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Abstract

We investigate the predictive power of Divisia monetary aggregates in explaining exchange rate variations for India, Israel, Poland, UK and the US, in the years leading up to and following the 2007-08 recessions. One valid concern for the chosen sample period is that the interest rate has been stuck at or near the zero lower bound (ZLB) for some major economies. Consequently, the interest rate has become uninformative about the monetary policy stance. An important innovation in our research is to adopt the Divisia monetary aggregate as an alternative to the policy indicator variable. We apply bootstrap Granger causality method which is robust to the presence of non-stationarity in our data. Additionally, we use bootstrap rolling window estimates to account for the problems of parameter non-constancy and structural breaks in our sample covering the Great recession. We find strong causality from Divisia money to exchange rates. By capturing the time-varying link of Divisia money to exchange rate, the importance of Divisia is further established at ZLB.

Keywords: Monetary Policy; Divisia Monetary Aggregates; Simple Sum; Nominal Exchange Rate; Real Effective Exchange Rate; Bootstrap Granger Causality

JEL Classification: C32, C43, E41, E51, E52, F31, F41

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1. Introduction

There is an extensive literature based on exchange rate and its nature of association with the macroeconomic fundamentals especially monetary variables in either explaining or forecasting exchange rate movements. However, the literature as of now stands largely fragmented in terms of generating a common consensus on such associations. A significant number of researchers found that long horizon out-of-sample predictive power of the monetary indicators in the exchange rate model is weak (Messe and Rogoff (1983a,b), Kilian (1999), Berkowitz and Giorgianni (1997), Groen (1997), Berben and van Dijk (1998)). On the other hand, there are studies that found support in favor of a long run relationship between exchange rate returns and monetary variables (MacDonald and Taylor (1993), Mark (1995), Chinn and Messe (1995), Mark and Sul (2001)). Among the monetary indicators, one valid concern with using the interest rate is that it has been stuck at or near the ZLB for almost a decade now, and consequently the short-term rates have become uninformative on the monetary policy stance for most central banks. Hence, it becomes important to have a relook at the money-exchange rate relationships and to test the hypothesis whether unidirectional causality exists from money to exchange rates, especially with the post-crisis data.

The classical flexible price monetary model provides the basic channel of transmission between the monetary aggregates and exchange rate. However, the assumptions underlying such models, for example, the purchasing power parity and the condition of uncovered interest parity, are generally too strong and are without much empirical support (Engle (2000)). On the other hand, Dornbusch's exchange rate model postulates that prices are sticky in the short run, and can theoretically explain short-run overshooting of the exchange rate (Dornbusch (1976)). In case of both the sticky price and flexible price models, the money supply and variables that determine the money demand, such as output and interest rate, play an important role in theoretically explaining exchange rate movements. However, there is absence of any definite empirical evidence on the relationship between the exchange rate and macro-aggregates such as money supply, output etc. and is often referred to as "exchange-rate disconnect puzzle" (Obstfeld and Rogoff (2000)).

Barnett and Kwag (2005) proposed a possible solution to the puzzle. Barnett et al. found strong evidence that the forecasting power of the exchange rate models can be considerably improved by adopting the index-number theoretic monetary aggregates such as Divisia. Chrystal and MacDonald (1995) hinted that the lack of such consensus in the exchange rate literature might be attributed to the failure of exchange rate models in adopting aggregation theoretic Divisia. The exchange rate models are purely built upon the assumption of a stable money demand function[1]. However, the stability of the money demand functions has broken down, especially for the US and UK since 1980s, that marked the beginning of the age of financial innovation and deregulation. Evidently, selecting simple sum aggregates in the exchange rate models may lead to inaccurate reflection of the money market equilibrium.

The paper examines the economies of India, Israel, Poland, UK and the US while assessing the merit of correctly measured money, as against simple sum measures and near term interest rates in exchange rate determination, for the years leading up to and following the 2007-08 recession.

[1] Hendrickson (2013) identified that Divisia aggregates with a stable money demand function can Granger cause output and prices.

Some of the recent studies (e.g. Darvas (2015), Keating et al. (2014), Belongia and Ireland (2015)) found evidence that broad Divisia monetary aggregates better reflect the policy stance of the central bank, especially in the aftermath of the financial crisis. However, most of such analyses are based on US Divisia. Also, the usefulness of Divisia money in the exchange rate literature is still not explored enough[2]. This study aims to fill this gap by analyzing multiple countries that stand at different stages of trade and financial market openness, varying degree of capital controls, and intermittent or no foreign-exchange interventions by the respective country's central banks. Despite all variations at the country level, the usefulness of Divisia money in the exchange rate determination holds strong in our study.

Moreover, the study focuses on the causal role of Divisia money in the post-recession period based on our hypothesis that Divisia money is more effective compared to interest rate or even simple sum money in the sample period that includes the ZLB. We suspect a structural break in the sample period, which is substantiated by the parameter stability tests. The results from a standard Granger causality tests might not be most reliable estimate, especially with the non-stationary time series data used in our analysis. We implement bootstrap Granger causality method as the test statistic generated from bootstrap method follows normal distribution irrespective of stationarity or non-stationarity or cointegration properties of the data. However, a full sample Granger causality test ignores the possibility of any structural break in the data. Hence, in addition to the full sample bootstrap Granger causality test, we implement fixed-length rolling window bootstrap Granger causality test to address the problem of structural break and parameter instability in the data. Therefore in the current study we adopt both the full sample bootstrap Granger causality method along with rolling window estimates to reexamine the evidence of time-varying causal link between Divisia money and exchange rate.

Our study contributes to the existing literature in two possible ways. Firstly, the findings from Litterman and Weiss (1985) that interest rate tend to absorb the predictive power of money may not necessarily hold true in general. The fact that money has lower predictive power for exchange rate than interest rates (see Bernanke and Blinder (1992)) and therefore, the more conventional "interest rate leads exchange rate" argument stands challenged when we adopt Divisia monetary aggregate. For example, from the full sample bootstrap Granger causality test, interest rate fails to Granger cause both the real effective exchange rate (REER) and nominal exchange rate (NER) for India and Poland across different lags, rendering interest rate completely ineffective against alternative monetary indicators. Interest rate also fails to Granger cause REER for the US. For UK and Israel, interest rate Granger causes REER but not the NER at different lags. Moreover, from the fixed-length rolling window bootstrap Granger causality method, the null of Granger non-causality from interest rate to REER is not rejected for India, Israel and the US for the entire period of analysis with the exceptions of UK and short intermittent phases for Poland where interest rate is significant. However, interest rate loses its predictive power on NER for UK compared to Divisia money which continues to hold a significant role in NER causality.

The causal link from monetary indicators to REER is stronger as compared to the causal link from monetary indicators to NER, but the results with Divisia money is unambiguously superior to simple sum or interest rate in both the links. This establishes the second main contribution of the paper. Divisia money plays a significant role in explaining exchange rate movements especially in the sample periods where interest rate is stuck at or near the ZLB and have become entirely non-informative. In fact the causality from Divisia to exchange rate is shown to be strongest during the phase of great recession and is more prominent for countries that have relatively open financial market, lower capital control and no foreign-exchange interventions by their central banks such as Poland, UK and the US. At the same time, Divisia money firmly holds its ground in predicting exchange rates for countries like India and Israel which had practiced more controls in

[2] Barnett et al. (2016) had found significant role of Indian Divisia on its nominal exchange rate vis-à-vis US dollar.

the past. The null of no causality from Divisia to REER is rejected for Poland, UK and the US for almost the entire sample especially covering the recession period and is rejected for considerable portion of the sample for India and Israel. Overall, our empirical analysis validates the usefulness of Divisia aggregate over the alternative monetary indicators particularly at ZLB.

The structure of the rest of the paper is as follows. Section 2 undertakes methodology and data, section 3 contains the empirical results, and finally section 4 concludes the paper.

2. Methodology and Data

2.1 The Standard Granger Causality Test

The standard Granger non-causality test suggests that a variable x is said to Granger-cause variable y if given the past values of y and past values of x, y can be predicted better compared to the prediction of y done using only the past values of y. In order to perform the Granger causality test, y is regressed on its own lagged values and on lagged values of x. Then the null hypothesis that the estimated coefficients on all lagged values of x are jointly zero is tested. A p-value of less than 0.05 fails to reject the null hypothesis, and the alternative hypothesis of existence of Granger causality is accepted. The standard Granger non-causality test is based on the assumption that the underlying data is stationary.

However, according to Sims, Stock and Watson (1990), the null hypothesis of a standard Granger causality test might have a non-standard distribution in presence of unit roots. Toda and Yamamoto (1995) paper proposed a solution to models where unit roots and co-integration are present and inference from the standard Granger causality test can be problematic. Toda and Yamamoto test suggest a modification to the standard Granger causality test, where a VAR (p) process, p being the number of lags, is estimated using one additional lag to allow for possible unit roots or co-integration. Although the proposed modified Granger causality test estimates a VAR ($p+1$) system, but test for Granger non-causality is performed on the first p lags. The test statistic from the modified Granger causality test is shown to follow standard asymptotic distributions under the null. However, ideally the test for Granger non-causality should be done for all the lags. Hence the modified Granger causality test has low power. It is in fact considered inappropriate as the test for non-causality is not done for all the lags with the possibility that the 'causality' may get shifted to the untested lags (Doan (2014)).

In presence of unit roots and co-integration, bootstrapping the standard Granger causality test is considered more appropriate where a case by case evaluation of true asymptotic is undertaken. Moreover, if the data contains parameter instability or structural breaks, the full sample bootstrap Granger causality tests could lead to non-uniform causal relation between the variables. The following sections provide evidence of presence of both unit roots and parameter instability in our data. This is not surprising as our sample includes the period of great recession. Hence, in addition to full sample bootstrap Granger causality tests, we extend our analysis to rolling window bootstrap causality estimations for all the countries.

Let us consider the following bivariate VAR (p) process for $t = 1 \ldots\ldots T$,

$$\left.\begin{aligned} y_t &= \alpha_0 + \sum_{j=1}^{p} \alpha_j y_{t-j} + \sum_{j=1}^{p} \beta_j x_{t-j} + \varepsilon_{yt} \\ x_t &= \gamma_0 + \sum_{j=1}^{p} \gamma_j x_{t-j} + \sum_{j=1}^{p} \delta_j y_{t-j} + \varepsilon_{xt} \end{aligned}\right\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where y denotes the exchange rate and x denotes the monetary aggregate or the monetary policy (interest rate). ε_{yt} and ε_{xt} are the independent white noise process with zero mean, a non-singular covariance matrix Σ_ε and p is the number of lag of the VAR system. The reported F-statistics for the null hypothesis that x (money or interest rate) does not Granger-cause y (nominal exchange rate or real effective exchange rate), are the Wald statistics for the joint hypothesis:

$$H_0 = \beta_1 = \beta_2 = \cdots \ldots . = \beta_p = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The Granger causality test measures precedence and information content of x on y. Similarly, we can check the reverse causality that y does not Granger-cause x by imposing zero restrictions on $\delta_j, j = 1, \ldots p;$ in the second regression. However, in the current context, we are not interested in this direction of causality and hence, do not report the test statistic for this test.

Rewriting the bivariate VAR (p) model given in equation (1), in compact form as,

$$Y = BZ + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (3)$$

Where,

$$Y = \begin{bmatrix} y_1 & \cdots & y_t & \cdots & y_T \\ x_1 & \cdots & y_t & \cdots & x_T \end{bmatrix} \text{ and } \varepsilon = \begin{bmatrix} \varepsilon_{y1} & \varepsilon_{y2} & \cdots & \varepsilon_{yT} \\ \varepsilon_{x1} & \varepsilon_{x2} & \cdots & \varepsilon_{xT} \end{bmatrix}$$

$$Z_t = \begin{bmatrix} 1 \\ y_{t-1} \\ \vdots \\ y_{t-p} \\ x_{t-1} \\ \vdots \\ x_{t-p} \end{bmatrix}$$

$$B = \begin{bmatrix} \alpha_0 & \alpha_1 & \cdots & \alpha_p & \beta_1 & \cdots & \beta_p \\ \gamma_0 & \delta_1 & \cdots & \delta_p & \gamma_1 & \cdots & \gamma_p \end{bmatrix} \text{ and } Z = [Z_0 \quad Z_1 \quad \cdots \quad Z_t \quad \cdots \quad Z_{T-1}]$$

The least square estimator of B in equation (3) is given by,

$$\hat{B} = YZ'(ZZ')^{-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Let SSE_r be the residual sum of squares from the restricted model under the null hypothesis of no-Granger causality in equation (2) and SSE_u be the residual sum of squares from the unrestricted regression in equation (4). Let T denotes the sample size, so the LR test statistic for a standard Granger non-causality test is given by,

$$LR = T[log(SSE_r) - \log(SSE_u)]$$

The LR test statistic is asymptotically χ^2 distributed.

2.2 The Bootstrap Methodology

The distribution of test statistic, generally, is known only asymptotically. This means that the tests may not have the correct size and the inferences from them could be misleading. On the other hand, the bootstrap method (see Efron (1971)) estimates the distribution of the test statistic by resampling of the data. Under the standard regularity conditions, the bootstrap method provides more accurate rejection probabilities of hypothesis tests than the asymptotic distribution theory.

Shukur and Mantalos (1997) have shown bootstrap critical values are more robust. Also in co-integrated time series, the critical values are more accurate than the asymptotic ones (Mantalos and Shukur (1998)). In fact, Mantalos (2000) found that regardless of the presence of co-integration or not in a VAR, bootstrap tests exhibits better power and size when compared with corrected–LR tests or the Wald causality tests. Based on the above discussion, we use bootstrap based standard Granger causality tests to examine the causal relationship between money and exchange rates.

The residual obtained using equation (4) is resampled. A direct residual resampling gives,

$$Y^* = \hat{B}Z^* + \varepsilon^* \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

Where ε^* are i.i.d observations $\varepsilon_1^*, \varepsilon_2^*, \ldots\ldots\ldots\ldots, \varepsilon_T^*$ drawn from the empirical distribution $\hat{F}_\varepsilon$ of ε_r and giving each residual an equal probability of selection (=1/T). ε_r is the matrix of residuals obtained from the restricted model under the null hypothesis of no causality.

The bootstrap tests requires drawing a number of bootstrap samples under the null hypothesis from the (restricted) model and calculate the bootstrap test statistic from the bootstrap sample drawn in equation (5). The bootstrap test statistic (LR^*) is then calculated N_b times. In our analysis, we obtain the bootstrap distribution of the test statistic, LR^*, by repeating the process 2000 ($= N_b$) times. We then consider α-th quintile of the bootstrap distribution of LR^* and obtain the α-level bootstrap critical values. We then calculate the observed test statistic calculated from the real data, LR. The inference of the test (null hypothesis of no Granger causality) is done through bootstrap p-value which is calculated as Prob ($LR^* \geq LR$).

We further extend our analysis to fixed rolling window bootstrap causality estimations due to presence of parameter instability in our data for all the countries. The essence is that, the rolling window sub-samples divides the full sample into multiple small samples covering homogenous data and the bootstrap Granger causality tests are performed on the smaller homogenous subsamples. The fixed length of the window chosen is 100. For our case of monthly data, the short sub-samples spans 8 years and 4 months. Thereby each subsequent rolling sub-sample starts and ends one period later from the initial start date and end date, respectively, maintaining the fixed window length. This continues till the last period of available data.

Both the full sample and rolling window subsample bootstrap Granger causality test confirms significant causality running from Divisia money to exchange rate for all the countries in our analysis. The strength of the causal link is sensitive to the period chosen for analysis, with the causality between Divisia and the exchange rate is shown to be strongest during the phase of great recession.

2.3 Data

The data are in monthly frequency for the sample period April 1994 - June 2008 for India, January 1994 - November 2011 for Israel, January 2001- June 2015 for Poland, January 1999 - December 2013 for UK and January 1994 - February 2017 for US. The monthly index of monetary financial institutions' sterling Divisia for UK is available from the Bank of England, the monthly Divisia monetary aggregate (DMA) with and without MAKAM[3]for Israel obtained from the Bank of Israel. The Divisia aggregates for Poland, Divisia 1, Divisia 2 and Divisia 3, which are the simple-sum counterpart of M1, M2 and M3 respectively available from the National Bank of Poland. The

[3] According to the Bank of Israel, gross financial asset portfolio of Israel's non-bank, non-government public amounted to 2.5 trillion New Israeli Shekels (NIS) as of June 2011, three times the nominal GDP. The NIS sector was considered for the DMA calculation and consists of narrow money and time deposits at commercial banks, which were included in the calculation, as well as two types of tradable bonds, Makam bills and Shachar bonds.

monthly index of the Divisia aggregates for US, Divisia M1, Divisia M2, Divisia M3, Divisia M4, Divisia M4-, Divisia All are made available by the Center for Financial Stability, New York, under a program Advances in Monetary and Financial Measurement (AMFM). Divisia monetary aggregates (DM2, DM3 and DL1) for India are obtained from Ramachandran et al. (2013). The short-term rate of interest or interbank rate, narrow money index for M1 (Index, 2010=100), broad money index for M3 (Index, 2010=100) and nominal exchange rate (Domestic currency per USD) are taken from OECD Database. Finally, the real (CPI-based) effective exchange rate, monthly averaged indices (2010=100) for India, Israel, Poland, UK and US obtained from the Bank for International Settlements. The estimations are done in RATS.

3. Empirical Results

3.1 Unit Root Test

Table A1-A5 in the appendix provides the Augmented Dickey Fuller test for India, Israel, Poland, UK and the US, respectively for interest rate, different money and different exchange rate variables. The null hypothesis for the test is defined as the variable has unit root. For robustness, we present the results for lags 6 and lags 12 for each country. Additionally, we perform the estimations of regressions for three cases namely, with no intercept and trend; with intercept; and with intercept and trend. Except Poland's interest rate (R), all the variables for all the countries analyzed at 'levels', fails to reject the null at 1% significance level. The null is however rejected for most of these cases at first differences of variables. In some cases, null is rejected for the second differences of variables. The test confirms that (except Poland's R) almost all the variables are at least I(1) with the possibility of some of them even being I(2). Hence, the results from standard Granger causality test on money and exchange rate are in fact unreliable.

3.2 VAR Parameter Stability Test

We check for parameter stability in our VAR system using Bai, Lumsdaine and Stock (1998) methodology. The Bai, Lumsdaine and Stock tests for existence of break, provides the point estimates for the break and confidence intervals for the break date for mean macroeconomic growth rates of various series. The Bai, Lumsdaine and Stock test has many advantages. First, knowledge of confidence intervals in addition to the point estimate of the break date is considered more useful as it provides more information on the time series analyzed. Second, the test looks for a single break in univariate and multivariate models where the time series could be integrated or co-integrated. In fact, the multivariate tests shows significant gains in precision in estimating break dates with narrower confidence interval. The idea behind this is multiple macroeconomic series could be affected due to common events in the economy and display break. Hence, according to Bai, Lumsdaine and Stock (1998), multivariate analysis may provide gains in the precision of estimates of the break dates, where multiple series are modeled as breaking simultaneously. Therefore, in our analysis, we perform both univariate and bivariate estimations of break date, if they exist, and estimate their confidence intervals. This test is in many ways superior to other existing tests on structural breaks in the literature such as Hansen (1992), Andrews(1993) or Andrews and Ploberger (1994) etc. which are usually concerned with only the point estimates of the break date or a treatment of the data where the break date is unknown.

Table A6 in the appendix presents the results from Bai, Lumsdaine and Stock test for India, Israel, Poland, UK and the US for both univariate cases (panel A) and bivariate cases (panel B). We take the logarithm of the monthly data that includes money, the nominal exchange rate and the real effective exchange rate for each country in our analysis. We also report the test results for interest rate (R) series. It is already been established in the previous section, that the majority of the time series involved in the analysis are I(1), contain unit root with a possibility of drift. Hence each series is differenced and modeled having the following univariate, stationary autoregressive representation,

$$y_t = \mu + \sum_{j=1}^{p} A_j y_{t-j} + d_t(k)\left(\lambda + \sum_{j=1}^{p} B_j y_{t-j}\right) + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots..(6)$$

Where y_t, μ, λ and ε_t are $n \times 1$ and $\{A_j\}$ and $\{B_j\}$ are $n \times n$; $d_t(k) = 0$ for $t \leq k$ and $d_t(k) = 1$ for $t > k$, where k is the estimated break date. The break date corresponds to shift in the mean growth rate of the series y analyzed. The lag length p is selected using the BIC criterion for each model. For the univariate analysis, y_t is the growth rate of the variables analyzed like growth rate of the nominal exchange rate (NER); or the growth rate of the real effective exchange rate (REER); or the growth rate of simple sum money (M1 and M3); or the growth rate of different Divisia money available for the countries considered. In the bivariate analysis, y_t in equation (6) is the vector of growth rates of exchange rate (nominal or real) and growth rate of money (simple sum or Divisia). The test also reports maximum Wald F-statistic (Sup-W-15%) and Andrews-Ploberger exponential Wald statistic (Exp-W-15%) with initial 15% of the sample trimmed.

According to Table A6, the univariate tests in panel A for India detect 1998 as the break year for all the Divisia money (DM3, DM2 and DL1), our key variable of interest. The simple sum money (M1 and M3) also show evidence of existence of break towards the end of the Indian sample. The conclusions do not change in the bivariate extension of the model when REER and NER jointly considered with money. Israel's money supply also shows significant evidence of existence of breaks. However, the confidence intervals for M1, R, NER and REER in the univariate version of the model are very wide. The confidence intervals narrows down considerably when REER or NER is jointly considered with Divisia money (panel B).

In Table A7, in the appendix, the confidence intervals are quite wide for all the series under consideration for the univariate analysis (panel A) for Poland. The intervals narrow down in the bivariate analysis (panel B) and the existence of break in the models cannot be ruled out. Similarly, for the UK much more precise estimates of the break dates are obtained from the bivariate version of the model with smaller confidence interval in all the models. We also witness the precision at which break dates are estimated to improve considerably in the bivariate version of US. Although for some of the models the confidence intervals still remain big. Nevertheless, the possibility of no break is ruled out. Interestingly, as expected, for Poland, UK and the US, the break dates and their confidence intervals lie around the recession period for most of the models.

Due to presence of breaks, parameter stability issues arise in our VAR and a full sample Granger causality test may not be reliable. To account for the presence of structural breaks and parameter instability in the data, we adopt a fixed window rolling bootstrap Granger non-causality tests (Balcilar (2015)). This breaks the full sample used for each country in our analysis in to many small sub-samples of fixed length on a rolling basis. It is a standard technique to break the sample into smaller ones to account for existence of structural breaks in the sample and hence capture the time-varying parameters that may exists in each sub-sample because of the presence of structural breaks.

3.3 Full Sample Bootstrap Granger Causality Test

The section presents the results from full sample bootstrap Granger causality test as well as standard causality test for India, Poland, UK, Israel and the US in tables 1 to 5. The symbols '*', '**' and '***' represents the cases where we reject the null at 1%, 5% and 10% significance level, respectively. Null hypothesis is defined as the row variables (interest rate, simple-sum monetary measure and Divisia monetary aggregates) do not Granger cause the exchange rate (real effective exchange rate and nominal exchange rate). Rejection of null implies that the row variable Granger causes the exchange rate. In our analysis, we consider both the real effective exchange rate and the nominal exchange rate for all the countries. We report the nominal exchange rate for all the countries as the domestic currency vis-à-vis US dollar and hence, the results for the US nominal exchange rate are not reported. Also we report the results for both lags 6 and 12, which are standard number of lags used for an average monthly data. The choice of end of sample for each country is based on the respective Divisia data availability.

Table 1: India Bivariate Bootstrap Granger Causality						
Null Hypothesis: Row variable does not Granger Causes Exchange Rate						
Estimation Period 1994 Apr-2008 Jun						
	Lags=6			**Lags=12**		
Real Effective Exchange Rate						
	F-Value	**Significance Level**	**Bootstrapped p-value**	**F-Value**	**Significance Level**	**Bootstrapped p-value**
Interest Rate	0.70	0.65	0.70	0.80	0.65	0.68
M1	1.19	0.32	0.40	1.64	0.09***	0.10
M3	1.19	0.32	0.41	2.12	0.02**	0.03**
DL1	2.18	0.05**	0.08***	2.96	0.00*	0.00*
DM2	2.18	0.05**	0.08***	2.88	0.00*	0.00*
DM3	2.18	0.05**	0.08***	2.96	0.00*	0.00*
Nominal Exchange Rate						
Interest Rate	0.90	0.49	0.52	1.08	0.38	0.41
M1	0.85	0.54	0.65	1.44	0.16	0.23
M3	0.44	0.85	0.89	1.34	0.20	0.27
DL1	0.70	0.65	0.72	1.50	0.13	0.17
DM2	1.22	0.30	0.39	1.54	0.12	0.16
DM3	0.70	0.65	0.73	1.50	0.13	0.17

Table 1 reports the results from both standard Granger causality and bootstrap Granger causality test for India. We reject the null hypothesis for all the available Divisia cases (DL1, DM2 and DM3) for real effective exchange rate for both lags 6 and 12. This implies that Divisia money significantly Granger causes the real effective exchange rate for India. For the cases with 12 lags, the standard Granger non-causality test as well as bootstrap Granger non-causality test rejects the null at 1% significance level for DL1, DM2, and DM3. M3 money also plays a significant role at 5% significance level. However, M1 money loses significance in Granger causing real effective exchange rate when we consider the bootstrap p-value. For the models with 6 lags, the standard Granger non-causality test rejects the null at 5% significance level for DL1, DM2, DM3 and the bootstrap Granger non-causality test still rejects the null at 10% significance level. However, simple sum money loses significance entirely. Divisia money consistently plays a significant role in Granger causing Indian real effective exchange rates. Surprisingly, the role of monetary policy as captured by interest rate remains insignificant in different samples under consideration. We fail to reject the null for any of the money variables for the nominal exchange rate for India. Perhaps, this is because the Reserve Bank of India's occasional intervention in the foreign exchange market to maintain orderly conditions and curb excess volatility, especially during the period following the East Asian crisis of 1997.

Table 2: Poland Bivariate Bootstrap Granger Causality

Null Hypothesis: Row variable does not Granger Causes Exchange Rate

Estimation Period 2001 Jan -2015 Jun

	Lags=6			**Lags=12**		
	Real Effective Exchange Rate					
	F-Value	**Significance Level**	**Bootstrapped p-value**	**F-Value**	**Significance Level**	**Bootstrapped p-value**
Interest Rate	1.27	0.28	0.31	0.88	0.61	0.57
M1	2.70	0.02**	0.02**	1.33	0.20	0.24
M2	2.09	0.06***	0.08***	2.60	0.00*	0.01**
M3	1.85	0.09***	0.12	2.32	0.01**	0.02**
Div1	2.36	0.03**	0.04**	1.22	0.27	0.31
Div2	3.82	0.00*	0.00*	2.67	0.00*	0.01**
Div3	3.78	0.00*	0.00*	2.61	0.00*	0.01**
Nominal Exchange Rate						
	F-Value	**Significance Level**	**Bootstrapped p-value**	**F-Value**	**Significance Level**	**Bootstrapped p-value**
Interest Rate	1.26	0.28	0.33	0.62	0.81	0.84
M1	1.55	0.16	0.23	1.00	0.45	0.55
M2	1.27	0.27	0.34	1.49	0.13	0.18
M3	1.26	0.28	0.35	1.48	0.14	0.19
Div1	1.65	0.14	0.19	1.02	0.44	0.53
Div2	2.36	0.03**	0.06***	1.81	0.05***	0.08***
Div3	2.34	0.03**	0.05***	1.78	0.06***	0.09***

Table 2 reports the result from the standard as well as bivariate bootstrap Granger causality test for Poland. We reject the null hypothesis for Divisia 1, Divisia 2 and Divisia 3 for both the real effective exchange rate and the nominal exchange rate. The test results are robust for Divisia, especially Divisia 2 and Divisia 3, which significantly Granger causes exchange rates at different lags (lags 6 and lags 12) for both standard Granger causality and bootstrap methods. While simple-sum M2 and M3 Granger cause Polish real effective exchange rate at both 6 and 12 lags, however, simple-sum measures fail to Granger cause nominal exchange rate. The short-term interest rates are rendered ineffective for both real effective exchange rate and nominal exchange at both 6 and 12 lags. The results strongly confirms our hypothesis that with the interest rate been stuck at or near the ZLB for long period, consequently, have become uninformative about the monetary policy stance. For example, the short-term rate/ interbank rate for Poland had dropped from 29 percent during January 1994 to 1.75 percent in March 2017, especially such sharp drop was recorded following the recession years.

Table 3: UK Bivariate Bootstrap Granger Causality						
Null Hypothesis: Row variable does not Granger Causes Exchange Rate						
Estimation Period 1999 Jan-2013 Dec						
	Lags 6			**Lags 12**		
Nominal Exchange Rate						
	F-Value	**Significance Level**	**Bootstrapped p-value**	**F-Value**	**Significance Level**	**Bootstrapped p-value**
Interest Rate	1.20	0.31	0.40	1.01	0.44	0.52
M1	0.90	0.50	0.58	1.12	0.35	0.43
M3	1.40	0.23	0.32	0.64	0.80	0.85
Divisia	4.67	0.00*	0.00*	3.13	0.00*	0.00*
Real Effective Exchange Rate						
	F-Value	**Significance Level**	**Bootstrapped p-value**	**F-Value**	**Significance Level**	**Bootstrapped p-value**
Interest Rate	3.33	0.00*	0.00*	2.10	0.02*	0.02*
M1	1.62	0.14	0.36	1.71	0.07**	0.16
M3	5.04	0.00*	0.00*	3.02	0.00*	0.00*
Divisia	5.37	0.00*	0.00*	3.49	0.00*	0.00*

Table 3 reports the results for UK. From the test results, we reject the null hypothesis for Divisia, both at 6 and 12 lags and at 1% level of significance for both the real effective exchange rate and the nominal exchange rate. This implies that Divisia money significantly Granger causes both the real effective exchange rate and the nominal exchange rate for UK. However with simple-sum M1, M2 and short-term interest rate, we fail to reject the null hypothesis in case of the nominal exchange rate at 6 and 12 lags. For real effective exchange rate, the short-term rate and simple-sum M3, we reject the null hypothesis at 1% level of significance, at different lag lengths and different test methods used.

Table 4: Israel Bivariate Bootstrap Granger Causality						
Null Hypothesis: Row variable does not Granger Causes Exchange Rate						
Estimation Period 2001 Jan-2014 Nov						
	Lags 6			**Lags 12**		
Real Effective Exchange Rate						
	F-Value	**Significance Level**	**Bootstrapped p-value**	**F-Value**	**Significance Level**	**Bootstrapped p-value**
Interest Rate	2.14	0.05***	0.07***	2.76	0.00*	0.00*
M1	4.25	0.00*	0.00*	3.38	0.00*	0.00*
M3	2.46	0.03**	0.05***	2.89	0.00*	0.00*
Divisia	2.13	0.09***	0.05***	1.91	0.04**	0.06***
Divisia Makam	1.87	0.09***	0.14	1.58	0.10	0.13
Nominal Exchange Rate						
	F-Value	**Significance Level**	**Bootstrapped p-value**	**F-Value**	**Significance Level**	**Bootstrapped p-value**
Interest Rate	1.69	0.13	0.14	1.57	0.11	0.10
M1	4.77	0.00*	0.00*	3.16	0.00*	0.00*
M3	2.50	0.02**	0.05***	1.58	0.11	0.17
Divisia	3.07	0.01**	0.02**	1.67	0.08***	0.13
Divisia Makam	2.97	0.01**	0.02**	1.50	0.13	0.20

Table 4 reports the results for Israel. We reject the null hypothesis for most of the monetary indicators i.e. short-term interest rates, simple sum M1, M3 and Divisia for real effective exchange rate at 6 and 12 lags. Israel is perhaps the only exception in our study, where we observe that short-term rates as well as narrow and broad monetary aggregates (simple-sum and Divisia) significantly Granger cause the real effective exchange rate. However, in the case of nominal exchange rate, we fail to reject the null hypothesis for the short-term interest rate. The results look consistent at different lag length and test methods. The narrow monetary aggregates (simple sum M1 and Divisia without MAKAM) seen to retain better predictability than their broader monetary counterpart (simple sum M3 and Divisia with MAKAM) in case of the nominal exchange rate. Divisia's role remains non trivial in explaining exchange rate movements.

Table 5: United States Bivariate Bootstrap Granger Causality						
Null Hypothesis: Row variable does not Granger Causes Exchange Rate						
Estimation Period 1994 Jan -2017 Feb						
	Lags=6			**Lags=12**		
	Real Effective Exchange Rate					
	F-Value	**Significance Level**	**Bootstrapped p-value**	**F-Value**	**Significance Level**	**Bootstrapped p-value**
Interest Rate	0.57	0.75	0.80	1.21	0.33	0.27
M1	0.82	0.56	0.66	1.01	0.44	0.54
M3	1.52	0.17	0.27	0.90	0.55	0.64
DivisiaM1	0.90	0.50	0.62	0.76	0.69	0.76
DivisiaM2	1.74	0.11	0.19	1.26	0.24	0.33
DivisiaALL	1.52	0.17	0.28	1.13	0.34	0.44
DivisiaM3	3.78	0.01**	0.02**	2.25	0.01**	0.03**
DivisiaM4-	2.43	0.03**	0.06***	1.88	0.03**	0.06***
DivisiaM4	2.50	0.02**	0.05***	1.93	0.03**	0.06***

Table 5 reports the results for the US. The test results for US looks promising and offers much support in favor of our hypothesis. Our finding suggests that Divisia is useful in the exchange rate models, especially when the short-term rates have become stuck at its ZLB. Both the standard causality test and bootstrap method suggest that Divisia indices, particularly Divisia M3, Divisia M4- and Divisia M4 can significantly Granger cause the real effective exchange rate at 6 and 12 lags. Among the Divisia aggregates at different levels of aggregation, Divisia M3 significantly Granger causes the real exchange rate at 5% level of significance.

Overall, the results reported in Table 1, 2, 3, 4 and 5 suggest that Divisia serves better as an alternative monetary policy indicator as against the conventional short-term rate of interest. Divisia significantly Granger cause the exchange rate for Israel, Poland, UK and US. The results consistently hold across alternative measures of the exchange rate i.e. the real effective exchange rate and the nominal exchange rate, for different test methods such as standard Granger causality test and bootstrap Granger causality method as well as for different choices of lags (both 6 and 12 lags). Among the Divisia aggregates, DM3, DM4-, DM4 for US, narrow Divisia for UK, Divisia 2 and Divisia 3 for Poland, Divisia without Makam, is most useful when the short-term rates are stuck at or near the ZLB. Also the Indian Divisia is shown to significantly Granger cause the real effective exchange rate.

3.4 Rolling Fixed Window (Subsample) Bootstrap Granger Causality Test

The bootstrap rolling window estimates of the Granger non-causality test for India, Israel, Poland, UK and U.S. are presented in this section. The length of the window is fixed at 100. That is we divide the full sample of monthly data for each country into several short sub-samples spanning

8 years and 4 months. As most of our data start for late 1990s or early 2000s, we choose the first sub-sample such that it starts at March, 2000 and ends at June, 2008 for Israel, UK and the US. Thereby each subsequent rolling sub-sample starts and ends one period later, maintaining the fixed window length. This continues till the last period of available data. For Poland the first subsample starts at August, 2001 and ends at December, 2009. The choice of window is based on Pesaran and Timmermann (2005) who have compared short window of 6 years and a longer window of 10 years and found that the longer window performed slightly better. Our results are robust to the fixed window length of 60 or 80. For India, the available time-series is short as Divisia is only available till June 2008. To get enough sub-samples, we choose the window length to 60 periods such that the first sub-sample starts at January, 2000 and ends at January, 2005. The rolling window estimates continue till the last sub-sample ends at June, 2008. The number of lags for each sub-sample is selected by AIC. 2000 draws are implemented to estimate bootstrap statistic for each sub-sample. The shaded region in the graphs captures the p-value for the test with null hypothesis that the variables under consideration (Divisia or M3 or interest rate) do not Granger cause the real effective exchange rate. The horizontal line denotes the p-value of 0.1 or 10 % level of significance. A p-value of less than 0.1 rejects the null at 10% level of significance. We also evaluate the test at 20% level of significance due to low power of the test associated with shorter sub-samples chosen.

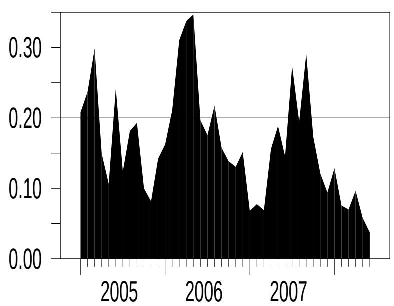
The plots of the bootstrap p-values of the rolling window statistics and the magnitude of the impact of the monetary indicators (simple-sum M3, broad Divisia aggregate and interest rate) on the real effective exchange rate are reported in Figure 1. For India, the null hypothesis is mostly rejected at 20% level of significance between January 2005 and June 2008 using Divisia M3, except few intermittent episodes of January 2005 - April 2005, February 2006 - May 2006, June 2007 - September 2007. However, for both simple sum M3 and interest rate we fail to reject the null hypothesis at the 20% level of significance for the entire period. For Israel, the rolling window test statistic shows that p-value for Divisia (without MAKAM) and simple sum M3 consistently stays below 10% level of significance between 2010 and 2014. Interestingly, interest rate is rendered completely ineffective when evaluated using the rolling causality test with p-values consistently exceeding 10% level of significance. Divisia 3 is by far the best monetary indicator for Poland with p-values consistently staying lower than 10% level of significance. However, for the simple sum M3 we fail to reject the null hypothesis for a considerable intervals lying in between 2010, 2012 and 2013. Similarly, the interest rate fare poorly and we fail to reject the null hypothesis for considerable intervals in 2010, during 2011 to 2013 and towards the end of the sample around 2014. The results for UK shows that all three monetary indicators namely, Divisia, simple-sum M3 and interest rate have p-values consistently lower than 10 percent. However, Divisia outperforms its simple sum counterpart and does relative better than the interest rate with the null hypothesis rejected at 10% level of significance between 2009 and 2013. Finally the rolling window test statistics for US shows that the null hypothesis is rejected at the 10% level of significance for Divisia M3 between 2009 and 2012 and then between 2015 and 2017. On the other hand, we fail to reject the null hypothesis for simple-sum M3 and interest rate at even 20% level of significance between 2009 and 2017. While the rolling causality test from figure 8 suggests that the Divisia aggregate is a more useful monetary indicator over other alternative indicators, particularly in Granger causing exchange rate in all countries under consideration. The hypothesis is captured relatively better in countries that have relatively open financial market, lower capital control and limited or no foreign-exchange interventions by their central banks, such as Poland, UK and US.

Figure 1: Rolling Causality Tests

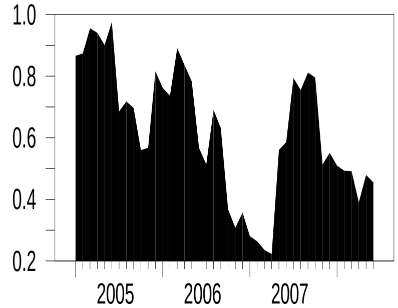
Null: Divisia / M3 / interest rate do not Granger cause real effective exchange rate

India

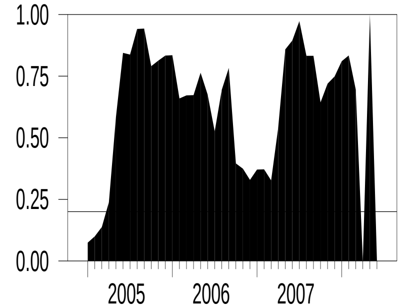
Divisia(DM3)



M3

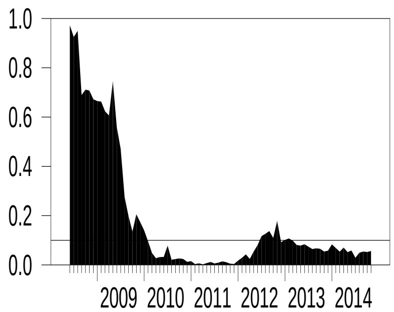


Interest Rate

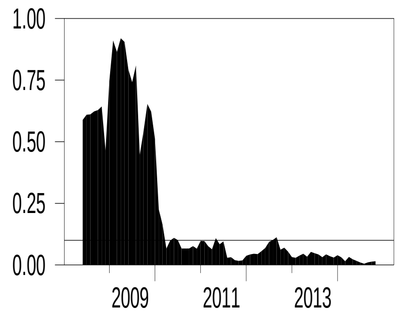


Israel

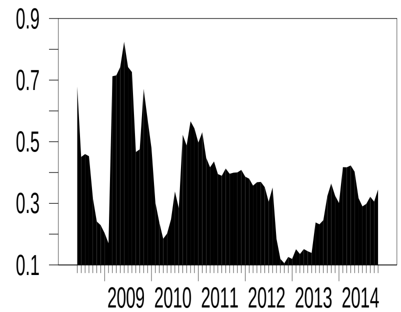
Divisia



M3

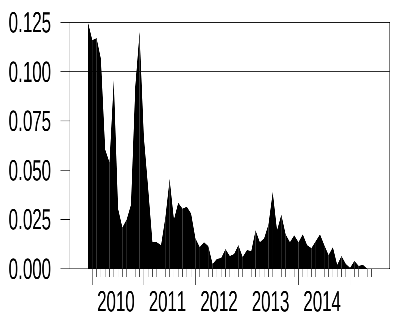


Interest Rate

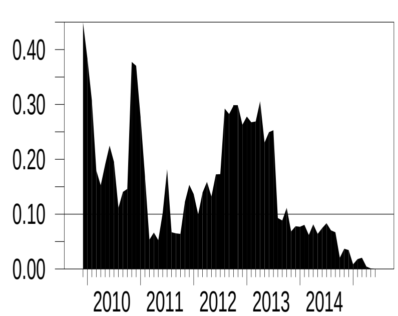


Poland

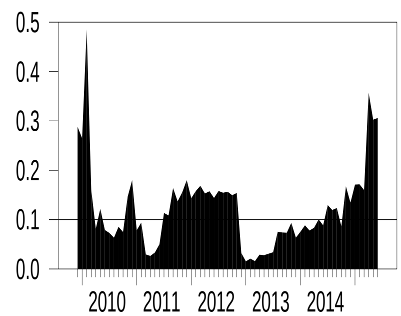
Divisia (Divisia 3)



M3

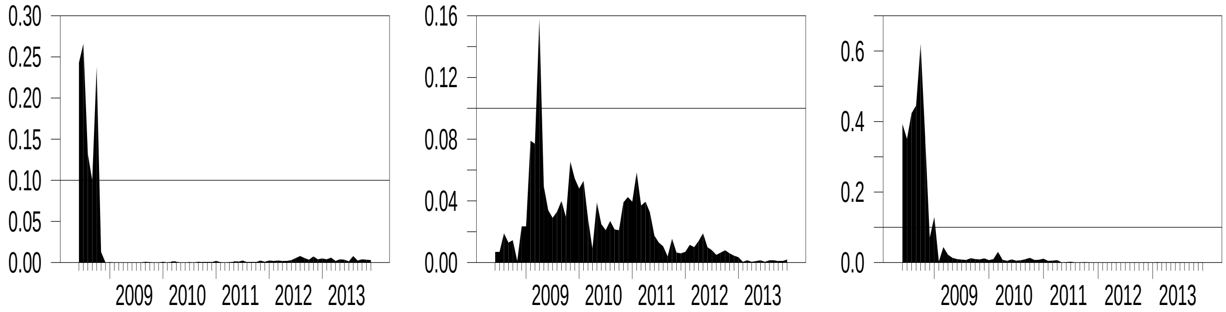


Interest Rate



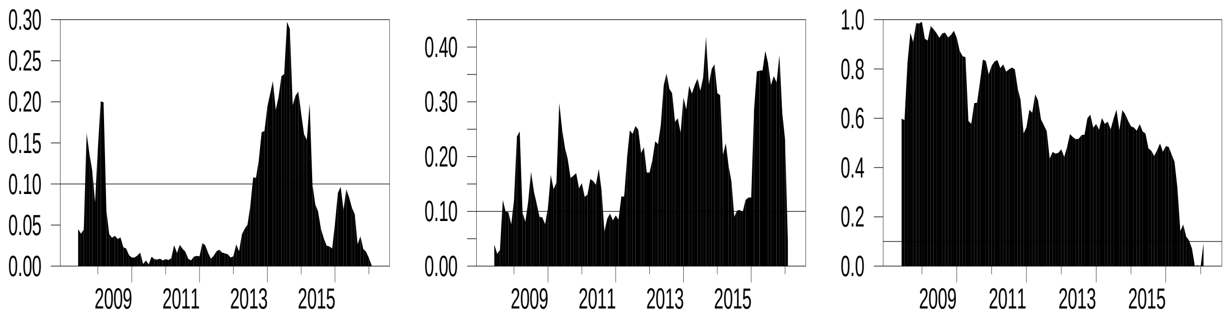
UK

Divisia M3 Interest Rate



US

Divisia (Divisia M3) M3 Interest Rate



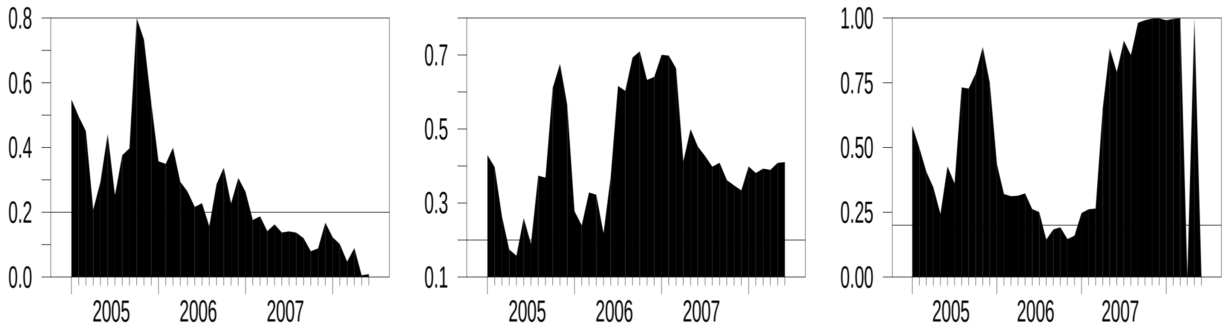
The plots of the bootstrap p-values of the rolling statistics and the magnitude of the impact of the monetary indicators (simple-sum M3, broad Divisia aggregate and interest rate) on the nominal exchange rate are reported in Figure 2. For India, the null hypothesis is rejected at 20% level of significance between January 2007 and June 2008, however, we fail to reject the null hypothesis for simple sum M3 and interest rate at 20% level of significance during the same period. Overall, Divisia M3 does relatively better than alternative monetary indicators (simple sum M3 and interest rate). The rolling window estimates for Israel shows improvement when we adopt Divisia over other monetary indicators during the recession years 2008 to 2012 where the p-value for Divisia stays below 20% level of significance especially the period covering August 2008 - March 2010 and January 2011- August 2011. Both simple sum M3 and interest rate are rendered completely ineffective when evaluated using the rolling causality test with p-values consistently exceeding 20% level of significance. Divisia 3 and interest rate is seen to perform relatively better as against the simple sum M3 for Poland. Divisia 3 and interest rate Granger cause nominal exchange rate at 20% level of significance in the period covering 2012 – to the end of sample for Divisia 3 and intermittent periods covering September 2010 – September 2011 and around 2013 - 2015 for interest rate. We fail to reject the null hypothesis for simple sum M3 i.e. the simple sum measure fails to Granger cause nominal exchange rate at 20% level of significance. The results for UK look promising as Divisia consistently reject the null hypothesis at 10 percent level i.e. Divisia can significantly Granger cause nominal exchange rate for a long period following the 2007-08 recession, especially between 2009 and beginning of 2013. The simple sum measure and interest rate Granger cause nominal exchange rate in few sporadic episodes, especially the intervals covering June 2012 - December 2013 for simple sum M3 and August 2011 - December 2013 for interest rate. Overall, Divisia is by far the best predictor of nominal exchange rate for UK and does relatively better than alternative monetary indicators (simple sum M3 and interest rate) for India and Israel. Both Divisia and interest rate is seen to perform well for Poland with simple sum M3 ineffective in the case of nominal exchange rate.

Figure 2: Rolling Causality Tests

Null: Divisia / M3 / interest rate do not Granger cause nominal exchange rate

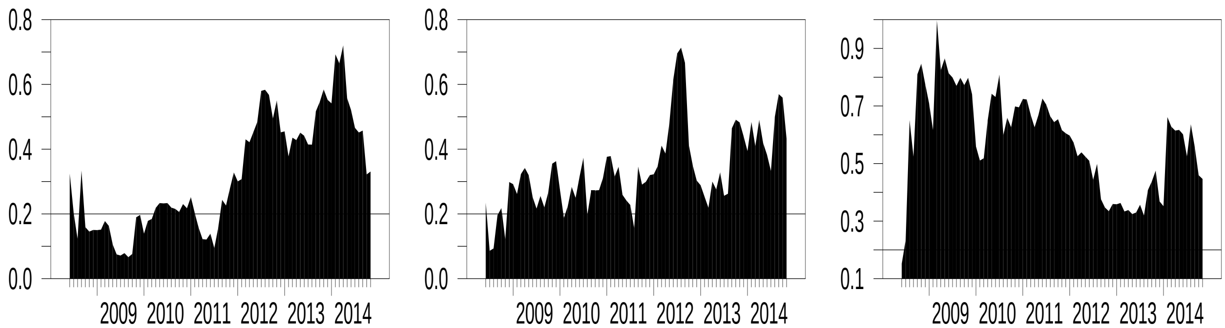
India

Divisia(DM3) M3 Interest Rate



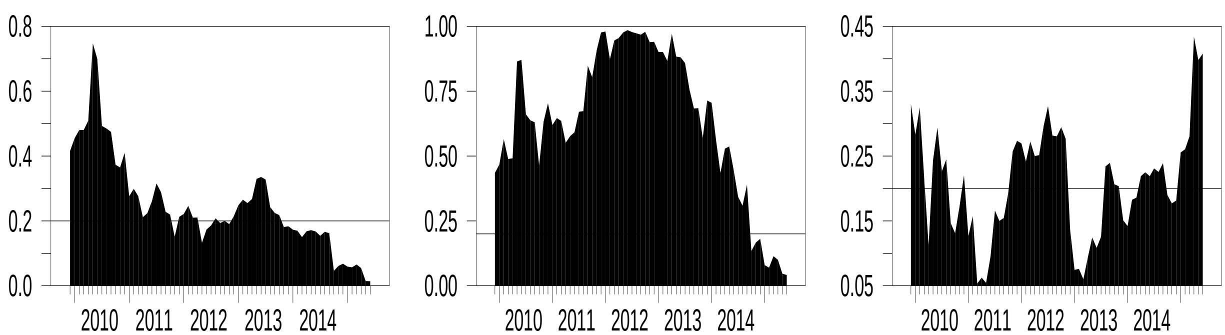
<u>Israel</u>

Divisia M3 Interest Rate



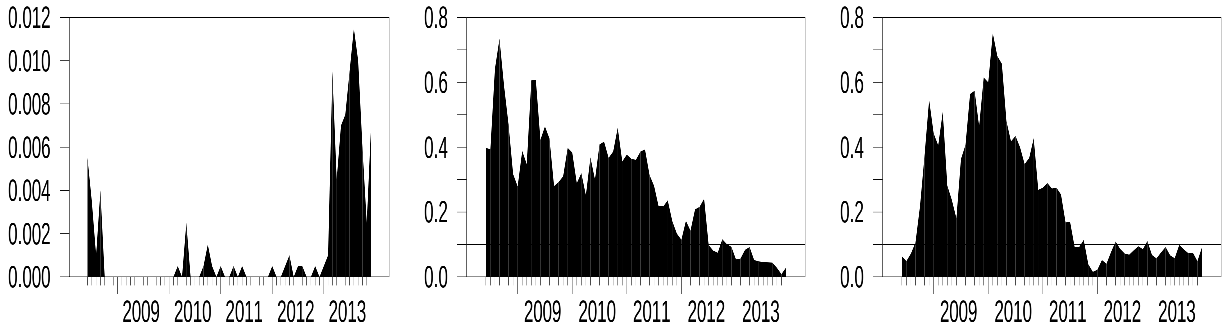
<u>Poland</u>

Divisia (Divisia 3) M3 Interest Rate



UK

Divisia M3 Interest Rate



4. Conclusion

We investigate the role of correctly measured money in exchange rate determination for India, Israel, Poland, UK and US for the estimation period covering the 2007-2008 crisis. The full sample residual bootstrap Granger causality test is employed as the test has considerable advantages over the asymptotic distribution test. The results from the full sample bootstrap method suggest that Divisia significantly Granger cause exchange rate for Israel, Poland, UK and US. The results consistently hold across alternative measures of exchange rate, different test methods as well as over different lags. Among the Divisia aggregates, DM3, DM4-, DM4 for US, narrow Divisia for UK, Divisia 2 and Divisia 3 for Poland, Divisia without Makam, are most useful when the short-term rates are stuck at or near the ZLB. For India as well Divisia significantly Granger causes the real effective exchange rate but not the nominal exchange rate.

The rolling causality test offers a couple of interesting insights, firstly, Divisia money plays a significant role in explaining exchange rate movements especially during the phase of great recession when interest rate is stuck at or near the ZLB and have become entirely non-informative. The Granger non-causality test from interest rate to REER cannot be rejected for India, US and Israel except for UK and some sporadic phases of Poland. Interest rate does even worse in predicting NER for all countries including UK. Secondly, the usefulness of adopting Divisia aggregate and the argument, Divisia Granger causes real effective exchange rate is better reflected in countries that have relatively open financial market, lower capital control and limited or no foreign-exchange interventions by their central banks, such as Poland, UK and US. At the same time, the performance of Divisia remains superior for countries like India and Israel which are characterized by more central bank interventions. Thirdly, Divisia is by far the best predictor of nominal exchange rate for UK and does relatively better than alternative monetary indicators (simple sum M3 and interest rate) for India and Israel. The exchange rate models of the 1970s and 80s were purely built upon the assumption of a stable money demand function and selecting simple sum aggregates in the exchange rate models have led to inaccurate reflection of the money market equilibrium. Our current research strongly puts forward a competing view against the conventional wisdom that “interest rate leads exchange rate” and suggests that there is a greater need for adopting Divisia aggregate in the exchange rate models.

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Appendix

Table A1: India						
Augmented Dickey Fuller Unit Root Test: Null Hypothesis: Variable has a unit root						
		Lags 6			Lags 12	
Variables	**Level**	**First Difference**	**Second Difference**	**Level**	**First Difference**	**Second Difference**
With Trend and Intercept						
R	0.96	0.00*		0.96	0.00*	
M1	0.97	0.00*		0.98	0.011**	0.00*
M3	0.87	0.012**	0.00*	0.86	0.16	0.00*
DL1	0.84	0.00*		0.68	0.00*	
DM2	0.83	0.00*		0.64	0.00*	
DM3	0.87	0.00*		0.79	0.00*	
REER	0.09***	0.00*		0.07***	0.00*	
NER	0.87	0.00*		0.87	0.00*	
With Intercept						
R	0.54	0.00*		0.54	0.00*	
M1	1.00	0.00*		1.00	0.013**	0.00*
M3	1.00	0.00*		1.00	0.08	0.00*
DL1	1.00	0.00*		1.00	0.06***	0.00*
DM2	1.00	0.00*		1.00	0.06***	0.00*
DM3	1.00	0.00*		1.00	0.06***	0.00*
REER	0.15	0.00*		0.15	0.00*	
NER	0.20	0.00*		0.20	0.00*	
Without Intercept and Trend						
R	0.011**	0.00*		0.011**	0.00*	
M1	1.00	0.18	0.00*	1.00	0.27	0.00*
M3	1.00	0.43	0.00*	1.00	0.52	0.00*
DL1	1.00	0.14	0.00*	1.00	0.42	0.00*
DM2	1.00	0.03**	0.00*	1.00	0.34	0.00*
DM3	1.00	0.14	0.00*	1.00	0.43	0.00*
REER	0.68	0.00*		0.68	0.00*	
NER	0.93	0.00*		0.93	0.00*	

Table A2: Israel						
Augmented Dickey Fuller Unit Root Test: Null Hypothesis: Variable has a unit root						
			Lags 6		**Lags 12**	
Variables	**Level**	**First Difference**	**Second Difference**	**Level**	**First Difference**	**Second Difference**
With Trend and Intercept						
R	0.11	0.00*		0.12	0.00*	
M1	0.27	0.13	0.00*	0.39	0.15	0.00*
M3	0.06***	0.00*		0.07***	0.00*	
Divisia	0.49	0.00*		0.13	0.03**	0.00*
Divisia-Makam	0.37	0.00*		0.23	0.03**	0.00*
REER	0.12	0.00*		0.12	0.00*	
NER	0.012**	0.00*		0.012**	0.00*	
With Intercept						
R	0.49	0.00*		0.7	0.00*	
M1	0.98	0.04**	0.00*	0.99	0.05**	0.00*
M3	0.98	0.00*		0.97	0.00*	
Divisia	0.99	0.00*		0.99	0.013**	0.00*
Divisia-Makam	0.94	0.00*		0.97	0.00*	
REER	0.09***	0.00*		0.17	0.00*	
NER	0.42	0.00*		0.42	0.00*	
Without Intercept and Trend						
R	0.1***	0.00*		0.15	0.00*	
M1	0.99	0.08***	0.00*	0.99	0.13	0.00*
M3	1	0.12	0.00*	1	0.12	0.00*
Divisia	1	0.015**	0.00*	0.99	0.09***	0.00*
Divisia-Makam	1	0.02**	0.00*	0.99	0.12	0.00*
REER	0.39	0.00*		0.39	0.00*	
NER	0.57	0.00*		0.57	0.00*	

Table A3: Poland						
Augmented Dickey Fuller Unit Root Test: Null Hypothesis: Variable has a unit root						
		Lags 6			**Lags 12**	
Variables	**Level**	**First Difference**	**Second Difference**	**Level**	**First Difference**	**Second Difference**
With Trend and Intercept						
R	0.00*			0.07***	0.23	0.00*
M1	0.95	0.02**	0.00*	0.83	0.09***	0.00*
M2	0.49	0.1***	0.00*	0.25	0.62	0.00*
M3	0.58	0.00*		0.41	0.54	0.00*
Div1	0.92	0.02**	0.00*	0.76	0.07***	0.00*
Div2	0.63	0.03**	0.00*	0.43	0.26	0.00*
Div3	0.68	0.03**	0.00*	0.49	0.24	0.00*
REER	0.1***	0.00*		0.1***	0.00*	
NER	0.51	0.00*		0.51	0.00*	
With Intercept						
R	0.00*			0.06***	0.01*	
M1	0.11	0.02**	0.00*	0.22	0.11	0.00*
M2	0.97	0.03**	0.00*	0.89	0.28	0.00*
M3	0.96	0.00*		0.86	0.22	0.00*
Div1	0.18	0.03**	0.00*	0.21	0.08***	0.00*
Div2	0.97	0.01*		0.94	0.08***	0.00*
Div3	0.96	0.00*		0.93	0.07***	0.00*
REER	0.03**	0.00*		0.03**	0.00*	
NER	0.16	0.00*		0.16	0.00*	
Without Intercept and Trend						
R	0.00*			0.12	0.00*	
M1	1	0.12	0.00*	0.99	0.27	0.00*
M2	0.99	0.07***	0.00*	0.98	0.36	0.00*
M3	1	0.07***	0.00*	0.98	0.34	0.00*
Div1	1	0.14	0.00*	0.99	0.29	0.00*
Div2	1	0.07***	0.00*	0.99	0.31	0.00*
Div3	1	0.06***	0.00*	0.99	0.28	0.00*
REER	0.57	0.00*		0.48	0.00*	
NER	0.54	0.00*		0.54	0.00*	

Table A4: UK						
Augmented Dickey Fuller Unit Root Test: Null Hypothesis: Variable has a unit root						
		Lags 6			**Lags 12**	
Variables	**Level**	**First Difference**	**Second Difference**	**Level**	**First Difference**	**Second Difference**
With Trend and Intercept						
M1	0.96	0.00*		0.83	0.06***	0.00*
M3	1.00	0.02**	0.00*	0.98	0.43	0.00*
NDivisia	0.76	0.23	0.00*	0.76	0.23	0.00*
R	0.28	0.00*		0.45	0.00*	
REER	0.57	0.00*		0.57	0.00*	
NER	0.63	0.00*		0.63	0.00*	
With Intercept						
M1	0.15	0.00*		0.34	0.04**	0.00*
M3	0.44	0.011**	0.00*	0.37	0.39	0.00*
NDivisia	0.76	0.08***	0.00*	0.76	0.08***	0.00*
R	0.75	0.00*		0.75	0.00*	
REER	0.72	0.00*		0.72	0.00*	
NER	0.32	0.00*		0.32	0.00*	
Without Intercept and Trend						
M1	1.00	0.04**	0.00*	0.99	0.14	0.00*
M3	1.00	0.03**	0.00*	0.97	0.25	0.00*
NDivisia	1.00	0.24	0.00*	1.00	0.24	0.00*
R	0.20	0.00*		0.20	0.00*	
REER	0.38	0.00*		0.38	0.00*	
NER	0.56	0.00*		0.56	0.00*	

Table A5: US						
Augmented Dickey Fuller Unit Root Test: Null Hypothesis: Variable has a unit root						
	Lags 6			**Lags 12**		
Variables	**Level**	**First Difference**	**Second Difference**	**Level**	**First Difference**	**Second Difference**
With Trend and Intercept						
R	0.02**	0.05**		0.011**	0.01*	
M1	0.75	0.00*		0.75	0.00*	
M3	0.07***	0.00*		0.07***	0.00*	
DivisiaAll	0.53	0.00*		0.53	0.00*	
DivisiaM1	0.94	0.00*		0.95	0.00*	
DivisiaM2	0.13	0.00*		0.13	0.00*	
DivisiaM3	0.92	0.02**	0.00*	0.92	0.02**	0.00*
DivisiaM4	0.98	0.00*		0.92	0.00*	
DivisiaM4-	0.89	0.011**	0.00*	0.89	0.011**	0.00*
REER	0.86	0.00*		0.86	0.00*	
With Intercept						
R	0.18	0.01*		0.21	0.00*	
M1	0.99	0.00*		0.99	0.00*	
M3	0.99	0.00*		0.99	0.00*	
DivisiaAll	0.83	0.00*		0.83	0.00*	
DivisiaM1	0.99	0.00*		0.99	0.00*	
DivisiaM2	0.99	0.00*		0.99	0.00*	
DivisiaM3	0.39	0.00*		0.39	0.00*	
DivisiaM4	0.27	0.00*		0.27	0.00*	
DivisiaM4-	0.29	0.01*		0.29	0.02**	0.00*
REER	0.58	0.00*		0.58	0.00*	
Without Trend and Intercept						
Interest Rate	0.07***	0.00*		0.07***	0.00*	
M1	0.99	0.00*		0.99	0.02**	0.00*
M3	1	0.07***	0.00*	1	0.2	0.00*
DivisiaAll	1	0.011**	0.00*	1	0.011**	0.00*
DivisiaM1	1	0.02**	0.00*	1	0.07***	0.00*
DivisiaM2	1	0.06***	0.00*	1	0.06***	0.00*
DivisiaM3	0.99	0.04**	0.00*	0.99	0.04**	0.00*
DivisiaM4	0.99	0.02**	0.00*	0.99	0.04**	0.00*
DivisiaM4-	0.99	0.04**	0.00*	0.99	0.07***	0.00*
REER	0.79	0.00*		0.79	0.00*	

Table A6: Parameter Stability Test					
VAR System (y_t)	**Lags**	**Exp-W-15%**	**Sup-W-15%**	**Break Date**	**90% Confidence Interval**
India (Sample 1994:4-2008:6)					
A. Univariate					
NER	1	2.08	6.34	1998:07	1995:11-2001:03
REER	2	0.11	1.15	1999:02	1995:07-2008:06
M3	5	1.87	9.64	2006:03	2005:03-2007:03
M1	5	4.37	14.61	2003:04	2002:03-2004:05
DM3	12	2.68	8.95	1998:03	1997:01-1999:05
DM2	12	2.59	9.11	1998:03	1997:01-1999:05
DL1	12	2.78	9.73	1998:03	1997:02-1999:04
R	3	1.20	4.20	2000:05	1995:07-2005:08
B. Bivariate					
REER, DM3	1	1.38	5.20	1997:09	1995:06-2000:05
REER, DM2	1	1.31	5.13	1998:03	1995:06-2001:04
REER, DL1	1	1.36	5.33	1997:09	1995:06-2000:04
REER, M3	2	5.67	19.27	2006:03	2005:07-2006:11
REER, M1	2	7.34	20.74	2003:04	2002:04-2004:04
NER, DM3	1	2.62	7.55	1998:09	1996:06-2000:12
NER, DM2	1	2.62	7.85	1998:09	1996:06-2000:11
NER, DL1	1	2.62	7.63	1998:09	1996:06-2000:12
NER, M3	2	6.64	21.37	2006:03	2005:08-2006:10
NER, M1	2	8.34	22.89	2003:04	2002:06-2004:02
Israel (Sample 1994:1-2014:11)					
A. Univariate					
NER	1	1.02	4.94	2002:07	1995:10-2009:04
REER	2	0.32	1.89	1998:04	1995:04-2008:04
M3	6	7.09	22.64	2001:03	2000:07-2001:11
M1	6	0.36	2.017	2003:08	1995:04-2014:11
DIVISIA	3	6.43	18.22	2001:10	2000:07-2003:01
DIVISIA MAKAM	3	7.85	22.17	2001:10	2000:10-2002:10

R	1	0.15	2.14	2002:02	1995:04-2014:11
B. Bivariate					
NER, M1	1	2.56	9.36	2003:03	1999:08-2006:10
NER, M3	1	11.27	30.61	2001:04	2000:08-2001:12
NER, DIVISIA	1	10.60	26.99	2001:11	2000:10-2002:12
NER, DIVISIA MAKAM	1	13.37	33.60	2001:10	2000:12-2002:08
REER, M1	1	0.80	3.42	2006:10	1996:07-2014:11
REER, M3	1	11.59	30.98	2001:04	2000:08-2001:12
REER, DIVISIA	1	10.77	27.23	2001:11	2000:10-2002:12
REER, DIVISIA MAKAM	1	13.27	32.67	2001:10	2000:11-2002:09

Table A7: Parameter Stability Test					
VAR System	**Lags**	**Exp-W-15%**	**Sup-W-15%**	**Break Date**	**90% Confidence Interval**
Poland (Sample 1994:4-2008:6)					
A. Univariate					
NER	1	0.44	4.16	2008:08	2002:01-2015:03
REER	1	0.12	1.90	2008:08	2000:04-2015:06
M3	1	1.24	5.13	2012:01	2008:02-2015:06
M1	12	0.78	4.19	2008:01	2002:05-2013:09
DIV1	12	0.56	3.33	2008:01	2000:08-2015:06
DIV2	1	0.59	3.44	2005:02	2000:04-2012:04
DIV3	1	0.57	3.16	2003:05	2000:04-2009:03
R	3	2.67	11.45	2002:11	2001:09-2004:01
B. Bivariate					
NER, M1	1	1.88	9.43	2008:08	2005:09-2011:07
NER, M3	1	2.13	8.67	2008:08	2005:06-2011:10
NER, DIV1	1	1.90	9.47	2008:08	2005:10-2011:06
NER, DIV2	1	1.11	6.58	2008:08	2004:06-2012:10
NER, DIV3	1	1.14	6.82	2008:08	2004:08-2012:08
REER, M1	1	1.37	7.61	2008:08	2005:01-2012:03
REER, M3	1	1.68	7.13	2004:03	2001:03-2007:03
REER, DIV1	1	1.27	7.48	2008:08	2004:12-2012:04
REER, DIV2	1	0.81	3.91	2004:03	2000:04-2009:09
REER, DIV3	1	0.79	3.96	2008:08	2001:08-2015:06
UK (Sample 1999:1-2013:12)					
A. Univariate					
NER	1	0.24	1.75	2007:12	2000:04-2013:12
REER	1	0.45	3.89	2009:02	2003:02-2013:12
M3	4	8.71	26.23	2010:03	2009:08-2010:10
M1	6	4.85	17.30	2008:03	2007:02-2009:04
NDIVISIA	1	7.93	22.34	2008:01	2006:12-2009:02
R	5	0.21	1.83	2009:01	2000:04-2013:12

B. Bivariate					
NER, M1	1	4.52	17.81	2008:03	2006:12-2009:06
NER, M3	1	7.33	23.96	2010:03	2009:06-2010:12
NER, NDIVISIA	1	7.77	21.87	2008:01	2006:12-2009:02
REER, M1	1	3.57	15.69	2008:03	2006:10-2009:08
REER, M3	1	6.26	21.78	2010:03	2009:05-2011:01
REER, NDIVISIA	1	8.29	23.28	2008:02	2007:02-2009:02
US (Sample 1994:1-2017:2)					
A. Univariate					
REER	2	0.74	3.59	2013:11	2008:02-2017:02
M3	1	0.18	1.74	2011:02	1995:04-2017:02
M1	1	16.92	41.58	2008:09	2007:11-2009:07
DIVISIAM1	3	3.11	11.40	2008:09	2005:11-2011:07
DIVISIAM2	3	0.18	1.77	2003:09	1995:04-2017:02
DIVISIAM3	1	10.73	29.85	2008:04	2007:01-2009:07
DIVISIAM4	1	11.45	32.61	2008:11	2007:10-2009:12
DIVISIAM4-	1	12.23	33.25	2008:04	2007:03-2009:05
DIVISIAALL	3	0.75	4.77	2001:10	1995:04-2008:11
R	2	0.25	1.76	2008:12	1995:04-2017:02
B. Bivariate					
RER, M1	1	18.07	43.77	2008:09	2007:11-2009:07
RER, M3	1	0.71	3.89	1998:09	1995:04-2004:03
REER, DIVISIAM1	1	6.88	19.87	2008:09	2006:11-2010:07
REER, DIVISIAM2	1	0.84	4.02	1998:09	1995:04-2004:01
REER, DIVISIAM3	1	11.75	32.21	2008:04	2007:02-2009:06
REER, DIVISIAM4	1	12.07	33.49	2008:11	2007:10-2009:12
REER, DIVISIAM4-	1	13.11	35.26	2008:04	2007:04-2009:04
REER, DIVISIAALL	2	1.52	6.09	2001:10	1996:05-2007:03