not sustained. My sub-sample estimates show that the reforms have reduced the income elasticities and slightly increased the rate of interest semi-elasticity. These changes in the estimated effects on the parameters seem to be marginally higher in the countries that have implemented the reforms early (1980s) than the late reform countries (1990s). This highlights improved economies of scale, payments technology and the use of money substitutes. An implication of our results is that financial reforms may have contributed to some instability in the demand for money. But the CUSUM and CUSUMSQ stability tests show that for all countries there is no instability in *M1* demand after 1998, except for Switzerland and the USA where some instability is observed during 2003 and 2005, respectively.

According to Poole (1970), money supply is the appropriate monetary policy instrument for central banks when the demand for money is stable. I concur with his conjecture that supply of money should be targeted by the central banks of both developing and advanced countries, except Switzerland and the USA. Because of the stage of development of financial instruments and monetary policy and due to increased openness in the capital markets, there are other policy tools which could be utilised. For example the PICs have recently experienced high import growth which reduced their foreign reserves. In this case, adjusting the availability of credit could have been an effective policy stance to reduce consumption and imports, see Kumar (2010). The Asian countries, for instance Singapore and Malaysia, find it useful to use the exchange rate policy to improve their foreign reserves. Similarly, some African (for example, Malawi) and Latin American (for example, Ecuador and Peru) countries find it useful to adjust the liquidity reserve requirements and open market operations to stabilise the inflation rate and productivity growth.

The instability in *M1* demand for Switzerland and the USA implies that it is not inappropriate to use the rate of interest policy in these two economies. In the late 1980s, Switzerland introduced new liquidity prescriptions and the Swiss Interbank Clearing system which boosted technology of the payments system, reduced the reserve requirements for banks and improved the financial management of bank assets. The US dollar is the world's primary reserve currency but it is continually being challenged in that role. In the 1990s, the USA government implemented a number of financial reforms and experienced technical innovation and bubble in stock valuations. It is likely that these changes in Switzerland and the USA have resulted in large shifts in the narrow monetary aggregates, respectively, in 2003 and 2005.

The next chapter details conclusions derived from this research. It summarises some useful insights from the existing literature and details the contributions and main findings of this study. It also discusses potential limitations of the study and identifies further avenues for research applying these methods.

## CHAPTER 5: CONCLUSIONS

### 5.1 Introduction

Utilising the latest time series and panel data estimation techniques, this thesis estimated the canonical and extended specifications of the demand for narrow money (*M1*) for selected advanced OECD and developing countries. This thesis builds on my existing work (Rao and Kumar, 2011a; Kumar and Webber, 2011; Kumar et al., 2011; Kumar, 2011; Kumar et al. 2011a; Singh and Kumar, 2011; Singh and Kumar, 2010; Kumar, 2010a; Kumar, 2010b; Rao and Kumar, 2009a; Rao and Kumar, 2009b; Kumar and Manoka, 2008; Rao and Kumar, 2007; Kumar, 2007); and it also utilizes Poole's (1970) conjectures on monetary policy to draw useful inferences on monetary policy operating procedures. Further, this study offers useful contemporary methodological guidelines for practitioners who are working with non-stationary time series and panels.

This chapter is organised as follows: Section 5.2 summarises some useful insights from the existing extensive literature which was critically reviewed in Chapter 2. Sections 5.3 and 5.4 details the contributions and main findings of this study, respectively. Finally, Section 5.5 discusses potential limitations of this study and identifies future research avenues on the topic.

### 5.2 Insights from the Literature

*The Issue*

A stable money demand function is a vital condition if the supply of money to be utilised as a tool of monetary policy (Goldfeld, 1994; Serletis, 2001). Poole (1970) argued that the money supply (interest rate) should be used as a tool of monetary policy when the demand for money relation is stable (unstable). According to Poole (1970), selecting the wrong instrument will cause further instability in a country's output. The recently developed framework of Taylor (1999) together with fundamental structural changes in the money market seems to have persuaded most central banks to use the rate of interest policy and consequently, central banks now pay less attention to the stability of money demand. In my view, stability tests on the demand for money are crucial because they help central banks formulate optimal monetary policy. To this end, Poole's (1970) conjectures are essential and should not be disregarded. The money demand stability is essentially an empirical issue and given the importance of the topic, this study has provided empirical results that build on Poole's (1970) work.

*The Literature*

Keynes (1936) and Friedman (1954) highlighted the importance of the demand for money. Keynes (1936) argued that the velocity is affected by behavioral economic variables, unlike the quantity theorists of money who assumed that velocity is constant. Keynes extended the Cambridge theory of money demand by analysing the impacts of changes in income, interest rates and expectations of future changes in the interest rate on money demand (Laidler, 1969, p. 52). The Keynesian theory of demand for money states that money demand is a negative function of the interest rate. Keynes argued that liquidity preference is based on three motives for holding money viz. transactions, precautionary and speculative. He did not regard the money demand arising from transactions and precautionary motives as technically fixed in its relationship to the level of income (Laidler, 1969, p. 52). I argue that the most vital innovation in Keynes' analysis is the speculative demand for money. The primary result of the Keynesian speculative theory is that there is a negative relationship between the demand for money and interest rate.

The Keynesian view that money does not matter was opposed by the prominent Monetarist Milton Friedman. Friedman (1956) presented the quantity theory as a theory of the demand for money. Friedman assumed that money is abstract purchasing power, i.e. money is one kind of asset or a way of holding wealth for households. Money is observed as a capital good to firms that, when combined with other productive services, yields the products that firms sell (Laidler, 1969, p. 56). According to Friedman, the Keynesian distinction between 'active balances' and 'idle balances' and 'transaction balances' and 'speculative balances' is irrelevant. Each unit of money renders a variety of services that the household or firm equates at the margin. Friedman argued that money matters a great deal for nominal income and prices in the long run and that it has an important effect on fluctuations in nominal and real income in the short run. Money does not matter, however over the long run for real magnitudes. Further, Friedman argued that the money demand function is highly stable and therefore the quantity of money demanded can be predicted precisely by the money demand function. Friedman's theory of the demand for money is a reformulation of the quantity theory of money, because it leads to the quantity theory conclusion that money is the main determinant of aggregate nominal spending (Serletis, 2001, p. 65).

Baumol (1952) and Tobin (1956) analyse the costs and benefits of holding money from a transactions perspective. The Baumol-Tobin model explains how the use of money in absolutely foreseen transactions implies economies of scale and offers an interest rate elasticity that is significantly different from zero (Serletis, 2001, p. 78). While much attention here is on the role of money as a medium of exchange in the goods and services market, it does not focus explicitly on the holding of money in terms of the transactions facilitating services provided by money, whereas money demand models, such as shopping-time and cash-in-advance, focus explicitly on transactions services, see Saving (1971).

Recent developments in the literature attempt to explain whether the demand for money has become irrelevant in the process of monetary policy procedures. Supporting Poole (1970), Goodfriend (1987) pointed out the advantages for using money based operating procedures to pursue long-term price stability. Subsequently, VanHoose (1989) criticised Goodfriend (1987) on the grounds that monetary aggregates are endogenous: if money supply is targeted, then this results in the emergence of non-stationarity price levels (Duca and VanHoose, 2004, p. 250). Barro (1989) extended Goodfriend's approach by showing that interest rate policy may result in nominal changes in the expected price levels. Thornton (2004) argued that monetary policy can be implemented solely via an interest rate instrument; similar to what was suggested by Taylor (1999). Further, McCallum (2004) argued that interest rate changes will have considerable impacts on nominal aggregate demand, thus allowing central banks to control inflation in the economy.

Identifying whether the money demand function is stable is an empirical issue that provides useful insights for theory and policy making. Since the 1980s, most empirical studies have focused on analysing the impact of financial reforms and liberalisation on the stability of demand for money. Some recent studies are Orden and Fisher (1993), Haug and Lucas (1996), Cassard et al. (1997), Lutkepohl et al. (1999), Ericsson and Sharma (1998), Dekle and Pradhan (1999), Fujiki (1999), Asano (1999), Karfakis and Opoulos (2000), Nagayasu (2003), Nell (2003), Pradhan and Subaramanian (2003), Hafer and Kutan (2003), Bahmani-Oskooee and Rehman (2005), Choi and Oxley (2004), James (2005) and Rao and Kumar (2007), among others. There appears to be no consensus on whether the money demand functions became unstable after the era of financial reforms in the 1980s. Controversy remains in the literature with respect to the estimates of the income elasticities of money demand, for example above unity found by McNown and Wallace (1992) and below unity found by Ball (2001) for the USA. Moreover, a few studies, such as Batten and Hafer (1985), Kremers and Lane (1990), Monticelli and Strauss-Kahn (1993) and Yildirim (2003) present estimations of the money demand functions to draw inferences on capital mobility and currency substitution. The findings imply that common currency areas could be formed if monetary policy procedures of individual countries are similar.

To examine the sources of variation in the results across individual money demand studies, I followed Knell and Stix (2005) and performed a meta-regression analysis. The results of benchmark meta-regressions imply that income elasticities of money demand are significantly higher if broader definitions of the monetary aggregates are used. This effect is marginally higher in advanced OECD countries. The inclusion of financial innovations seems to have reduced the estimates of the income elasticity slightly more in advanced OECD than the developing countries. Further, the income elasticities are unaffected by the study characteristics, for example, type of econometric techniques used. Further, for the developing countries sample, the exchange and inflation rates do not seem to have significant impacts on income elasticity.

### 5.3 Contributions to the Literature

The stability of money demand is an empirical issue and given the significance of the topic, robust empirical results are required. Regrettably, the existing literature does not offer guidelines on identifying strong empirical evidence given the multitude of econometric methods that are on offer. Actually, most studies have utilised time series techniques[152]to estimate money demand relationships but there remains some controversial issues that are unresolved. Most of the earlier research that employed cointegration methods in estimating the money demand functions interpreted cointegration among the variables as a sign of stable money demand function, for example Arestis (1988), Karfakis (1991), Papadopoulos and Zis (1997) and Karfakis and Sidiropoulos (2000), among others. I argue that the variables in the money demand function could be cointegrated but the estimated cointegrating equation may be unstable. To this end, applied economists should utilise appropriate stability tests (for example, CUSUM (Cumulative Sum) and CUSUMSQ (CUSUM of Squares) of recursive residuals or Nyblom (1989) tests) to test for constancy of the long run estimates as well as the short run dynamics.

The investigations on how a structural change influences the money demand functions have been trivialised in the literature. Most of the earlier studies have used dummy variables to capture the impacts of structural changes on the demand for money, for example among others are Hoffman and Rasche (1991), Hayo (2000), Hafer and Kutan (2003), Choi and Oxley (2004), Maravic and Palic (2005) and Wu (2009). While this type of approach is uncomplicated, it is limited in explaining the shifts associated with the intercept, trend or regime. Perhaps including a dummy variable in the cointegrating equation could only capture the level shift. This study attempts to fill this gap by applying two structural change tests viz. Gregory and Hansen (1996a & b) and Westerlund (2006). My existing work (Rao and Kumar,

[152] The widely used single-equation and system-equation estimation methods include the London School of Economics Hendry's General to Specific (GETS), Engle and Granger's two step procedure (EG), Phillip and Hansen's fully modified ordinary least squares (FMOLS), Stock and Watson's dynamic ordinary least squares (DOLS), Johansen's maximum likelihood (JML) and Pesaran's autoregressive distributed lag model (ARDL).

2007; Rao and Kumar, 2009b) also attempted to address this issue, however it was limited to only a selection of Asian countries.

Three other issues emerge from the existing empirical literature. First, most of the earlier works (before 1990) employed the partial adjustment models (PAM) to analyse the demand for money (for example, among others are Hossain, 2006; Apostolou and Varelas, 1987; Himarios, 1986; Santomero and Seater, 1981). It is well known that the PAM approach ignores the dynamic adjustments and as a result it becomes difficult to measure the stability of the money demand. Second, a number of earlier studies (for example Diz, 1970; Brissimis and Leventakis, 1981; Panayiotopoulos, 1984; Arize et al., 1990; Hossain, 2006, among others) have ignored to investigate the integrated properties of the time series. Moreover, there is possibility of breaks in the unit roots as suggested by Perron (1989) and in such circumstances the conventional unit root test results will be biased. To fill these gaps, this study employed both conventional and structural break unit root tests.

Third, there exist contrasting views in relation to the estimates of income elasticity of money demand. Most of the studies have attained implausibly high or low income elasticity of the demand for various monetary aggregates. The Baumol-Tobin model and the quantity theory predict the income elasticity to be 0.5 and 1, respectively (Baumol, 1952; Tobin, 1956; Friedman, 1956). There exists uncertainty on what cost of holding money proxies should be used for advanced OECD and developing countries. Mundell (1963) argued that in addition to the interest rates and real income, the determinants of the demand for money should be augmented by the exchange rate. Inflation rate, capital mobility and credit availability are also frequently used in money demand estimations, see Bahmani-Oskooee and Rehman (2005) and Rao and Kumar (2011b). Thus in this study I have utilised the extreme bounds analysis to test the robustness of the determinants of the demand for money; this investigation has been ignored in the literature.

This study identifies that the money demand stability is useful for policy and it requires strong empirical investigations. To this end, the study offers structured, logical and detailed way of navigating through the empirical issues and challenges that have emerged in the literature. The first major contribution to the literature is that a wide range of latest time series and panel data techniques are used to examine the *M1* demand relationships for a large sample of countries (advanced OECD, Pacific Islands, Asian, African and Latin American). Results show that the income elasticity is less (around or slightly higher) than unity in advanced OECD (developing) countries; contrary to what is achieved by most studies in the literature. The elasticities with respect to the cost of holding money are small in magnitudes and have expected signs. These long run estimates are statistically significant at conventional levels. To this end, it could be asserted that financial markets are relatively well developed in the advanced OECD countries.

The second major contribution of this study is that a comprehensive set of unit root and cointegration tests are structured in the form of flowcharts which illustrate when it is appropriate to apply them. It is a fairly complicated task to 'systemise' the application of unit root and cointegration tests by such means because the choices depend on the wider context and usually researchers employ techniques that are relevant to the purpose of their research. However, I have considered some decisions on the basis of what the data 'are' and some others on the basis of what the researcher 'prefers'. This could serve as a useful guide to applied economists who are working with non-stationary time series and panels. This study has followed the flowcharts in order to offer examples and cross-checks of the results for specific and groups of countries using the appropriate methodologies. This thesis therefore serve as an examination of other's studies while also offering new results and establishing the degree of importance of following the correct technique.

The final major contribution of this study is associated with the process of monetary policy procedures. The stability tests on *M1* demand imply that the developing countries should re-consider their choice of using the rate of interest as an instrument of monetary policy. It appears that most developing countries are imitating the monetary policy procedures of the advanced OECD countries. It is pragmatic for the advanced OECD countries, especially Switzerland and the USA, to utilise the rate of interest policy because their money demand functions are found to be temporally unstable. In contrast there seems to be no significant evidence that the demand for money in the developing countries has become unstable. Nevertheless, central banks in many developing countries have also switched to the bank rate as their instrument of monetary policy. Such an unconsidered choice of monetary policy instrument could actually lead to increased instability in output. Hence, consistent with Poole's (1970) analysis, I conclude that the supply of money is the appropriate monetary policy instrument to be used by the central banks of developing countries.

### 5.4 Findings and Discussion

I have applied alternative time series and panel methods to estimate *M1* demand for developing (5 Pacific Islands countries, 18 Asian countries, 10 African countries and 10 Latin American countries) and advanced OECD countries (10 advanced OECD countries). The study initially applies the conventional unit root tests such as Augmented Dickey Fuller (ADF), Phillips Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) to ascertain the time series properties of the variables. As noted earlier a number of previous studies (Diz, 1970; Brissimis and Leventakis, 1981; Panayiotopoulos, 1984; Arize et al., 1990; Hossain, 2006) ignored the implications of the time series methods of estimation. Following the method outlined in Flowchart 3.1 (p. 137), the first part in cointegration analysis is testing for non-stationarity in the variables. This step is vital because most cointegration methods can be used if the variables are I(1) in levels, see Engle and Granger (1987). According to Flowchart 3.1, KPSS and PP are somewhat different than the ADF. Also note that unlike ADF and PP, KPSS tests the null hypothesis of stationarity against the alternative of a unit root. The ADF, PP and KPSS results suggest that all the variables appear to be I(1) processes, excluding Israel and Columbia where the inflation rate is stationary.

Conventional unit root tests fail to yield robust results if there are structural breaks in the data series.  Flowchart 3.1 illustrates the type of structural break unit root tests that could be used in the possibility of breaks in the data series. For robustness of the results, I applied three tests viz. Zivot and Andrews (ZA), Lee and Strazicich (LS) and Bai and Perron (BP). As illustrated in Flowchart 3.1, ZA tests for a single break and LS and BP, respectively, tests for two and multiple breaks. In the ZA and LS tests, I selected the model that considers breaks in the intercept and trend. Both tests indicated structural breaks in the series during the 1980s and 1990s for most countries and importantly, all variables are found to be I(1) in levels. The BP tests gave three break points for 24 countries (Fiji, Samoa, PNG, India, Indonesia, Israel, Jordon, Korea, Malaysia, the Philippines, Pakistan, Oman, Ivory Coast, South Africa, Rwanda, Nigeria, Uganda, Argentina, Brazil, Mexico, Canada, Denmark, Greece and New Zealand) and four breaks for six countries (Bangladesh, Singapore, Thailand, Australia, Japan and the USA). The break dates attained across the three methods are comparable, mostly located during the 1980s and 1990s. These break points appears to be related to the economic and financial incidents of these countries, for example, oil price shocks, adoption of flexible exchange rate regimes, advances in computer technology, market-oriented reforms, etc. Some countries had more break dates than others because they had a number of economic and financial incidents. My earlier work (Rao and Kumar, 2007; Kumar, 2007; Kumar and Manoka, 2008; Kumar, 2010b; Kumar, 2011; Rao and Kumar, 2009a,) did not utilise structural break unit root tests but mainly used the conventional tests like ADF and PP. In the empirical literature only a few studies used unit root tests that accommodate structural breaks, for example, see Lee and Chien (2008) and Choi and Jung (2009).

The country specific tests for cointegration among the variables in the canonical (real *M1*, real income and nominal rate of interest) and extended (real *M1*, real income, nominal rate of interest, nominal exchange rate and inflation rate) specifications of money demand are performed using the Johansen's maximum likelihood (JML) technique. Flowchart 3.2 (p. 139) illustrates that this is a system-based technique that considers testing for cointegration relationships in the context of ECMs and corrects endogeneity bias. The null of no cointegration is rejected at the 5% level for all countries, except for Korea, Malaysia, Pakistan, the Philippines, Singapore, Thailand, South Africa, Uruguay, Brazil, Australia, Japan, Canada and the USA. In my earlier work (for example see, Rao and Kumar, 2007 & 2009a), I argued that if there are structural breaks in the cointegration relationship of money demand, it is unlikely that the conventional cointegration techniques will give robust results. Further, Flowchart 3.3 (p. 141) illustrates that less robust results in cointegration analysis may be attained due to the structural breaks and thus empiricists should utilise appropriate structural change tests.

Application of five time series estimators (ARDL, GETS, EG, FMOLS and JML) revealed that the income elasticity is unity in all selected Pacific Islands, Asian, African and Latin American countries, except PNG, Oman, Cameroon, Ivory Coast, Rwanda, Ethiopia, Malawi, Uganda, Bolivia and Ecuador where it is slightly higher than unity. Alternatively, the income elasticities are less than unity for advanced OECD countries. Note that the recorded income elasticities are fairly consistent with Figure 2.1 (p. 36) which illustrates how to evaluate the income elasticity of demand for money. The consistent results attained across the five estimation techniques provide support for the canonical specification (extended specification) of money demand for developing (advanced OECD) countries.[153] Most studies (for example, see Arize, 1994; Siklos, 1995a & b; Khamis and Leone, 1999; Valadkhani, 2002) have obtained implausibly high or low income elasticity of the demand for various monetary aggregates. The Baumol-Tobin model and the quantity theory predict the income elasticity to be 0.5 and 1, respectively (Baumol, 1952; Tobin, 1956; Friedman, 1956); these were summarised in Figure 2.1. Kumar and Webber (2011) asserted that the often found income elasticity above unity is explained within the standard portfolio approach through the neglect of a wealth variable in the cointegrating vector.

Unlike the Zivot and Andrews (1992), Perron (1997), Bai and Perron (2003) and Lee and Strazicich (2003) tests, Gregory and Hansen's (1996a & b) method is a test for structural changes in the cointegrating vector. Again following the guidelines set out in my Flowchart 3.3, I used the Gregory and Hansen method to test for structural breaks in *M1* demand relationship for 12 countries (Korea, Malaysia, Pakistan, the Philippines, Singapore, Thailand, South Africa, Uruguay, Brazil, Canada, Australia, Japan and the USA). Results imply that in at least one of the four models (level shift; level shift with trend; regime shift in intercept and slope coefficients; and regime

[153] N.B. some exceptions such as India where both canonical and extended specifications produced good results. In advanced OECD countries, Austria and Switzerland's *M1* demand seems to be better explained by canonical specification.

shift in intercept, trend and slope coefficients), there is cointegration between the variables in canonical and extended equations. With the exception of Canada, Japan, Australia and the USA, the income elasticity is around unity. The costs of holding money estimates are statistically significant at the conventional levels. For Canada, Japan, Australia and the USA, income elasticity is less than unity.

Further, alternative panel data estimation methods are used to estimate the cointegrating equations for *M1* demand. Prior to applying the panel cointegration techniques, I performed the panel unit root tests to verify that all variables are integrated to the same order. In doing so, I have used the Levin, Lin and Chu (2002, LLC), Breitung (2000), Im, Pesaran and Shin (2003, IPS), ADF Fisher $\chi^2$ (ADF), PP Fisher $\chi^2$ (PP) and Hadri (2000) tests. The LLC and Breitung tests do not allow for heterogeneity in the autoregressive coefficient, while the IPS, PP and Hadri tests are less restrictive and more powerful. However, these are all first generation panel unit root tests, see Flowchart 3.1. Results from these tests indicate that the variables in level are non-stationary and stationary in first-differences.[154] According to Flowchart 3.2, if variables in a panel data are non-stationary then panel cointegration methods similar to Pedroni (2004), Breitung (2005) and Westerlund (2007) can be employed. Although the first and second generation panel unit root tests offer vital insights on integrated properties of the variables, these tests do not accommodate for structural changes. For this purpose it seems necessary for further theoretical developments with endogenous structural breaks in the panel data unit roots.

The Pedroni and Westerlund methods are utilised to test for cointegration between the variables in canonical and extended equations. Five sets of panel data are developed that grouped countries on the basis of their region, i.e. the Pacific Islands, Asian, African, Latin American and advanced OECD. It can be inferred that the variables in canonical and extended equations are cointegrated and a long run *M1* demand function exists for the groups as a whole and the members of the panels. A number of studies (Harb, 2004; Dreger et al., 2007; Carerra, 2008; Hamori, 2008;

[154] For the sake of robustness, I have also applied the second generation panel unit root test of Pesaran (2007) and found similar results.

Rao and Kumar, 2009b) have used the Pedroni method, however with the exception of Rao and Kumar (2011b), none have applied the Westerlund method. As illustrated in my Flowchart 3.3, Westerlund's method utilises the error correction framework. Further this method also has good sample properties.

Panel cointegrating equations of fixed and random effects are estimated with the Pedroni's (2004) FMOLS, Mark and Sul's (2003) DOLS and Breitung (2005) methods. Results show that canonical specification performs better than extended specification for developing countries (Pacific Islands, Asian, African and Latin American countries). Estimates of income elasticity and semi-interest elasticity vary only marginally in these three methods. The income elasticity is close to unity and the rate of interest coefficient has the expected negative signs; both parameters are statistically significant at the 5% level. For advanced OECD countries, both canonical and extended specifications gave plausible estimates. The income elasticity is less than unity and estimates of the cost of holding money variables have expected signs and magnitudes. The panel income elasticities are comparable to the country-specific estimates and imply that the quantity theory of money and Baumol-Tobin model is valid for developing and advanced OECD countries, respectively. Further, on the basis of these results it is difficult to argue that the Mark-Sul and Breitung methods are conclusively more efficient than the Pedroni method. Note that all three methods yielded similar cointegration coefficients.

The existence of a cointegrating relationship implies that there could be causality among the variables, see Flowchart 3.3. I used Hurlin (2004) and Hurlin and Venet's (2001) panel Granger causality tests to test for causality between real income, real *M1* and inflation rate. I found that a uni-directional causality runs from real *M1* to real income and a bi-directional causality runs between real income (real *M1*) and inflation rate for developing countries. For advanced OECD countries there exists a bi-directional causality between real *M1*, real income and inflation rate. Although this study fills an important gap in empirical money demand literature by applying panel Granger causality tests; it is necessary that further theoretical developments are made on the panel Granger causality tests with structural breaks.

There exists uncertainty on which cost of holding money proxies should be employed for advanced OECD and developing countries. Knell and Stix (2005) showed the impact of neglecting wealth variable on money demand relationships. Similarly, Mundell (1963) supports the use of the exchange rate in the money demand functions. Inflation rate, capital mobility and credit availability are also used in money demand estimations, see Bahmani-Oskooee and Rehman (2005) and Rao and Kumar (2011b). Following the test illustrated in Flowchart 3.3, I utilised Leamer's (1983 & 1985) extreme bounds analysis to test for robust determinants of the demand for money. Results indicate that for developing countries only the short-term rate of interest is the robust explanatory variable. Other proxies for cost of holding money (long-term interest rate, credit conditions, inflation and exchange rates) are fragile explanatory variables. With the exception of long-term interest rate and credit conditions, other proxies such as the short-term rate of interest, inflation and exchange rates are all robust determinants of the demand for money in advanced OECD countries. These results corroborate with the earlier findings that canonical specification (extended specification) performs better for developing countries (advanced OECD countries).

Stability of *M1* demand is analysed through the application of Westerlund's (2006) structural break and Brown et al.'s (1975) CUSUM and CUSUMSQ of recursive residuals tests. According to my Flowchart 3.3, Westerlund (2006) or Banerjee and Carrion-i-Silvestre (2006) tests could be utilised to test for structural breaks in the panel data. While Westerlund's method considers breaks in the intercept and trend, Banerjee and Carrion-i-Silvestre's test accommodates breaks in the panel cointegrating vector. Although the latter is more demanding, it is a complicated test to perform in GAUSS 11.0 and to this end theoretical econometricians should re-focus on its application procedures so that it becomes more explicit to researchers. Application of the Westerlund method yielded break dates mostly in the 1980s and 1990s. Consequently, I selected 1985 and 1995 as early and late break dates, respectively, to develop pre- and post-reform sub-samples. My sub-sample estimates show that reforms have reduced the income elasticities and the rate of interest semi-elasticity has increased in absolute value. In the context of money demand, this highlights improved economies of scale, payments technology and the use of money substitutes. An implication of our results is that financial reforms may have contributed to some instability in the demand for money. But when structural changes are allowed the pre- and post-reforms sub-sample estimates imply that there is a stable and well-defined demand functions for money in all sub-samples. The changes in the estimated effects on the parameters seem to be marginally higher in the countries that implemented reforms early. This finding is consistent with my earlier findings, for example see Kumar (2011), Kumar et al. (2011) and Rao and Kumar (2009b).

The stability of *M1* demand functions are also assessed using the CUSUM and CUSUMSQ tests. These stability tests illustrate that *M1* demand functions were unstable in nine countries (Israel, Korea, Singapore, South Africa, Australia, Canada, Denmark, Japan and New Zealand) over the 1984-1998 period. For Argentina, Greece and Thailand the stability of *M1* demand is rejected over the 1980-1995 period. These findings suggest that the 1980s reforms did have a significant impact on the demand for money.[155] However, the impact on *M1* stability was transitory, as stability of *M1* demand is not rejected after 1995 or 1998, except for Switzerland and the USA where some instability is observed during 2003 and 2005, respectively.

An important implication of our findings is that the central banks in these countries, except Switzerland and the USA, should reconsider their choice of using the interest rate as their monetary policy instrument because according to Poole (1970) money supply should be used as the monetary policy instrument when the demand for money is stable. In other words, it would not have been unreasonable for their central banks to use the rate of interest as an instrument of monetary policy during the period of instability.

The instability in *M1* demand for Switzerland and the USA implies that it is not unsuitable to use the rate of interest policy in these two economies. In the late 1980s,

[155] The switch from money supply to interest rate, as the monetary policy instrument, has taken place in the advanced OECD countries due to the belief that financial market reforms may have contributed to instability in money demand functions. One of the main objectives of monetary policy in advanced OECD countries is attaining inflation and financial stability and these goals are achieved via adjustments in short-term interest rates.

Switzerland initiated new liquidity prescriptions and the Swiss Interbank Clearing system which enhanced technology of the payments system, reduced the reserve requirements for banks and improved the financial management of bank assets. In the 1990s, the US Federal Reserve / Treasury implemented a number of financial reforms and, consequently the economy underwent technical innovation and investment bubble in stock valuations. It is likely that these changes in Switzerland and the USA have resulted in large shifts in the narrow monetary aggregates, respectively, in 2003 and 2005.

The central banks in many developing countries have also switched to the bank rate as their instrument of monetary policy. Financial market reforms in most developing countries started in the early 1980s and by end of the 1990s most central banks had formally or informally abandoned monetary targeting in favour of the rate of interest policy. A significant number of studies show that the demand for money had become unstable due to financial reforms and therefore led support the use of rate of interest policy by the central banks, for instance see McPhail (1991), Haug (1999), Caporale and Gil-Alana (2005) and Maki and Kitasaka (2006). In contrast, several studies favour monetary aggregates in the monetary policy procedure because they found limited evidence of instability in the money demand functions (Bahmani-Oskooee and Rehman, 2005; Das and Mandal, 2000 and Rao and Kumar, 2009a). My earlier work (Kumar, 2011; Singh and Kumar, 2011; Singh and Kumar, 2010; Rao and Kumar, 2009a; Rao and Kumar, 2009b; Kumar and Manoka, 2008; Rao and Kumar, 2007; Kumar, 2007) showed that money demand functions were stable in developing countries over the time period 1970-2007 and continued use of the money supply as the monetary policy instrument by the respective central banks was feasible. This is reinforced in this study.

### 5.5 Limitations and Future Research

Poole (1970) emphasized that the choice between the monetary policy instruments should depend on the stability of money demand. He pointed out that when the money demand function is unstable (stable), it is feasible for the central bank to utilize the rate of interest (money supply) as an instrument of monetary policy. This study has built on Poole's work and has offered new results to establish the degree of importance of using correct instrument for monetary policy. Although this study has potential limitations it is consistent with Poole's (1970) analysis.

Given that the demand for money is a broad area of research, it is therefore difficult to address all issues in a single piece of research. Effectively constraint by this, this study has focused on investigating mainly the stability of the demand for money. To this end, the research builds on the conjectures made by Poole (1970) but there are a number of recent studies that have proposed alternative frameworks for monetary policy, for example see Taylor (1999), Goodfriend (1987), Woodford (2003) and McCallum (2004), among others. Central banks of most countries seem to be attracted to these new frameworks which directly or indirectly support the rate of interest policy. Moreover, the decisions on monetary policy operating procedures also depend on the objectives and interests of the Monetary Policy Committees which may be independent to these frameworks. Further, the research did not consider the theoretical insights provided by Goodhart (1975). Goodhart's law effectively states that what is stable in normal conditions breaks down once it is used for control purposes. To this end, the stability of money demand may not be a valid condition for supply of money to be used for policy. However, further empirical investigations into the Goodhart's law would be useful future development in the literature.

Given that only *M1* demand was considered in investigating the stability, this raises the question of how consistent the conclusions are without examining the broader monetary aggregates. However I take the view that most central banks find it relatively easy to control *M1* and thus it is a useful policy instrument. Existing studies on money demand did investigate the stability of broader monetary aggregates but many found income elasticity estimates substantially larger than unity. Moreover, I did not consider the distinction between financial innovations and financial reforms and instead assumed that they are similar which may be the case only to some extent. In particular the former may be downplayed at the expense of the latter and future research could focus on analysing the individual impacts of these innovations and reforms. Further, the possibility of short sample and endogeneity biases remains in the country-specific time series estimates. Relatively small number of observations raises the concern of endogeneity and short sample bias, however according to Rao (2007b) if alternative time series methods give consistent cointegrating estimates then the aforesaid issues are minimal.

While the panel data results for the entire sample periods are reasonable and close in the alternative estimation methods, estimates for the individual countries are not always plausible. For some countries like Sri Lanka and Oman income elasticity is as high as around 4 percent and for Syria and Ethiopia it is as low as 0.2 percent and statistically insignificant at conventional levels. Such results are not unusual with panel data methods. Moreover, my choice of break dates as 1985 and 1995 are somewhat arbitrary, however for the purpose of grouping them into early and late break countries, it is important to select common break dates. Further I assumed that the break dates signify the incidences of financial reforms which may not be the case for all countries in the sample.

Given the defined boundaries of this thesis, I have not attempted to extend this work along in the lines of forecasting and policy formulation even though findings from money demand forecasts would clearly be useful in monetary policy formulations. Further, I have not discussed threshold impacts on the money demand relationship and their implications on monetary policy; again because these lie outside the boundaries of this current work, however future research could investigate the application of these techniques to these issues.

Finally, this study emphasizes that the demand for money is crucial and central banks need to monitor the stability of the money demand function to formulate optimal monetary policy. Due to financial reforms of the 1980s the demand for money was unstable in many countries however, in general, the impact was not sustained and money demand is now largely stable in most advanced OECD countries[156]. To this end, it is not unreasonable for central banks to use the supply of

[156] For our sample, excluding Switzerland and the USA.

money to attain price and macroeconomic stability. Thus continued research on money demand stability is essential.

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# APPENDICES

## APPENDIX 1: List of studies used for meta-analysis

| **Advanced OECD Countries** | **Developing Countries** |
|---|---|
| Adam (1991) | Adam (1992) |
| Akcay (1997) | Adam (1999) |
| Akhtar and Putnam (1980) | Adam (2000) |
| Alexakis (1980) | Adom et al. (2009) |
| Amano and Wirjanto (2000) | Ahumada (1992) |
| Andersen (2004) | Ahmed (2001) |
| Angelini et al. (1994) | Ahmad and Khan (1990) |
| Angeloni et al. (1994) | Akhtaruzzaman (2007) |
| Apostolou and Varelas (1987) | Akinlo (2006) |
| Arestis (1988) | Arestis and Demetriades (1991) |
| Arestis et al. (1992) | Arize and Lott (1985) |
| Arize and Shwiff (1993) | Arize and Malindretos (2000) |
| Arnold (2003) | Arrau and Gregorio (1993) |
| Artis et al. (1993) | Arrau et al. (1995) |
| Asano (1999) | Atkins (2005) |
| Baade and Nazmi (1989) | Baharumshah et al. (2009) |
| Baba (1989) | Bahmani-Oskooee (1996) |
| Baba et al. (1992) | Bahmani-Oskooee and Gelan (2009) |
| Bagliano (1996) | Bahmani-Oskooee and Malixi (1991) |
| Bahmani-Oskooee (2001) | Bahmani-Oskooee and Ng (2002) |
| Bahmani-Oskooee and Bohl (2000) | Bahmani-Oskooee and Rehman (2005) |
| Bahmani-Oskooee and Chomsisengphet (2002) | Bahmani-Oskooee and Sungwon (2002) |
| Bahmani-Oskooee and Economidou (2005) | Bahmani-Oskooee and Tanku (2006) |
| Bahmani-Oskooee et al. (1998) | Bahmani-Oskooee and Techaratanachai (2001) |
| Bahmani-Oskooee and Muge (2006) | Bhattacharya (1995) |
| Bahmani-Oskooee and Shabsigh (1996) | Bjornland (2005) |
| Ball (2001) | Blevins et al. (1999) |
| Baltensperger et al. (2001) | Bynoe (2002) |
| Batten and Hafer (1985) | Carruth and Sanchez-Fung (2000) |
| Belongia (1988) | Chan et al. (1991) |
| Blundell-Wignall and Thorp (1987) | Chen (1997) |
| Bond et al. (2007) | Cheong (2003) |
| Boothe and Poloz (1988) | Choudhry (1995a) |
| Breuer and Lippert (1996) | Choudhry (1995b) |
| Brissimis et al. (2003) | Cuthbertson and Galindo (1999) |
| Brissimis and Leventakis (1985) | Dahalan et al. (2005) |
| Bruggemann and Nautz (1997) | Dahalan et al. (2007) |
| Buch (2001) | Darrat (1986) |
| Bundesbank (1995) | Das and Mandal (2000) |
| Butter and Fase (1981) | Dekle and Pradhan (1999) |
| Capasso and Napolitano (2012) | Deng and Liu (1999) |

**Advanced OECD Countries**
Caporale and Gil-Alana (2005)
Caramazza et al. (1990)
Caruso (2006)
Cassard et al. (1997)
Cesar et al. (1990)
Cesarano (1990 & 1991)
Choi and Jung (2009)
Choi and Oxley (2004)
Choudhry (1996)
Chowdhury (1995)
Christensen and Jensen (1987)
Corker (1990)
Cover and Hooks (1993)
de Brouwer et al. (1993)
De Freitas (2006)
Dooley and Spinelli (1989)
Drake and Chrystal (1994)
Ebrill (1989)
Elysiani and Zadeh (1995)
Escribano (2004)
Ericsson et al. (1998)
Ericsson and Sharma (1998)
Ewing and Payne (1999b)
Fagan and Henry (1998)
Fase and Winder (1990 & 1996)
Fase and Winder (1996)
Felmingham and Zhang (2001)
Filosa (1995)
Friedman and Schwartz (1982)
Fujiki (1999)
Georgopoulos (2000)
Gerlach-Kristen (2001)
Grice and Bennett (1984)
Hafer and Jansen (1991)
Hall et al. (1989)
Hansen and Kim (1995)
Hayo (2000)
Haug (2006)
Haug and Lucas (1996)
Hendry (1995)
Hendry and Ericsson (1991)
Herwartz and Reimers (2003)
Herz and Roeger (1990)
Himarios (1987)

**Developing Countries**
Dobson and Ramlogan (2001)
Ewing and Payne (1999a)
Fielding (1994)
Ghartey (1998a)
Ghartey (1998b)
Gupta and Moazzami (1989)
Habibulah (1989)
Habibulah and Ghaffar (1987)
Hafer and Khutan (1993 & 1994)
Hafer and Khutan (2003)
Hall et al. (2008)
Henstridge (1999)
Hoffman and Tahiri (1994)
Hossain (1993, 2006 & 2010)
Hossain (1994)
Huang (1994)
Huang et al. (2001)
Hussain and Liew (2006)
Hussain et al. (2006)
Ibrahim (1998 & 2001)
Inoue and Hamori (2008)
James (2005)
Jayaraman and Ward (1998 & 2000)
Jenkins (1999)
Kamath (1985)
Katafono (2001)
Khamis and Leone (1999)
Khan (1980)
Khan and Ali (1997)
Kogar (1995)
Kumar (2011)
Kumar (2010b)
Kumar (2007)
Kumar and Manoka (2008)
Kumar et al. (2011a)
Lee and Chien (2008)
Majid (2004)
Marashdeh (1997)
Maravic and Palic (2005)
Melnick (1995)
Moll (2000)
Moosa (1992)
Nachega (2001)
Nag and Upadhyay (1993)

**Advanced OECD Countries**

Hoffman and Rasche (1991)
Hoffman et al. (1995)
Holman and Graves (2002)
Hoque and Al-Mutairi (1996)
Hunt and Volker (1981)
Ishida (1984)
Janssen (1998)
Kabir and Mangla (1988)
Karfakis and Opoulos (2000)
Komlos (1987)
La Cour (1999)
Leventakis (1993)
Lim (1995)
Loizos and Thompson (2001)
Lutkepohl et al. (1999)
Lutkepohl and Wolters (1998)
Maghyereh (2003)
Maki and Kitasaka (2006)
Mariscal et al. (1995)
McNown and Wallace (1992)
Monticelli and Strauss-Kahn (1993)
Muscatelli and Papi (1990)
Muscatelli and Spinelli (1996 & 2000)
Nagayasu (2003)
Nielsen (2007)
Orden and Fisher (1993)
Ordonez (2003)
Pagan and Volker (1981)
Panayotopoulos (1983)
Papadopoulos and Zis (1997)
Peytrignet and Stahel (1998)
Poloz (1980)
Rao and Kumar (2011a)
Schebeck and Thury (1987)
Sekine (1998)
Serletis (1987)
Shekar and Hafizur (1996)
Sterken (1992)
Swamy (1987)
Taylor (1986)
Traa (1991)
Valadkhani (2002)

**Developing Countries**

Nair et al. (2008)
Narayan (2007)
Nell (1999 & 2003)
Nisar and Aslam (1983)
Offenbacher and Kamel (2007)
Padhan (2006 & 2011)
Pinon-Farah (1998)
Pradhan and Subramanian (1997 & 2003)
Price and Insukindro (1994)
Price and Nasim (1999)
Qayyum (1998, 2001 & 2005)
Qin (1994)
Ramachandran (2004)
Ramos-Francia (1993)
Randa (1999)
Rao and Kumar (2007)
Rao and Kumar (2009a)
Rao and Shalabh (1995)
Rao and Singh (2005a & b)
Rao and Singh (2005c)
Rodriguez and Turner (2003)
Samudram (1981)
Sanchez-Fung (2007)
Simmons (1992)
Singh and Kumar (2010)
Singh and Kumar (2011)
Singh and Pandey (2009)
Slavova (2003)
Soto and Tapia (2001)
Sterken (2004)
Sumner (2009)
Tabesh (2000)
Tan (1997)
Teriba (2006)
Thornton (1996)
Tlelima and Turner (2004)
Turner and Benavides (2001)
Weliwita and Ekanayake (1998)
Wesso (2002)
Wu (2009)
Wu et al. (2005)
Wu and Hu (2007)

**Advanced OECD Countries**
Valadkhani (2005)
Vega (1998)
Wolters et al. (1998)
Yildirim (2003)
Yoshida (1990)
Yoshida and Rasche (1990)
Ziegelschmidt (1985)

**Developing Countries**
Yashiv (1994)
Yu and Gan (2009)

## APPENDIX 2

## Table A1. ADF Unit Root Tests- Pacific Islands and Asian Countries

| *Country* | $\ln m_t$ | $\Delta\ln m_t$ | $\ln y_t$ | $\Delta\ln y_t$ | $R_t$ | $\Delta R_t$ | $\ln E_t$ | $\Delta\ln E_t$ | $\pi_t$ | $\Delta\pi_t$ |
|---|---|---|---|---|---|---|---|---|---|---|
| *PICs* | | | | | | | | | | |
| FJI | -1.266 (2) | -3.475 (0) | -0.256 (1) | -4.377 (0) | -2.003 (1) | -3.211 (1) | -0.998 (1) | -4.568 (3) | -4.452 (1) | -3.400 (1) |
| PNG | -2.370 (1) | -5.869 (2) | -2.573 (0) | -8.964 (2) | -2.746 (2) | -3.638 (1) | -1.455 (4) | -4.569 (0) | -1.007 (1) | -3.294 (2) |
| WSM | -2.120 (2) | -4.568 (1) | -2.105 (3) | -3.362 (2) | -2.552 (3) | -3.208 (2) | -0.780 (0) | -9.201 (3) | -0.256 (1) | -3.284 (0) |
| SLB | -0.790 (3) | -5.792 (1) | -0.346 (4) | -8.914 (1) | -0.293 (2) | -3.711 (3) | -1.232 (1) | -7.207 (3) | -2.127 (2) | -3.118 (0) |
| VUT | -1.519 (0) | -7.976 (0) | -2.239 (1) | -6.075 (0) | -0.360 (1) | -4.313 (2) | -0.980 (3) | -6.235 (1) | -1.675 (4) | -5.362 (1) |
| *Asian* | | | | | | | | | | |
| BGD | -1.266 (2) | -3.455 (2) | -1.677 (0) | -4.667 (1) | -2.376 (0) | -3.276 (2) | -2.200 (0) | -3.283 (0) | -0.736 (1) | -2.976 (0) |
| MMR | -2.765 (4) | -4.300 (0) | -2.113 (2) | -6.378 (0) | -1.400 (1) | -8.297 (0) | -2.179 (1) | -3.100 (0) | -2.837 (1) | -3.125 (1) |
| IND | -0.264 (2) | -4.561 (2) | -0.870 (0) | -3.467 (1) | -2.356 (2) | -5.380 (3) | -0.251 (2) | -4.290 (3) | -0.267 (0) | -3.436 (3) |
| IDN | -2.006 (0) | -7.823 (1) | -1.247 (1) | -9.459 (4) | -0.052 (0) | -9.005 (5) | -0.899 (1) | -5.900 (0) | -2.835 (0) | -3.161 (4) |
| IRN | -1.232 (1) | -2.999 (0) | -1.554 (0) | -4.500 (0) | -2.670 (1) | -3.002 (1) | -1.247 (0) | -4.291 (1) | -1.256 (1) | -3.343 (2) |
| ISR | -0.926 (3) | -3.246 (2) | -1.439 (3) | -3.097 (4) | -1.236 (1) | -4.276 (2) | -1.078 (1) | -3.289 (1) | -3.267 (1) | -2.969 (0) |
| JOR | -1.255 (1) | -4.771 (0) | -0.786 (6) | -8.836 (3) | -2.387 (2) | -2.995 (3) | -0.221 (1) | -3.367 (1) | -1.289 (0) | -3.126 (0) |
| KOR | -1.560 (0) | -3.455 (1) | -2.451 (0) | -3.221 (0) | -0.678 (2) | -7.356 (0) | -2.466 (4) | -5.377 (0) | -1.439 (3) | -4.061 (2) |
| KWT | -3.300 (0) | -4.326 (2) | -2.007 (3) | -3.001 (0) | -1.254 (1) | -5.255 (2) | -1.200 (1) | -4.081 (1) | -0.200 (2) | -4.765 (0) |
| MYS | -1.255 (2) | -5.635 (2) | -1.650 (3) | -4.650 (2) | -1.388 (2) | -3.254 (1) | -0.081 (0) | -3.123 (0) | -1.006 (0) | -6.032 (3) |
| NPL | -0.669 (0) | -3.277 (4) | -0.878 (4) | -5.378 (1) | -1.280 (1) | -4.087 (1) | -1.256 (2) | -3.072 (1) | -1.137 (2) | -3.135 (0) |
| PAK | -2.190 (5) | -8.025 (2) | -0.960 (2) | -3.056 (5) | -0.627 (1) | -7.008 (4) | -2.007 (0) | -8.016 (2) | -1.780 (1) | -3.877 (0) |
| OMN | -1.200 (1) | -3.400 (1) | -1.336 (0) | -2.995 (0) | -0.980 (0) | -3.086 (1) | -0.800 (0) | -5.073 (4) | -0.038 (1) | -3.225 (2) |
| PHL | -0.870 (0) | -5.273 (2) | -0.519 (4) | -8.256 (4) | -0.726 (5) | -4.023 (2) | -1.976 (1) | -4.209 (1) | -0.080 (1) | -3.400 (1) |
| SGP | -1.211 (0) | -2.987 (1) | -2.658 (3) | -9.732 (0) | -2.113 (3) | -3.665 (0) | -0.674 (0) | -3.450 (0) | -1.186 (3) | -3.103 (2) |
| LKA | -2.177 (2) | -4.222 (0) | -0.892 (0) | -3.298 (2) | -2.078 (0) | -3.489 (1) | -0.710 (0) | -5.390 (0) | -2.979 (0) | -2.996 (0) |
| SYR | -0.782 (2) | -3.568 (0) | -1.258 (3) | -7.356 (3) | -1.006 (0) | -4.309 (1) | -1.357 (1) | -3.054 (1) | -2.613 (3) | -3.027 (1) |
| THA | -1.347 (3) | -6.564 (2) | -1.369 (1) | -6.004 (0) | -2.173 (1) | -12.52 (2) | -1.277 (0) | -4.003 (0) | -0.126 (0) | -3.173 (1) |

Notes: The ADF critical value at 5% is 2.970. The lag lengths are in parenthesis. PICs and Asian represents Pacific Islands and Asian developing countries.

## Table A2. ADF Unit Root Tests- African, Latin American and Advanced OECD Countries

| *Country* | $\ln m_t$ | $\Delta\ln m_t$ | $\ln y_t$ | $\Delta\ln y_t$ | $R_t$ | $\Delta R_t$ | $\ln E_t$ | $\Delta\ln E_t$ | $\pi_t$ | $\Delta\pi_t$ |
|---|---|---|---|---|---|---|---|---|---|---|
| *African* | | | | | | | | | | |
| CMR | -0.450 (0) | -4.745 (1) | -1.369 (0) | -5.055 (2) | -0.133 (1) | -3.025 (2) | -0.211 (0) | -4.568 (3) | -1.258 (3) | -6.564 (1) |
| KEN | -1.185 (0) | -3.063 (2) | -2.935 (5) | -4.004 (1) | -0.146 (0) | -5.006 (1) | -1.228 (1) | -4.569 (0) | -1.369 (1) | -5.908 (1) |
| ZAF | -1.347 (1) | -10.29 (0) | -1.709 (2) | -3.127 (1) | -1.352 (1) | -4.192 (2) | -0.154 (1) | -3.101 (2) | -1.422(2) | -5.667 (2) |
| RWA | -2.163 (0) | -5.393 (4) | -0.247 (3) | -8.058 (4) | -1.293 (4) | -5.117 (5) | -0.822 (3) | -3.845 (4) | -1.171(1) | -3.756(1) |
| EGY | -1.278 (1) | -8.125 (5) | -1.350 (0) | -4.116 (1) | -1.370 (1) | -5.060 (2) | -1.116 (3) | -4.036 (5) | -2.186(2) | -5.228(3) |
| ETH | -0.906 (2) | -3.472 (0) | -0.485 (0) | -3.133 (2) | -1.396 (0) | -3.305 (3) | -2.081 (5) | -5.003 (4) | -1.503(5) | -5.792(4) |
| CIV | -1.738 (1) | -4.006 (2) | -1.347 (1) | -4.895 (0) | -1.430 (1) | -3.402 (1) | -0.227 (2) | -3.140 (0) | -0.346(1) | -5.869(2) |
| MWI | -1.508 (0) | -3.205 (4) | -0.873 (0) | -3.129 (1) | -2.206 (3) | -5.976 (2) | -0.150 (3) | -5.006 (1) | -2.573(0) | -7.081(1) |
| NGA | -1.478 (1) | -7.056 (0) | -1.278 (1) | -4.069 (1) | -2.152 (0) | -3.125 (3) | -1.778 (4) | -3.904 (2) | -0.053(1) | -5.245(2) |
| UGA | -1.227 (1) | -3.290 (3) | -1.956 (2) | -6.652 (2) | -1.470 (1) | -6.480 (1) | -1.923 (0) | -4.331 (0) | -1.679(1) | -6.407(1) |
| *LACs* | | | | | | | | | | |
| ARG | -0.360 (4) | -4.930 (0) | -0.034 (4) | -4.252 (2) | -2.255 (3) | -4.104 (4) | -0.136 (3) | -3.569 (2) | -2.563(3) | -7.976(4) |
| BRA | -2.113 (0) | -4.651 (0) | -0.439 (0) | -9.074 (1) | -1.006 (2) | -3.284 (0) | -2.239 (1) | -8.067 (0) | -2.239(1) | -4.611(2) |
| BOL | -2.870 (5) | -3.059 (1) | -1.296 (1) | -5.125 (0) | -1.068 (0) | -8.078 (0) | -0.958 (2) | -5.637 (0) | -1.964(1) | -3.756(2) |
| CHL | -0.297 (1) | -3.647 (1) | -3.680 (3) | -5.837 (1) | -0.204 (4) | -3.112 (2) | -1.892 (1) | -3.481 (0) | -2.598(0) | -9.073(0) |
| COL | -2.874 (4) | -8.277 (1) | -2.368 (0) | -3.178 (0) | -0.308 (2) | -3.286 (0) | -2.760 (1) | -3.323 (1) | -3.354 (2) | -3.844(1) |
| ECU | -2.439 (3) | -6.181 (1) | -2.243 (1) | -3.347 (1) | -1.180 (1) | -8.155 (0) | -1.936 (0) | -3.972 (1) | -1.172(0) | -4.218(1) |
| PER | -2.707 (0) | -12.43 (2) | -0.080 (5) | -4.559 (4) | -2.627 (5) | -5.236 (4) | -1.220 (5) | -4.016 (3) | -1.479(2) | -3.324(0) |
| URY | -2.431 (0) | -3.122 (1) | -2.199 (1) | -3.200 (0) | -1.900 (0) | -4.771 (0) | -2.336 (1) | -5.373 (1) | -1.403(1) | -8.914(0) |
| VEN | -2.034 (4) | -4.330 (0) | -2.317 (0) | -3.777 (4) | -2.726 (5) | -4.283 (3) | -0.982 (0) | -3.209 (1) | -0.790(1) | -3.964(1) |
| MEX | -3.053 (3) | -4.771 (2) | -1.958 (1) | -4.123 (0) | -0.183 (2) | -3.239 (0) | -2.020 (0) | -3.780 (0) | -2.370(1) | -5.747(0) |
| *OECD* | | | | | | | | | | |
| AUS | -0.804 (4) | -6.023 (2) | -2.006 (2) | -3.272 (1) | -1.038 (0) | -3.406 (2) | -0.136 (0) | -5.970 (0) | -2.612(0) | -4.618(2) |
| AUT | -0.399 (3) | -3.039 (0) | -2.652 (4) | -3.816 (2) | -0.070 (5) | -3.367 (3) | -0.357 (2) | -4.354 (2) | -1.311(1) | -3.618(0) |
| CAN | -1.397 (0) | -4.106 (2) | -0.236 (1) | -4.183 (4) | -1.197 (3) | -3.856 (1) | -2.378 (2) | -3.095 (2) | -1.778(0) | -6.075(1) |
| DNK | -1.988 (0) | -4.335 (0) | -1.637 (1) | -4.659 (1) | -0.802 (1) | -4.346 (2) | -2.477 (1) | -3.331 (1) | -1.519(0) | -4.772(2) |
| GRC | -0.341 (1) | -3.877 (1) | -3.057 (3) | -3.070 (0) | -1.479 (1) | -7.155 (2) | -0.833 (0) | -7.349 (1) | -2.032(1) | -10.28(2) |
| JPN | -2.056 (0) | -7.985 (2) | -2.835 (0) | -5.450 (3) | -1.727 (0) | -4.534 (1) | -1.036 (1) | -3.267 (1) | -1.254(1) | -3.208 (1) |
| NOR | -1.027 (4) | -13.00 (1) | -1.256 (1) | -4.980 (0) | -1.401 (0) | -3.097 (1) | -1.532 (0) | -4.376 (0) | -0.235 (0) | -3.450 (2) |
| NZL | -0.254 (1) | -3.103 (2) | -0.667 (4) | -4.231 (0) | -2.874 (4) | -3.158 (3) | -0.113 (4) | -3.581 (3) | -2.366 (2) | -5.377 (1) |
| CHE | -2.675 (3) | -4.876 (1) | -1.256 (3) | -4.569 (1) | -1.213 (3) | -5.296 (1) | -1.707 (2) | -5.723 (0) | -2.080(1) | -3.986 (2) |
| USA | -2.008 (2) | -5.105 (0) | -2.076 (1) | -4.227 (1) | -0.567 (2) | -5.333 (2) | -1.244 (4) | -3.072 (3) | -0.890 (2) | -4.532 (0) |

Notes: The ADF critical value at 5% is 2.970. The lag lengths are in parenthesis. African, LACs and OECD represent African, Latin American and advanced OECD countries.

## Table A3. PP Unit Root Tests- Pacific Islands and Asian Countries

| *Country* | $\ln m_t$ | $\Delta\ln m_t$ | $\ln y_t$ | $\Delta\ln y_t$ | $R_t$ | $\Delta R_t$ | $\ln E_t$ | $\Delta\ln E_t$ | $\pi_t$ | $\Delta\pi_t$ |
|---|---|---|---|---|---|---|---|---|---|---|
| *PICs* | | | | | | | | | | |
| FJI | -0.149 (4) | -4.127 (5) | -0.026 (3) | -8.017 (1) | -0.856 (1) | -4.340 (0) | -1.026 (1) | -3.737 (3) | -3.103 (1) | -5.649 (2) |
| PNG | -2.040 (2) | -3.378 (2) | -2.293 (0) | -10.63 (1) | -2.467 (4) | -4.390 (5) | -1.383 (3) | -4.287 (5) | -0.054 (3) | -8.837 (2) |
| WSM | -1.370 (0) | -4.028 (1) | -1.137 (1) | -3.122 (2) | -0.450 (5) | -10.02 (3) | -0.060 (1) | -7.371 (3) | -1.879 (1) | -5.457 (0) |
| SLB | -0.980 (2) | -3.112 (1) | -1.126 (6) | -8.674 (1) | -1.986 (1) | -4.371 (1) | -1.367 (2) | -5.373 (0) | -2.390 (2) | -3.591 (3) |
| VUT | -1.123 (0) | -9.026 (0) | -2.459 (2) | -4.265 (0) | -1.024 (0) | -3.399 (1) | -0.134 (0) | -4.482 (2) | -0.586 (0) | -8.753 (0) |
| *Asian* | | | | | | | | | | |
| BGD | -2.113 (2) | -3.455 (1) | -2.387 (0) | -4.667 (1) | -0.490 (2) | -3.677 (2) | -0.087 (3) | -9.496 (3) | -0.973 (2) | -3.392 (2) |
| MMR | -2.765 (3) | -4.116 (2) | -1.243 (2) | -3.054 (2) | -1.087 (1) | -5.237 (0) | -0.656 (2) | -5.943 (3) | -1.057 (3) | -8.348 (5) |
| IND | -0.288 (6) | -4.397 (4) | -0.980 (0) | -4.123 (0) | -1.897 (3) | -4.341 (5) | -1.367 (6) | -5.679 (5) | -0.342 (6) | -5.943 (4) |
| IDN | -1.103 (4) | -3.129 (2) | -2.007 (2) | -4.078 (4) | -0.341 (0) | -3.853 (0) | -1.399 (2) | -3.320 (1) | -1.270 (1) | -5.219 (3) |
| IRN | -0.637 (5) | -4.337 (3) | -0.224 (0) | -4.689 (0) | -1.778 (4) | -3.392 (2) | -1.343 (1) | -4.970 (1) | -0.980 (0) | -3.150 (6) |
| ISR | -2.036 (3) | -3.026 (2) | -0.117 (3) | -3.561 (4) | -1.383 (0) | -8.038 (2) | -0.436 (0) | -3.034 (0) | -4.311 (3) | -5.096 (4) |
| JOR | -2.639 (1) | -5.664 (0) | -0.026 (4) | -6.125 (5) | -2.026 (3) | -5.843 (4) | -1.007 (2) | -7.773 (0) | -1.164 (2) | -4.244 (2) |
| KOR | -1.030 (2) | -3.385 (0) | -1.277 (0) | -4.986 (5) | -1.239 (1) | -4.349 (1) | -1.239 (0) | -4.108 (2) | -0.266 (4) | -3.375 (0) |
| KWT | -0.326 (0) | -3.371 (1) | -1.839 (2) | -5.343 (6) | -0.958 (4) | -3.450 (6) | -2.205 (4) | -6.389 (0) | -1.303 (3) | -9.471 (1) |
| MYS | -1.233 (2) | -4.043 (2) | -1.123 (1) | -3.020 (0) | -1.092 (1) | -5.346 (1) | -2.729 (3) | -3.371 (3) | -2.580 (0) | -6.383 (4) |
| NPL | -1.687 (3) | -11.36 (2) | -0.126 (0) | -5.446 (1) | -2.280 (1) | -3.344 (2) | -1.027 (3) | -4.565 (2) | -1.066 (3) | -10.13 (2) |
| PAK | -1.002 (6) | -5.107 (4) | -0.847 (2) | -3.907 (3) | -1.126 (3) | -4.561 (0) | -0.120 (2) | -4.936 (5) | -2.390 (5) | -5.657 (4) |
| OMN | -1.030 (1) | -5.660 (3) | -2.108 (0) | -4.336 (0) | -1.340 (5) | -3.949 (2) | -0.875 (0) | -4.273 (6) | -2.386 (3) | -13.50 (3) |
| PHL | -0.040 (0) | -4.105 (2) | -1.267 (4) | -4.239 (3) | -2.386 (3) | -8.387 (1) | -1.227 (4) | -3.020 (2) | -0.352 (0) | -4.575 (2) |
| SGP | -2.311 (3) | -3.402 (1) | -2.125 (3) | -8.387 (0) | -0.032 (0) | -10.13 (0) | -0.074 (2) | -13.26 (3) | -1.878 (2) | -3.842 (4) |
| LKA | -2.164 (2) | -4.086 (2) | -0.036 (0) | -5.387 (0) | -2.338 (2) | -3.399 (1) | -0.120 (2) | -3.487 (3) | -3.676 (0) | -4.496 (2) |
| SYR | -0.036 (4) | -3.195 (4) | -0.134 (3) | -9.071 (1) | -1.326 (0) | -4.399 (1) | -1.767 (1) | -5.466 (2) | -0.563 (2) | -3.385 (4) |
| THA | -1.303 (3) | -3.806 (2) | -1.169 (1) | -3.453 (1) | -2.333 (2) | -8.232 (0) | -1.987 (0) | -4.279 (2) | -1.923 (1) | -7.386 (2) |

Notes: The ADF critical value at 5% is 2.939. The lag lengths are in parenthesis. PICs and Asian represents Pacific Island and Asian developing countries.

## Table A4. PP Unit Root Tests- African, Latin American and Advanced OECD Countries

| *Country* | $\ln m_t$ | $\Delta\ln m_t$ | $\ln y_t$ | $\Delta\ln y_t$ | $R_t$ | $\Delta R_t$ | $\ln E_t$ | $\Delta\ln E_t$ | $\pi_t$ | $\Delta\pi_t$ |
|---|---|---|---|---|---|---|---|---|---|---|
| *African* | | | | | | | | | | |
| CMR | -1.110 (0) | -3.245 (1) | -1.989 (0) | -4.282 (1) | -0.923 (1) | -3.345 (2) | -0.229 (0) | -9.487 (1) | -0.376 (3) | -3.965 (3) |
| KEN | -1.255 (2) | -3.063 (3) | -2.045 (6) | -4.056 (5) | -0.286 (3) | -5.396 (1) | -1.067 (1) | -5.497 (0) | -1.872 (1) | -6.063 (3) |
| ZAF | -0.107 (1) | -4.129 (0) | -2.349 (3) | -7.283 (1) | -1.382 (1) | -4.352 (2) | -1.120 (3) | -9.371 (2) | -1.083 (2) | -4.129 (2) |
| RWA | -1.023 (1) | -5.993 (2) | -1.347 (3) | -4.209 (1) | -1.373 (2) | -5.237 (2) | -0.926 (0) | -3.493 (2) | -0.453 (3) | -5.373 (2) |
| EGY | -2.078 (1) | -8.125 (3) | -1.870 (4) | -3.780 (1) | -1.520 (1) | -5.350 (2) | -2.643 (3) | -4.472 (1) | -0.394 (1) | -8.945 (2) |
| ETH | -0.637 (3) | -3.472 (3) | -0.065 (0) | -14.70 (0) | -2.286 (3) | -10.35 (3) | -0.154 (1) | -4.956 (2) | -2.375 (2) | -4.272 (4) |
| CIV | -1.063 (1) | -12.06 (2) | -1.557 (4) | -3.154 (3) | -2.020 (1) | -3.452 (1) | -1.287 (3) | -7.393 (2) | -1.773 (2) | -3.390 (1) |
| MWI | -2.027 (1) | -3.205 (2) | -0.393 (0) | -3.859 (1) | -0.226 (3) | -5.386 (2) | -1.309 (1) | -4.009 (2) | -0.651(1) | -14.70 (0) |
| NGA | -0.278 (2) | -7.056 (1) | -2.228 (2) | -5.009 (4) | -1.238 (2) | -3.385 (2) | -1.423(2) | -8.380 (3) | -1.875(2) | -6.384 (3) |
| UGA | -0.113 (1) | -3.290 (1) | -2.076 (2) | -4.352 (2) | -1.294 (1) | -6.470 (3) | -1.108(1) | -5.370 (2) | -0.467(1) | -3.389 (2) |
| *LACs* | | | | | | | | | | |
| ARG | -0.035 (3) | -4.930 (2) | -1.234 (3) | -4.972 (2) | -2.037 (2) | -4.344 (3) | -2.385(2) | -3.484 (3) | -1.086(4) | -9.009 (4) |
| BRA | -2.047 (0) | -4.651 (1) | -1.039 (0) | -6.362 (3) | -1.376 (2) | -7.424 (1) | -1.309(2) | -3.749 (0) | -1.271(2) | -4.352 (3) |
| BOL | -2.663 (3) | -3.059 (2) | -2.198 (2) | -3.206 (4) | -1.128 (1) | -8.998 (0) | -0.387(1) | -10.39 (2) | -1.320 (4) | -5.972 (2) |
| CHL | -0.394 (1) | -3.647 (2) | -3.553 (3) | -3.885 (3) | -0.324 (4) | -3.392 (2) | -2.509(0) | -4.792 (3) | -0.655 (0) | -6.362 (2) |
| COL | -1.035 (2) | -8.277 (2) | -2.390 (1) | -6.250 (1) | -1.456 (4) | -4.266 (1) | -1.370 (1) | -4.882 (0) | -4.747 (4) | -7.206 (3) |
| ECU | -1.273 (2) | -4.036 (3) | -1.143 (1) | -4.254 (2) | -0.389 (0) | -8.755 (1) | -2.276 (3) | -7.009 (4) | -0.393 (0) | -5.885 (2) |
| PER | -1.036 (0) | -5.003 (4) | -1.380 (3) | -3.264 (2) | -2.393 (4) | -8.234(0) | -2.230 (1) | -4.392 (0) | -0.768 (2) | -6.250 (2) |
| URY | -0.221 (1) | -3.140 (0) | -1.599 (2) | -3.648 (0) | -0.386 (0) | -9.544(2) | -0.856 (3) | -6.542 (2) | -0.976 (2) | -3.744 (3) |
| VEN | -0.354 (4) | -5.006 (3) | -1.389 (0) | -4.412 (2) | -1.248 (5) | -5.497(0) | -1.248 (1) | -6.492 (3) | -1.564 (3) | -4.384 (2) |
| MEX | -1.274 (4) | -3.904 (3) | -1.933(2) | -5.586 (0) | -2.069 (1) | -4.968(2) | -1.384 (1) | -4.946 (0) | -1.759 (0) | -9.768 (1) |
| *OECD* | | | | | | | | | | |
| AUS | -0.384 (3) | -4.331 (4) | -2.032 (3) | -3.775 (0) | -2.222(3) | -3.488(2) | -2.847 (4) | -3.275 (0) | -0.190(2) | -7.262 (3) |
| AUT | -0.289 (3) | -3.179 (5) | -0.223 (2) | -5.986 (2) | -1.391(1) | -6.975(1) | -1.396 (2) | -3.490 (1) | -1.373 (3) | -5.176 (1) |
| CAN | -1.377 (0) | -3.267 (0) | -0.099 (1) | -4.761 (0) | -2.386(2) | -8.982(2) | -1.388 (4) | -4.494 (0) | -0.780 (1) | -3.295 (1) |
| DNK | -2.078 (1) | -4.207 (1) | -1.347 (0) | -4.343 (1) | -0.523(2) | -7.928(3) | -0.964 (4) | -3.394 (2) | -1.733 (1) | -5.376 (2) |
| GRC | -2.371 (1) | -9.580 (0) | -4.767 (0) | -4.659 (0) | -1.187(1) | -3.708 (1) | -1.236 (5) | -8.648 (0) | -1.750 (3) | -4.041 (1) |
| JPN | -1.025 (1) | -3.483 (1) | -2.055 (1) | -3.386 (2) | -2.537(1) | -3.840 (2) | -0.279 (0) | -4.472 (0) | -2.799 (2) | -3.863 (1) |
| NOR | -0.997 (4) | -3.232 (2) | -1.346 (1) | -5.387 (3) | -1.434 (0) | -5.347 (1) | -2.283 (4) | -5.876 (1) | -1.749 (0) | -3.469 (1) |
| NZL | -0.129 (1) | -4.376 (3) | -1.907 (3) | -3.346 (5) | -2.834 (4) | -4.786 (2) | -0.353 (3) | -7.735 (0) | -1.673(2) | -4.056 (2) |
| CHE | -1.368 (3) | -6.943 (2) | -1.046 (3) | -4.776 (2) | -1.213 (3) | -5.766 (1) | -1.267 (2) | -5.456 (2) | -0.962 (3) | -5.147 (5) |
| USA | -0.127 (2) | -4.139 (1) | -2.986 (0) | -7.375 (1) | -1.467 (1) | -7.383 (3) | -1.384 (1) | -6.142 (0) | -0.652 (0) | -6.489(2) |

Notes: The ADF critical value at 5% is 2.939. The lag lengths are in parenthesis. African, LACs and OECD represents African, Latin American and advanced OECD countries.

## Table A5. KPSS Unit Root Tests- African and Asian Countries

| *Country* | ln$m_t$ | | ln$y_t$ | | $R_t$ | | ln$E_t$ | | $\pi_t$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ |
| *African* | | | | | | | | | | |
| CMR | 0.523 | 1.153 | 1.509 | 0.310 | 0.487 | 0.348 | 0.650 | 0.246 | 0.811 | 0.204 |
| KEN | 1.620 | 0.200 | 0.921 | 0.225 | 0.598 | 0.189 | 0.494 | 0.212 | 0.635 | 0.375 |
| ZAF | 1.595 | 0.197 | 0.623 | 0.436 | 0.563 | 0.151 | 0.539 | 0.187 | 0.532 | 0.155 |
| RWA | 0.616 | 0.200 | 0.509 | 0.271 | 0.482 | 0.355 | 0.530 | 0.304 | 1.608 | 0.149 |
| EGY | 1.612 | 0.199 | 0.529 | 0.170 | 0.935 | 0.555 | 0.699 | 0.347 | 1.781 | 0.204 |
| ETH | 1.683 | 0.208 | 0.495 | 0.278 | 0.533 | 0.170 | 0.520 | 0.152 | 0.593 | 0.186 |
| CIV | 0.773 | 0.387 | 0.470 | 0.285 | 0.620 | 0.271 | 0.514 | 0.434 | 0.658 | 0.153 |
| MWI | 0.665 | 0.232 | 0.506 | 0.183 | 0.464 | 0.878 | 0.489 | 0.290 | 0.493 | 0.769 |
| NGA | 2.003 | 1.201 | 0.514 | 0.384 | 0.529 | 0.188 | 0.438 | 0.196 | 0.793 | 0.401 |
| UGA | 0.959 | 0.380 | 0.528 | 0.388 | 0.500 | 0.296 | 0.736 | 0.147 | 0.549 | 0.425 |
| *Asian* | | | | | | | | | | |
| BGD | 1.031 | 0.227 | 0.588 | 0.353 | 0.467 | 0.192 | 0.519 | 0.202 | 0.545 | 0.246 |
| MMR | 0.991 | 0.152 | 1.012 | 0.192 | 1.274 | 0.250 | 1.474 | 0.187 | 0.597 | 0.403 |
| IND | 1.163 | 0.944 | 0.457 | 0.295 | 0.563 | 0.154 | 0.526 | 0.237 | 0.495 | 0.238 |
| IDN | 0.840 | 0.504 | 0.587 | 0.197 | 0.648 | 0.906 | 0.605 | 0.166 | 0.974 | 0.746 |
| IRN | 0.483 | 0.602 | 0.795 | 0.246 | 0.980 | 1.221 | 0.489 | 0.151 | 0.479 | 0.269 |
| ISR | 0.845 | 0.704 | 0.607 | 0.149 | 1.120 | 0.540 | 0.517 | 1.159 | 0.094 | 0.114 |
| JOR | 0.902 | 1.111 | 0.615 | 0.251 | 0.487 | 0.843 | 0.495 | 0.223 | 0.732 | 0.187 |
| KOR | 0.534 | 0.403 | 0.514 | 0.168 | 0.784 | 0.452 | 0.479 | 0.186 | 0.657 | 0.237 |
| KWT | 0.803 | 0.199 | 0.519 | 0.270 | 1.153 | 0.270 | 0.768 | 0.204 | 0.564 | 0.179 |
| MYS | 0.725 | 0.689 | 0.724 | 0.174 | 0.976 | 0.394 | 0.580 | 0.199 | 1.009 | 0.218 |
| NPL | 0.672 | 0.483 | 0.526 | 0.465 | 0.476 | 0.189 | 1.489 | 0.203 | 0.984 | 0.347 |
| PAK | 0.657 | 0.281 | 0.525 | 0.167 | 0.600 | 0.174 | 0.921 | 0.337 | 0.465 | 0.202 |
| OMN | 0.824 | 0.172 | 0.689 | 0.147 | 0.475 | 0.291 | 0.693 | 0.206 | 0.863 | 1.221 |
| PHL | 1.139 | 0.191 | 0.717 | 0.265 | 0.550 | 0.159 | 0.529 | 1.003 | 1.329 | 0.390 |
| SGP | 0.974 | 0.160 | 0.495 | 0.167 | 0.714 | 0.444 | 0.563 | 0.338 | 1.063 | 0.511 |
| LKA | 1.014 | 0.175 | 0.479 | 0.269 | 0.834 | 0.851 | 0.482 | 0.446 | 0.559 | 0.274 |
| SYR | 0.943 | 0.156 | 0.468 | 0.156 | 0.648 | 0.354 | 0.875 | 0.209 | 1.601 | 0.274 |
| THA | 1.359 | 0.148 | 0.500 | 0.201 | 0.514 | 0.953 | 1.513 | 0.146 | 0.869 | 0.153 |

Notes: The critical values for $\eta_\mu$ and $\eta_\tau$ at 5% are 0.463 and 0.146 and at 1% are 0.739 and 0.216, respectively (Kwiatkowski et al., 1992; Table 1). African and Asian represents African and Asian developing countries.

**Table A6. KPSS Unit Root Tests- Pacific Islands, Latin American and Advanced OECD Countries**

| *Country* | $\ln m_t$ | | $\ln y_t$ | | $R_t$ | | $\ln E_t$ | | $\pi_t$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ |
| *PICs* | | | | | | | | | | |
| FJI | 1.227 | 0.151 | 0.577 | 0.339 | 0.487 | 0.156 | 0.478 | 0.148 | 1.024 | 0.153 |
| PNG | 1.123 | 0.239 | 0.484 | 0.243 | 0.857 | 0.298 | 1.871 | 0.155 | 0.488 | 0.221 |
| WSM | 1.042 | 0.229 | 0.959 | 0.176 | 0.846 | 0.207 | 0.533 | 0.166 | 1.244 | 0.159 |
| SLB | 0.843 | 0.194 | 0.469 | 0.291 | 0.571 | 0.196 | 0.485 | 0.178 | 0.487 | 0.233 |
| VUT | 0.923 | 1.114 | 1.574 | 0.347 | 0.623 | 0.146 | 0.984 | 1.153 | 0.537 | 0.187 |
| *LACs* | | | | | | | | | | |
| ARG | 1.031 | 0.515 | 0.724 | 0.196 | 0.609 | 1.204 | 0.626 | 0.181 | 0.503 | 0.358 |
| BRA | 0.569 | 0.284 | 0.539 | 0.403 | 0.550 | 1.215 | 0.509 | 0.237 | 0.493 | 0.289 |
| BOL | 1.608 | 0.304 | 0.554 | 0.215 | 0.536 | 0.219 | 0.556 | 0.154 | 0.894 | 0.203 |
| CHL | 0.635 | 0.218 | 0.866 | 0.147 | 0.627 | 0.621 | 1.002 | 0.206 | 1.506 | 0.347 |
| COL | 0.622 | 0.311 | 0.487 | 0.177 | 0.642 | 0.924 | 0.533 | 1.241 | 0.199 | 0.104 |
| ECU | 1.638 | 0.219 | 0.499 | 0.278 | 0.535 | 0.428 | 0.474 | 0.530 | 0.644 | 0.159 |
| PER | 1.761 | 0.381 | 0.670 | 0.174 | 0.468 | 0.432 | 0.823 | 0.883 | 0.509 | 0.302 |
| URY | 0.563 | 2.281 | 0.472 | 0.181 | 0.648 | 0.340 | 0.831 | 0.442 | 0.520 | 0.162 |
| VEN | 0.678 | 0.339 | 0.680 | 0.362 | 0.714 | 0.244 | 0.991 | 0.210 | 0.589 | 0.223 |
| MEX | 0.483 | 0.241 | 0.594 | 0.257 | 0.629 | 0.247 | 1.043 | 0.304 | 0.540 | 0.376 |
| *OECD* | | | | | | | | | | |
| AUS | 0.795 | 0.398 | 0.479 | 0.187 | 0.524 | 0.351 | 0.870 | 0.149 | 0.491 | 0.201 |
| AUT | 1.700 | 0.150 | 0.488 | 0.262 | 0.526 | 0.154 | 0.403 | 0.194 | 0.508 | 1.212 |
| CAN | 0.580 | 0.290 | 0.706 | 0.371 | 0.625 | 0.158 | 0.825 | 0.154 | 0.533 | 0.356 |
| DNK | 0.527 | 0.263 | 0.626 | 0.169 | 0.689 | 0.364 | 0.942 | 1.026 | 0.499 | 0.563 |
| GRC | 0.481 | 0.149 | 0.649 | 0.148 | 0.717 | 0.170 | 0.594 | 1.327 | 0.903 | 0.252 |
| JPN | 1.391 | 0.195 | 0.546 | 0.288 | 0.695 | 0.278 | 0.843 | 0.214 | 0.512 | 0.311 |
| NOR | 0.867 | 0.147 | 1.209 | 0.150 | 0.498 | 0.167 | 0.705 | 0.146 | 0.469 | 0.223 |
| NZL | 0.499 | 0.169 | 0.633 | 0.149 | 0.467 | 0.189 | 0.470 | 0.155 | 0.500 | 0.149 |
| CHE | 0.739 | 0.221 | 0.468 | 1.025 | 0.564 | 0.230 | 0.552 | 0.286 | 1.028 | 0.153 |
| USA | 0.931 | 0.189 | 0.479 | 0.187 | 0.530 | 0.148 | 0.465 | 0.148 | 0.547 | 0.159 |

Notes: The critical values for $\eta_\mu$ and $\eta_\tau$ at 5% are 0.463 and 0.146 and at 1% are 0.739 and 0.216, respectively (Kwiatkowski et al., 1992; Table 1). PICs, LACs and OECD represent Pacific Islands, Latin American and advanced OECD countries.

## Table A7. KPSS Unit Root Tests- African and Asian Countries

| *Country* | $\Delta \ln m_t$ | | $\Delta \ln y_t$ | | $\Delta R_t$ | | $\Delta \ln E_t$ | | $\Delta \pi_t$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ |
| *African* | | | | | | | | | | |
| CMR | 0.158 | 0.024 | 0.057 | 0.039 | 0.082 | 0.071 | 0.047 | 0.056 | 0.097 | 0.009 |
| KEN | 0.052 | 0.092 | 0.077 | 0.058 | 0.075 | 0.018 | 0.070 | 0.092 | 0.060 | 0.016 |
| ZAF | 0.025 | 0.044 | 0.014 | 0.074 | 0.068 | 0.029 | 0.101 | 0.082 | 0.023 | 0.056 |
| RWA | 0.059 | 0.075 | 0.011 | 0.088 | 0.014 | 0.088 | 0.006 | 0.064 | 0.096 | 0.032 |
| EGY | 0.061 | 0.084 | 0.020 | 0.110 | 0.019 | 0.097 | 0.070 | 0.025 | 0.019 | 0.071 |
| ETH | 0.099 | 0.017 | 0.009 | 0.070 | 0.030 | 0.056 | 0.089 | 0.051 | 0.177 | 0.048 |
| CIV | 0.064 | 0.026 | 0.179 | 0.112 | 0.043 | 0.038 | 0.031 | 0.078 | 0.069 | 0.099 |
| MWI | 0.022 | 0.099 | 0.010 | 0.100 | 0.058 | 0.055 | 0.074 | 0.074 | 0.059 | 0.043 |
| NGA | 0.070 | 0.052 | 0.034 | 0.071 | 0.075 | 0.108 | 0.025 | 0.059 | 0.049 | 0.023 |
| UGA | 0.088 | 0.036 | 0.053 | 0.036 | 0.097 | 0.054 | 0.090 | 0.026 | 0.065 | 0.059 |
| *Asian* | | | | | | | | | | |
| BGD | 0.094 | 0.080 | 0.036 | 0.063 | 0.020 | 0.021 | 0.105 | 0.012 | 0.087 | 0.013 |
| MMR | 0.011 | 0.025 | 0.055 | 0.085 | 0.075 | 0.094 | 0.089 | 0.070 | 0.067 | 0.045 |
| IND | 0.076 | 0.032 | 0.080 | 0.050 | 0.012 | 0.112 | 0.026 | 0.078 | 0.025 | 0.092 |
| IDN | 0.023 | 0.015 | 0.219 | 0.032 | 0.092 | 0.006 | 0.015 | 0.025 | 0.058 | 0.091 |
| IRN | 0.047 | 0.094 | 0.061 | 0.098 | 0.071 | 0.113 | 0.070 | 0.058 | 0.030 | 0.100 |
| ISR | 0.093 | 0.139 | 0.021 | 0.018 | 0.035 | 0.067 | 0.098 | 0.042 | 0.065 | 0.058 |
| JOR | 0.021 | 0.137 | 0.010 | 0.030 | 0.063 | 0.043 | 0.088 | 0.037 | 0.092 | 0.015 |
| KOR | 0.012 | 0.020 | 0.140 | 0.028 | 0.189 | 0.039 | 0.022 | 0.103 | 0.037 | 0.023 |
| KWT | 0.078 | 0.099 | 0.220 | 0.115 | 0.029 | 0.019 | 0.065 | 0.040 | 0.058 | 0.086 |
| MYS | 0.082 | 0.015 | 0.016 | 0.061 | 0.075 | 0.023 | 0.060 | 0.024 | 0.068 | 0.021 |
| NPL | 0.175 | 0.067 | 0.072 | 0.003 | 0.188 | 0.096 | 0.056 | 0.047 | 0.012 | 0.017 |
| PAK | 0.068 | 0.089 | 0.034 | 0.045 | 0.231 | 0.065 | 0.035 | 0.058 | 0.028 | 0.048 |
| OMN | 0.028 | 0.020 | 0.074 | 0.073 | 0.171 | 0.083 | 0.086 | 0.076 | 0.050 | 0.046 |
| PHL | 0.182 | 0.039 | 0.002 | 0.015 | 0.074 | 0.089 | 0.098 | 0.013 | 0.061 | 0.016 |
| SGP | 0.267 | 0.073 | 0.013 | 0.025 | 0.081 | 0.028 | 0.008 | 0.018 | 0.094 | 0.008 |
| LKA | 0.058 | 0.071 | 0.026 | 0.082 | 0.069 | 0.043 | 0.067 | 0.051 | 0.007 | 0.107 |
| SYR | 0.156 | 0.007 | 0.084 | 0.073 | 0.071 | 0.033 | 0.011 | 0.048 | 0.196 | 0.029 |
| THA | 0.060 | 0.015 | 0.033 | 0.079 | 0.047 | 0.066 | 0.031 | 0.022 | 0.107 | 0.083 |

Notes: The critical values for $\eta_\mu$ and $\eta_\tau$ at 5% are 0.463 and 0.146 and at 1% are 0.739 and 0.216, respectively (Kwiatkowski et al., 1992; Table 1). African and Asian represents African and Asian developing countries.

## Table A8. KPSS Unit Root Tests- Pacific Islands, Latin American and Advanced OECD Countries

| *Country* | $\Delta \ln m_t$ | | $\Delta \ln y_t$ | | $\Delta R_t$ | | $\Delta \ln E_t$ | | $\Delta \pi_t$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ | $\eta_\mu$ | $\eta_\tau$ |
| *PICs* | | | | | | | | | | |
| *FJI* | 0.012 | 0.062 | 0.042 | 0.081 | 0.023 | 0.075 | 0.023 | 0.061 | 0.092 | 0.014 |
| *PNG* | 0.046 | 0.014 | 0.085 | 0.065 | 0.082 | 0.017 | 0.094 | 0.097 | 0.083 | 0.034 |
| *WSM* | 0.114 | 0.025 | 0.116 | 0.024 | 0.011 | 0.031 | 0.113 | 0.113 | 0.029 | 0.063 |
| *SLB* | 0.011 | 0.042 | 0.115 | 0.017 | 0.048 | 0.082 | 0.217 | 0.025 | 0.186 | 0.096 |
| *VUT* | 0.159 | 0.095 | 0.096 | 0.011 | 0.064 | 0.096 | 0.010 | 0.065 | 0.200 | 0.058 |
| *LACs* | | | | | | | | | | |
| ARG | 0.056 | 0.057 | 0.072 | 0.014 | 0.027 | 0.038 | 0.069 | 0.003 | 0.039 | 0.045 |
| BRA | 0.003 | 0.051 | 0.010 | 0.130 | 0.099 | 0.013 | 0.035 | 0.053 | 0.015 | 0.075 |
| BOL | 0.097 | 0.027 | 0.009 | 0.114 | 0.089 | 0.002 | 0.027 | 0.026 | 0.010 | 0.066 |
| CHL | 0.268 | 0.085 | 0.031 | 0.088 | 0.036 | 0.133 | 0.084 | 0.045 | 0.015 | 0.059 |
| COL | 0.066 | 0.016 | 0.083 | 0.029 | 0.092 | 0.030 | 0.037 | 0.016 | 0.027 | 0.092 |
| ECU | 0.071 | 0.035 | 0.053 | 0.079 | 0.041 | 0.077 | 0.041 | 0.095 | 0.083 | 0.101 |
| PER | 0.035 | 0.025 | 0.012 | 0.032 | 0.188 | 0.064 | 0.014 | 0.059 | 0.070 | 0.090 |
| URY | 0.028 | 0.105 | 0.011 | 0.088 | 0.080 | 0.014 | 0.026 | 0.085 | 0.093 | 0.077 |
| VEN | 0.049 | 0.017 | 0.032 | 0.096 | 0.182 | 0.056 | 0.089 | 0.060 | 0.076 | 0.017 |
| MEX | 0.099 | 0.084 | 0.022 | 0.046 | 0.178 | 0.094 | 0.093 | 0.072 | 0.069 | 0.027 |
| *OECD* | | | | | | | | | | |
| AUS | 0.015 | 0.043 | 0.092 | 0.066 | 0.054 | 0.027 | 0.028 | 0.015 | 0.029 | 0.016 |
| AUT | 0.061 | 0.026 | 0.030 | 0.097 | 0.068 | 0.051 | 0.014 | 0.094 | 0.079 | 0.012 |
| CAN | 0.041 | 0.019 | 0.059 | 0.115 | 0.043 | 0.071 | 0.121 | 0.021 | 0.029 | 0.083 |
| DNK | 0.068 | 0.091 | 0.008 | 0.077 | 0.093 | 0.086 | 0.050 | 0.037 | 0.186 | 0.015 |
| GRC | 0.030 | 0.005 | 0.048 | 0.031 | 0.027 | 0.035 | 0.040 | 0.083 | 0.023 | 0.085 |
| JPN | 0.168 | 0.106 | 0.082 | 0.023 | 0.015 | 0.083 | 0.133 | 0.028 | 0.026 | 0.049 |
| NOR | 0.038 | 0.109 | 0.125 | 0.056 | 0.200 | 0.012 | 0.027 | 0.026 | 0.165 | 0.037 |
| NZL | 0.071 | 0.026 | 0.065 | 0.028 | 0.125 | 0.026 | 0.038 | 0.101 | 0.230 | 0.098 |
| CHE | 0.170 | 0.022 | 0.014 | 0.109 | 0.067 | 0.098 | 0.056 | 0.024 | 0.096 | 0.105 |
| USA | 0.067 | 0.085 | 0.027 | 0.025 | 0.013 | 0.004 | 0.082 | 0.096 | 0.002 | 0.076 |

Notes: The critical values for $\eta_\mu$ and $\eta_\tau$ at 5% are 0.463 and 0.146 and at 1% are 0.739 and 0.216, respectively (Kwiatkowski et al., 1992; Table 1). PICs, LACs and OECD represents Pacific Islands, Latin American and advanced OECD countries.

**Table A9. Panel Cointegration Tests for the Sub-samples-Developing Countries**

| Test Statistic | Pre-Reforms Sub-Samples | | Post-Reforms Sub-Samples | |
|---|---|---|---|---|
| | Early Break Countries 1970-1984 | Late Break Countries 1970-1994 | Early Break Countries 1985-2009 | Late Break Countries 1995-2009 |
| Panel *υ*- statistic | | | | |
| Canonical eq. | 4.283* | 2.002* | 2.543* | -3.027* |
| Extended eq. | -2.902* | 3.127* | 1.040 | -1.691** |
| Panel *σ*- statistic | | | | |
| Canonical eq. | 5.283* | -2.611* | -3.602* | -2.127* |
| Extended eq. | 2.902* | -1.032 | -3.264* | -1.980* |
| Panel *ρρ*- statistic | | | | |
| Canonical eq. | -6.184* | -1.030 | -2.124* | -1.035 |
| Extended eq. | 3.286* | -1.697** | -2.189* | -1.718** |
| Panel ADF-statistic | | | | |
| Canonical eq. | 3.381* | -2.431* | 1.850** | 4.184* |
| Extended eq. | 3.539* | -5.462* | 4.700* | 2.231* |
| Group *σ*- statistic | | | | |
| Canonical eq. | -2.162* | -1.832** | -3.254* | -4.193* |
| Extended eq. | 2.071* | -1.707** | 2.210* | -2.006* |
| Group *ρρ*- statistic | | | | |
| Canonical eq. | -1.261 | -2.283* | -3.189* | -1.835** |
| Extended eq. | -1.695** | -3.104* | -2.176* | -1.042 |
| Group ADF-statistic | | | | |
| Canonical eq. | 1.770** | -3.984* | 2.078* | 4.421* |
| Extended eq. | 2.409* | -2.147* | -2.103* | 2.062* |

Notes: Fiji, Samoa, Vanuatu, Bangladesh, India, Indonesia, Iran, Kuwait, Nepal, Pakistan, Thailand, Cameroon, Kenya, Egypt, Ethiopia, Nigeria, Argentina, Brazil, Chile, Columbia, Peru, Uruguay and Venezuela are the countries that have an early break. Countries that have a late break are PNG, Solomons, Myanmar, Israel, Jordon, Korea, Malaysia, Oman, Philippines, Singapore, Sri Lanka, Syria, South Africa, Rwanda, Ivory Coast, Malawi, Uganda, Bolivia, Ecuador and Mexico. The test statistics are distributed as $N(0,1)$. The critical values at 5% and 10% levels are 1.96 and 1.64, respectively. * and ** denotes significance, respectively, at 5% and 10% levels.

## Table A10. Panel Cointegration Tests for the Sub-samples-Advanced OECD Countries

| Test Statistic | Pre-Reforms Sub-Samples | | Post-Reforms Sub-Samples | |
|---|---|---|---|---|
| | Early Break Countries 1970-1984 | Late Break Countries 1970-1994 | Early Break Countries 1985-2009 | Late Break Countries 1995-2009 |
| Panel *υ*- statistic | | | | |
| Canonical eq. | 3.100* | -2.132* | -4.371* | -1.230 |
| Extended eq. | 4.141* | 3.474* | -2.005* | -2.155* |
| Panel *σ*- statistic | | | | |
| Canonical eq. | -5.378* | -4.372* | 2.377* | -2.703* |
| Extended eq. | -2.103* | -1.745** | 4.102* | -3.780* |
| Panel *ρρ*- statistic | | | | |
| Canonical eq. | 2.043* | 6.012* | -2.376* | -2.452* |
| Extended eq. | -3.488* | 1.835** | -3.956* | -1.860** |
| Panel ADF-statistic | | | | |
| Canonical eq. | 1.200 | -2.047* | -3.651* | 8.240* |
| Extended eq. | 3.005* | -3.201* | 2.014* | -2.324* |
| Group *σ*- statistic | | | | |
| Canonical eq. | -2.641* | 1.048 | 2.349* | -4.355* |
| Extended eq. | -3.213* | 1.675** | 3.010* | -2.106* |
| Group *ρρ*- statistic | | | | |
| Canonical eq. | -3.554* | 0.493 | 1.650** | 1.900** |
| Extended eq. | -2.192* | -2.338* | 2.341* | 3.120* |
| Group ADF-statistic | | | | |
| Canonical eq. | -4.185* | -2.374* | 1.892** | -3.465* |
| Extended eq. | -2.313* | -3.002* | 3.027* | -2.470* |

Notes: Australia, Canada, Denmark, Norway, New Zealand and USA are the countries that have an early break. Countries that have a late break are Austria, Greece, Japan and Switzerland. The test statistics are distributed as $N(0,1)$. The critical values at 5% and 10% levels are 1.96 and 1.64, respectively. * and ** denotes significance, respectively, at 5% and 10% levels.

**APPENDIX 3**

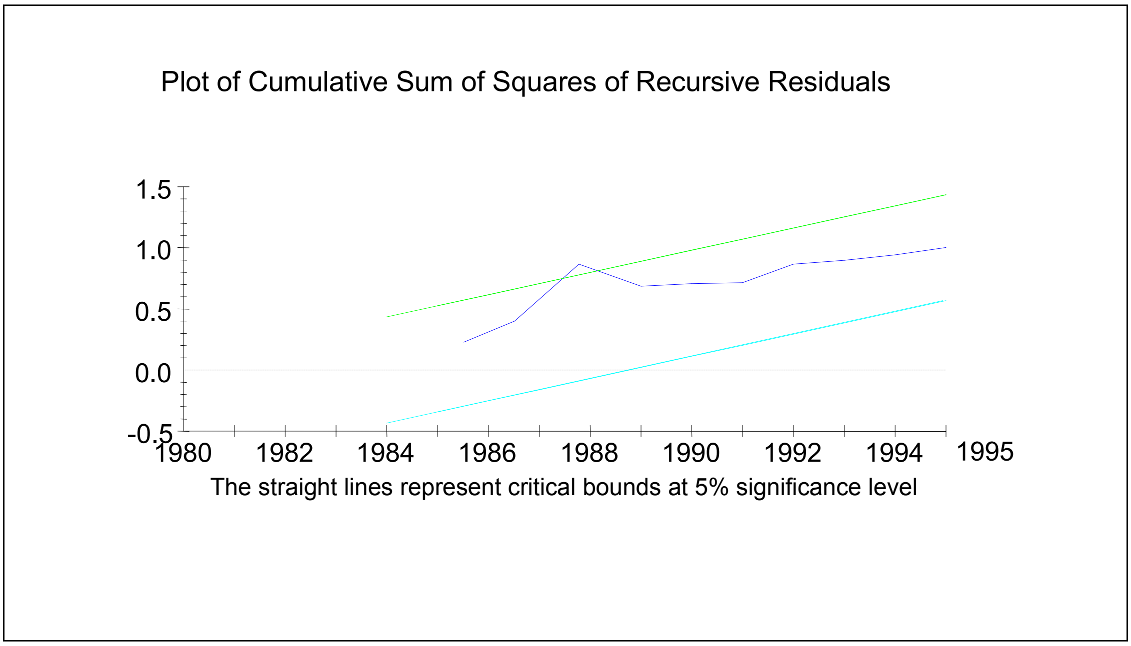


**Figure A1: Argentina *M1* stability, 1980-1995**

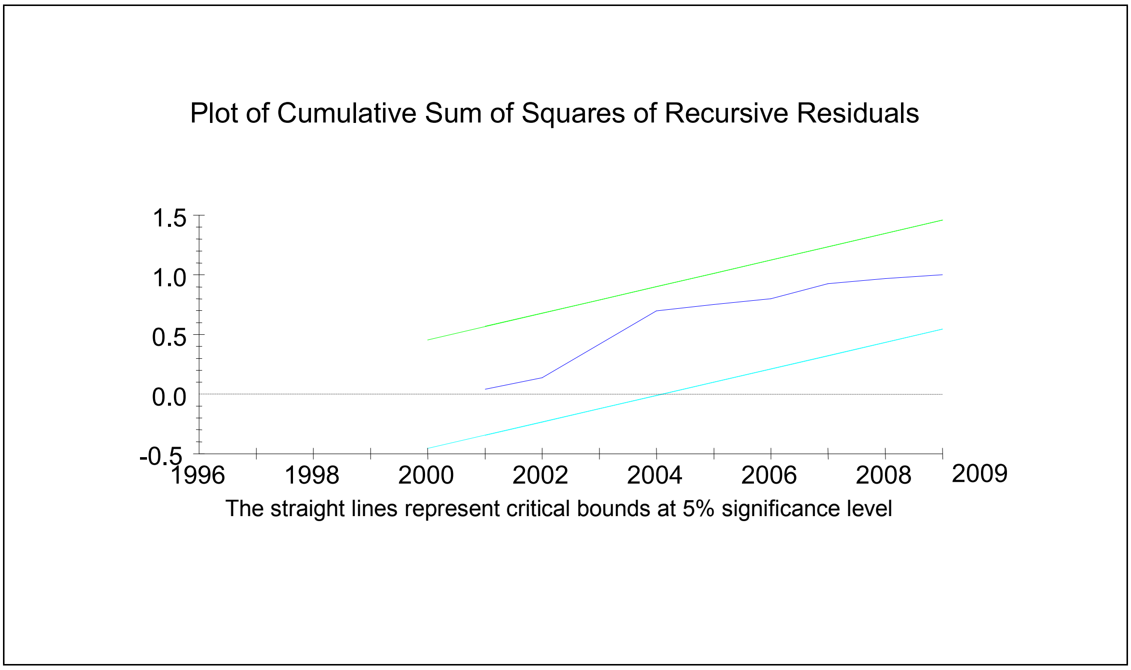


**Figure A2: Argentina *M1* stability, 1996-2009**

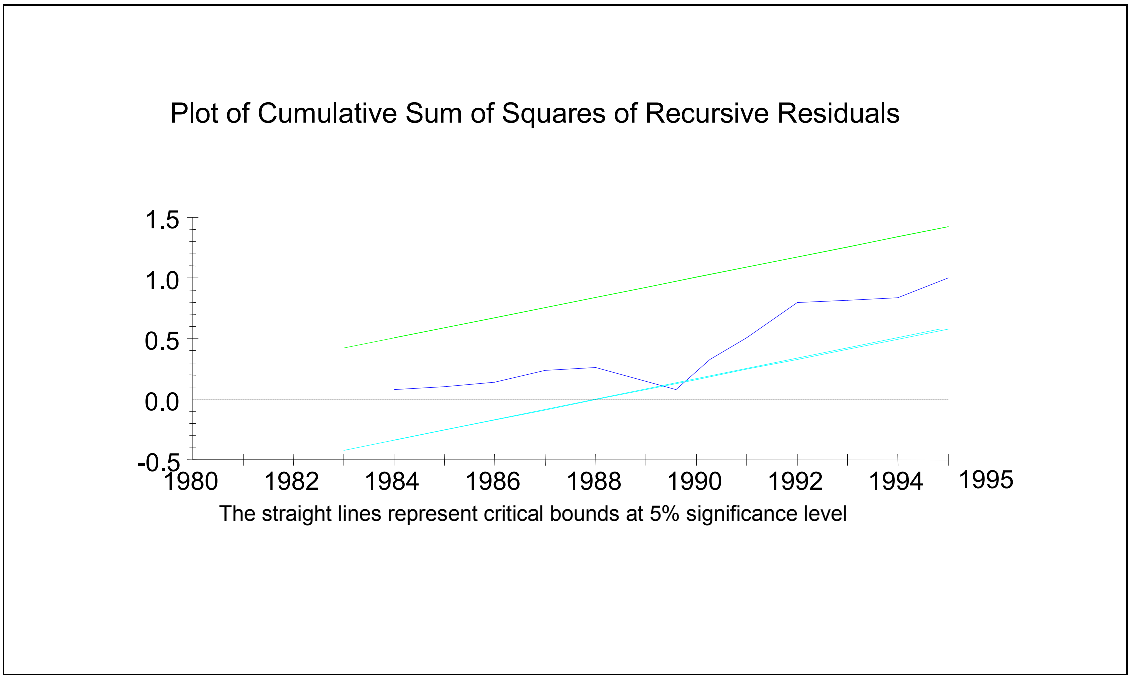


**Figure A3: Greece *M1* stability, 1980-1995**

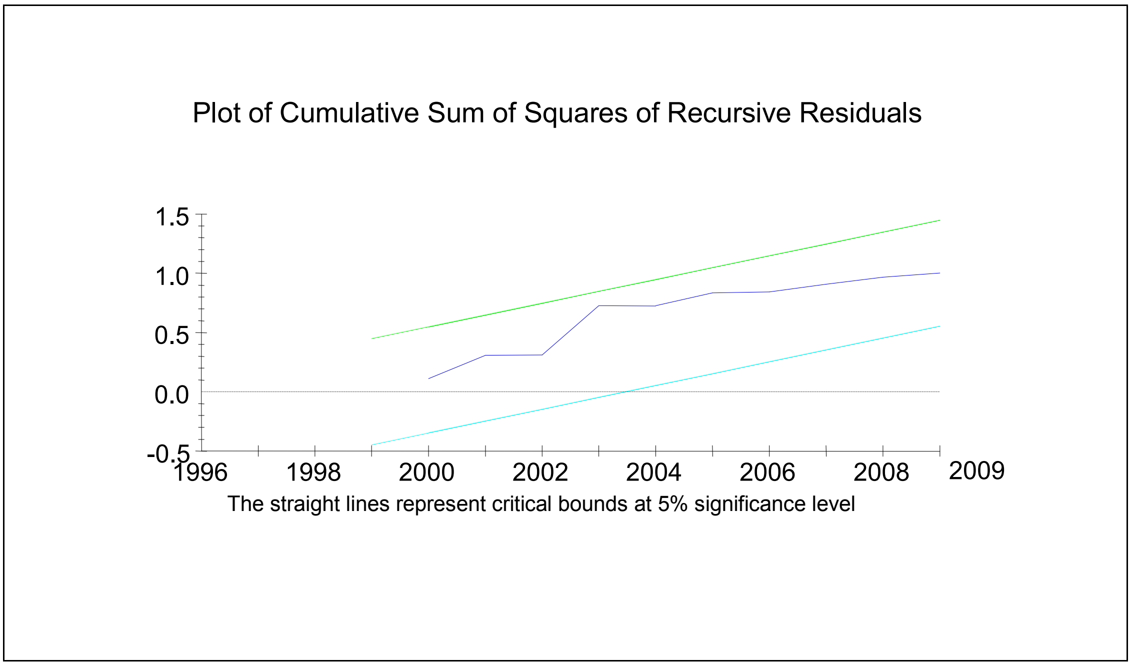


**Figure A4: Greece *M1* stability, 1996-2009**

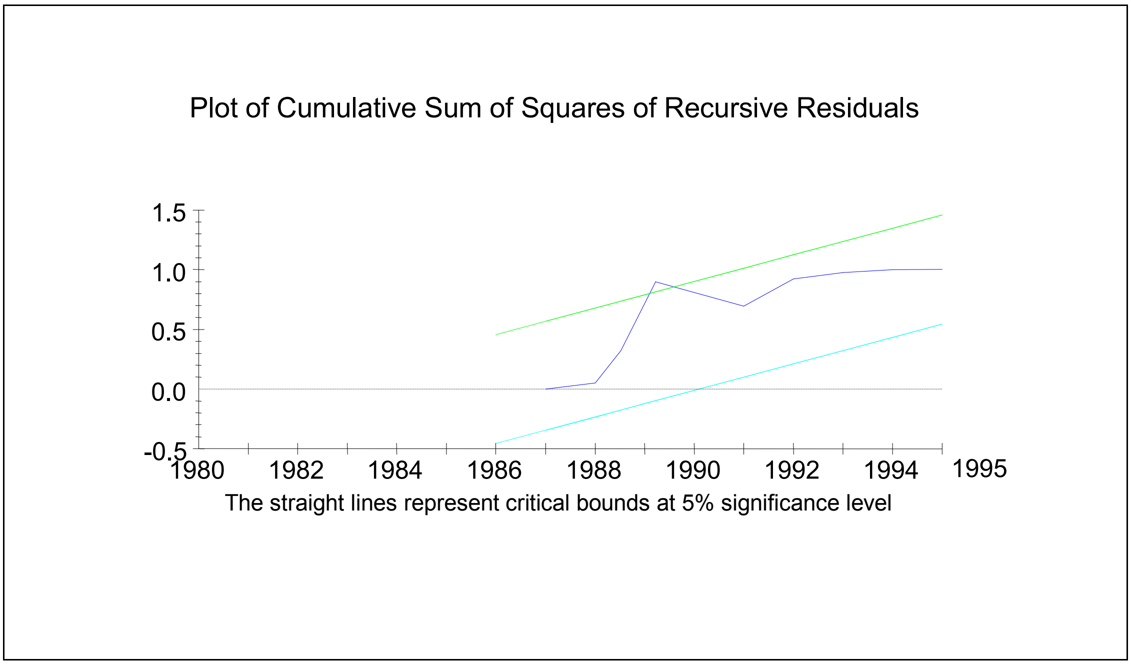


**Figure A5: Thailand *M1* stability, 1980-1995**

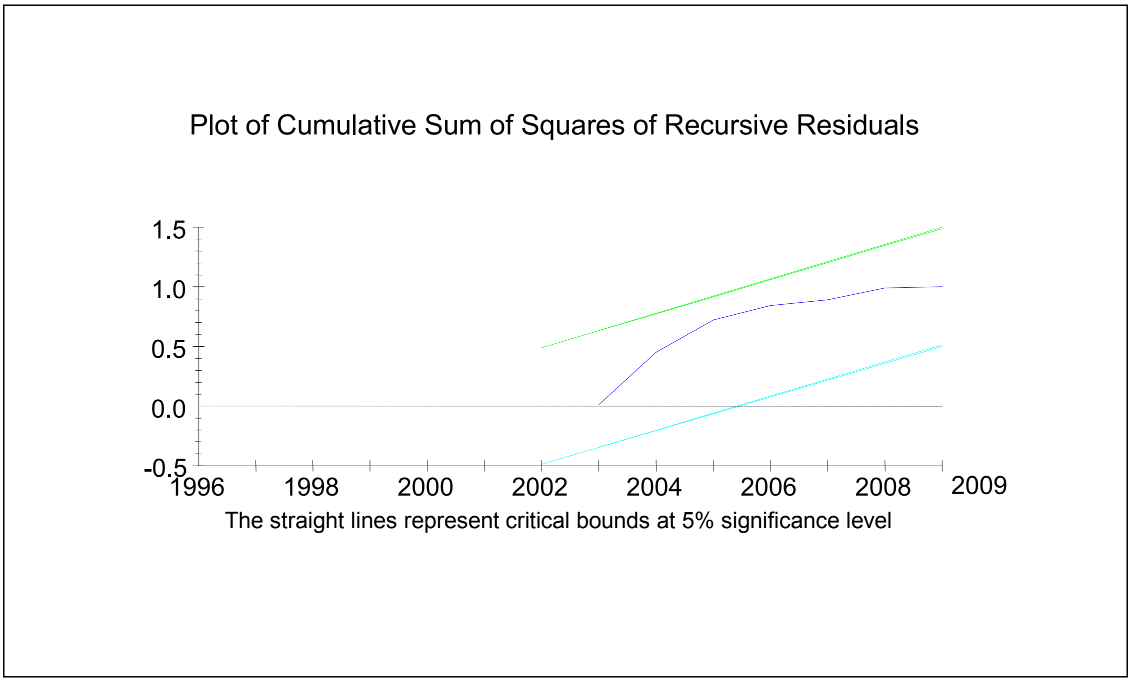


**Figure A6: Thailand *M1* stability, 1996-2009**

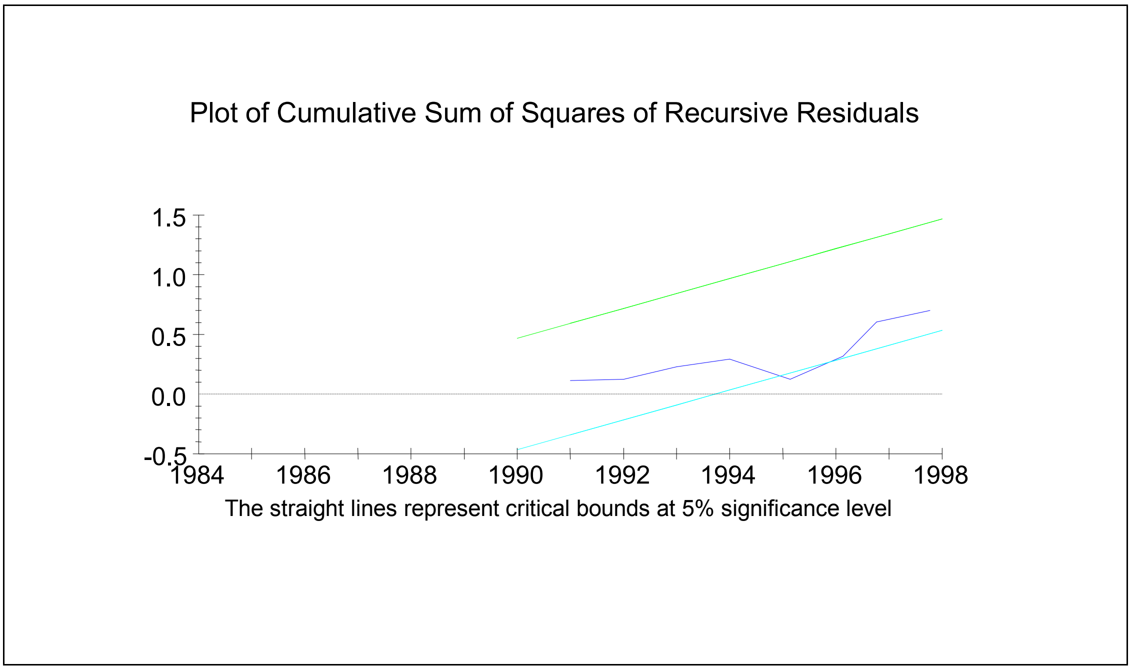


**Figure A7: Israel *M1* stability, 1984-1998**

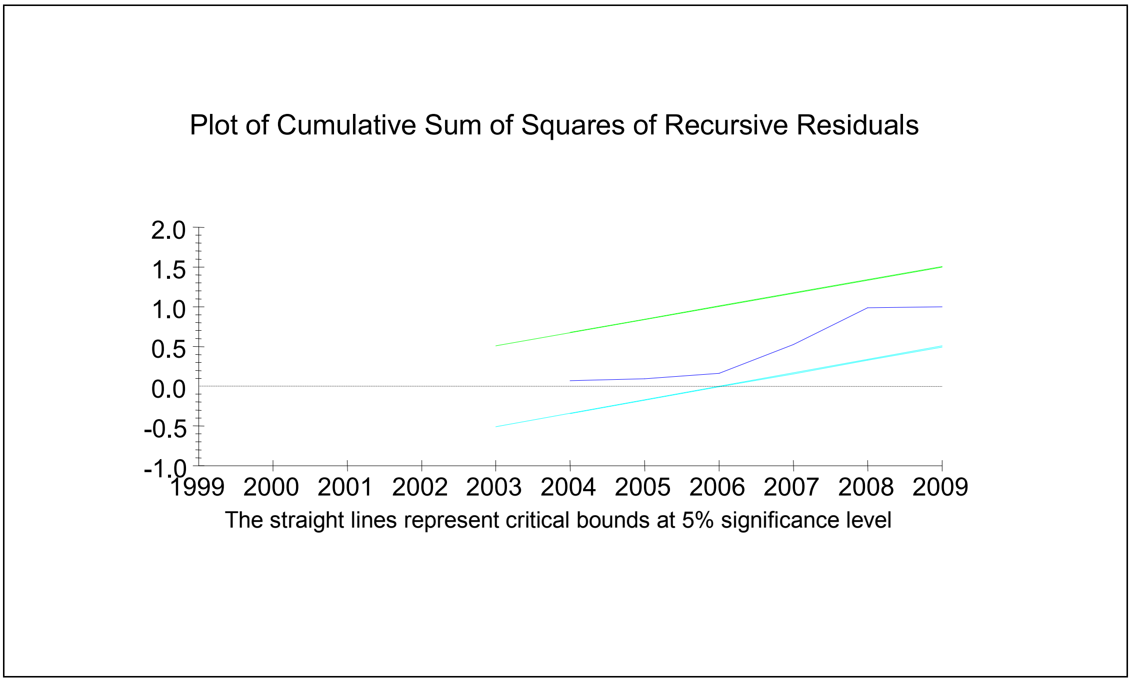


**Figure A8: Israel *M1* stability, 1999-2009**

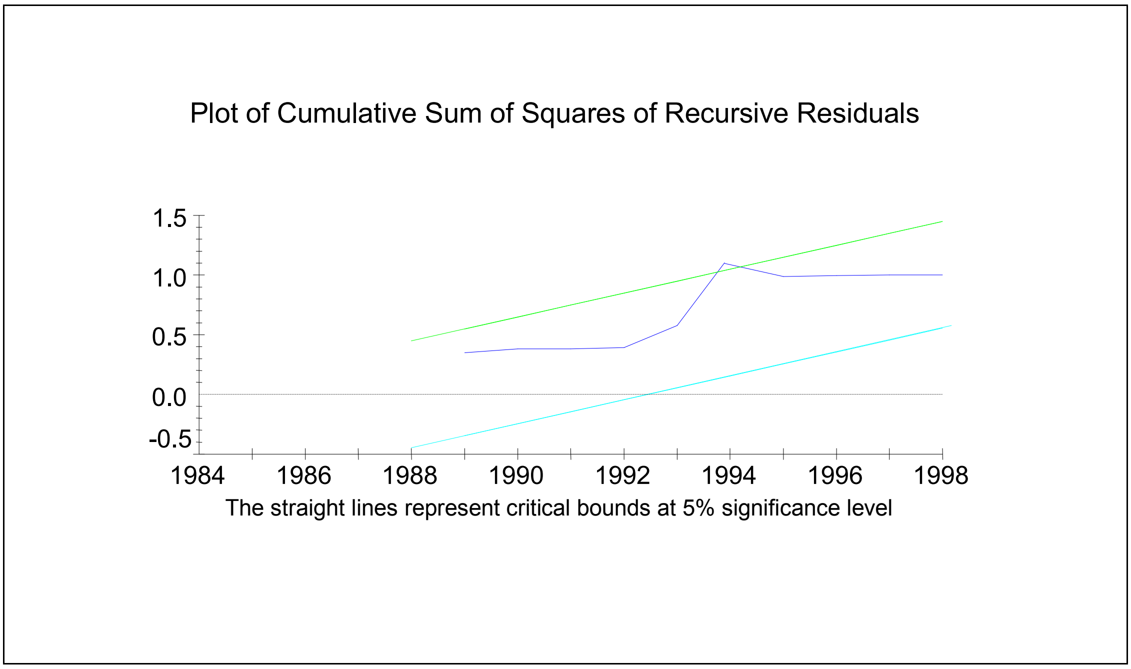


**Figure A9: South Korea *M1* stability, 1984-1998**

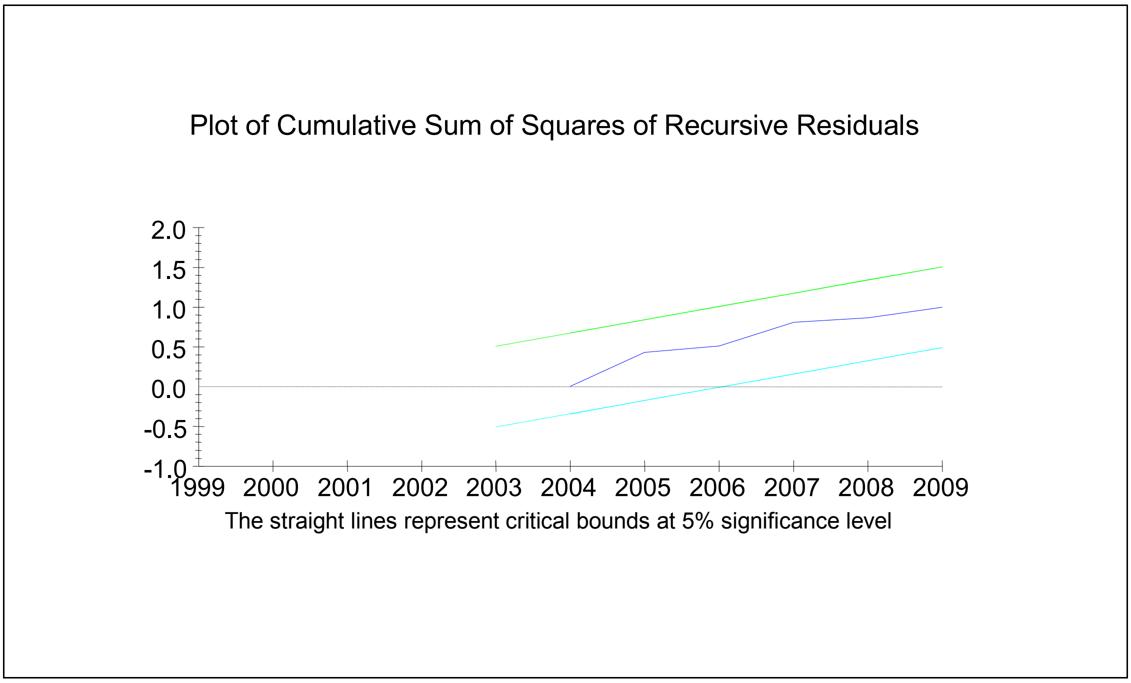


**Figure A10: South Korea *M1* stability, 1999-2009**

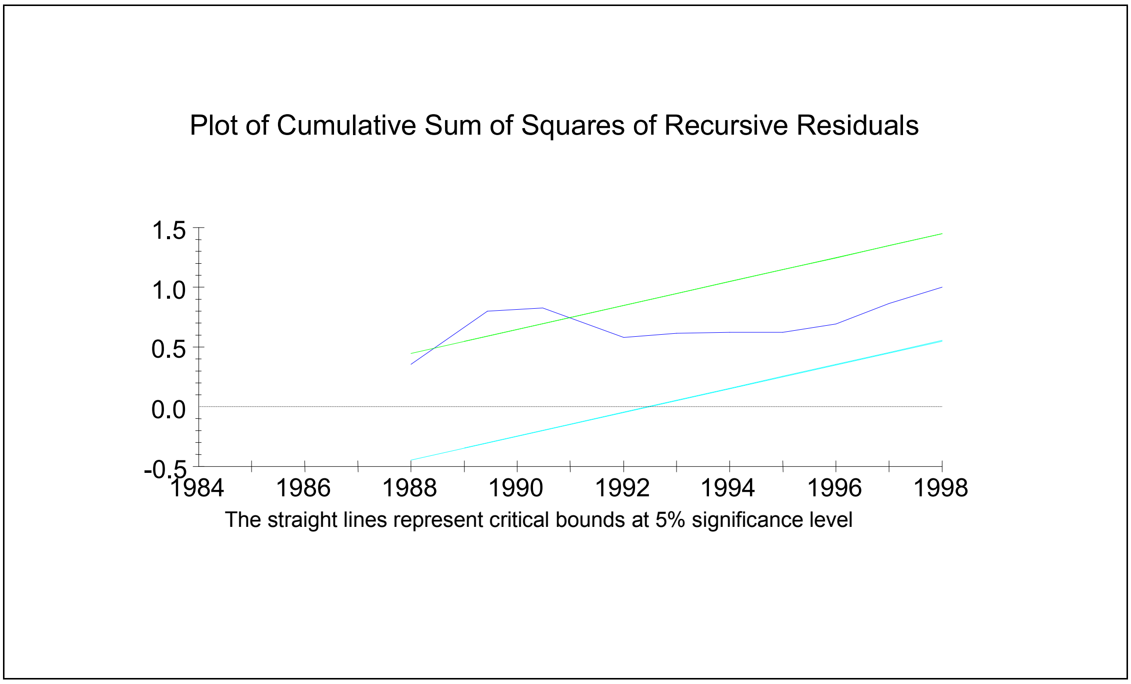


**Figure A11: Singapore *M1* stability, 1984-1998**

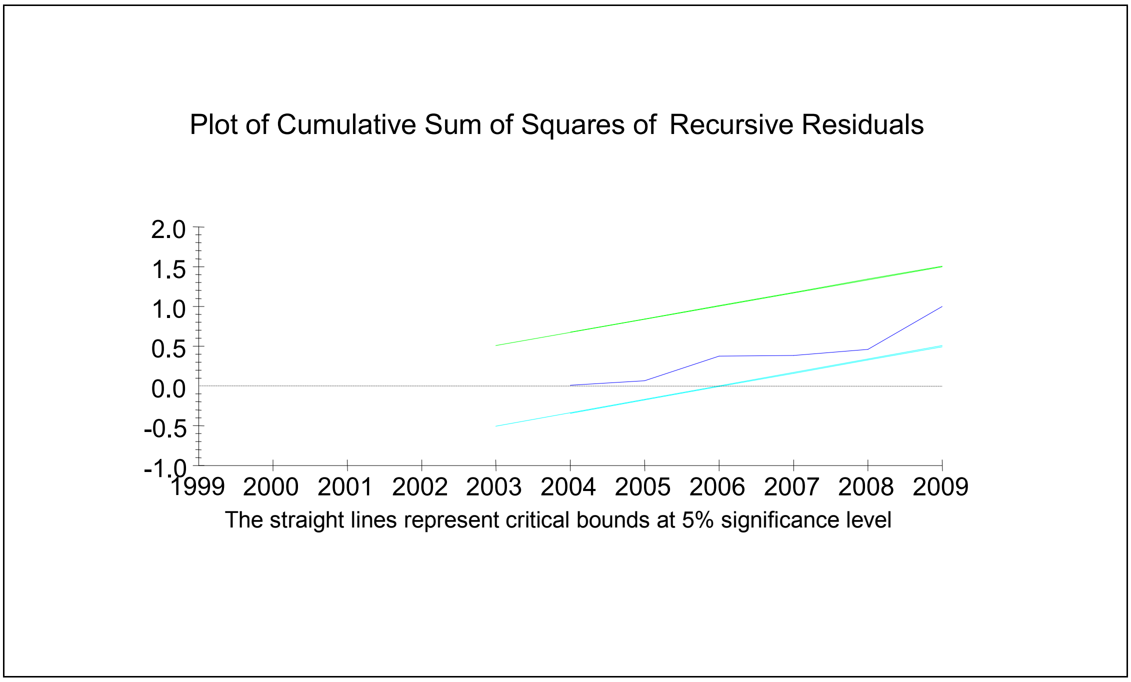


**Figure A12: Singapore *M1* stability, 1999-2009**

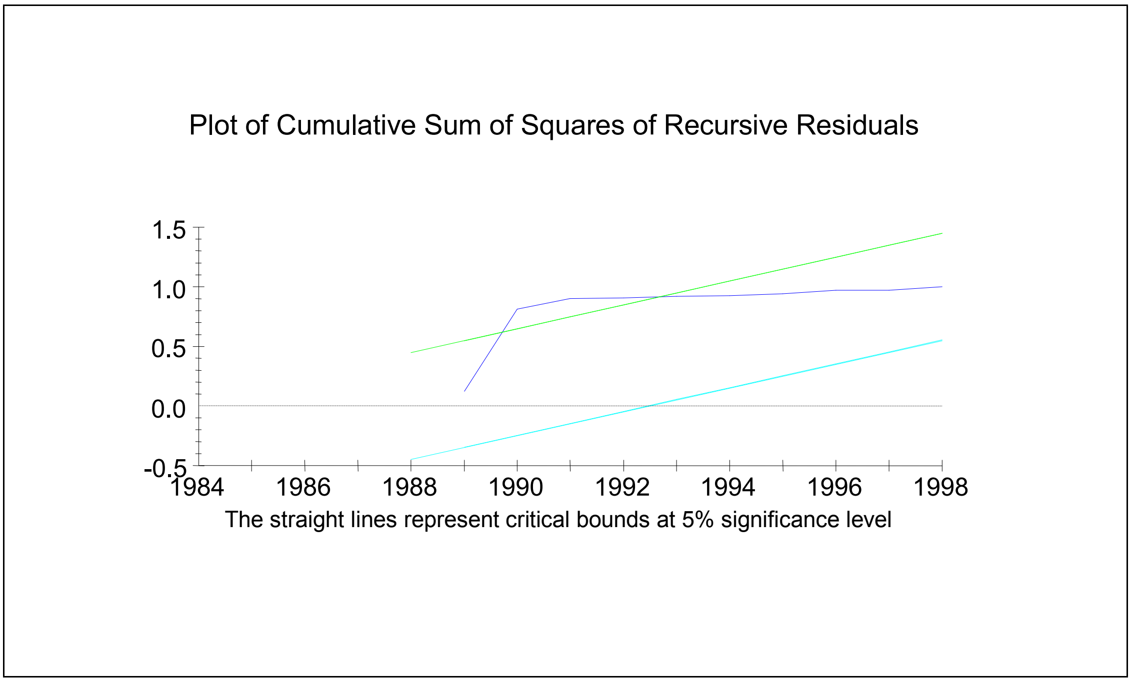


**Figure A13: South Africa *M1* stability, 1984-1998**

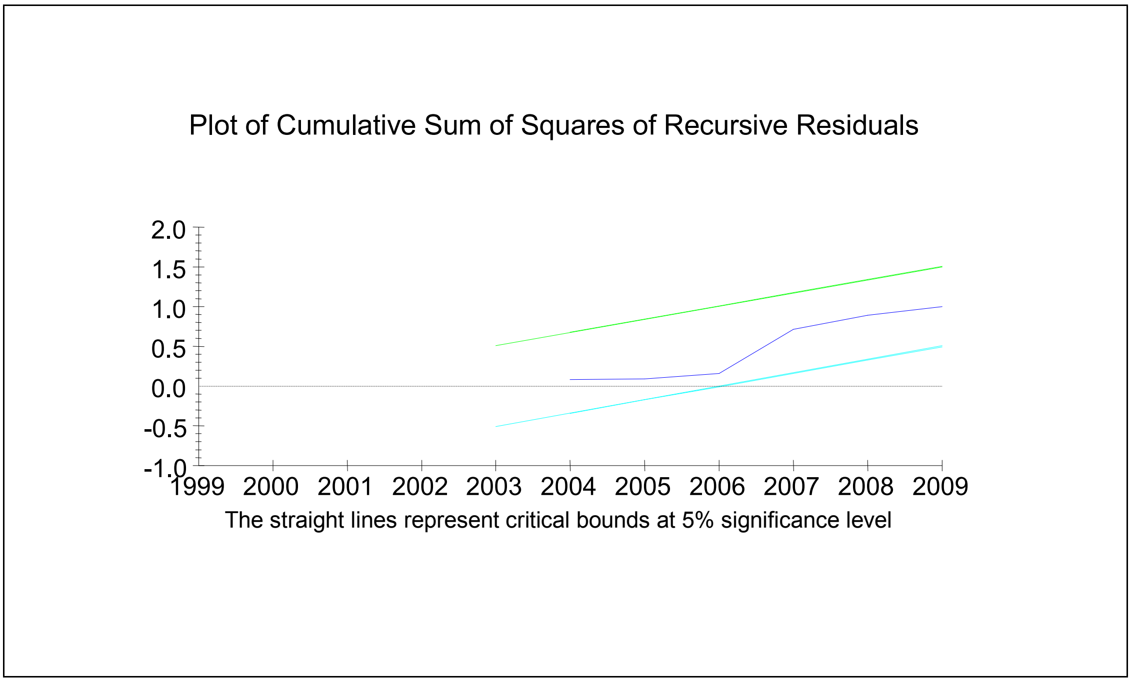


**Figure A14: South Africa *M1* stability, 1999-2009**

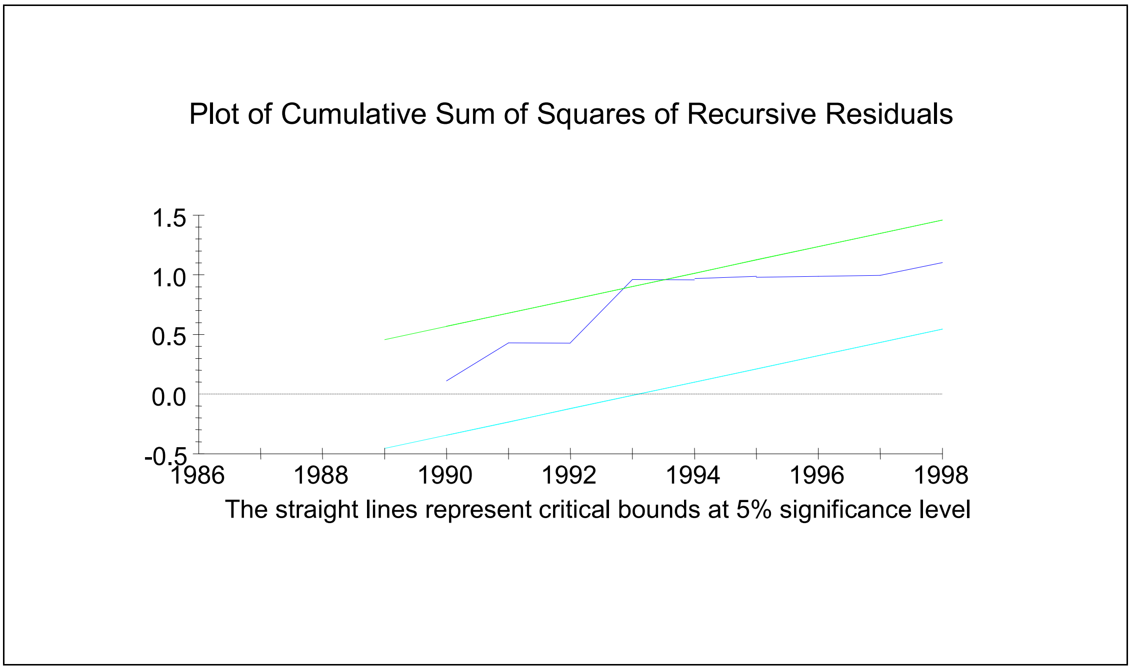


**Figure A15: Australia *M1* stability, 1984-1998**

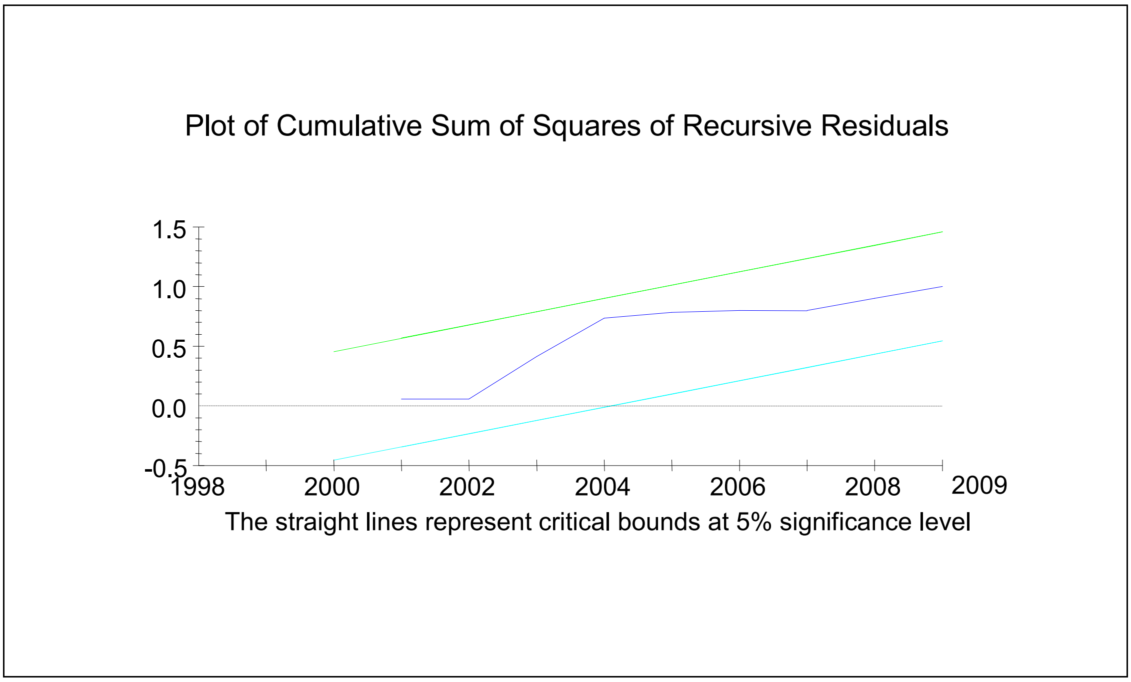


**Figure A16: Australia *M1* stability, 1999-2009**

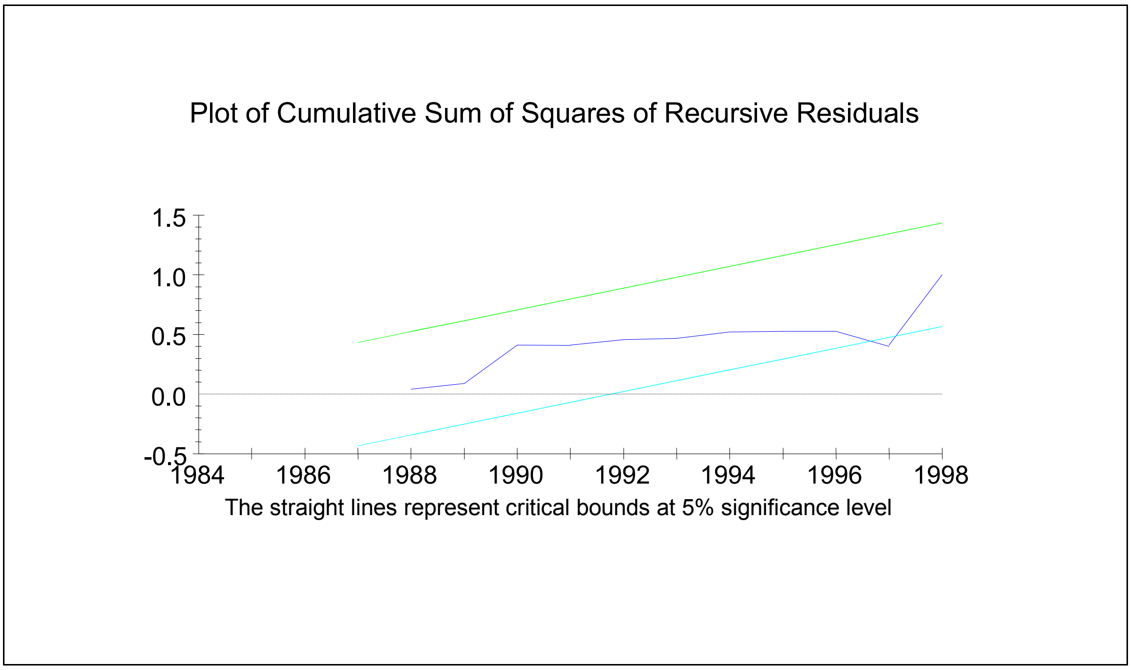


**Figure A17: Canada *M1* stability, 1984-1998**

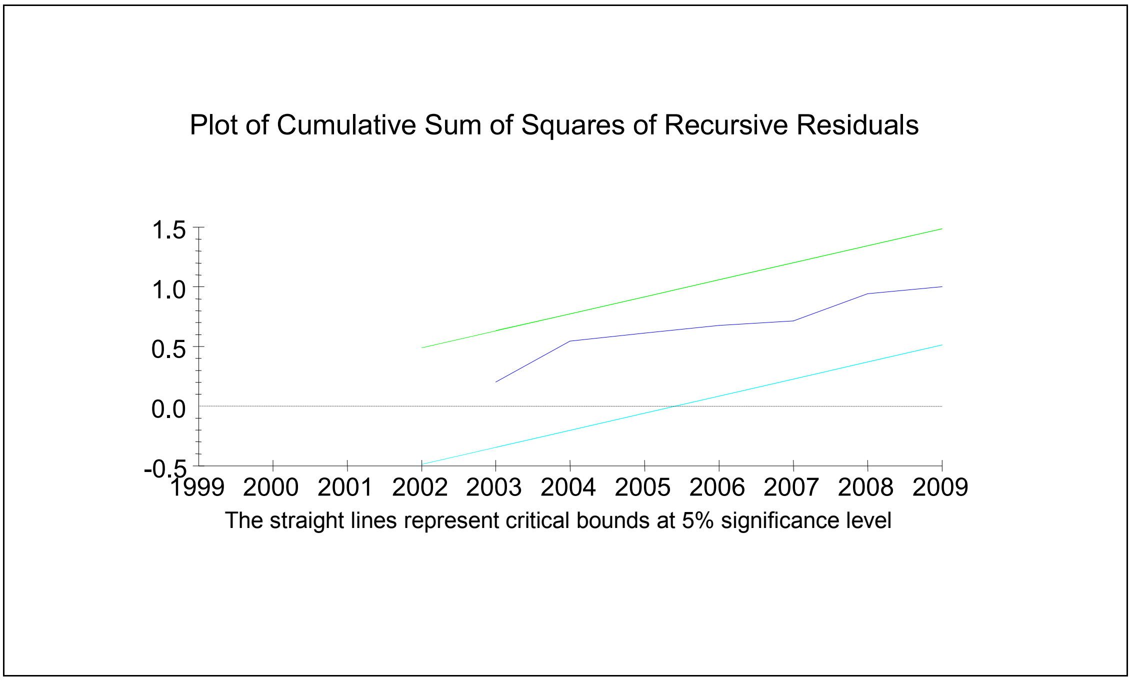


**Figure A18: Canada *M1* stability, 1999-2009**

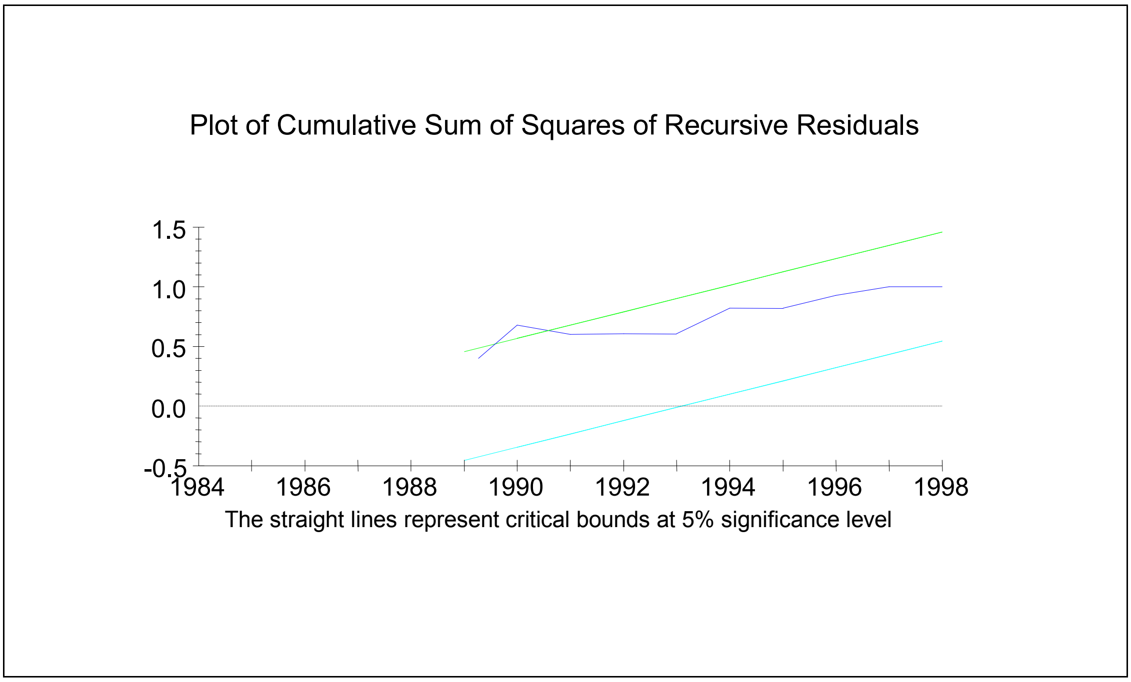


**Figure A19: Denmark *M1* stability, 1984-1998**

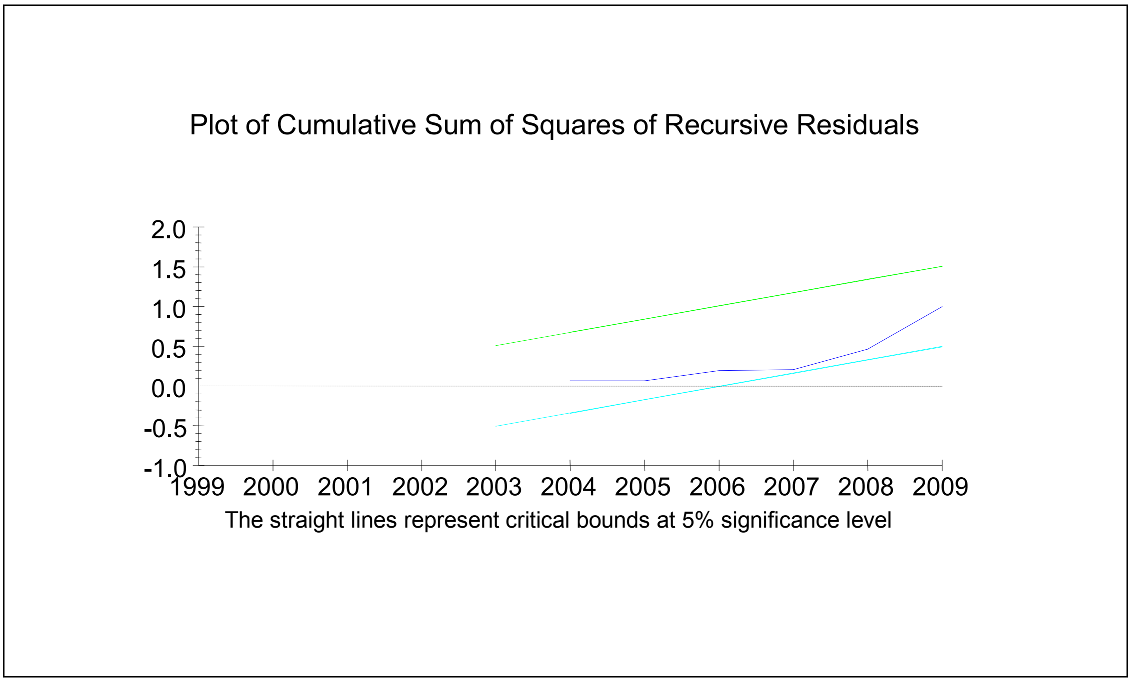


**Figure A20: Denmark *M1* stability, 1999-2009**

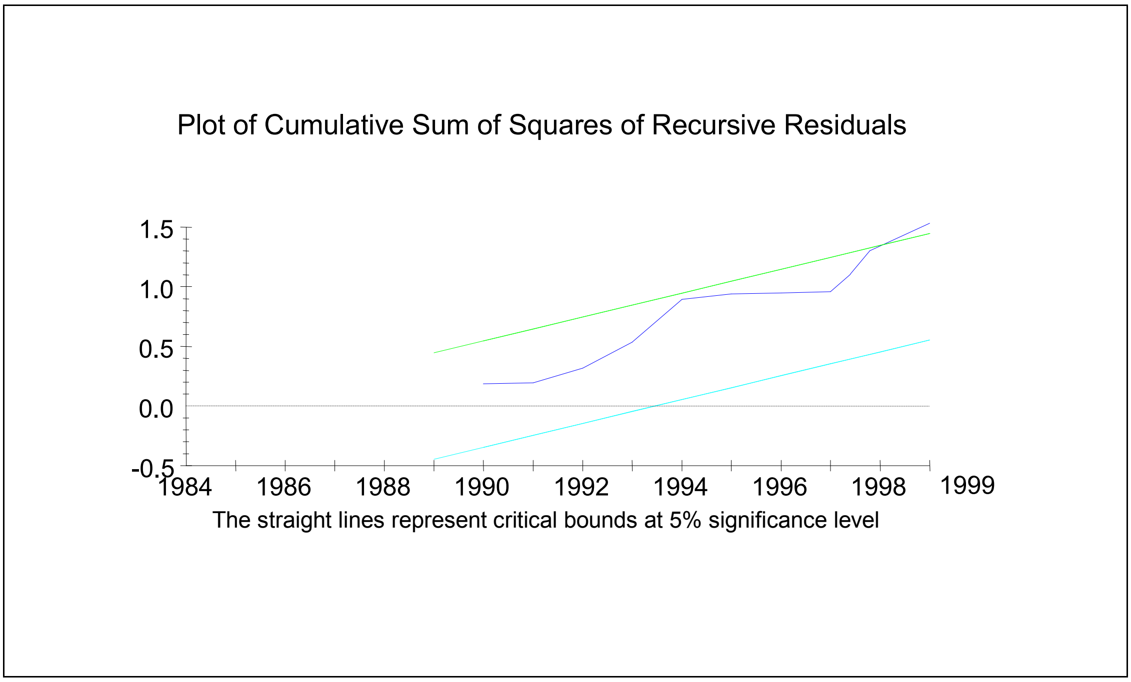


**Figure A21: Japan *M1* stability, 1984-1998**

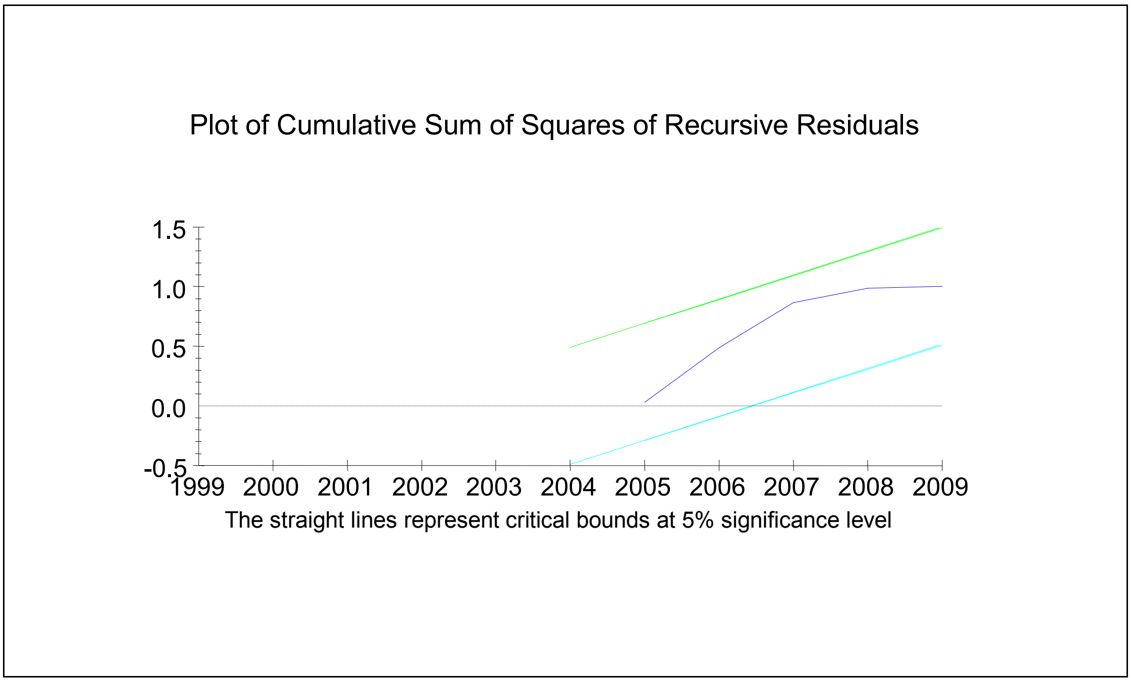


**Figure A22: Japan *M1* stability, 1999-2009**

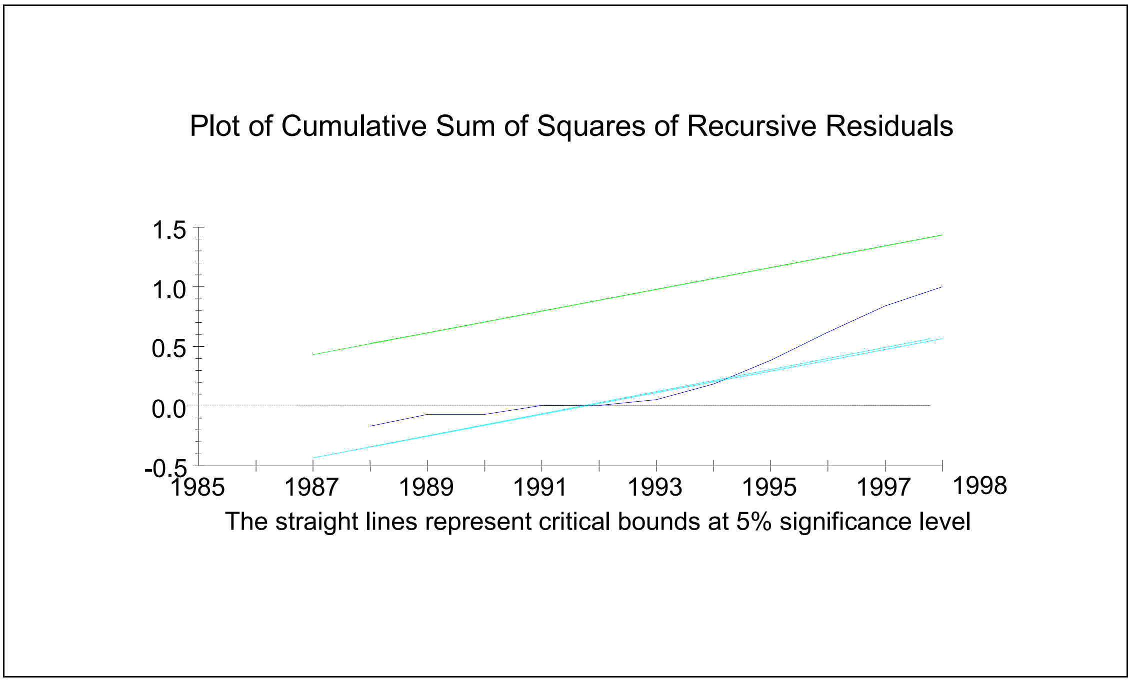


**Figure A23: New Zealand *M1* stability, 1984-1998**

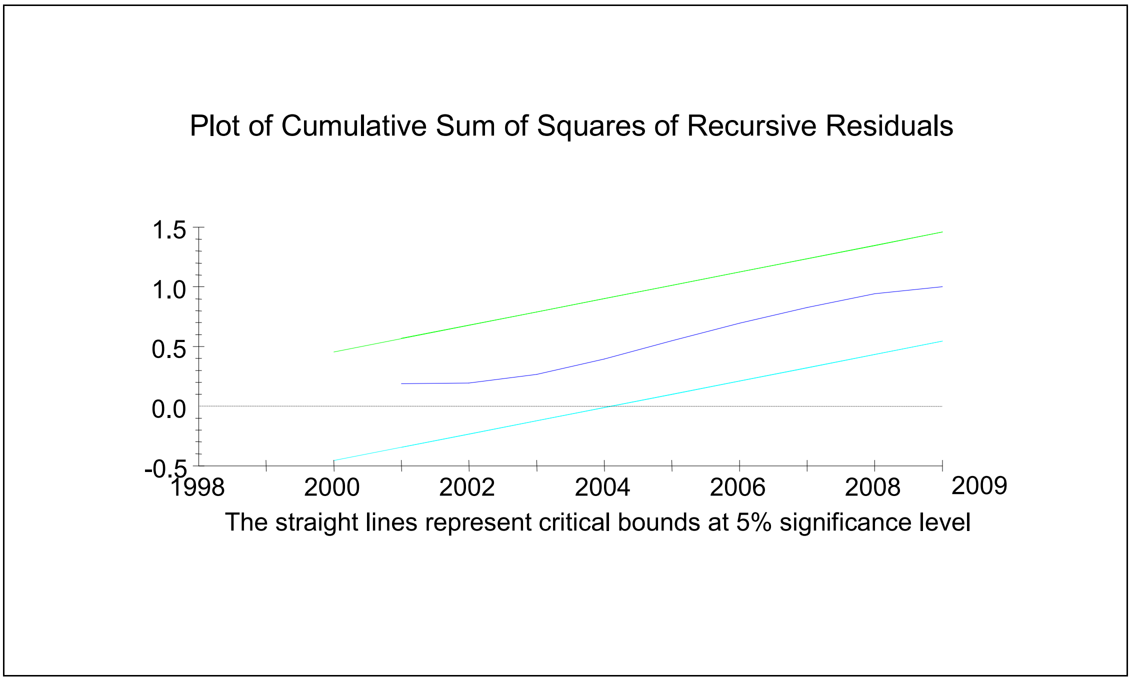


**Figure A24: New Zealand *M1* stability, 1999-2009**

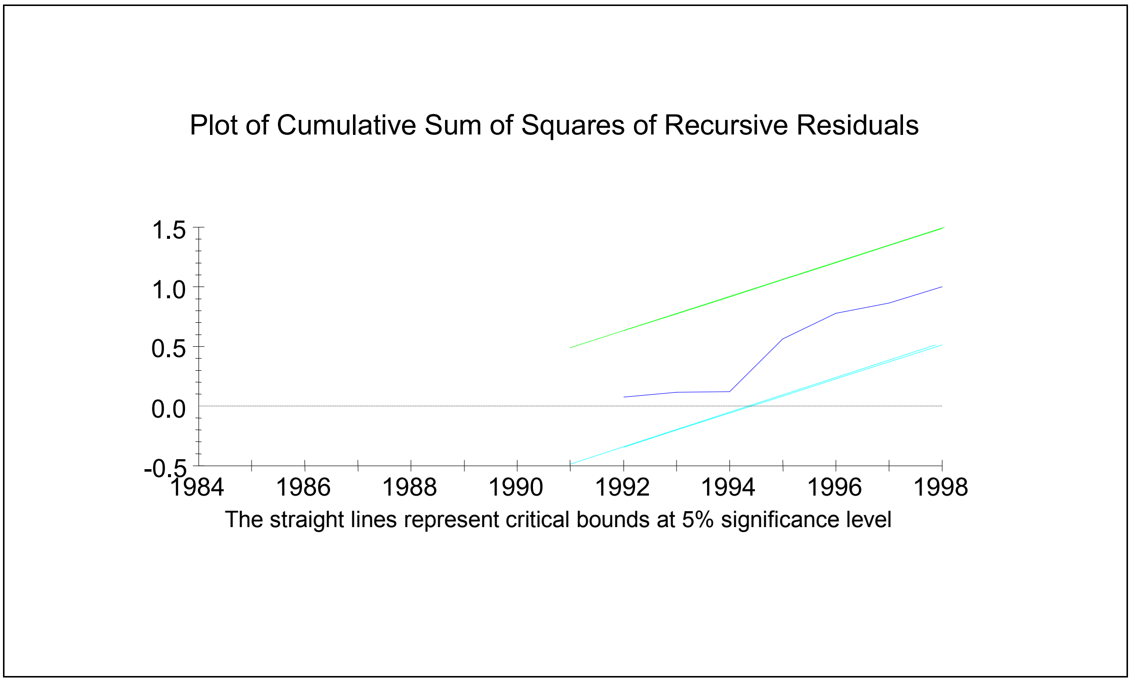


**Figure A25: Switzerland *M1* stability, 1984-1998**

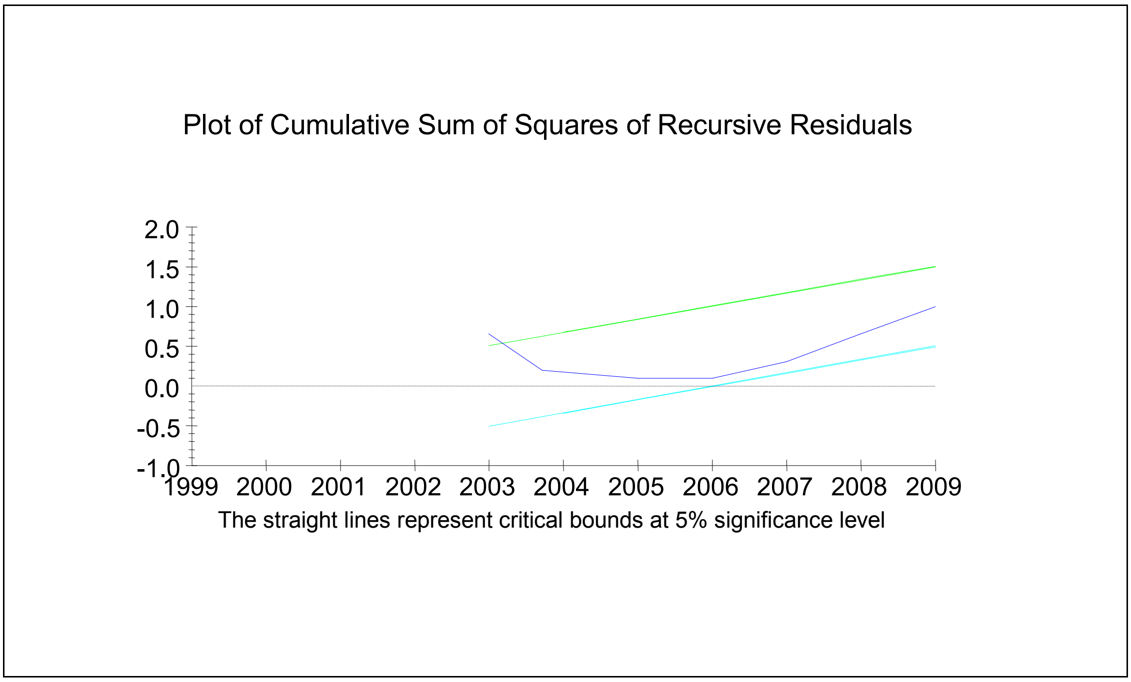


**Figure A26: Switzerland *M1* stability, 1999-2009**

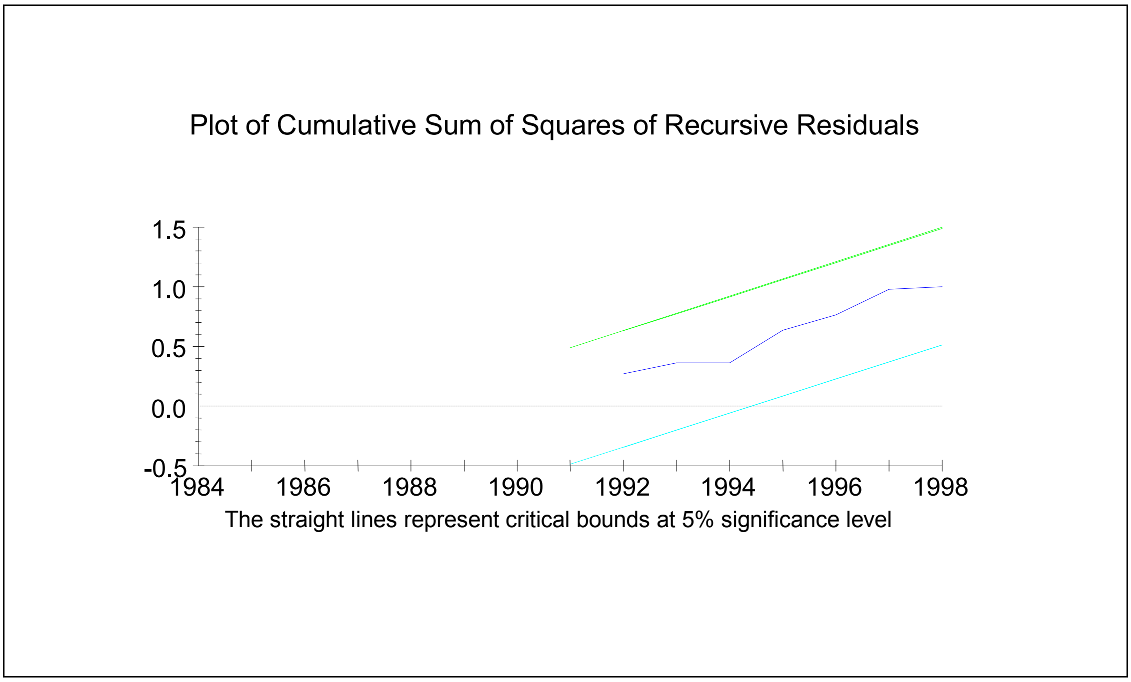


**Figure A27: USA *M1* stability, 1984-1998**

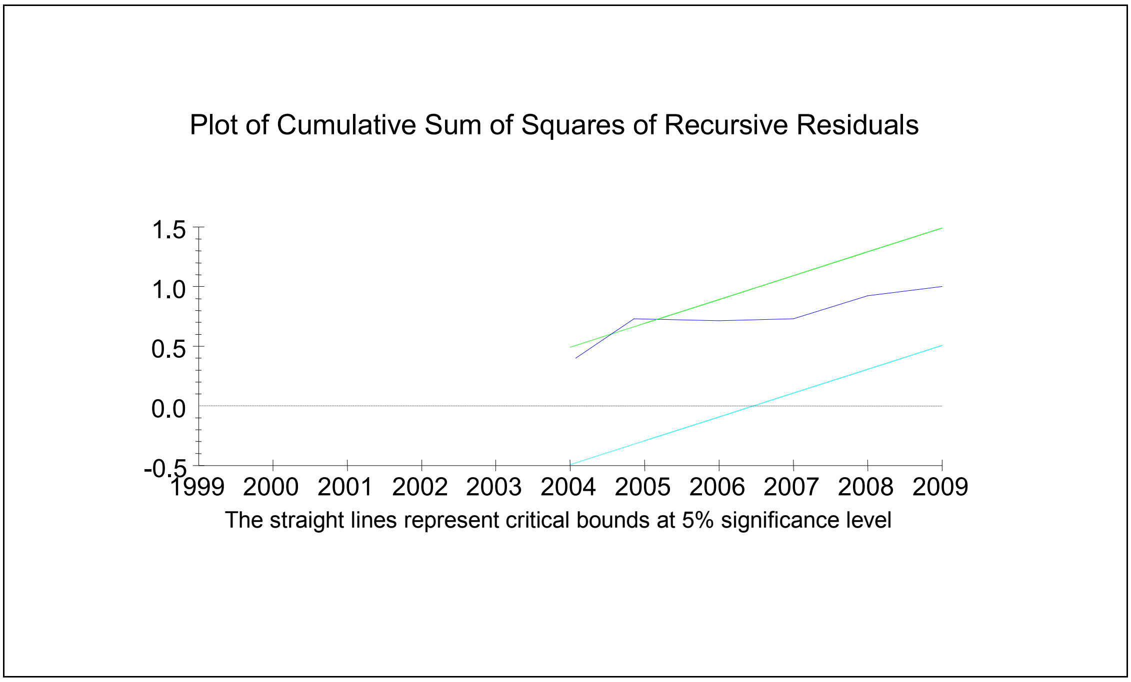


**Figure A28: USA *M1* stability, 1999-2009**