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Abstract:

We revisit the issue of stable demand for money, using quarterly data for the European Monetary Union, India, Israel, Poland, the UK, and the US. We use a modern version of the same linear time-series macroeconometric modeling and specification approach that had previously cast doubt on money demand stability. Autoregressive distributed lag (ARDL) cointegration models are used in the study to establish a long-term relationship among real money balances, real output, interest rate, and real effective exchange rate. For all the countries analyzed, evidence of stable demand for money is found. Broad money in general is better at capturing a stable demand for money than narrow money. The stability results are especially strong, when broad Divisia money is used instead of its simple sum counterpart. Our results are consistent with the large literature on the Barnett critique, which is based on a different methodological tradition that employs microeconometric modeling of integrable consumer demand systems. That literature has never found the demand for monetary services, measured using reputable index number and aggregation theory, to be any more difficult to model or less stable than the demand for any other good or service in the economy.

Keywords: Narrow money demand, broad money demand, simple-sum monetary aggregates, Divisia monetary aggregates, ARDL cointegration approach

JEL Classification: C23, E41, E52

1. Introduction

We examine the nature of the demand for money in the Euro Area, India, Israel, Poland, the UK, and the U.S, using the modern autoregressive distributed lag (ARDL) cointegration technique. The stability of the money demand function is one of the most extensively researched topics in the literature on monetary policy. According to the classical monetary theory of price determination, stable money demand is critical to establishing a long run equilibrium relationship between money, output, prices, interest rates, and exchange rates. The quantity theory prediction that inflation is ultimately determined by the rate of money supply growth is predicated upon the existence of stable money demand. By exploiting this quantity theoretic link, if stable, central banks can more effectively achieve their goal of long run price stability by closely monitoring money demand and supply.

Money began to play a minor role in policy after a series of papers in the 1970s indicated that demand for central banks' official simple-sum monetary aggregates was unstable in some countries.[1] Traditional linear demand for money functions using simple-sum monetary aggregates frequently over-predicted money demand, raising concerns about the "missing money" mystery. Furthermore, those linear money demand functions appeared to be unstable, with frequent shifts in their parameters. These empirical irregularities were primarily attributed to financial innovation and institutional/regulatory changes (e.g., James (2005), Adil et al. (2020a)). Money was largely abandoned under the New Keynesian tradition, and the central banks adopted interest rate as the primary monetary policy tool. However, during the 2008 Great Financial Crisis (GFC), interest rates at the zero lower bound lost credibility as reliable monetary policy tools.

While interest rates at zero, economies were in a liquidity trap with low inflation and output. Despite introducing alternative policy tools such as quantitative easing and forward guidance, monetary policy appeared not to be adequately accommodating. Money growth in those economies was declining, but that fact was being overlooked. More recently, there was a

[1] See, for example, Goldfeld, Fand, and Brainard (1976) and Roley (1985) in the case of the US and Darrat (1986) in the case of four Latin American countries.

huge spike in monetary growth during the pandemic. Despite the surge in liquidity, central banks routinely predicted zero inflation for at least three years into the future along with interest rates remaining at zero. But with a lag of about a year during the pandemic, inflation has reappeared in a worrisome manner, casting doubt on the credibility of "forward guidance." Consequently, there has been a resurgence of interest in the role of money. See, for example, Belongia and Ireland (2016), Ghosh and Parab (2019), Hendrickson (2014), Keating et al. (2019), Serletis and Gogas (2014), and Barnett, Park, and Park (2021).

The empirical failure of money demand has been attributed to the use of simple-sum monetary measures, according to the literature on aggregation-theoretic measurement of money. Simple sum and arithmetic average aggregation, treating components as indistinguishable perfect substitutes, have been discredited in index number and aggregation theory since Fisher's (1922) classic study appeared. In Divisia monetary aggregation, the growth rates of components of money are weighted to reflect their relative contributions to monetary service flows and are directly derived from microeconomic optimizing behavior. A consequence is the ability of Divisia monetary aggregates to measure changes in the economy's liquidity, even as new monetary instruments are introduced (Barnett (1980), Belongia and Binner (2001)).

The research using Divisia monetary aggregates, which are derived from microeconomic aggregation theory, has never confirmed any of the findings of "missing money" or unstable money demand. See, for example, Barnett (1980, 1982, 1997), Barnett, Offenbacher, and Spindt (1984), and Barnett, Fisher, and Serletis (1992). A table of relevant early empirical tests is available in Barnett (1982, Table 1). Moreover, many researchers have continued to look into those early debates using more recent data, but they have mostly focused on US data. Hendrickson (2014), Belongia and Ireland (2016), and Serletis and Gogas (2014), for example, discovered a stable Divisia money demand equation for the US and found that Divisia money outperformed simple sum. In addition, Belongia and Ireland (2016) discovered that demand for Divisia money remained stable throughout the 1980s financial innovations as well as the Great Recession of 2008. The authors pointed out that the perceived instability of money demand was due to monetary mismeasurement rather than a dysfunctional relationship between money, real income, and interest rate.

As Barnett and Alkhareif (2013) observed, inflation can better be predicted by information contained in Divisia money rather than their simple-sum counterparts. The conclusion that unstable money demand is a consequence of an internal contradiction between simple sum aggregation and the microeconomic theory producing money demand functions has become known as the Barnett Critique. See, for example, Chrystal and MacDonald (1994), Belongia and Ireland (2014), and the open access encyclopedia entry, Barnett, Park, and Park (2021).

Our research is based on a traditional linear time-series approach to modeling money demand, rather than the microeconomic theory-based approach favored by advocates of the Barnett Critique. In fact, the latter approach has never found that money demand is less stable than any other good's demand in the economy. The long literature on the Barnett critique is based on the micro-theoretic approach, on which index number and aggregation theory are themselves based. The micro-theoretic approach produces integrable nonlinear systems of demand equations and has been applied to money demand in the Barnett critique literature using state-of-the-art models from the consumer demand systems literature, such as the Rotterdam model demand system, Fourier demand system, Laurent series demand system (the minflex Laurent model), and the Muntz-Szatz series expansion system (the AIM demand system).[2]

But the published findings of unstable money demand have not used demand systems derivable from microeconomic theory. Instead that literature has used *ad hoc* linear systems that are not integrable to utility of production functions. For that reason, we use a modern version of the traditional linear time-series approach to specification, which produced the influential literature on unstable money demand. We are not advocating that approach over the rigorously micro-founded approach. Rather, we are investigating the literature on unstable money demand on its own methodological grounds, but using a newer linear time series inference method.

The presence of a combination of stationary and non-stationary variables in our data causes the ARDL cointegration technique to be particularly suitable for the analysis. In capturing the long-run demand for money, we compare the merits of correctly measured Divisia money with those of simple sum measures, as well as the merits of narrow money with those of broad money. In earlier studies, the effectiveness of Divisia money in capturing stable demand for money was mostly based on US data. We broaden the analysis to include five more countries along with the US. While the earlier studies were based on a closed economy version of demand for money, we estimate a theoretically more appropriate open economy version for those economies. In addition, for both simple sum and its Divisia counterpart, we compare narrow money with broad money to explore whether narrow money or broad money more accurately characterizes the demand for monetary services of each country.

Our results establish the existence of stable demand for broad money for all the countries analyzed. Divisia money delivers superior results compared to its simple sum counterpart, with

[2] A useful source of recent research on the subject of stability of money demand and the Barnett Critique is the library online at the Center for Financial Stability at www.centerforfinancialstability.org/amfm_library.php.

Divisia M3 providing the best outcome among all the models evaluated. We find the existence of a long-run cointegrating relation between real money balances, real income, interest rates, and the real effective exchange rate. We also find statistically significant and economically meaningful long-run and short-run coefficients of the three explanatory variables in the demand for money equations. The results hold across the six countries and are robust to use of different lag selection criteria. We recommend that properly measured money (broad Divisia) growth be used as a key information variable in monetary policy. Central banks can more effectively achieve their goal of long run "price stability" by closely monitoring money demand and supply, while utilizing the quantity theoretic link between money growth and inflation.

These conclusions remain relevant, when central banks use alternative policy tools, such as quantitative easing or forward guidance, whose short-term and long-term effects on inflation are not yet clear. In fact, Barnett, Bella, Ghosh, Mattana, and Venturi (2021) have found that the widespread central bank focus on myopic interest rate feedback (Taylor) rules, without a terminal condition or long run anchor, may have been responsible during the past three decades for the unintended downward drift in interest rates to their lower bound.

The rest of the paper is organized as follows. Section 2 reviews the previous literature on stability issues. Section 3 defines the dataset, model specification, and empirical methodology. Section 4 discusses the empirical results. Section 5 summarizes the results and provides robustness checks of the models under study. Section 6 is the conclusion.

2. Literature review

The demand for money has been a cornerstone of monetary policy design for many years. To ensure price stability and maintain economic growth, economists and policymakers have long been studying money demand behavior and its interactions with macroeconomic fundamentals, particularly inflation and output. A theoretical linear money demand functions using simple sum monetary aggregates became unstable in the late 1970s and 1980s, with that instability commonly imputed to financial innovation. Consequently, most central bankers and monetary authorities have abandoned the use of money in monetary policy formulation. Most central banks eventually shifted their attention away from intermediate monetary aggregate targeting and towards an inflation targeting framework.[3] Nevertheless, the European Central Bank (ECB) has continued to assign a special role to money as part of its 'two-pillar strategy,' consisting of 'economic analysis' and 'monetary analysis.' A wide set of short-term indicators in economic analysis are complemented by the long-term determinants of inflation in monetary analysis. See European Central Bank (2004).

The Quantity Theory of Money, which states that money supply growth determines the long run inflation rate, supports the use of money as an essential indicator in monetary analysis. If these two pillars were to be merged in the future, a larger pillar would likely emerge, with money playing a prominent role in guiding the ECB's monetary policy decisions in the long run. Monitoring money growth as an important information variable could serve as a long-run check on whether the ECB's short-run interest rate decisions have paved the way to achieve price stability without unexpected adverse long run consequences. This role for money is possible, if money demand remains stable regardless of structural changes brought on by financial innovation. Indeed, financial innovation, being a supply side phenomenon, need not alter the demand for monetary services.

[3] Inflation targeting has been practiced in advanced economies, such as Australia since 1993, Canada since 1990-91, Japan since 2013, New Zealand since 1989-90, and Norway since 2001. Some of the countries in emerging market economies are moving towards inflation targeting, e.g. Chile since 1999, Brazil since 1999, Hungary since 2001, Indonesia since 2005, and South Africa since 2000. See the Reserve Bank of India (2014).

In response to the global financial crisis of 2008-09 and Europe's sovereign debt crisis, the ECB lowered its policy rate. Despite the remarkably low interest rates, inflation has remained consistently below the targeted rate, and economic output did not recover to its previous level. The interest-rate-based monetary policy rule has been called into question and has lost its appeal as a sole intermediate monetary policy target. During the crisis, monetary policy implementation by setting a target for a short-term interest rate was seen as ineffective, because interest rates remained near the zero lower bound (Belongia and Ireland (2021)).

With the preceding discussions in mind, one might wonder if the ECB could have used Quantity Theoretic relationships between money growth and inflation rate to achieve its price stabilization goal more effectively without adverse consequences for growth and without interest rates declining to the lower bound, far below the marginal product of capital. Such an alternative policy would have focused on the second pillar of monetary analysis. The fact that the policy interest rate has been at or below the zero lower bound lends credence to the common view that the ECB had taken all necessary steps to assist the economy in recovering from its financial and sovereign debt crises. Nevertheless, monetary policy seemed to be insufficiently accommodating to overcome the crisis. Perhaps the ECB could have conducted monetary policy more effectively during the crisis, if it had focused on its second pillar of monetary analysis. More recently, the resurgence of inflation in the US following a surge in money supply growth during the pandemic was not anticipated by the Federal Reserve. In fact, the Chairman of the Federal Reserve Board had been publicly predicting that the surge in money growth would not produce inflation, and zero inflation could be expected for at least three more years with interest rates remaining at zero. These forecasting errors harmed the credibility of the forward guidance instrument of policy. As a result of monetary policy problems during financial crisis period and the subsequent pandemic period, it has become important to reconsider money's role in monetary policy and thereby the stability of money demand.

Simple-sum aggregation is based on the assumption of perfect substitutability among all components. For monetary aggregation, this assumption is most plausible for the narrowest aggregate, M1, provided that currency in circulation and demand deposits yield zero nominal interest. However, this assumption will clearly not be relevant for broader monetary aggregates, such as M2 and broader aggregates (e.g., Barnett (1982), Alkharief and Al-Rasasi (2021)). Contrary to simple-sum aggregation, the Divisia monetary index is rigorously consistent with the microeconomic foundations and aggregation theories from which the Divisia index was derived. No assumptions are made about the aggregator function other than that it is increasing, concave, and linearly homogeneous. As a result, the Divisia monetary aggregates accurately weight all monetary assets within the monetary aggregates.[4] We briefly survey some of the prominent literature on money demand estimation and its stability properties for the countries used in our empirical analysis.

By developing a nonlinear cointegration technique, Bae and Jong (2007) examine logarithmic money demand specifications to investigate the presence of nonlinearity in the long-run cointegrating relationship in the US. The nonlinear cointegration least squares (NCLS) model provides superior out-of-sample prediction and is robust to serial correlation in the errors. Consequently, the study argues that their US long-run money demand function is well-specified. According to Lucas and Nicolini (2015), money demand instability in the US during the 1980s was caused by banking sector regulatory changes, although there is no explanation about why supply side structural changes should have affected demand side stability. The study constructs a

[4] Further details on simple-sum and the Divisia monetary aggregates can be found in the series of seminal works by Barnett (1980, 1982) and Barnett et al. (1984).

new simple-sum monetary aggregate (New M1) to resolve the presumed empirical breakdown of money demand function stability. Their New M1 aggregate was found to perform remarkably well during 1915-2012. “We are trying to get the quantity theory of money back to where it seemed to be in 1980,” they conclude.

Ball (2001) examines the money demand function with post-war US data. Estimates of scale and opportunity cost variables are found to be nearly 0.5 and -0.05, respectively. When compared to the prewar period's corresponding parameters, these estimates are lower. In the New Keynesian macroeconomic framework, Nelson (2003) investigates the role of money. The study looks at the relationship between money and inflation, as well as the relationship between money and aggregate demand. The study empirically supports the role of money in an effective monetary policy.

Research using Divisia monetary aggregates never confirmed the “missing money” paradox or other early findings of unstable money demand. Nevertheless, many researchers have continued investigating those early controversies with more recent data. Hendrickson (2014), for example, used a cointegrated vector-autoregressive model to estimate a stable Divisia money demand equation for the US and concluded that the information content of Divisia money qualifies it as an appropriate intermediate target for the US monetary policy. A cointegrating money demand was also identified by Belongia and Ireland (2016). In their tests, they discovered that Divisia money outperformed simple sum, and that demand for Divisia money remained stable throughout the financial innovations of the 1980s, as well as during the Great Recession of 2008. The authors emphasized that the perceived instability of money demand was caused by the mismeasurement of money, rather than any dysfunctional relationship between money, real income, and interest rate. Serletis and Gogas (2014) have also found stable long-run money demand relationships for the US Divisia monetary aggregates, while the simple sum demand for money was found to be largely unstable.

Except for a few outliers, Artis and Lewis (1984) argue that the simple-sum money demand function in the UK is stable over time. The relationship accurately describes the mid-1970s observations. They mentioned a number of plausible explanations for the outliers (mid-1970s), including institutional changes, Competition and Credit Control reforms, supply shocks, movement toward a flexible exchange rate regime, and budget deficits. Again there is no explanation why supply side phenomena should have affected demand function stability. From 1997:Q1 to 2013:Q3, Bahmani-Oskooee et al. (2015) investigate the impact of policy uncertainty on simple-sum money demand in the UK. The use of a bounds testing approach to cointegration shows that money and its covariates have a stable relationship.

Funke (2001) examines the factors influencing simple-sum money demand in the Euro Area using data from 1980:Q1 to 1998:Q4 and finds that broad money demand is stable while narrow money demand is unstable. The study's significance is highlighted by the ECB's "two-pillar strategy." As Funke (2001, p. 710) points out relative to that strategy: "Whether the announced growth rate of broad money still deserves to be called an intermediate target or would have to be called just an indicator, is a matter of semantics." A hybrid monetary strategy is also recommended by the Deutsche Bundesbank (1998). Brand and Cassola (2004) study simple-sum M3 money stock for the Euro Area from 1980:Q1-1999:Q3 to measure the implications of monetary and financial developments on key macroeconomic variables. They use structural VAR and cointegration analysis to model the dynamics of inflation, income, money, and interest rates. Coenen and Vega (2001) examine the simple-sum M3 money stock in the Euro Area and find three cointegrating relationships with economic content. The study depicts no misspecification of the money demand function during the sample period.

Buch (2001) examines simple-sum money demand stability and its determinants in Hungary and Poland during their transitional periods, using data from 1991:M01 to 1998:06 and 1991:M01 to 1998:M08, respectively. The model depicts stable money in some of the specifications, despite structural changes caused by regime shifts in exchange rate policies. On the basis of stable money demand, however, they are unable to conclude whether inflation targeting is better than monetary targeting, since it is difficult to measure and forecast inflation during a transitional phase. In Hungary, the deposit and inflation rates have a statistically significant negative effect on simple-sum M1 and M2, according to the study. In Poland, deposit and inflation rates have statistically significant positive and negative effects on simple-sum money demand, respectively. Furthermore, because the simple-sum money demand function was found to be stable, the study suggests that in advanced reform states, a monetary target should not be dismissed *a priori*.

Yashiv (1994) investigates the simple-sum money demand function in Israel from 1965 to 1989 using the cointegration method. The increased use of liquid indexed assets, according to the study, caused the shift in the money demand function in the early 1980s. The study does, however, find cointegration of money demand with its covariates, namely the interest rate and real private consumption.

The failure to factor financial innovation into the simple-sum money demand function, according to Adil et al. (2020a), leads to stability problems such as persistent over-prediction, implausible parameter estimates, and high serial correlation in the errors. Using the bounds testing approach to cointegration, Adil et al. (2020a) find stable short- and long-run money demand functions despite structural changes in the Indian economy. The study concludes that incorporating financial innovation into money demand functions results in more plausible coefficient estimates, with income and interest rate elasticities of money demand that are consistent with economic theory, as well as stable money demand. Nevertheless, microeconomic theory does not provide reason to believe that supply side structural change would alter stability of the demand for services. In the case of India, Haider et al. (2017) and Adil et al. (2020,b,c) find stable simple-sum money demand functions. In India, despite the existence of a stable money demand function, evidence of unstable money demand is found after the economic reform period (Aggarwal (2016)).

According to the reviewed literature, studies on estimating simple-sum money demand function stability have mixed results. This is not the case with studies of demand for Divisia money. Those studies have overwhelmingly found stable demand for money. Divisia money does not measure money stock. In index number and aggregation theory, the Divisia index measures service flows. There is no reason to expect structural change on the supply side to alter the properties of service flow demand functions. But there has been a consistent difference in the methodology used in studies of simple-sum versus Divisia money demand. The Barnett Critique seeks internal consistency of the theory producing the demand functions with the aggregation theory producing the aggregator functions nested within the demand functions. In accordance with that critique, most studies of Divisia money demand have used state-of-the-art consumer demand modeling methodology requiring integrability to a flexible utility function. In contrast, simple-sum monetary aggregates are known to be inadmissible in index number theory and aggregation theory and thereby inherently in conflict with microeconomic theory. As a result, studies of simple-sum money demand have generally been conducted using atheoretical linear time series methodology.

Divisia consistently outperforms its simple-sum counterparts in empirical studies, including money demand function estimation See, e.g., Barnett (1980, 1982), Barnett et al. (1984), Serletis and Gogas (2014), Darvas (2015), Belongia and Ireland (2019, 2021), Jadidzadeh and Serletis (2019), De La Fuente et al. (2020), and Alkharief and Al-Rasasi (2021). On theoretical grounds, there is no contest at all. While the Divisia index is highly regarded in index number and aggregation theory and directly derived from microeconomic theory, the simple sum and arithmetic average index numbers were found by Fisher (1922) to be the very worst index numbers ever proposed and are universally considered to be inadmissible by index number and aggregation theorists, except when aggregating over indistinguishable perfect substitutes (i.e., adding apples and apples, not apples and oranges).

Despite the fact that there is a large body of literature on money demand, the current study is unique in comparison to the previous literature in the following ways.

(i) We seek to gain a better understanding of money growth as an essential “indicator or information” variable in the conduct of an effective monetary policy for the concerned sample countries, namely the US, the UK, the Euro Area, Israel, India and Poland, and to strengthen the second-pillar of the ECB's monetary analyses. We estimate money demand equations based on both simple-sum and the Divisia monetary aggregates.

(ii) We do so using a macroeconomic time series approach consistent with the methodologies used by critics of money demand stability, rather than the state-of-the-art micro-founded consumer demand system modeling approach preferred by advocates of the Barnett Critique.

(iii) Unlike other studies, the current study was motivated by a more prominent theoretical framework of Keynesian money demand to estimate money demand specification in an open economy framework. The main benefit of this model is that it allows us to model the impact of a new explanatory variable, the real effective exchange rate (REER), in addition to the traditional variables, scale and opportunity cost variables. As a result, the model can provide monetary authorities with a better understanding of monetary policy moves in terms of the following: (a) whether the depreciation has a wealth or currency substitution effect; (b) whether the interest elasticity of money demand is elastic or inelastic; and (c) whether the income elasticity of money demand is elastic or inelastic.

(iv) We explicitly check money demand function stability by applying parameter stability tests developed by Brown et al. (1975). As a result, we can determine whether money demand with broad money is more stable than money demand with narrow money, and whether money demand with Divisia money is more stable than its simple-sum counterparts. Our findings can have significant policy implications for today's monetary policy: the inflation targeting framework widely followed by most central bankers around the world.

3. Dataset, model specification, and econometric methodology

3.1 Dataset and model specification:

Table 2 outlines the countries, variables, data sources, and time periods under study.

Table 2: Data description

Country	Variable	Database	Time period
Euro Area	M1, M3, GDP, 3IR, LTIR Div M1, Div M3 REER, CPI	OECD Bruegel BIS	2001: Q1 - 2018: Q2
India	M1, M3, GDP Div M2[5], Div M3 TB-364, G-Sec 10 REER, CPI CMR	OECD Ramachandran et al. (2010) EPWRF BIS HSIE	1996: Q2 - 2008: Q2
Israel	M1, M3, GDP, 3IR Div M1 REER, CPI	OECD Bank of Israel BIS	1995: Q1 - 2014: Q3
Poland	M1, M3, GDP, OIR, 3IR Div M1, Div M3 REER, CPI	OECD Narodowy Bank Polski BIS	1997: Q1 - 2018: Q4
UK	M1, M3, GDP, 3IR, LTIR Div M3 REER, CPI	OECD Bank of England BIS	1994: Q1 - 2019: Q1
US	M1, M3, GDP, 3IR, LTIR Div M1, Div M3 REER, CPI	OECD Center for Financial Stability BIS	1994: Q1 - 2019: Q1

Notes: (a) OECD denotes Organization for Economic Co-operation and Development; EPWRF denotes Economic and Political Weekly Research Foundation; BIS denotes Bank for International Settlement; HSIE denotes Handbook of Statistics on Indian Economy; (b) M1 denotes simple sum monetary aggregate M1; M3 denotes simple sum monetary aggregate M3; GDP denotes gross domestic product; 3IR denotes 3 month interbank rate; LTIR denotes long term interest rate, refer to government bonds maturing in ten years; Div M1 denotes Divisia monetary aggregate M1; Div M3 denotes Divisia monetary aggregate M3; REER denotes the real effective exchange rates, where we have used Broad (60 economies) indices in the case of every country/area; CPI denotes consumer price index; TB-364 denotes 364 Day Treasury Bill rate; G-Sec 10 denotes 10 year government securities; CMR denotes weighted average call money rate; OIR denotes overnight interbank rate; (c) All series are quarterly and seasonally adjusted; (d) The time period differs in case of different countries depending on the availability of the data; (e) For India and the UK, narrow-Divisia (Div M1) is unavailable and for Israel broad-Divisia (Div M3) is unavailable.

Laidler (1982) suggested that a “stable demand for money function” implies, at the very least, that money holdings can be explained, to conventionally acceptable levels of statistical significance, by functional relationships including a relatively small number of arguments. Further, he mentioned: “In practice a ‘small’ number of arguments has meant three or four—

[5] As the narrow-Divisia (Div M1) is unavailable for India, we begin with Divisia M2 denoted by Div M2.

typically including a scale variable such as income, permanent income or wealth, an opportunity cost variable such as a nominal interest rate or some measure of the expected inflation rate, and, if the nominal balances have been the dependent variable, the general price level."[6] In addition to the scale and opportunity cost variables, Mundell (1963) proposed that demand for money might also be dependent on the exchange rate. An open economy money demand specification would therefore incorporate foreign interest rates and the exchange rate, in order to take into account the wealth-holders' portfolio-adjustment responses to changes in returns on domestic and foreign assets (Hossain (2012), Bahmani-Oskooee (2001)).

This study specifies an open economy version of the specification for money demand, rather than the closed economy versions used in most prior studies. An open economy money demand specification has performed well in several countries (see Bahmani-Oskooee & Malixi (1991)). Therefore, a scale variable, an opportunity cost variable, and the exchange rate are included in the present analysis. The following log-linearized version of a conventional long-run money demand function is specified and applied with simple sum and Divisia monetary aggregates:

$$ln\, M_{jt} = \alpha_0 + \alpha_1 ln\, Y_t + \alpha_2 R_t + \alpha_3 ln\, E_t \, . \qquad (1)$$

With $ln\, M_{jt}$ to be real money balances for time period t, with $j=N$ designating narrow simple-sum money, $j=B$ designating broad simple-sum money, $j=DN$ designating narrow Divisia money, and $j=DB$ designating broad Divisia money.[7] We define "narrow" to be M1 and "broad" to be M3, while Y_t stands for real GDP during period

[6] See Laidler (1982, pp. 39-40).

[7] The log of real money balances are calculated by subtracting the log of the CPI from the log of nominal money balances.

t, R_t stands for interest rate during period t,[8] and E_t stands for the real effective exchange rate (REER)[9] during period t. The structural parameters are α_n, for n = 0,1,2,3.

All series are at quarterly frequency and seasonally adjusted. The equation above depicts the long run relationship. The goal of this study is to examine the short-and long-run dynamic relationship between real money balances and their determinants/covariates, such as real income, interest rate, and exchange rate. We also explore the stability of each relationship, including the elasticity of real money balances with respect to real income, interest rate, and exchange rate. Rule-based monetary policies focus not so much on the short-run demand for money specification, rather on the long-run equation (Laidler (1993)). The present study attempts to check whether the long run money demand is sufficiently stable for each model to be used to predict output gaps or inflation gaps under an inflation targeting framework.

In the specified money demand equation, economic theory indicates that scale and opportunity cost variables should be positively and negatively related, respectively, to real money balances. The sign of the coefficient of exchange rate is ambiguous (Arango and Nadiri (1981)). It may have a positive or negative relationship with respect to real money balances, indicating whether a currency substitution effect or a wealth effect outweighs the other in

[8] Belongia and Ireland (2016) advocate the use of user cost as the opportunity cost variable in the demand for Divisia money instead of the interest rates. That choice would be consistent with the literature on microeconomic foundations for money demand, as mentioned above and summarized in Barnett (1997). However, official data sources on user costs are available for a very few countries in our analysis and are not used in the conventional approach to modeling money demand addressed in our paper. We use the standard interest rate as the opportunity cost variable to achieve comparability with the conventional literature arguing for unstable money demand. We are not thereby advocating the conventional specification, rather investigating its conclusions on its own grounds. Depending on the availability of data in different countries, our study employs a variety of interest rate proxies. Demand for narrow money (simple M1 and Divisia M1) is typically estimated using a short-term interest rate, whereas demand for broad money (simple M3 and Divisia M3) is typically estimated using a long-term interest rate. The conventional rationale for this choice is that many components of broad money, such as time deposits, are associated with long-term interest rates.

[9] An increase in the REER value denotes an appreciation of the currency of the country against the currencies of its trading partners.

management of wealth-holder portfolios of domestic and foreign assets. The wealth effect is caused by the fact that the value of foreign currency-denominated assets held by domestic residents rises as the domestic currency falls in value. If the outcome is an increase in wealth, the wealth effect will increase demand for domestic money (Arango and Nadiri (1981)). However, if the domestic currency is expected to depreciate further, the domestic agent will substitute foreign currencies for the domestic currency, lowering demand for the latter. As a result, the currency substitution effect occurs. In other words, depending on which of these two effects takes precedence, money demand can move in either direction.

3.2 Econometric Methodology

In time series econometrics, there are two frequently used cointegration techniques to establish the long-run equilibrium relationship among variables: the Engle-Granger two-step residual-based procedure (Engle and Granger (1987)) and Johansen's system-based reduced rank regression approach (Johansen (1988); Johansen and Juselius (1990)). These two approaches are based on the assumption that the variables under consideration are I(1); that is, have unit roots. However, owing to the restrictive nature of that assumption, which needs to be tested, a more general approach has emerged. Voluminous research uses that recently developed technique, the autoregressive distributed lag (ARDL) approach to cointegration. The ARDL approach, developed in a series of articles by Pesaran and Shin (1996), Pesaran and Smith (1998), and Pesaran et al. (2001), has several advantages over the conventional methods of cointegration testing. The technique can be used regardless of the order of integration of the series, whether the series are I(1) processes, I(0) processes, or a combination of both.

Following Pesaran and Pesaran (1997), the unrestricted error correction form of the money demand equation and its determinants can be specified in the following log-linearized

$$\Delta ln\,M_t = C_0 + \sum_{i=1}^{n_1}\phi_{1i}\Delta ln\,M_{j,t-i} + \sum_{i=0}^{n_2}\phi_{2i}\Delta ln\,Y_{t-i} + \sum_{i=0}^{n_3}\phi_{3i}\Delta\,R_{t-i} + \sum_{i=0}^{n_4}\phi_{4i}\Delta ln\,E_{t-i} + \beta_1 ln\,M_{j,t-1} + \beta_2 ln\,Y_{t-1} + \beta_3 R_{t-1} + \beta_4 ln\,E_{t-1} + \varepsilon_t \quad (2)$$

where Δ is first difference operator, C_0 is the intercept in Equation (2), $\phi_{1i}, \phi_{2i}, \phi_{3i}, and\ \phi_{4i}$ are the coefficients of short-run dynamics of the underlying variables in the ARDL model, with lag lengths $n_1, n_2, n_3,\ and\ n_4$ respectively, and $\beta_1, \beta_2, \beta_3,$ and β_4 are the coefficients of the long-run relationship of the variables in the cointegrating set. Lastly, ε_t represents the error term which follows white noise process.

The first step in ARDL modeling is to estimate Equation (2) by using ordinary least squares (OLS) to confirm a long run relationship among the underlying variables. For this purpose, the Wald test (F-statistic) is used by setting the long-run coefficients of one-period lagged levels of the variables to zero as the null hypothesis. In Equation (2), where the log change of real money balances is the dependent variable, the null hypothesis of no cointegration is, therefore, $H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$, against the alternative $H_1 : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$.

After confirming the long-run relationship among the variables, the F-statistic reflects which variable in the system should be normalized. We represent the F-statistic that normalizes on real money balances as $F_P(ln\,M_j \mid ln\,Y, R, ln\,E)$. The computed F-statistic is compared with critical values given in Pesaran et al. (2001). They provide the two sets of critical values. The decision about cointegration can be made without knowing the order of integration of the explanatory variables, as long as the computed F-statistic falls outside of either of the two critical bounds. If the computed F-statistic is greater than the upper critical bound, the null hypothesis of no cointegration is rejected, indicating that cointegration exists between the variables. If the estimated F-statistic is smaller than the lower critical bound, the null hypothesis of no cointegration cannot be rejected. However, if the F-statistic lies between the lower and upper bounds, the result is inconclusive.

After establishing cointegration using the F-statistic, the second step of ARDL modeling involves estimating the long-run equilibrium money demand relationship using the following equation. The appropriate lag length needs to be determined to estimate the long-run relationship:

$$ln\,M_{jt} = C_0 + \sum_{i=1}^{n_1} \phi_{1i} ln\,M_{j,t-i} + \sum_{i=0}^{n_2} \phi_{2i} ln\,Y_{t-i} + \sum_{i=0}^{n_3} \phi_{3i} R_{t-i} + \sum_{i=0}^{n_4} \phi_{4i} ln\,E_{t-i} + \mu_t\,, \qquad (3)$$

where μ_t is an error term. In the third step of this bounds testing approach, short-run dynamic parameters are obtained by estimating an error correction model (ECM) associated with long run estimates. The ECM is specified as follows:

$$\Delta ln\,M_{jt} = C_0 + \sum_{i=1}^{n_1} \phi_{1i} \Delta ln\,M_{j,t-i} + \sum_{i=0}^{n_2} \phi_{2i} \Delta ln\,Y_{t-i} + \sum_{i=0}^{n_3} \phi_{3i} \Delta R_{t-i} + \sum_{i=0}^{n_4} \phi_{4i} \Delta ln\,E_{t-i} + \psi ECT_{t-1} + \mu_t\,, \qquad (4)$$

where ψ is the coefficient of the error correction term (ECT_{t-1}), which measures the speed of adjustment to long-run equilibrium. The term measures the speed with which the dependent variable returns to equilibrium, following a shock to the system.

4. Empirical analysis

The ARDL approach to cointegration can be used, even if the variables are not integrated in the same order. Variables can be I(0), I(1), or a combination of the two. However, the variables should not be I(2), because the resulting test statistic would be invalid (Pesaran et al. (2001)). As a result, it is critical to test for the order of integration. To that end, we use the augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1981) and the Phillips-Perron (P-P) test developed by Phillips and Perron (1988). The null hypothesis in both tests is that the series has a unit root. Table A1 in the appendix contains the results. The application of unit root tests reveals that almost every level series is non-stationary but becomes stationary after first differencing. Except for Israel, where all series follow I(1) process, our research finds mixtures of I(0) and I(1) series for all countries. Thus, the application of the ARDL method is justifiable.

Table 3 shows the bounds test for cointegration between real money balances and their determinants for the four models, when real balances are calculated using the simple-sum monetary aggregates, M1 and M3, and the Divisia monetary aggregates, Divisia M1 and Divisia M3. For the Euro Area, the F-tests for models M1 and Div M1 are equal to 1.36 and 2.57, respectively, implying that the joint significance of the lagged level variables is lower than its critical value of 2.72 at the 10% level of significance. Hence, there is no cointegration among the variables. The F-test values for models M3 and Div M3 are equal to 15.52 and 6.05, respectively, both of which are higher than the critical value of 3.77. Hence, for the Euro area, the variables are cointegrated for the broad-money models. The simple-sum broad money models reject the null hypothesis of no cointegration for all six nations. Except for Poland, the cointegration results for the model with Div M3 are similar to those for the model with M3. Cointegration is evident in the simple-sum narrow money models for India, Poland, the UK, and the US. While Israel's simple-sum narrow money model, M1, does not capture any cointegration, its Divisia counterpart does.

Focusing on India's Div M1 and Div M3 models, we find the F-test values to be 3.47 and 3.51 respectively, falling between the lower, 2.72, and upper, 3.77, critical bounds. They lie in the inconclusive region. Following the study of Kremers et al. (1992) and Banerjee et al. (1998), the ECM term of the respective models is useful in establishing cointegration in such an inconclusive case. These two models' ECM terms are both negative and significant, confirming the existence of cointegration.

Table 3: Bounds test for cointegration relationship

	Models			
Countries	M1	M3	Div M1	Div M3
Euro Area	1.36	15.52***	2.57	6.05***
India	3.82*	6.15***	3.47#	3.51
Israel	1.57	6.88***	4.91**	-
Poland	12.56***	4.58**	8.12***	1.57
UK	6.31***	9.18***	-	6.28***
US	18.04***	7.91***	9.63***	5.68***

Source: Authors' Calculations

Notes: (a) Bounds tests are based on *F* statistics. The lower and upper critical bounds values of the F statistic at the 10% level of significance are 2.72 and 3.77 respectively; at the 5% level of significance are 3.23 and 4.35 respectively; at the 1% level of significance are 4.29 and 5.61 respectively. The critical value bounds of the *F*-statistic come from Pesaran et al. (2001, Table CI [iii]-Case III: Unrestricted intercept and no trend, p. 300); (b) Div stands for Divisia; (c) Instead of Divisia M1, # denotes the F value for model Divisia M2. (d) Cointegration at the 1%, 5%, and 10% levels are denoted by '***', '**', and '*'.

In almost every model, the rejection of no cointegration provides strong evidence of a long-run relationship between real money balances and their determinants. The determinants, including the scale variable, opportunity cost variable, and exchange rate, are therefore confirmed as long-run forcing variables for real money balances. The second step of ARDL modeling involves estimating the long-run coefficients of equilibrating real money balance. The inferences about the coefficients are drawn and evaluated in the light of the relevant economic theories.

Table 4 provides the estimated coefficients of long-run real income, interest rate, and exchange rate for the equilibrium real money balances equation of the four models for all countries. In almost each model, the real income and interest rate coefficients have their theoretically expected signs at each level of significance. The sign of the exchange rate coefficient is either positive or negative, reflecting either currency substitution or wealth effect, respectively.

We find that, in the long-run, real income is the most important determinant of real money balances, followed by the exchange rate and interest rate. According to Laidler (1982) "parameters should not change too much for stable money demand function. The requirement that parameters not change 'too much' has meant not only that they have been expected to take their theoretically predicted sign, but also to stay within reasonable quantitative ranges as well, in the region of 0.5 — 1.0 or a little greater for the real income elasticity of demand for money, somewhere around -0.1 — -0.5 or less for the interest elasticity depending upon the interest rate."[10] Using the M1 model for India as a point of reference, *ceteris paribus,* one percent change in real income will increase the real money balance by 1.35 percent; magnitude of the income elasticity is greater than unity.[11] We also find that a one-unit change in interest rate, *ceteris paribus,* will decrease real money balances about 0.6 percent. Similarly, a one percent change in exchange rate, *ceteris paribus,* will decrease the real money balances by 0.097 percent, representing the wealth effect for India. Other coefficients can also be interpreted similarly.

[10] See Laidler (1982, pp. 39-40).

[11] Several other studies (see Dekle and Pradhan (1999), Hossain (2012)) also show similar coefficient of income elasticity.

According to Dekle and Pradhan (1999), a greater-than-unity coefficient of the scale variable may reflect technological advances that have altered the relationship between nominal money and prices, as well as reflect changes in financial markets and private sector money-holding behavior. The income elasticity of demand for real money balances is generally greater than one in an emerging economy. The reason for this could be the evolving monetization of the economy and/or a lack of high-return financial assets in which to invest household savings (Hossain and Younus (2009)). The evolving monetization process reinforces the need for transaction balances. The rate of money growth is, thus, an indicator of financial development, reflecting both a reduction in the barter system and an increase in the commercial banking system (Hossain (2012) quotes Goldsmith (1969) and Bordo and Jonung (2003)).

Since money can also act as a store of value in a low inflationary economy, demand for money can increase more than proportionately to an increase in income (Hossain (2012)). Nevertheless, there is no consensus on why the income elasticity of real money balances is greater than unity in advanced economies. Friedman (1959, p. 348) argued that interpreting the greater than unity magnitude of real income coefficient within the transaction demand for money is difficult. A magnitude of real income coefficient greater than unity could reflect the liquidity of the real money balances along with other services of money. Baharumshah et al. (2009) argued that wealth effects may provide another justification for real income elasticity greater than unity. Hence, wealth could be another scale variable along with income in the specification of money demand, provided asset prices are increasing sharply. Consequently, failure to include wealth in the model could lead to biased income-elasticity estimates of real money balances, although it would be difficult in theory to justify including both income and wealth simultaneously in a demand function.

Attempts to justify high elasticity values in terms of theory, however, may be misguided, because these demand for money functions are not directly derived from microeconomic theory. For example, the scale values in these models are not measures of the income of any "representative" economic agent in the economy, and hence the coefficient of the scale value in these models is only loosely interpreted as "income" elasticity. These "demand functions" are best viewed as purely empirical relationships widely used in policy and thereby very influential (see, for example, Barnett (1997, 2000)).

Table 4: Estimated long-run coefficients

Countries	Models	Regressors							
		ln Y		R		ln E		Constant	
Euro Area	M1	4.033	(0.00)	-0.066	(0.00)	-0.062	(0.75)	-58.869	(0.00)
	M3	2.295	(0.00)	-0.028	(0.00)	0.303	(0.02)	-34.952	(0.00)
	Div M1	2.691	(0.09)	-0.120	(0.17)	0.121	(0.82)	-38.757	(0.08)
	Div M3	1.204	(0.02)	-0.089	(0.00)	0.428	(0.06)	-18.578	(0.01)
India	M1	1.346	(0.00)	-0.006	(0.02)	-0.097	(0.50)	-22.528	(0.00)
	M3	1.133	(0.00)	-0.009	(0.20)	3.347	(0.01)	-34.741	(0.00)
	Div M2	1.376	(0.00)	-0.013	(0.00)	-0.044	(0.79)	-20.367	(0.00)
	Div M3	1.405	(0.00)	-0.016	(0.00)	-0.015	(0.93)	-20.847	(0.00)
Israel	M1	5.752	(0.42)	0.047	(0.82)	-3.793	(0.69)	-53.818	(0.32)
	M3	3.661	(0.42)	0.153	(0.65)	-1.252	(0.55)	-39.666	(0.40)
	Div M1	1.539	(0.00)	-0.021	(0.04)	0.153	(0.40)	-16.289	(0.00)
	Div M3	-	-	-	-	-	-	-	-
Poland	M1	3.586	(0.00)	0.063	(0.10)	1.078	(0.24)	-52.010	(0.00)
	M3	1.937	(0.00)	0.002	(0.51)	-0.175	(0.28)	-24.339	(0.00)
	Div M1	4.643	(0.19)	0.146	(0.54)	1.889	(0.63)	-68.067	(0.29)
	Div M3	2.165	(0.00)	-0.001	(0.92)	-0.810	(0.08)	-22.244	(0.00)
UK	M1	2.889	(0.00)	-0.015	(0.35)	0.257	(0.40)	-39.020	(0.00)
	M3	4.029	(0.00)	0.196	(0.10)	0.303	(0.68)	-54.415	(0.00)
	Div M1	-	-	-	-	-	-	-	-
	Div M3	2.033	(0.00)	-0.018	(0.28)	0.515	(0.29)	-26.069	(0.00)

	M1	-0.697	(0.80)	-0.911	(0.39)	-1.897	(0.56)	23.555	(0.66)
US	M3	0.049	(0.93)	-0.205	(0.00)	0.724	(0.09)	-3.389	(0.65)
	Div M1	7.836	(0.53)	0.913	(0.62)	-0.172	(0.95)	-120.638	(0.55)
	Div M3	1.027	(0.00)	-0.018	(0.25)	0.447	(0.02)	-15.230	(0.00)

Source: Authors' Calculation

Notes: (a) Value in parentheses is P-value of the null hypothesis that the parameter equals zero. (b) *ln* stands for natural logarithm

The next step in ARDL approach is to estimate the ECM; the results are presented in Table 5. The estimated ECM shows the dynamic behavior of the money demand specification. According to Pesaran and Pesaran (1997), the short-run dynamics are essential for stability of the model's long-run coefficients. They suggest estimating the ECM for this purpose, provided the response variable has a long-run relationship among variables. More specifically, the significant coefficient's estimate of the ECM represents the short-run dynamics correcting the disequilibrium in the short-run, if any, created by a shock to the system. In turn, that estimation reinforces the long-run stable cointegrating relationship among variables. In fact, Laidler (1993) argued that the problem of instability in the money demand relationship arose as a result of inadequate modeling of the short-run dynamics, producing departures from the long-run equilibrium money demand relationship.

In most of the models, in the short run, the coefficient estimates of real income and interest rate have their expected sign. The sign of the exchange rate is mixed, as found in the long-run, implying the prevalence of wealth and currency substitution effects. Nearly every estimated ECM is robust, as evidenced by statistically significant coefficient estimates in most of the short-term dynamic relationships. The ECT, which is derived from the long-run relationship, is an important component of the ECM. In most of the models, the ECT term is correctly signed, i.e., negative, and statistically significant, thereby ensuring the attainment of a long-run equilibrium relationship in response to a system shock. The models with significant negative ECT coefficients are highlighted in bold.

The ECT coefficient measures the speed of adjustment of long-run real money balances, if disturbed by changes in its explanatory variables. As a reference point, the estimated value for the ECT coefficient in the Euro Area is -0.122 for the M1 model. Hence, the speed of convergence of the relationship to its steady state equilibrium is 12.2% per quarter, following a long-run deviation in the preceding period. In the case of India, the F-statistic for the Div M2 and Div M3 models lie between the lower and upper critical bounds, with the ECT being -0.590 and -0.495, respectively, which are negatively statistically significant. In this scenario, as Boutbba (2014) mentions, following Kremers et al. (1992) and Banerjee et al. (1998), the ECT term is helpful in establishing cointegration for the Div M2 and Div M3 models in India. The presence of a significant ECT term, therefore, reinforces the presence of a long-run relationship between real money balances and its determinants. Thus, the given ECM can be used to check of whether models are capable of tracking the movement of real money balances over time.

Table 5: Error correction representation for the selected autoregressive distributed lag (ARDL) models

		Regressors										
Countries	Models	Δ ln (DV)		Δ ln Y		Δ R		Δ Ln E		ECT_{t-1}		Selected ARDL
Euro Area	**M1**	0.248	(0.03)	0.493	(0.04)	-0.025	(0.00)	-0.138	(0.02)	**-0.122**	**(0.02)**	[3, 0, 1, 1]
	M3	-	-	-0.333	(0.03)	-0.004	(0.00)	-0.063	(0.12)	**-0.127**	**(0.00)**	[1, 1, 1, 0]
	Div M1	-	-	0.134	(0.60)	-0.017	(0.01)	0.006	(0.79)	-0.050	(0.47)	[1, 0, 0, 1]
	Div M3	-	-	-0.285	(0.08)	-0.007	(0.00)	0.033	(0.05)	**-0.078**	**(0.00)**	[1, 1, 0, 0]
India	**M1**	-	-	0.554	(0.00)	-0.001	(0.48)	-0.040	(0.51)	**-0.412**	**(0.00)**	[1, 0, 0, 1]
	M3	-	-	0.143	(0.01)	-0.001	(0.28)	-0.302	(0.00)	**-0.126**	**(0.00)**	[1, 0, 6, 0]
	Div M2	-	-	0.812	(0.00)	-0.008	(0.00)	-0.026	(0.79)	**-0.590**	**(0.00)**	[1, 0, 0, 0]
	Div M3	-	-	0.696	(0.00)	-0.008	(0.00)	-0.008	(0.93)	**-0.495**	**(0.00)**	[1, 0, 0, 0]
Israel	M1	0.615	(0.00)	0.048	(0.45)	-0.013	(0.00)	-0.237	(0.01)	-0.008	(0.66)	[2, 0, 1, 2]
	M3	-	-	0.066	(0.10)	-0.007	(0.00)	-0.022	(0.33)	-0.018	(0.56)	[1, 0, 0, 1]
	Div M1	-	-	0.216	(0.00)	-0.014	(0.00)	0.021	(0.43)	**-0.140**	**(0.00)**	[1, 0, 0, 1]
	Div M3	-	-	-	-	-	-	-	-	-	-	-
Poland	M1			-0.188	(0.02)	-0.009	(0.00)	0.177	(0.00)	0.052	(0.08)	[1, 0, 2, 2]
	M3	0.181	(0.05)	0.207	(0.00)	-0.003	(0.03)	0.139	(0.00)	**-0.107**	**(0.00)**	[3, 0, 1, 2]
	Div M1			-0.101	(0.26)	-0.012	(0.00)	0.211	(0.00)	0.022	(0.53)	[1, 0, 2, 2]
	Div M3	0.341	(0.00)	0.173	(0.08)	-0.007	(0.01)	0.229	(0.00)	**-0.080**	**(0.08)**	[2, 0, 2, 2]
UK	**M1**	0.244	(0.01)	0.260	(0.00)	-0.001	(0.35)	-0.160	(0.02)	**-0.090**	**(0.00)**	[2, 0, 1, 0]
	M3	-	-	0.118	(0.01)	0.006	(0.00)	-0.239	(0.00)	**-0.029**	**(0.06)**	[1, 0, 1, 0]
	Div M1	-	-	-	-	-	-	-	-	-	-	-
	Div M3	-	-	0.664	(0.00)	-0.007	(0.00)	0.032	(0.06)	**-0.062**	**(0.06)**	[1, 1, 0, 1]
US	M1	-	-	-0.930	(0.00)	-0.005	(0.00)	0.135	(0.02)	-0.006	(0.39)	[1, 1, 1, 0]
	M3	**-**	**-**	-0.289	(0.03)	-0.010	(0.00)	0.162	(0.00)	**-0.030**	**(0.01)**	**[1, 1, 1, 1]**
	Div M1	-	-	-0.602	(0.00)	-0.004	(0.00)	0.142	(0.00)	0.004	(0.62)	[1, 1, 0, 1]
	Div M3	0.417	(0.00)	0.068	(0.00)	-0.008	(0.00)	0.030	(0.00)	**-0.066**	**(0.00)**	**[2, 0, 1, 0]**

Source: Authors' Calculation

Notes: (a) Values in ( ) are probability values; *Ln* stands for natural logarithm; Δ stands for the first difference operator (b) Values in [ ] represents the selected ARDL model, which is based on Schwarz Bayesian Criterion (SBC) (c) DV stands for dependent variable

Table 6 reports the results of diagnostic tests to gauge the accuracy and predictability of the estimated models. The diagnostic tests check for the presence of serial correlation, heteroscedasticity, functional form misspecification, and normality of the residual term. We use the Breusch-Godfrey statistic to test for serial correlation, the Breusch-Pagan-Godfrey statistic to test for heteroscedasticity, Ramsey's RESET statistic to test for misspecification in functional form, and the Jarque-Bera statistic to test for normality of the error structure. The bold highlighted results in Table 6 are for the models that passed all the diagnostic checks.

The M1 model passes all diagnostic tests for both Israel and Poland, whereas the M3 model only passes diagnostic tests for Israel. The Div M1 model only passes all diagnostic tests for Israel, whereas the Div M3 model passes all diagnostic tests for all countries in our analysis, except for the UK. Overall, when compared to any other monetary aggregate, regressions with Div M3 performed the best in the diagnostic tests and can thus be considered the most reliable.

Table 6: Diagnostic testing

Countries	Models	Adj R^2	BG-LM		RESET		Jarque-Bera		BPG	
Euro Area	M1	0.999	1.272	(0.53)	0.164	(0.69)	27.480	(0.00)	15.863	(0.04)
	M3	0.998	13.187	(0.00)	2.215	(0.14)	0.841	(0.66)	9.586	(0.14)
	Div M1	0.998	12.093	(0.00)	0.845	(0.36)	0.379	(0.83)	5.532	(0.35)
	Div M3	**0.998**	**9.269**	**(0.01)**	**3.832**	**(0.05)**	**0.737**	**(0.69)**	**11.460**	**(0.04)**
India	M1	0.999	0.030	(0.98)	0.591	(0.45)	0.516	(0.77)	14.007	(0.02)
	M3	0.999	4.319	(0.12)	9.632	(0.00)	0.340	(0.84)	12.468	(0.25)
	Div M2	**0.998**	**2.751**	**(0.25)**	**2.941**	**(0.09)**	**0.720**	**(0.70)**	**2.653**	**(0.62)**
	Div M3	**0.998**	**0.666**	**(0.72)**	**1.958**	**(0.17)**	**1.787**	**(0.41)**	**2.914**	**(0.57)**
Israel	**M1**	**0.999**	**1.601**	**(0.45)**	**0.897**	**(0.35)**	**10.389**	**(0.01)**	**12.399**	**(0.13)**
	M3	**0.999**	**9.632**	**(0.01)**	**3.888**	**(0.05)**	**6.750**	**(0.03)**	**10.169**	**(0.07)**
	Div M1	**0.999**	**5.074**	**(0.08)**	**2.481**	**(0.12)**	**1.450**	**(0.48)**	**10.215**	**(0.07)**
	Div M3	-	-	-	-	-	-	-	-	-
Poland	**M1**	**0.999**	**3.539**	**(0.17)**	**2.537**	**(0.12)**	**2.309**	**(0.32)**	**7.413**	**(0.49)**
	M3	0.999	7.157	(0.03)	0.011	(0.92)	13.606	(0.00)	16.172	(0.06)
	Div M1	0.999	0.075	(0.96)	2.150	(0.15)	2.686	(0.26)	22.591	(0.00)
	Div M3	**0.9989**	**1.608**	**(0.45)**	**1.520**	**(0.22)**	**2.882**	**(0.24)**	**12.629**	**(0.18)**
UK	M1	0.999	3.664	(0.16)	0.165	(0.69)	130.835	(0.00)	12.617	(0.05)
	M3	0.999	7.225	(0.03)	8.425	(0.00)	27.702	(0.00)	16.260	(0.01)
	Div M1	-	-	-	-	-	-	-	-	-
	Div M3	0.999	18.902	(0.00)	7.014	(0.01)	7.174	(0.03)	13.433	(0.04)
US	M1	0.998	3.765	(0.15)	0.000	(0.98)	40.680	(0.00)	16.943	(0.01)
	M3	0.999	2.115	(0.35)	1.209	(0.27)	4.464	(0.11)	23.598	(0.00)
	Div M1	0.999	10.786	(0.00)	0.652	(0.42)	4.311	(0.12)	14.439	(0.03)
	Div M3	**0.999**	**1.306**	**(0.52)**	**3.100**	**(0.08)**	**2.800**	**(0.25)**	**6.027**	**(0.42)**

Source: Authors' Calculations.

Notes: (a) Values in parentheses are P-values of the null hypothesis that the parameter is zero. (b) *Adj* R^2 stands for adjusted R^2. (c) *BG-LM* is the Breusch Godfrey Serial Correlation Lagrange Multiplier test. (d) *RESET* is Ramsey's regression specification error test. (e) *Jarque-Berra* is used for testing normality. (f) *BPG* is the Breusch-Pagan-Godfrey test for heteroscedasticity.

After model estimation, to assess parameter constancy, Pesaran and Pesaran (1997) suggest applying the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) of recursive residual tests, developed by Brown et al. (1975), to examine the structural stability of the ECM. After estimating the models using OLS, we subjected the residuals to CUSUM and CUSUMSQ. The robustness of the ECM is reflected in Figure 1 in the appendix. The figure plots the CUSUM and CUSUMSQ of the recursive residuals. For nearly every country, each model predicts no systematic or haphazard changes in regression coefficients. The parameter estimates in most models do not exceed the 5% critical bounds for parameter stability.

5. Summary of the results and robustness check

Table 7 summarizes the results of our analyzed models. According to the bounds tests, the error correction terms, the respective model's diagnostic tests, and CUSUM and CUSUMSQ of the recursive residuals, Divisia monetary aggregates outperform simple-sum monetary aggregates in most countries. Both within the simple-sum monetary aggregates and the Divisia monetary aggregates, the broad monetary aggregate is stable and performs well. By both methods of aggregation, the broad estimates provide more robust results and provide coefficients more consistent with economic theory than the narrow aggregates.

Table 7: Summary

Model	Cointegration	Number of significant long-run and short-run coefficients out of 6	Negative and Significant ECM	Number of diagnostic tests satisfied out of 4	CUSUM	CUSUMSQ	Interpretation
Models with SBC lag selection criterion							
EURO							
M1	×	5	✓	3	✓	✓	Unstable
M3	✓	5	✓	3	✓	✓	Potentially Stable
Div M1	×	2	×	3	✓	✓	Unstable
Div M3	✓	6	✓	4	✓	✓	**STABLE**
India							
M1	✓	3	✓	4	✓	✓	**STABLE**
M3	✓	4	✓	3	✓	✓	Potentially Stable
Div M2	✓	4	✓	4	✓	✓	**STABLE**
Div M3	✓	4	✓	4	✓	✓	**STABLE**
Israel							
M1	×	2	×	4	✓	✓	Unstable
M3	✓	2	×	4	✓	✓	Unstable
Div M1	✓	4	✓	4	✓	✓	**STABLE**
Div M3	-	-	-	-	-	-	-
Poland							
M1	✓	5	✓	4	✓	✓	**STABLE**
M3	✓	4	✓	3	✓	✓	Potentially Stable
Div M1	✓	2	×	3	✓	✓	Unstable
Div M3	×	5	✓	4	✓	✓	Unstable
UK							
M1	✓	3	✓	3	✓	✓	Potentially Stable
M3	✓	5	✓	2	✓	✓	Potentially Stable
Div M1	-	-	-	-	-	-	-
Div M3	✓	4	✓	3	✓	✓	Potentially Stable
US							
M1	✓	3	×	3	✓	✓	Unstable
M3	✓	5	✓	3	✓	✓	Potentially Stable
Div M1	✓	3	×	3	✓	✓	Unstable
Div M3	✓	5	✓	4	✓	✓	**STABLE**

Overall, the broad Divisia monetary aggregate, Div M3, provides the best model for five countries (the Euro area, India, Israel, the UK and the US) out of the six used in the analysis. Unstable demand for money was displayed in Table 7 by Div M3 for Poland, when the SBC lag selection criterion was used. However, Poland shows evidence of stable demand for money, when the AIC lag selection criterion was used. As further robustness check, the results with the AIC criterion for all countries are given in Table 8 with the broad Divisia monetary aggregate, Div M3.

Table 8: Robustness Check

Models for DIV M3 with AIC lag selection criterion							
Model	Cointegration	No. of significant long-run and short-run coefficients out of 6	Negative and Significant ECM	Number of diagnostic tests satisfied out of 4	CUSUM	CUSUMSQ	Interpretation
Euro	✓	5	✓	4	✓	✓	**STABLE**
India	×	4	✓	4	✓	✓	**STABLE**[12]
Israel	✓	5	✓	4	✓	✓	**STABLE**
Poland	✓	5	✓	4	✓	✓	**STABLE**
UK	✓	1	✓	3	✓	✓	Potentially Stable
US	✓	4	✓	2	✓	✓	Potentially Stable

6. Conclusion

Money demand and its covariates depict the nature and magnitude of any economy's interaction between the monetary and real sectors. However, as Arrau et al. (1995) point out, the stability of the money demand function is a prerequisite for an effective modeling of the transmission mechanism of monetary and fiscal policy. In addition, policy evaluations require knowledge of the parameters that characterize that important macroeconomic relationship. Furthermore, the occurrence of financial innovations in various economies in the late 1970s and early 1980s made simple-sum money demand unstable and unpredictable. As a result, the entire

[12] Although the F-statistic's value, 3.51, lies between the two critical bounds, indicating inconclusive cointegration results, we conclude cointegrating demand for Div M3 money on the basis of significantly negative ECM.

literature on the role of money in monetary policy has been divided into two schools of thought: New Keynesians, who usually oppose the role of money in monetary policy, and new monetarists, who believe that money plays an important role in monetary policy. Nevertheless, the Divisia monetary aggregates measure service flows in accordance with aggregation and index number theory. There is no reason to expect supply side structural change to alter demand for monetary service flows on the demand side. The large literature on the Barnett Critique has shown that the demand for monetary services is no more difficult to model and estimate than the demand for any other good or service, if monetary services are measured in accordance with reputable aggregation and index number theory and if money demand is modeled using state-of-the-art integrable demand functions systems directly derived from microeconomic theory. That conclusion has applied to research with 1970s and 1980s data as well as to more recent decades' data.

But advocates of the view that money demand has become unstable did not use index number theory or aggregation theory to measure monetary services and did not use flexible econometric specifications of consumer demand systems, integrable to a utility function. The focus of monetary authorities shifted from monetary aggregate targeting to interest rate targeting and then to inflation targeting, with the use of an interest rate feedback rule. Despite the fact that most central bankers around the world have adhered to an inflation targeting framework, the ECB's Governing Council remains focused on the development of monetary aggregates as well as other indicators as part of its "two-pillars" monetary policy strategy.

In light of the preceding, the current study examines whether money demand functions are stable in various countries, including the Eurozone, when Divisia monetary aggregates are compared with their simple-sum counterparts. Our model does not use the consumer demand modeling system wide approach advocated by the Barnett Critique, but rather a modern version of the linear time series macroeconometric approach, in order to permit direct comparison with the conclusions of critics of money demand function stability. To that end, the study employs the ARDL cointegration approach in an open economy framework.

We find stable demand for broad money in the Eurozone, India, Israel, Poland, the UK, and the US. The conclusion is based on the existence of long-term cointegration relationships among real money balances, real output, interest rate, and real effective exchange rate using the error correction mechanism. The long-run and short-run coefficients of the independent variables are found to be statistically significant and economically meaningful. Demand for broad Divisia money yields the best results in terms of the following: long-term cointegration, meaningful and significant long-run and short-run coefficients, significantly negative ECM, and overall satisfaction of all diagnostic tests.

Having found stable money demand functions in the concerned sample countries, the current study supports focusing on monetary aggregate as one of the important indicators, while conducting the inflation targeting framework. Furthermore, based on consistent empirical findings, the current study supports the new monetarists' perspective giving money a role in monetary policy as a long run anchor to the otherwise myopic short run interest rate feedback policy. In its second pillar of “monetary analysis,” the ECB’s approach of focusing on money alongside other important indicators is reinforced.

Finally, we discuss some of the study's limitations, such as the fact that the sample period varies and is limited for some countries, as a consequence of constraints on the availability of Divisia monetary aggregates data. Furthermore, we do not adopt the user cost as the opportunity cost variable in estimating the demand for Divisia money, as advocated by Belongia and Ireland

(2016) and Barnett (1983). Official data on user costs are unavailable for some of the countries included in our analysis. In addition, introducing user cost pricing into our model would move towards the Barnett Critique literature approach and diverge from the approach that had produced the controversies with which we seek comparability. Furthermore, the response of money demand to its explanatory variables is thought to have become nonlinear over time. We can investigate those asymmetric responses to money demand in the future, but again that possible future research will tend to diverge from literature that produced the controversies with which see seek comparability in this study.

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Appendix:

Table A1: Unit root test results (ADF and PP)

Country	Variables	ADF Statistics				PP Statistics			
		Level	P-Value	First Diff	P-Value	Level	P-Value	First Diff	P-Value
Euro Area	ln M1	-2.757	(0.22)	-4.983	(0.00)	-1.848	(0.67)	-4.859	(0.00)
	ln M3	-2.227	(0.03)	-	-	-1.556	(0.80)	-4.764	(0.00)
	ln GDP	-2.557	(0.30)	-3.700	(0.03)	-1.819	(0.69)	-3.783	(0.02)
	3IR	-3.082	(0.12)	-4.257	(0.01)	-2.336	(0.41)	-4.198	(0.01)
	LTIR	-2.308	(0.42)	-6.418	(0.00)	-2.023	(0.58)	-6.377	(0.00)
	ln Div M1	-2.857	(0.18)	-3.726	(0.03)	-1.683	(0.75)	-5.685	(0.00)
	ln Div M3	-4.030	(0.02)	-	-	-1.563	(0.80)	-7.558	(0.00)
	ln REER	-3.062	(0.12)	-6.641	(0.00)	-2.369	(0.39)	-6.641	(0.00)
India	ln M1	-1.349	(0.86)	-5.703	(0.00)	-1.388	(0.85)	-5.708	(0.00)
	ln M3	-2.553	(0.30)	-4.297	(0.01)	-1.804	(0.69)	-4.338	(0.01)
	ln GDP	-0.987	(0.94)	-4.035	(0.01)	-1.066	(0.92)	-6.668	(0.00)
	CMR	-4.779	(0.00)	-	-	-4.903	(0.00)	-	-
	TB-364	-2.536	(0.31)	-9.289	(0.00)	-2.419	(0.37)	-9.449	(0.00)
	G-Sec 10	-0.714	(0.97)	-5.949	(0.00)	-0.610	(0.97)	-5.950	(0.00)
	ln Div M2	-1.079	(0.92)	-4.500	(0.00)	-2.876	(0.18)	-23.779	(0.00)
	ln Div M3	-1.174	(0.90)	-4.344	(0.01)	-2.940	(0.16)	-22.477	(0.00)
	ln REER	-2.440	(0.36)	-5.459	(0.00)	-2.814	(0.20)	-5.446	(0.00)
Israel	ln M1	-3.128	(0.11)	-4.870	(0.00)	-2.050	(0.56)	-3.804	(0.02
	ln M3	-2.014	(0.58)	-5.182	(0.00)	-2.141	(0.51)	-5.254	(0.00)
	ln GDP	-2.887	(0.17)	-6.726	(0.00)	-2.477	(0.34)	-6.829	(0.00)
	3IR	-2.801	(0.20)	-7.097	(0.00)	-2.574	(0.29)	-6.754	(0.00)
	ln Div M1	-2.304	(0.43)	-5.780	(0.00)	-2.340	(0.41)	-5.728	(0.00)
	ln REER	-1.125	(0.92)	-7.606	(0.00)	-1.435	(0.84)	-7.667	(0.00)

Poland	ln M1	-3.105	(0.11)	-3.355	(0.06)	-2.124	(0.52)	-5.296	(0.00)
	ln M3	-3.458	(0.05)	-	-	-2.266	(0.45)	-5.940	(0.00)
	ln GDP	-2.196	(0.49)	-10.825	(0.00)	-2.221	(0.47)	-10.806	(0.00)
	3IR	-2.772	(0.21)	-4.767	(0.00)	-2.053	(0.56)	-4.872	(0.00)
	OIR	-2.593	(0.28)	-5.602	(0.00)	-1.746	(0.72)	-5.012	(0.00)
	ln Div M1	-3.817	(0.02)	-	-	-2.231	(0.47)	-7.021	(0.00)
	ln Div M3	-2.083	(0.55)	-4.847	(0.00)	-1.623	(0.78)	-8.051	(0.00)
	ln REER	-3.128	(0.11)	-7.090	(0.00)	-2.639	(0.26)	-6.831	(0.00)
UK	ln M1	-1.021	(0.94)	-6.970	(0.00)	-0.807	(0.96)	-6.866	(0.00)
	ln M3	-0.583	(0.98)	-6.801	(0.00)	-0.653	(0.97)	-6.800	(0.00)
	ln GDP	-1.840	(0.68)	-5.117	(0.00)	-1.771	(0.71)	-5.082	(0.00)
	3IR	-3.685	(0.03)	-	-	-2.757	(0.22)	-5.183	(0.00)
	LTIR	-3.341	(0.07)	-	-	-3.128	(0.11)	-8.805	(0.00)
	ln Div M3	-1.819	(0.69)	-3.745	(0.02)	-1.306	(0.88)	-6.114	(0.00)
	ln REER	-2.426	(0.36)	-6.115	(0.00)	-2.135	(0.52)	-6.114	(0.00)
US	ln M1	-1.977	(0.61)	-5.604	(0.00)	-1.732	(0.73)	-5.552	(0.00)
	ln M3	-3.179	(0.09)	-	-	-3.078	(0.12)	-6.396	(0.00)
	ln GDP	-1.910	(0.64)	-6.916	(0.00)	-2.062	(0.56)	-7.158	(0.00)
	3IR	-2.403	(0.38)	-5.531	(0.00)	-2.469	(0.34)	-5.432	(0.00)
	LTIR	-3.749	(0.02)	-	-	-3.293	(0.07)	-	-
	ln Div M1	-1.583	(0.79)	-5.385	(0.00)	-1.367	(0.86)	-5.323	(0.00)
	ln Div M3	-1.404	(0.85)	-5.300	(0.00)	-1.151	(0.91)	-5.221	(0.00)
	ln REER	-1.754	(0.72)	-7.472	(0.00)	-1.280	(0.89)	-7.473	(0.00)

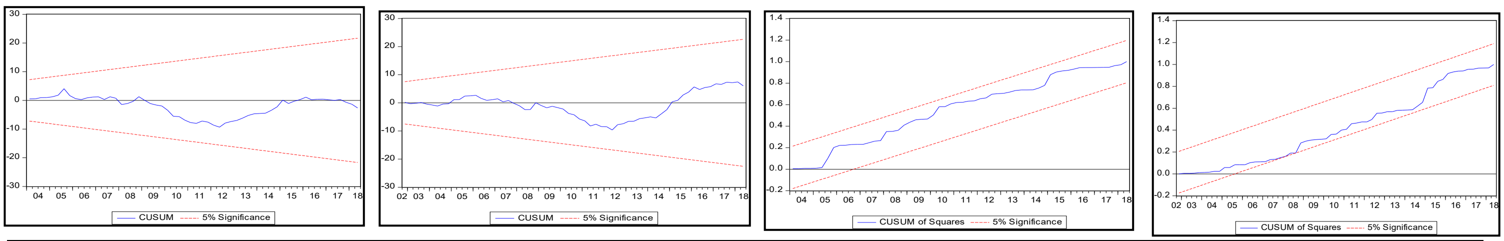
Notes: (a) P-Value stands for P-value of the null hypothesis that the parameter is zero.
(b) First Diff stand for first difference .

Figure 1: Plots of CUSUM and CUSUMSQ for narrow money for different countries.

CUSUM		CUSUMSQ	
Narrow- Simple Sum	Narrow- Divisia	Narrow- Simple Sum	Narrow- Divisia

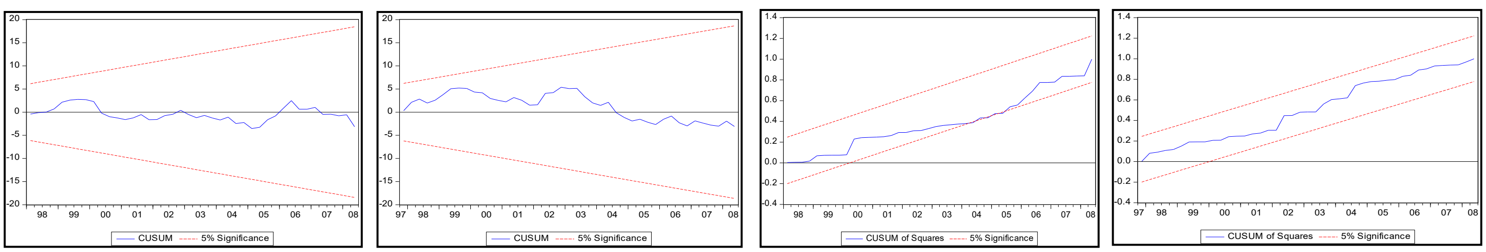
Euro Area

M1	Div M1	M1	Div M1



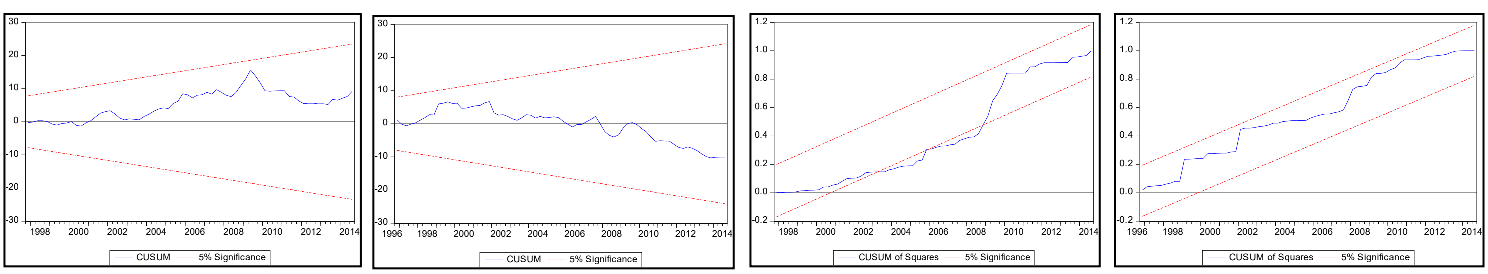
India

M1	Div M2	M1	Div M2



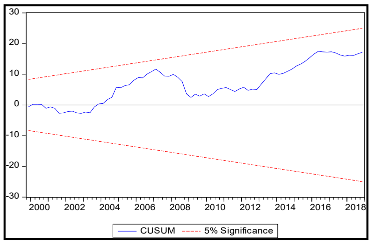
Israel

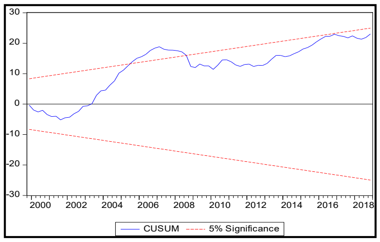
M1	Div M1	M1	Div M1

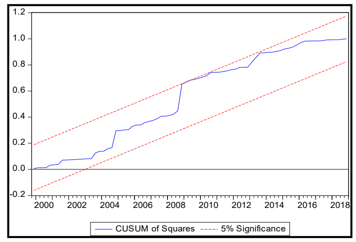


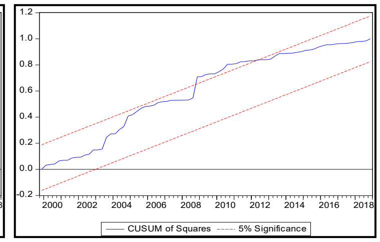
Poland

M1	Div M1	M1	Div M1



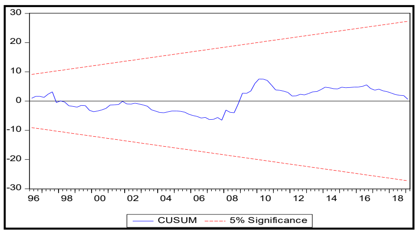






UK

M1	Div M1	M1	Div M1



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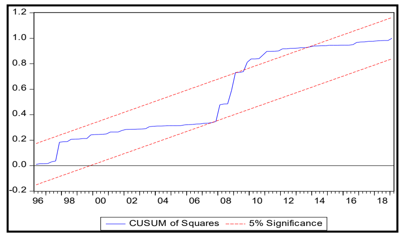
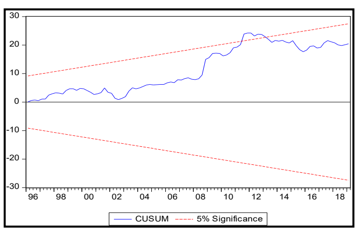
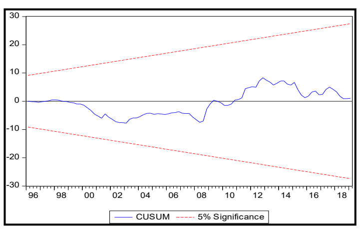


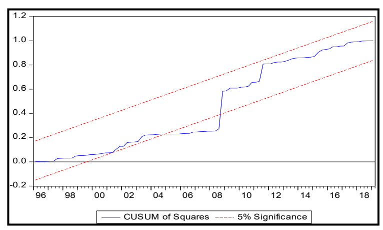
Not Available

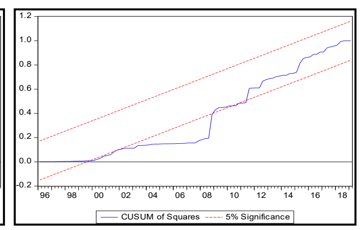
US

M1	Div M1	M1	Div M1







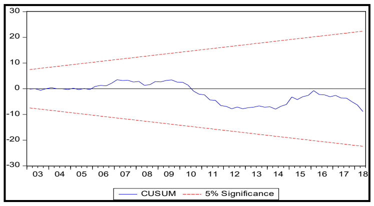
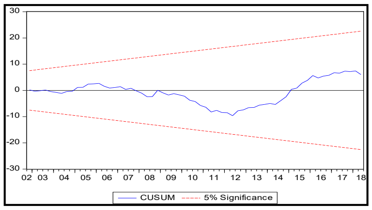
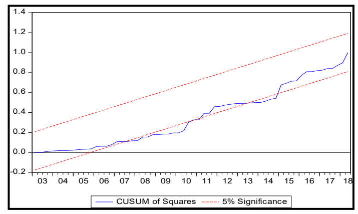
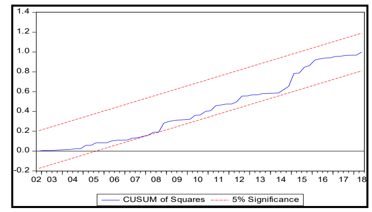


Source: Authors' Calculation

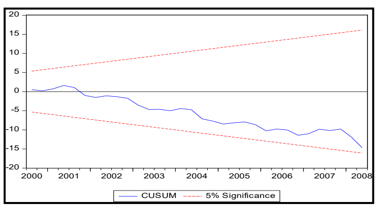
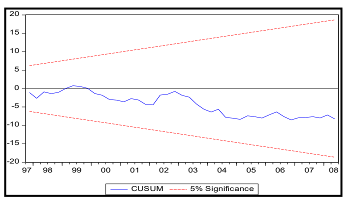
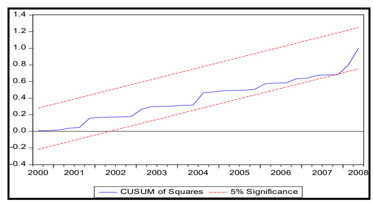
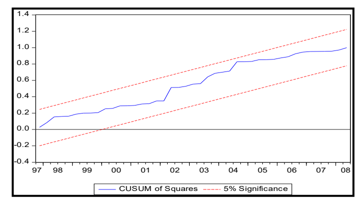
Figure 2: Plots of CUSUM and CUSUMSQ for broad money for different countries.

CUSUM		CUSUMSQ	
Broad- Simple Sum	Broad - Divisia	Broad - Simple Sum	Broad - Divisia

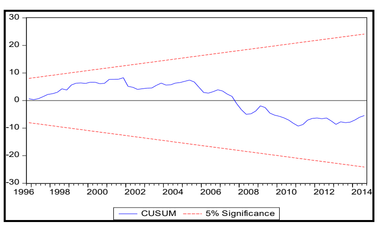
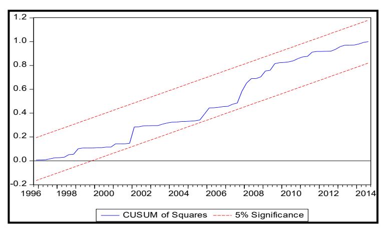
Euro Area

M3	Div M3	M3	Div M3
			

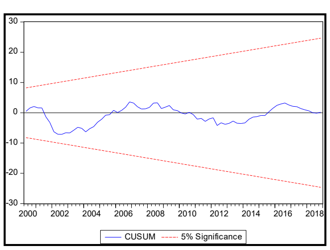
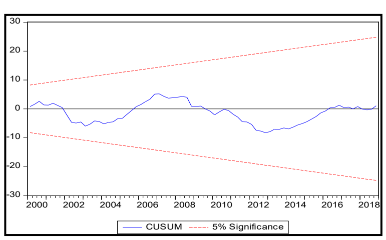
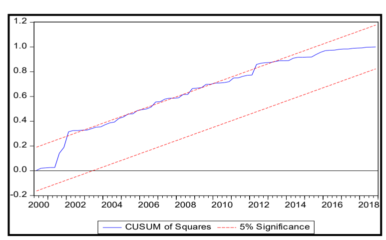
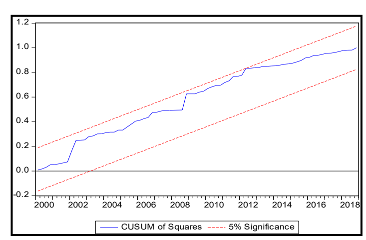
India

M3	Div M3	M3	Div M3
			

Israel

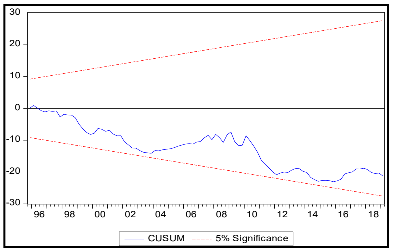
M3	Div M3	M3	Div M3
	Not Available		Not Available

Poland

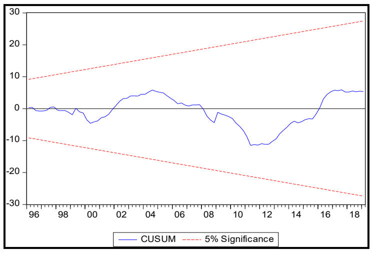
M3	Div M3	M3	Div M3
			

UK

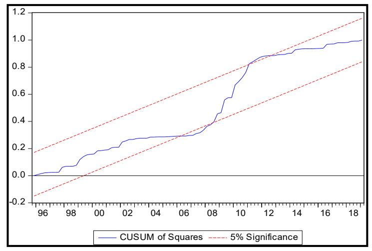
M3



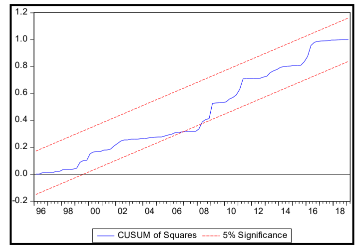
Div M3



M3

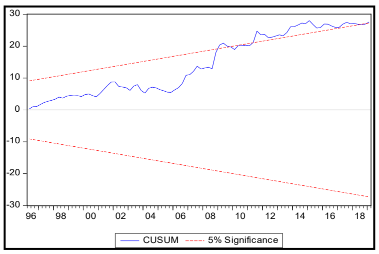


Div M3

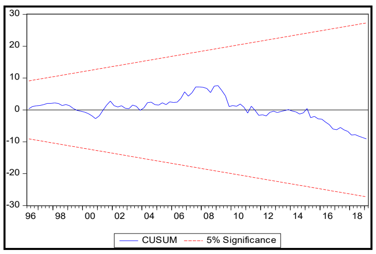


US

M3



Div M3



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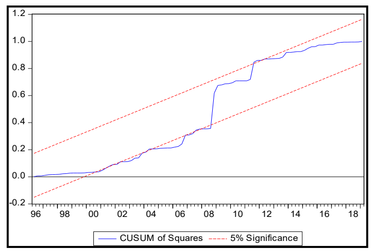
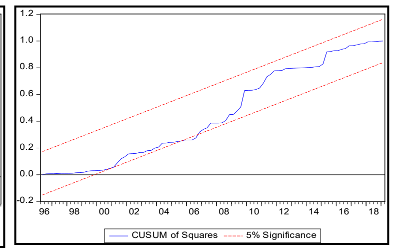


Div M3



Source: Authors' Calculation