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Abstract

After almost 15 years, following the flagship exchange-rate paper written by Kim and Roubini (K&R henceforth); we revisit the widely relevant questions on monetary policy, exchange rate delayed overshooting, inflationary puzzle and weak monetary transmission mechanism in the Indian context. We further try to incorporate a superior form of the monetary measure called the Divisia monetary aggregate in the K&R setup. Our paper still rediscovers the efficacy of K&R contemporaneous restriction (customized for the Indian economy which is a developing G-20 nation unlike advanced G-6 nations that K&R worked with) especially when we compared with the recursive structure (which is plagued by price puzzle and exchange rate puzzle). The importance of bringing back 'Money' in the exchange rate model especially correctly measured monetary aggregate is convincingly illustrated, when we contested across models with no-money, simple-sum monetary models and Divisia monetary models; in terms of impulse response (eliminating some of the persistent puzzles), variance decomposition analysis (policy variable explaining more of the exchange rate fluctuation) and out-of-sample forecasting (LER forecasting graph). Further, we do a flip-flop variance decomposition analysis, which leads us to conclude two important phenomena in the Indian economy, (i) weak link between the nominal-policy variable and the real-economic activity (ii) Indian monetary authority had inflation-targeting as one of their primary goals, in tune with the RBI Act. These two main results are robust, holding across different time period, dissimilar monetary aggregates and diverse exogenous model setups.

Keywords: Monetary Policy; Monetary Aggregates; Divisia; Structural VAR; Exchange Rate Overshooting; Liquidity Puzzle; Price Puzzle; Exchange Rate Puzzle; Forward Discount Bias Puzzle

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Section 1: Introduction

"To raise new questions, new possibilities, to regard old problems from a new angle, require creative imagination and marks real advance in science"

- Albert Einstein

Post 2008-crisis has witnessed a series of unconventional monetary policies such as large-scale asset purchase, long-maturity lending to banks, cutting deposit rates below zero, purchase of asset backed securities and covered bank bonds; implemented fervently by the Central Banks of US, UK, Japan and ECB. Naturally such unconventional monetary policy measures fail to get correctly captured in the key policy rates. In fact it will be misleading to measure the impact of monetary policy and thereby rightly track the monetary policy transmission mechanism with the interest rates alone (when the rates are already stuck near zero). Leeper and Roush (2003, L&R henceforth) mention that "Monetary policy without money is so widely accepted that it appears in pedagogical writings at the undergraduate and graduate levels". Evidently, in this kind of zero lower bound environments, the need to have an additional monetary indicator is even more pressing in the monetary models of exchange rate determination. A theoretically grounded and properly measured indicator of money (the so-called Divisia monetary aggregate) is one such measure that can rightly trace the monetary transmission mechanism of these unconventional policy stances by the Central Banks.

Money overtime has been deemphasized from most of the macroeconomic models and especially from the monetary models of the exchange rate. In majority of exchange rate literature, interest rate alone plays the role of monetary policy instrument. Chrystal and McDonald (1995) claims that the breakdown of the monetary models of exchange rate is not surprising when viewed against the backdrop of the behavior of the monetary aggregate in some major countries like USA and UK. The velocity of M1, which had been stable since 1945, suddenly took a sharp downward trend after 1980 (Stone and Thronton, 1987). L&R agree with Chrystal and McDonald that traditionally stable money demand functions were widely perceived to have broken down. Reasons for the disappearance range from the declining correlations between conventional monetary measures and economic activity to the frustrating instability of empirical money demand specification. Accordingly majority of the model on recent exchange rate literature have deemphasized the role of money in monetary model of exchange rate determination; with interest rate (short-term rate/ immediate rates) playing indicator and or targets of the monetary policy.

In this paper we emphasize to bring monetary aggregate back into the system other than the interest rate. Why should we include 'money' in our model? The following contribution and relevant work attempts to justify our stand. Rotemberg and Woodford (1999) show that a Taylor (1993) rule is nearly optimal in the context of a standard New Keynesian model. Ireland (2001a, 2001b) finds empirical support for including money growth in the interest rule for policy. In Ireland's model, money ambiguously plays an informational rather than a causal role by helping to forecast future nominal interest rate. The realization of this neglect has revived attempts to assess the role of money in monetary policy making, by examining the "information content" of various monetary aggregates for predicting inflation (and output) over the alternate time horizons (Masuch et al.2003; Bruggean et al.2005 etc).[2]

Practical consideration also suggest including money in the Central Bank's policy rule. If the Central Bank does not have contemporaneous information on inflation and output, but it does have observation on the money stock, then money may help the Central Bank infer current values of the variable it cares about directly. Surprisingly, however, we find evidence of the central banks round the world, to increasingly relegate monetary aggregate to a secondary status as one of the several monetary policy indicators. At least a part of the reason for this apathy towards monetary aggregates stems from a conviction of their vanishing role in influencing the macroeconomy.

Goodfriend (1999) argues that money plays a critical role even under an interest rate policy because ``credibility for a price-path objective stems from a central bank's power to manage the stock of money, if need be, to enforce the objective.''. In equilibrium money is not playing a causal role, yet it is essential for establishing the credibility that allows the Central bank to determine expected inflation at every point in time. Goodfriend calls for the exploration of models in which "monetary aggregate plays a role in transmitting monetary policy independently of interest rate policy". Similar argument have been posited by the following authors Christiano et al. (2007); Cochrane (2007) that monetary aggregates may play a nominal anchor role, whereby the announcement of a reference trajectory for future monetary growth, help agents form expectations about future prices. In comparison to model without money and the models with some contemporaneous interactions between money and funds rate, L&R (2003) have found large and significant effects on the estimated real and nominal effects of policy. Hence

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[2] Nelson (2003) offers an alternative role of money. He posits that money demand depends on a long-term interest rate. This is because the long rates matter for aggregate demand and the inclusion of a long rate in money demand amplifies the effects of changes in the stock of money on real aggregate demand. Nelson's specification of the Fed's interest rate rule is a dynamic generalization of the conventional Taylor rule, which exclude money. Money now has a direct effect that is independent of the short-term interest rate, an effect that Nelson argues support U.S. data. Anderson and Kavajecz (1994) noted that monetary aggregates can largely play as an indicator and/or targets of the monetary policy. Also several recent studies, most notably Nicoletti-Altimari (2001), Trecoci and Vega (2002), Jansen (2004) and Assenmacher-Wesche and Gerlach (2006), etc. have found a useful leading indicator role for the monetary and credit aggregate with respect to the low-frequency trends in inflation.

money provides information important to identifying monetary policy-information that is not contained in the Federal fund rate.

Our novelty will also lie in introducing theoretically grounded, superlative measure of money i.e. Divisia monetary aggregate in the K&R setup. Divisia monetary aggregate are derived from the microeconomic aggregation theory, built upon the theory of superlative index number with Barnett (1980) and Diewert (1976) being the pioneers of this aggregate. Divisia aggregate measure the aggregate flow of the monetary services derived from a collection of assets that are imperfectly substitutable as compared to the simple sum aggregate that adopts the assumption that all monetary assets are perfectly substitutable, see Barnett (1980). There have been questions raised before whether or not Divisia indexes can be used to provide better out-of-sample forecast of inflation or economic activity. Schunk (2001) and Drake and Mills (2005) have tried to investigate the relative forecasting performance of Divisia and simple sum monetary aggregate in the U.S. Stock and Watson (1999) investigates a broader question of whether Divisia monetary aggregate has an edge over the simple sum measure in forecasting inflation. Chrystal and McDonald (1995) believe that in a period of rapid financial liberalization such data dynamics will not suffice to track the exchange rate when simple sum money is the preferred monetary measure. In particular, they find that for the sterling-dollar exchange rate the use of short run/long run modelling framework is capable of producing a sensible long-run equilibrium relationship and reasonable out-of-sample forecasts when Divisia money is used.[3] These result cast doubt on the adequacy of the conventional models that focus on interest rates alone. They also highlights that all monetary disturbance have an important "quantitative" component which is captured by movements in a properly measured monetary aggregate.

We believe that monetary aggregate when measured properly (especially Divisia aggregates) can contain important information about the monetary service flow, thereby, can play the role of an informational variable in the model. In order to add credence to our claim, we compare across models that contain no money (with interbank rates of interest being the only monetary policy variable), then we add simple-sum money in our model along with the policy rate variables and finally we add the superior monetary measure, called Divisia money. We extensively compare across these three sets of models. Furthermore we tried comparing across the monetary models at different levels of aggregation. There has been a dominant contribution in the exchange rate literature by K&R (2000) that has worked perfectly well with the industrialized economies i.e. G6 economies. The results have worked wonderfully well in terms of eliminating some of the most common anomalies, like liquidity puzzle, price puzzle, exchange rate puzzle and forward discount puzzle, which have plagued the empirical literature especially on exchange rate.

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[3]Belongia and Ireland (2012) mention that superlative (Divisia) measures of money often help in forecasting movements in the key macroeconomic variables and that the statistical fit of a structural vector auto regression deteriorates significantly if such measures of money are excluded when identifying monetary policy shocks.

Almost 15 years post publication of K&R; we want to revisit similar small open economy structural vector auto-regression (SVAR) model setting. However this time for an economy that is relatively open, one of the biggest importers of oil, on the transition path to becoming one of the emerging Asian economies, a member of the G20 nations, and of course governed by Central Bank that tries not to intervene heavily in the foreign exchange market. The country that we want to extensively study is India. Our model builds on the K&R model and is customized for the Indian economy. Our model better fits the Indian economy as it is able to identify the Indian monetary policy correctly wherein a monetary policy shock gives mostly puzzle- free results.

The paper tries to examine the impact of the monetary policy shocks on the price level, output, exchange rate and thereby explores if the monetary policy shocks have a delayed and gradual effect on the price levels, whether a shock to the policy have a small and temporary or a substantive and permanent effect on the output; if monetary policy serves to dampen output and price fluctuation for the Indian economy. Finally if there is existence of the delayed exchange rate overshooting contrary to the Dornbusch's overshooting, given a monetary policy impact. The interest rate equation in our model is interpreted as the policy reaction function of the Central bank with immediate rates: call money/interbank rate for India being the rate that we are using. The monetary aggregate equation is specified as the standard money demand equation, dependent upon output, price and interest rates.

The paper presents a table that extensively evaluates how the different model setups with no money, money at different levels of aggregation perform in terms of doing away with the puzzles. We have also done a variance decomposition analysis and try to see how much of the policy variable can explain the fluctuation in the exchange rate. For models with money, especially Divisia money, the policy variable can clearly explain more of the exchange rate fluctuation, as compared to the model with the simple-sum monetary aggregate and the no-money model. This makes us believe that money plays the role of the informational variable in terms of rightly capturing the flow of monetary variables and we believe that monetary aggregate increases the predictive content of the policy variables. We define a monetary aggregate to play an informational role if it facilitates the domestic interest rate to explain a significant part of the exchange rate fluctuation and causal role if the monetary aggregates by itself explain a significant part of the exchange rate fluctuation.

We further attempt an interesting analysis from our variance decomposition results, trying to figure out, how much of the fluctuations in the three fundamental variables in our model, output, prices and exchange rate are being explained by the policy variables; also how much these three fundamental variables are able to explain the movements in the policy rates. Finally, we try to test the out-of-sample forecasting power of the different model setup. We evaluate the models on the basis of the RMSE and Theil U. We will be alternatively using M1 and M3 as the simple-sum monetary aggregate in the money demand equation and thereby compare the result with their Divisia counterparts namely DL1, DM2 and DM3. Our result shows that the models with monetary aggregate do significantly better than the no-money models and furthermore we

observe that models with the correctly measured monetary aggregate to outperform their simple-sum counterpart.
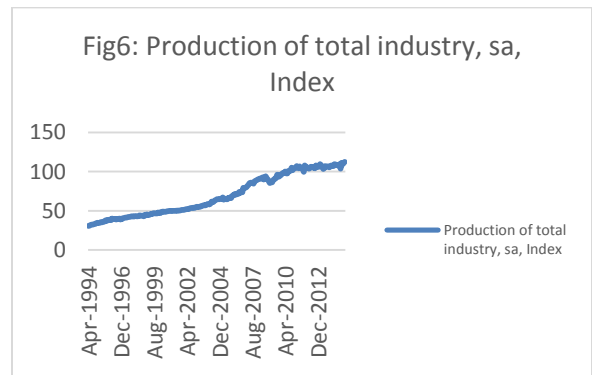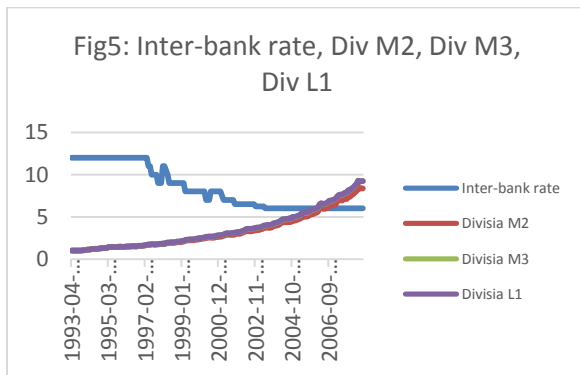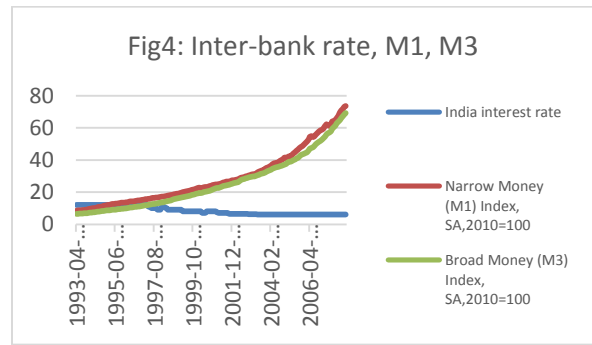
Section 2: The Indian economy at a glance

Fig1: Oil price index, World Commodity Price Index, CPI

Fig2: Nominal and Real Interbank rate

Fig3: Interrest-rate differential, Exchange rate

Fig4: Inter-bank rate, M1, M3

Fig5: Inter-bank rate, Div M2, Div M3, Div L1
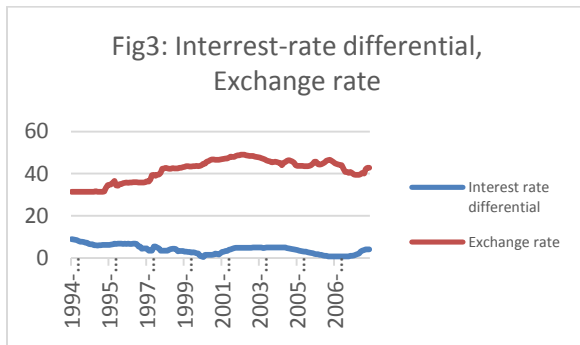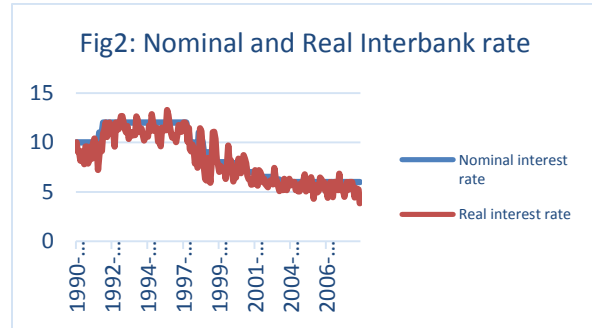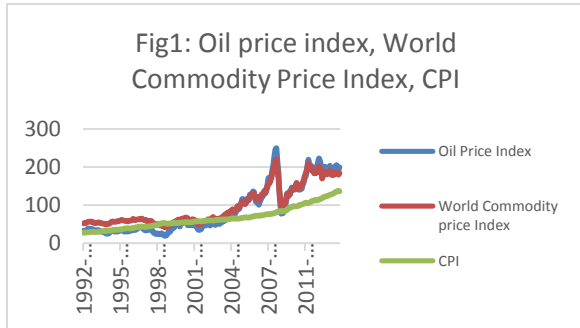

Fig6: Production of total industry, sa, Index

Fig1 shows the Indian economy experienced an overwhelmingly high inflation in the last 24 years or so- CPI between the first quarter of 1992 and the last quarter of 2013 rose by 384 percent. This would mean on an average there was 17 percent price rise (captured by the CPI) ever year during the time period. However between the period of first quarter of 1992 and first quarter of 2000, however, CPI rose by 89%, which would mean on an average there was a 9 percent price rise every year during the time period.

Fig2 shows that monetary stance began to loosen since early 1997- Loose monetary stance seemed to be one of the dominant features of the economy between 1992 and 1997. As shown in

the figure, the nominal and real interest rates were mostly double-digits prior to the first quarter of 1997, with a few exceptions of brief episodes of interest rates falling slightly short of 10 percent between 1990 and 1992.

Fig3 shows the interest rate differential between India and U.S. and a depreciation of the India rupee- The figure suggests that the movement of the nominal exchange rate seems to have followed the interest rate differential with a lag; with a mild depreciation following a decrease in the interest rate differential and vice versa.

Fig4 shows the accelerated growth in the money supply for both M1 and M3- During the same period of loosening of inter-bank rates, we observe that the seasonally adjusted, monthly M3 and M1, money index (2010=100) for India growing quite rapidly. We observe that the growth in the seasonally adjusted M3 index is even higher compared to M1 between the period of 1990 and 2008.

Fig5 tries to evaluate the liquidity base of the Indian economy using a theoretically grounded and superior measure of money called the Divisia monetary aggregates- We have used Divisia M2, Divisia M3 and Divisia L1 between the second quarter of 1993 and the second quarter of 2008. The Divisia M2, Divisia M3 and Divisia L1 started with an index value of 1 (re-based for the purpose of graph). Divisia reflects a great deal of liquidity injection into the economy but not as much as the simple-sum M1 and M3 monetary index.

Fig6 shows the index of industrial production for India. The period of highest industrial growth was observed between 2002 and 2007, after which it seems the growth stagnated.

Section 3: Estimation
Model

The system of equation representing dynamic structural models can be collected and written in the vector form as

$$B_0 y_t = k + B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_p y_{t-p} + u_t \tag{3.1}$$

Where y_t is an $n \times 1$ data vector, k is an $n \times 1$ data vector of constants and u_t is an $n \times 1$ structural disturbances vector. u_t is serially and mutually uncorrelated. p denotes the number of lags.

$$B_0 = \begin{bmatrix} 1 & -B_{12}^{(0)} & . & . & . & . & -B_{1n}^{(0)} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ -B_{n1}^{(0)} & -B_{n2}^{(0)} & . & . & . & . & 1 \end{bmatrix} \tag{3.2}$$

B_s is a $(n \times n)$ matrix whose row i, column j element is given by $B_{ij}^{(s)}$ for s =1, 2... p.

If each side of [3.1] is pre-multiplied by B_0^{-1}, the result is

$$y_t = c + \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + \cdots + \emptyset_p y_{t-p} + \epsilon_t \tag{3.3}$$

Where, $c = B_0^{-1}k$ $\hspace{4cm}$ (3.4)

$\hspace{1.5cm} \emptyset_s = B_0^{-1}B_s \quad ; \quad for\ s = 1,2,3 \ldots \ldots, p \hspace{2cm}$ (3.5)

$\hspace{1.5cm} \epsilon_t = B_0^{-1}u_t \hspace{6cm}$ (3.6)

Thus VAR can be viewed as the reduced form of a general dynamic structural model. The structural disturbance u_t and reduced form residuals ϵ_t are related by

$$u_t = B_0 \epsilon_t \tag{3.7}$$

To estimate the parameters from the structural form equations requires that the model be either exactly identified or over-identified. A necessary condition for exact identification is that there should be same number of parameters in B_0 and D (covariance matrix of the structural form, $Eu_t u_t' = D$) as there are in, Ω the covariance matrix from the reduced form, ϵ_t . In other words, it must be possible to recover the structural parameters from the reduced form model, which is known as the order condition. In addition the model should be able to satisfy the rank condition that is more difficult to verify. One of the older but still popular way of doing that is the Cholesky decomposition of reduced from innovations as suggested by Sims (1980). This imposes a recursive structure to identify the model. There are other methods like structural VAR which can be non-recursive with restrictions imposed on instantaneous relations between the variables coming from theory (see Bernanke,1986 for example).Letting Ω denote the variance-covariance matrix of ϵ_t , implies

$$\Omega = E(\epsilon_t \epsilon_t') = B_0^{-1}E(u_t u_t')(B_0^{-1})' = B_0^{-1}D(B_0^{-1})' \tag{3.8}$$

Since Ω symmetric, it has $n(n+1)/2$ parameters. It is standard in SVAR literature to have D as the diagonal matrix which requires n parameters. Hence B_0 can have no more than $n.(n-1)/2$ restrictions for exact identification. B_0 is a triangular matrix for the VAR with Cholesky

decomposition of the innovations which makes the economic interpretation of the model difficult.

For an exactly identified model, a simple two-step maximum likelihood estimation (MLE) procedure can be employed, assuming the structural errors are jointly normal. This is the full information maximum likelihood (FIML) estimator for the SVAR model. First, Ω is estimated as, $\qquad \hat{\Omega} = (1/T) \sum_{t=1}^{T} \hat{\epsilon}_t \, \hat{\epsilon}_t{}'$ $\qquad\qquad\qquad\qquad\qquad$ (3.9)

Estimates of B_0 and D are then obtained by maximizing the log likelihood for the system conditioned on $\hat{\Omega}$. When the model is over-identified, however, the two-step procedure is not the FIML estimator for the SVAR model. The estimates are consistent but not efficient, since they do not take the over-identification restrictions into account when estimating the reduced form. For an over-identified system, we estimate the VAR model without additional restrictions and the VAR model with additional restrictions to obtain 'unrestricted' and 'restricted' variance-covariance matrix, respectively, by maximizing the likelihood function. The difference in determinants of the restricted and unrestricted variance-covariance matrix will be distributed χ^2 with degrees of freedom equal to number of additional restrictions exceeding a just identified system. The χ^2 test statistic is used to test the restricted system.

Ideally, the restrictions imposed to identify a SVAR model would result from a fully specified macroeconomic model. In practice, however, this is rarely done. Instead, the more common approach is to impose a set of identification restrictions that are broadly consistent with the economic theories and provide sensible outcomes. Generally, the metric used is whether the behavior of the dynamic responses of the model accords with the economic theories. Given a set of variables of interest and criteria for model selection, identification restrictions can be imposed in a number of different ways. Most commonly, these involve restrictions on B_0 (the contemporaneous relationships between the variables in the system), $B_0{}^{-1}$ or the long run restrictions.

Identification

We have a 7-variable VAR[4] that includes the world oil price index/commodity price index (oilp/wpcom), federal fund rate (rfed), India index of industrial production (iip), the level of inflation in the domestic small open economy (π), domestic monetary aggregate, for example Divisia M2 (dm2), nominal short-term domestic interest rate (rdom) and nominal exchange rate, domestic currency per USD (er). Our identification scheme based on equation (3.7) is given below.

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[4] It is shown that differencing of variables do not provide gain in asymptotic efficiency of the model and may throw away information regarding the co-movements in the data like cointegrating relationship between the variables in a VAR. Hence, we have a VAR in levels.

$$
\begin{pmatrix} u_t^{oil\ or\ wcom} \\ u_t^{rfed} \\ u_t^{iip} \\ u_t^{\pi} \\ u_t^{MD} \\ u_t^{MP} \\ u_t^{ER} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b21 & 1 & 0 & 0 & 0 & 0 & 0 \\ b31 & b32 & 1 & 0 & 0 & 0 & 0 \\ b41 & 0 & b43 & 1 & 0 & 0 & 0 \\ 0 & b52 & b53 & b54 & 1 & b56 & b57 \\ b61 & 0 & 0 & 0 & b65 & 1 & b67 \\ b71 & b72 & b73 & b74 & b75 & b76 & 1 \end{pmatrix} \begin{pmatrix} \epsilon_t^{oil\ or\ wcom} \\ \epsilon_t^{rfed} \\ \epsilon_t^{iip} \\ \epsilon_t^{\pi} \\ \epsilon_t^{MD} \\ \epsilon_t^{MP} \\ \epsilon_t^{ER} \end{pmatrix} \qquad (3.10)
$$

u is the vector of structural innovations and ϵ is the vector of errors from the reduced form equations where the vector is given by (world price of oil/world price of commodities shocks, Fed funds rate shocks, iip shocks, inflation shocks, money demand shocks, monetary policy shocks, and exchange rate shocks). This is very similar to K&R but modified to fit the Indian economy better and render rigorous comparisons of different monetary aggregates in the Indian context. Generally, restrictions on B_0 are motivated in the following way. As K&R, we have a "contemporaneously" exogenous world shock variable (which we have alternatively captured using the world commodity price index and world price index). Although none of the domestic variables can affect the world variables contemporaneously, but it can do so over the time. Similarly, Fed fund rate, the short term interest rate of the U.S. in the small open economy framework is only affected by the world event shocks. No domestic events have enough firepower to influence the policy variables of the largest economy in the world. It is necessary to include these two variables to isolate and control the exogenous component of monetary policy shocks (K&R, 2000). A further type of behavioral restriction often imposed is that certain variables respond slowly to movements in financial and policy variables. So, for example, output and prices do not respond contemporaneously to changes in domestic monetary policy variables and exchange rates. Real activity like the industrial production responds to domestic price and financial signals (interest rate and exchange rate) with a lag; due to the presence of high adjustment costs to production. However, the industrial production of the small, open, economy is deeply impacted by the world or outside shocks. Inflation is affected by the world shock (world commodity price shock / oil price shock) and the current state of industrial production. People's willingness to hold cash given by the standard money demand function usually depends on real income (industrial production adjusted of the cpi inflation) and the domestic interest rate, As we want to explore how different monetary aggregates compare in identifying the monetary policy for a small open economy like India and how they contribute to explaining the exchange rate movements, it is crucial to assume that in addition to the real income and the domestic interest rate, the money demand function also depends on the foreign (US) interest rate and the prevailing exchange rates. For an open economy, domestic investor definitely pays heed to the foreign interest rates and the exchange rates in deciding how much currency to hold. Monetary policy equation is assumed to be the reaction function of the monetary authority, which sets the interest rate after observing the current value of money supply, the interest rate and the exchange

rate. We believe that the monetary authorities cannot ignore the exchange rate movements; this follows from the small open economy assumption. Also when the monetary authorities sets its interest rate, we assume that it keeps an eye on the outside shocks (world commodity price shock / oil price shock) which have serious repercussion on the small open economy. Finally, we have the nominal exchange rate variable in the model. Exchange rate is one of the most volatile variables in the model and is quick to react to almost all shocks be it from inside or outside, be it nominal or real variable shock.

The data are in monthly frequency for the sample period January 2000- January 2008. The sample period for India, we choose is more appropriate because of the structural changes, in particular financial market deregulation that occurred post-1990s. Also the way, the Central bank of India set their policy rates have underwent massive transformation post-2000. The foreign variables crude oil (petroleum), price index, is simple average of three spot prices; Brent, West Texas Intermediate and Dubai Fateh, obtained from the database of Index Mundi; all commodity price index, fuel and non-fuel, data source IMF commodities is obtained Econ stats website. The Indian variables: index on the production of total industry as a proxy for the real GDP; consumer price index; immediate interest rate (call money\interbank rate); simple-sum monetary aggregate index (M1) and (M3)[5]; nominal exchange rate (Indian rupee per USD), and the US Federal funds rate are obtained from the OECD database. Divisia monetary aggregate (DM2), (DM3), (DL1), are obtained from Ramachandran, Das and Bhoi, 2010. All the series are seasonally adjusted by the official sources except the Indian Divisia, world oil prices and world price of commodities which are seasonally adjusted using frequency domain deseasonalization in RATS (see Doan 2013). All variables are in logarithms except the interest rates. Inflation (π) is calculated as the annual change in log of consumer prices. Monthly VAR is estimated using 6 lags. The lags are selected by sequential likelihood ratio test in RATS (see Doan 2013). The results from sequential likelihood ratio test is presented in table A in the appendix.

In this estimation section, we have 4 subsections, Subsection 3.1 we have done impulse response analysis, Subsection 3.2 is presented with the variance decomposition analysis, a flip-flop analysis is shown in the Subsection 3.3 and we have the out-of-sample forecasting in Subsection 3.4 Finally we conclude in section 5.

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[5] Measures of monetary aggregates: M2 = currency with the public + demand deposits with banks + other deposits with the RBI + time liability proportion of the savings deposits with banks + term deposits with the contractual maturity of up to and including one year with banks + certificate of deposits issued by banks. M3 = M2 + term deposits with the contractual maturity of over one year with banks + call borrowings from non-depository financial corporations by banks. L1 = M3 + all deposits with the Post Office Savings Banks (excluding National Savings Certificates)

Subsection 3.1: Impulse Response Analysis

We evaluate the following model setups given in Table 1 in terms of the 4 prevalent puzzle that have plagued the empirical exchange rate literature, namely, liquidity puzzle, price puzzle, exchange rate puzzle and forward discount bias puzzle. In this section we also offer three impulse response graphs, one for the recursive model with no money (Model 16), the SVAR model with simple-sum M3 (Model 2) and Divisia M3 (Model 1). [6]

Table 1[7]		
SVAR Model [Non-Recursive (NR) Structure]		
Model 1	{oilp, rfed, iip, pi, dm3, rdom, er}	(NR, OIL, DM3)
Model 2	{oilp, rfed, iip, pi, m3, rdom, er}	(NR, OIL, M3)
Model 3	{oilp, rfed, iip, pi, m1, rdom, er}	(NR, OIL, M1)
Model 4	{oilp, rfed, iip, pi, dl1, rdom, er}	(NR, OIL, DL1)
Model 5	{oilp, rfed, iip, pi, dm2, rdom, er}	(NR, OIL, DM2)
Model 6	{wcom, rfed, iip, pi, dm3, rdom, er}	(NR, COM, DM3)
Model 7	{wcom, rfed, iip, pi, m3, rdom, er}	(NR, COM, M3)
Model 8	{wcom, rfed, iip, pi, m1, rdom, er}	(NR, COM, M1)
Model 9	{wcom, rfed, iip, pi, dl1, rdom, er}	(NR, COM, DL1)
Model 10	{wcom, rfed, iip, pi, dm2, rdom, er}	(NR,COM,DM2)
VAR Models with Cholesky Decomposition [Recursive (R) Structure]		
Model 11	{oilp, rfed, iip, pi, dm3, rdom, er}	(R, OIL, DM3)
Model 12	{oilp, rfed, iip, pi, m3, rdom, er}	(R, OIL, M3)
Model 13	{oilp, rfed, iip, pi, m1, rdom, er}	(R, OIL, M1)
Model 14	{oilp, rfed, iip, pi, dl1, rdom, er}	(R, OIL, DL1)
Model 15	{oilp, rfed, iip, pi, dm2, rdom, er}	(R, OIL, DM2)
Model 16	{oilp, rfed, iip, pi, rdom, er}	(R,OIL, X)

We now briefly define the four notorious puzzles that have been widely prevalent in the exchange rate literature. Theory predicts that an increase in the domestic interest rates should lead to on impact appreciation of the exchange rate (exchange rate overshooting) and thereafter depreciation of the currency in line with the uncovered interest parity. Higher return on investments due to increase in interest rates in the domestic economy leads to a higher demand for domestic currency, appreciating the domestic currency vis-à-vis the foreign currency. The exchange rate puzzle occurs when a restrictive domestic monetary policy leads to on impact depreciation of domestic currency. Or, if it appreciates, it does so for a prolonged period of time violating the uncovered interest parity condition which is known as the forward discount bias puzzle or delayed overshooting.

[6] The result of other models can be made available on request.

[7] The code in the parenthesis represents the model structure (Non-Recursive or Recursive), the world variable (World price of OIL or World COMmodity price) and monetary aggregate (DM3,M3,M1,DL1,DM2,X i.e. no money).

The liquidity puzzle is an empirical finding when a money market shock is associated with increases in the interest rate instead of a decrease. This is the absence of the liquidity effect (negative correlation between monetary aggregates and interest rates) in the system. "Price puzzle" is a phenomenon where a contractionary monetary policy shocks identified with an increase in interest rates, leads to a persistent rise in price level instead of a reduction of it. Table 2 summarizes the main results that we obtain from models with Cholesky ordering and the SVAR models.

Table 2				
Model & Code	Liquidity Puzzle	Price Puzzle	Exchange Rate Puzzle	Forward Discount Bias Puzzle
1 (NR,OIL,DM3)	Slight to none	None	None	None
2 (NR,OIL,M3)	Insignificant	None	Slight to None	None
3 (NR,OIL,M1)	Yes	Yes	None	None
4 (NR,OIL,DL1)	Slight to none	None	None	None
5 (NR,OIL,DM2)	Slight to none	None	None	None
6(NR,COM,DM3)	Slight to none	Slight to none	None	None
7 (NR,COM,M3)	Insignificant	Insignificant	None	None
8 (NR,COM,M1)	Insignificant	None	None	None
9 (NR,COM,DL1)	Insignificant	Insignificant	None	None
10(NR,COM,DM2)	Insignificant	None	None	None
11 (R,OIL,DM3)	Yes	Yes	Slight to None	Yes
12 (R,OIL,M3)	Insignificant	Yes	Yes	Yes
13 (R,OIL,M1)	None	Yes	Yes	Yes
14 (R,OIL,DL1)	Yes	Yes	Slight to None	Yes
15 (R,OIL,DM2)	Yes	Yes	Slight to None	Yes
16 (R,OIL,X)	Yes	Yes	Yes	Yes

We encounter almost all the puzzles in the recursive models (model 11-16). Figure 7 below gives the impulse response graphs for a recursive model with no money. In the graphs below the effect of monetary policy shock is normalized so that interest rates increase by one percentage point in the first month and a decrease in exchange rate implies appreciation. A one percentage point increase in the interest rate leads to on impact depreciation of the currency and persistent depreciation thereafter (exchange rate puzzle and forward discount bias puzzle). There is also a persistent rise in inflation (price puzzle) from a contractionary monetary policy shocks.

Figure 7

Impulse Responses for Monetary Policy Shock (Recursive Model)
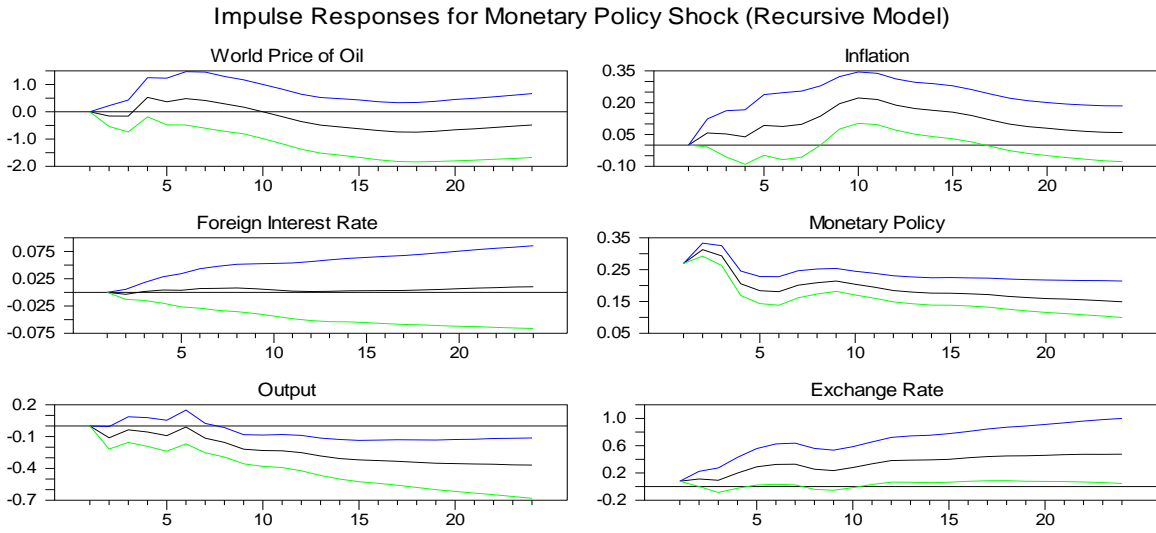
This motivates us towards our preferred SVAR (non-recursive) models which identifies the Indian monetary policy correctly. Most of the puzzles are eliminated and the results are robust. We see the intensity of liquidity effect and exchange rate overshooting is more pronounced (significant) for the model with Divisia M3 as compared to the simple sum M3.

Figure 8
Impulse Responses for Monetary Policy Shocks (Non-Recursive Model)

Model with Divisia M3 (Model1)   Model with M3 (Model 2)
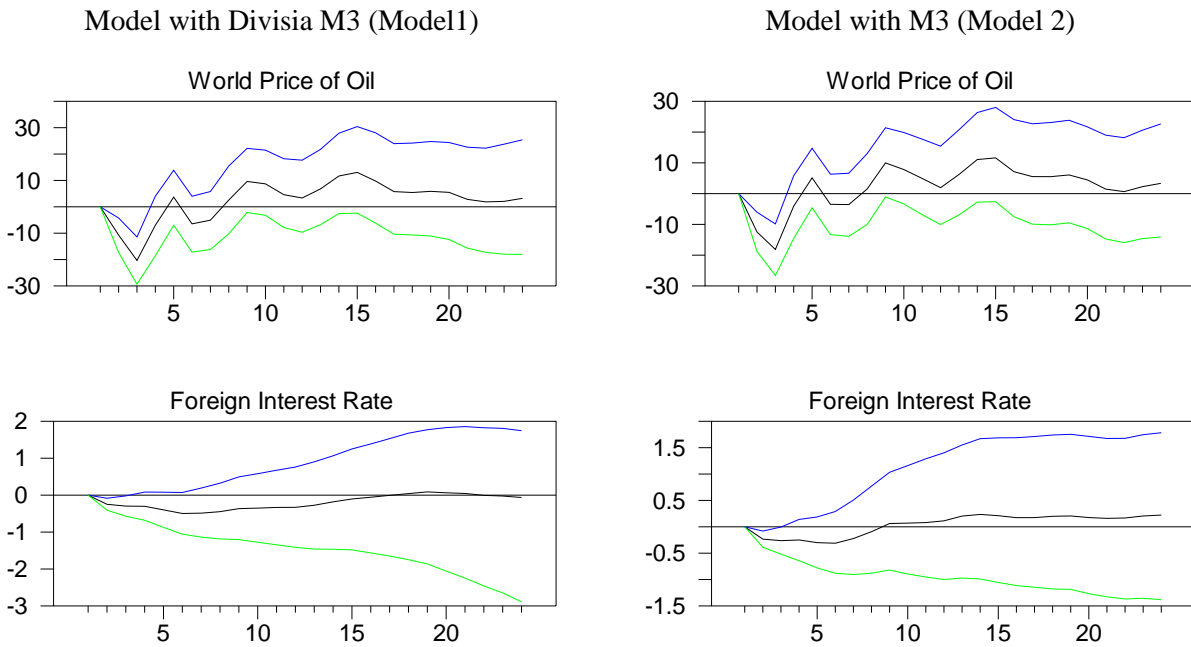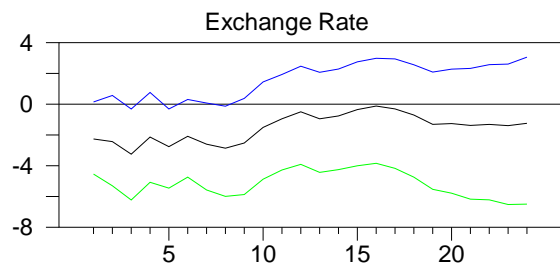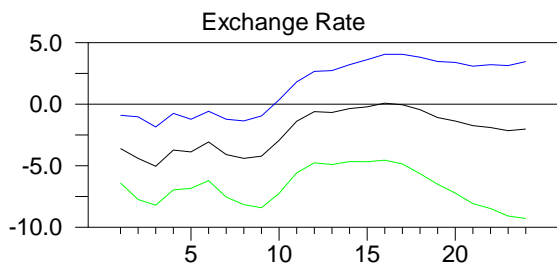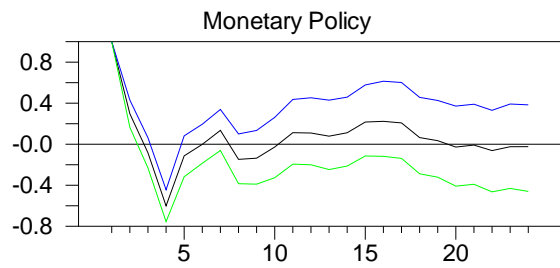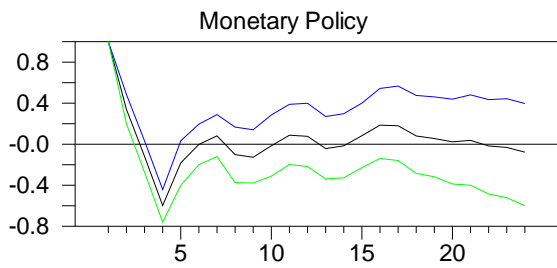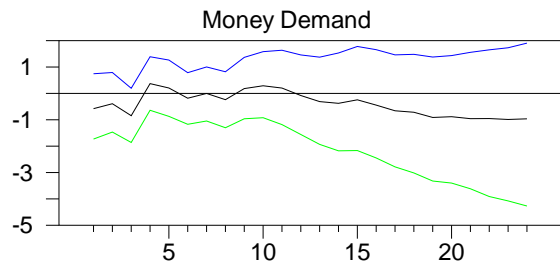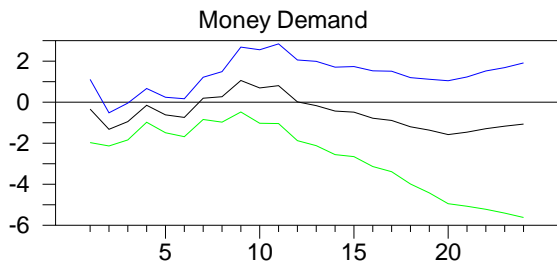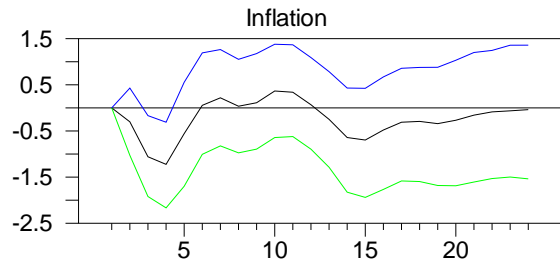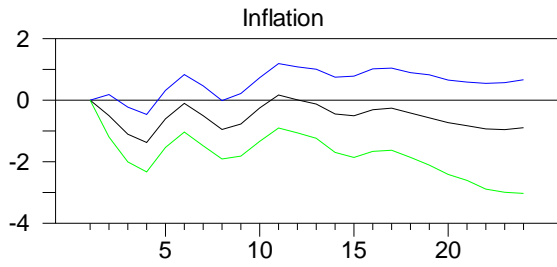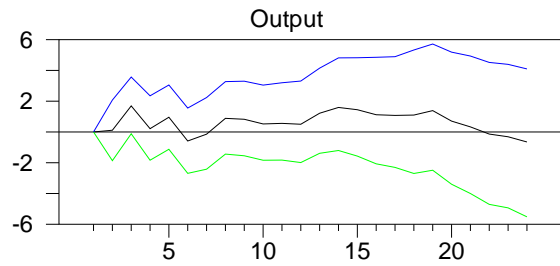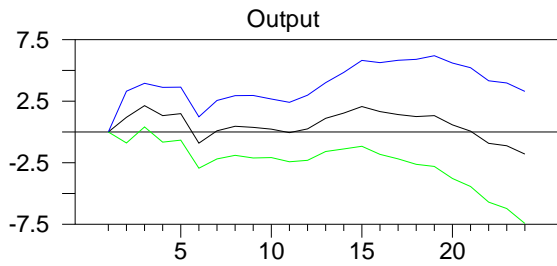
The statistical significance of impulse responses are examined using the Bayesian Monte Carlo integration in RATS. Random Walk Metropolis Hastings method is used to draw 10000 replications for the over-identified SVAR model. The 0.16 and 0.84 fractiles corresponds to the upper and lower dashed lines of the probability bands (see Doan, 2013).

From model 1, we observe, monetary policy shock has no initial impact on oil price. However overtime, we observe a growth in the oil price especially between 10th and 15th month. The fact that such giant oil-importing countries like India are able to influence price is certainly not surprising. Policy shock hardly affects the fed fund rate on impact and overtime. This follows from the small country assumption. Monetary policy shock seems to have a short-lasting impact on the industrial production. We observe a hump-response of the industrial production in the first 5 months to a monetary policy shock. This probably makes us think that since the financial market is still not developed, the monetary transmission of financial signals into the real sectors of the economy takes some time to kick in. Also notice that India is large economy with missing middle, in the sense that the Indian economy directly leapfrogged from the agriculture to service sector, bypassing the manufacturing or the industrial sector in the middle. Accordingly, the immune response or the delayed response of the industrial production to a monetary policy shock is not surprising. The contraction in monetary policy seems to keep the growth in prices or inflation consistently below the zero level. Contractionary monetary policy shock seems to have no response on the money demand. We observe exchange rate overshooting in response to a monetary policy shock. The exchange rate appreciates on impact, before it starts to depreciate.

In the model 2, we observe, contractionary monetary policy shock seems to show a slight increasing trend in the oil prices with effects peaking up on the 10th and 15th month respectively. Monetary policy shock seems to have a slight to no-impact on the fed fund rate in the first 8 months or so and thereby the fund rate increases. However response of the fed fund rate to domestic policy shock is insignificant. The response of industrial production to a monetary policy shock is also insignificant. It stays irresponsive to such shock and instead of showing any decline in its trajectory, stays above the positive axis. Price growth measured using the CPI for India, stays negative on the initial impact of the shock. However between the 6th and the 12th month, we observe a positive price growth. This leads us to believe that the impact of the policy shock is kind of short-lived. The money demand, measured using the simple-sum, exhibits a mild growth with effect peaking up between 10th and 14th month, on the impact of the monetary policy shock. Exchange rate appreciates on the impact of a monetary policy shock. However, there is delayed overshooting in this setup

Hence we observe that SVAR models generally doing way better than the recursive models and models with the Divisia monetary aggregates are doing better than simple-sum monetary aggregate. We compare across Divisia M3 and Simple-sum M3 with models including world price of oil and world price of commodities alternatively. The Divisia did better than the simple-sum counterpart. This holds true for other available Indian Divisia aggregates (Divisa L1, Divisia M2 etc) as well. Out of all the four notorious puzzles, resolving at least the price puzzle and exchange rate puzzle is the bare minimum, according to Brischetto and Voss (2004). Our model

is able to do eliminate these puzzles. And clearly from the impulse response diagrams we observe SVAR model with Divisia does much better.

The results we have found are robust to different number of lags and different variables eg. consumer price index and wholesale price index for prices; index of total industrial production and industrial production for output; different measures of money as the monetary aggregate; world price of commodities or world price of oil as the world variable. The results also remain robust to different ordering of variables and to different samples or sub-periods

Subsection 3.2: Variance Decomposition

In this section we offer the variance decomposition for some selected models in Table 3.[8] The table represents model 1 and model 2 where we compare across monetary aggregate M3 and Divisia M3 (DM3) with world oil price as the (contemporaneously) exogenous world variable. In model 6 and model 7 we compare across the same set of monetary aggregates, however, with the world price of commodities as the (contemporaneously) exogenous world variable.

Table 3							
Forecast Error Decomposition: Contribution of Monetary Policy Shocks to Exchange Rate Variation (in percentages)							
Month	Model 1	Model 2	Model 4	Model 5	Model 6	Model 7	Model 10
1	15.97	5.71	17.31	23.97	21.09	8.03	28.42
2	17.10	5.45	18.46	25.17	22.70	7.75	29.89
3	19.67	7.51	20.89	28.29	25.43	10.10	33.09
10	14.95	6.79	15.67	17.92	21.26	7.97	25.16
11	14.35	6.32	15.05	17.13	20.13	7.47	24.01
12	13.95	5.94	14.62	16.55	18.95	7.09	22.67
22	10.99	4.64	11.38	13.18	14.33	4.88	17.97
23	10.38	4.60	10.71	12.39	13.90	4.67	17.47
24	9.77	4.58	10.07	11.59	13.54	4.47	17.05

Interbank rate of interest is the monetary policy variable and DM3 in model 1 acts as an informational variable (thereby rightly capturing the information about the flow of monetary services in the economy) in helping interest rate explain about 15.97% of the exchange rate fluctuation in the 1st month which improves to 19.67% in the 3rd month following the monetary policy shock. Even after 10 months following the shock, policy variable can explain almost 15% of the exchange rate fluctuation. Interestingly, 10% of the exchange rate fluctuation is still explained by the interest rate, 24 months after the monetary policy shock hit the system. From the variance decomposition analysis we believe that monetary aggregate especially Divisia money mostly play the role of an information variable thereby facilitating policy rate to explain

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[8] The result for other models are made available on request.

higher percentage of the exchange rate fluctuation than the role of causal variable i.e. explaining by itself a significant part of the exchange rate fluctuation on impact and thereafter.

Model 2 has the world oil price as the exogenous world variable and the Simple-sum M3 (M3) as the monetary aggregate, other than the monetary policy variable which is the interbank rate of interest. M3 in this setup helps interest rate just explain about 5.71% of the exchange rate fluctuation in the 1st month which improves to 7.51% in the 3rd month following the monetary policy shock. After 10 months following the shock, policy variable can explain about 6.79% of the exchange rate fluctuation. About 5% of the exchange rate fluctuation is explained by the interest rate, 24 months after the monetary policy shock hit the system. From the variance decomposition analysis we believe that the simple-sum M3 monetary aggregate when replaces the Divisia monetary aggregate DM3, fails to rightly feed-in the information on the flow of the monetary service into the system. Accordingly, we observe that the explanatory power of the policy variable gets drastically lowered in explaining the exchange rate fluctuation.

 Model 6 has the world commodity price as the exogenous variable and the Divisia M3 (DM3) as the monetary aggregate, other than the monetary policy variable which is the interbank rate of interest. DM3 in this setup acts as an informational variable (thereby rightly capturing the information about the flow of monetary service in the economy) in helping interest rate explain about 21.09% of the exchange rate fluctuation in the 1st month which improves to 25.43% in the 3rd month following the monetary policy shock. Even after 10 months following the shock, policy variable can explain almost 21.26% of the exchange rate fluctuation. Interestingly, 13.54% of the exchange rate fluctuation is still explained by the interest rate, 24 months after the monetary policy shock hit the system. From the variance decomposition analysis we believe that monetary aggregate especially Divisia money mostly play the role of an information variable thereby facilitating policy rate to explain higher percentage of the exchange rate fluctuation than the role of causal variable i.e. explaining by itself a significant part of the exchange rate fluctuation on impact and thereafter. We believe the current setup where we have the world commodity price instead of the world oil price, does better in the sense that monetary policy can explain higher percentage of the exchange rate fluctuation (compare setup 1 and setup 6)

We have the world commodity price as the exogenous variable in model 7and the Simple-sum M3 (M3) as the monetary aggregate, other than the monetary policy variable which is the interbank rate of interest. M3 in this setup helps interest rate just explain about 8.03% of the exchange rate fluctuation in the 1st month which improves to 10.10% in the 3rd month following the monetary policy shock. After 10 months following the shock, policy variable can explain about 8% of the exchange rate fluctuation. About 5% of the exchange rate fluctuation is explained by the interest rate, 24 months after the monetary policy shock hit the system. From the variance decomposition analysis we believe that the simple-sum M3 monetary aggregate when replaces the Divisia monetary aggregate DM3, fails to rightly feed-in the information on the flow of the monetary service into the system. Accordingly, we observe that the explanatory power of the policy variable gets drastically lowered in explaining the exchange rate fluctuation.

We have model 10 the world commodity price as the exogenous variable and the Divisia M2 (DM2) as the monetary aggregate, other than the monetary policy variable which is the interbank rate of interest. DM2 in this setup acts as an informational variable (thereby rightly capturing the information about the flow of monetary service in the economy) in helping interest rate explain about 28.42% of the exchange rate fluctuation in the 1st month which improves to 33.09% in the 3rd month following the monetary policy shock. Even after 10 months following the shock, policy variable can explain almost 25.16% of the exchange rate fluctuation. Interestingly, 17.05% of the exchange rate fluctuation is still explained by the interest rate, 24 months after the monetary policy shock hit the system. From the variance decomposition analysis we believe that monetary aggregate especially Divisia money mostly play the role of an information variable thereby facilitating policy rate to explain higher percentage of the exchange rate fluctuation than the role of causal variable i.e. explaining by itself a significant part of the exchange rate fluctuation on impact and thereafter. However if are to compare between the Divisia aggregates at the different levels of aggregation, we believe that DM2 works the best, followed by DL1 and DM3.

Hence, out of all the setup that tries to evaluate the role of the monetary policy shock in explaining the exchange rate movement, we find that setup with the world commodity price and the Divisia M2 works the best. (See -model 10).Out of all the Divisia aggregate that we have analyzed, DM2 consistently works the best followed by DL1 and finally DM3 in different models (compare between model 1, model 4, model 5 and between model 6, model 9, model 10). Between the simple-sum monetary measure M3 and M1, we found the narrower monetary aggregate consistently worked the best at different exogenous setup including the world oil price and the world commodity price (compare between model 2, model 3 and between model 7, model 8). Also we have compared across the monetary aggregate M3, using simple sum measure and Divisia measure. Our analysis shows that Divisia M3 consistently helps monetary policy better explain fluctuation in the exchange rate (compare between model 1 and model 2 and between model 6 and model 7)

Subsection 3.3: Flip-flop analysis

In this section we try to do the flip-flop analysis where we have couple of figures, figure 9 represents the fluctuation in the fundamental variables (exchange rate, inflation and economic activity) that are being explained by the policy variable. On the other hand, figure 10, we represent how much of the same fundamental variables are able to explain the movement in the policy variable. We have analyzed the first 10 models. However for convenience we represent model 5.[9]

In Figure 9, in the order of importance, monetary policy shock is able to explain 25-30% of the fluctuation in the exchange rate in the first 6 months, which drops down to 25-15% between the

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[9] The result for other models are made available on request.

6th and 18th month. Monetary policy shock explains 5-10% of the prices fluctuation throughout most part of the trajectory. On the other hand, the monetary policy shock is unable to explain much of the fluctuation in the real variables like industrial production that represents the GDP (less than 5%). The reason behind the weak monetary transmission mechanism is underdeveloped financial sector.
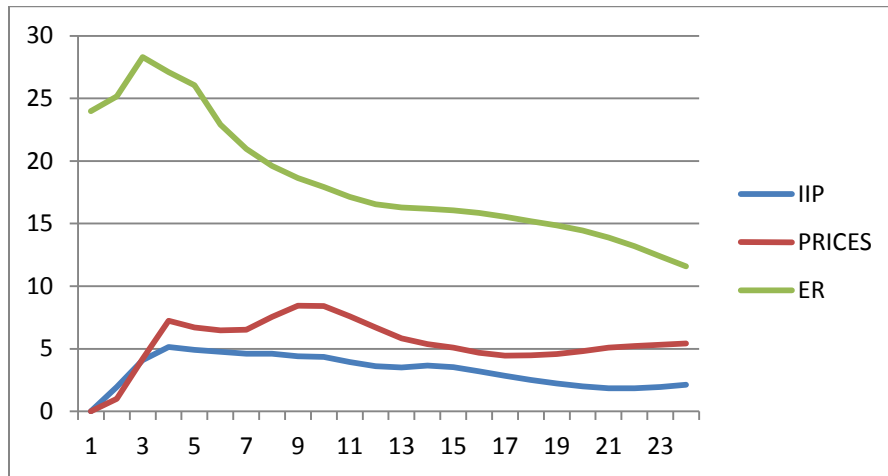
Figure 9

Figure 10
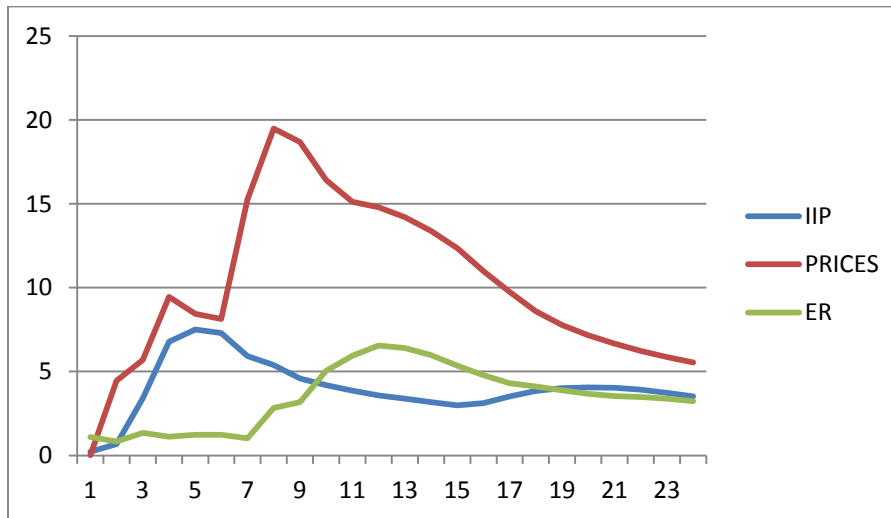
According to Figure 10, in the order of importance, central bank in India seems to set the monetary policy rule with inflation-targeting in mind. In fact, as close to 20% of the fluctuation in the monetary policy variable is being explained by the inflation on the 8th month following the shock. For the GDP and NER, their order of importance in explaining policy variable fluctuation gets switched over. For example, for the first 10 months, GDP explains more of the fluctuation in the policy variable, however, for the next 8 months, NER explains more of it. In fact, both the variables can account for 3%-7% of the fluctuation in the interest rate.

In general, we observe there is a weak link between the nominal-policy variable and the real-economic activity and Indian monetary authority had inflation-targeting as one of their primary goals, in tune with the RBI Act. These two main results are robust, holding across different time period, dissimilar monetary aggregates and diverse exogenous model setups.

Subsection 3.4: Forecast statistics for Exchange Rate

In this section we try to compare different VAR models in terms of its ability to perform out-of-sample forecasts of exchange rates. The forecast performance of a model is assessed in terms of criteria which are based on forecast errors. The criteria used are Root Mean Square Error (RMSE) and Theil U. We calculate "out-of-sample" forecasts with in the data range using Kalman filter to estimate the model using only the data up to the starting period of each set of forecasts. Please note that our purpose in this section is not to fit the best forecasting model but to see how the forecasting performance of the model changes when we add money to the system and when we add different types of money. The choice of the sample is driven by the availability of the Indian Divisia data which ends at 2008:6. Obviously we need the actual data to compare the forecast performance. Hence we estimate the model through 2006:6 and do updates for the period 2006:7 to 2008:6 (24 steps) using Kalman filter. Forecast performance statistics (RMSE and Theil U) is compiled over that period and are given by the following formulas,

$$e_{it} = y_t - \hat{y}_{it} \tag{3.11}$$

Where $\hat{y}_{it}$ is the forecast at step t from the ith call and y_t is the actual value of the dependent variable. Let N_t be the number of times that a forecast has been computed for horizon t, i = $1, 2, \ldots \ldots N_t$.

Root Mean Square Error: $RMSE_t = \sqrt{\sum_{i=1}^{N_t} e_{it}^2 \Big/ N_t}$ (3.12)

RMSE of no-change forecasts: $RMSENCF_t = \sqrt{\sum_{i=1}^{N_t} (y_{it} - y_{i0})^2 \Big/ N_t}$ (3.13)

Where y_{i0} is the "naïve" or flat forecast---simply the value of the dependent variable at the period (start-1) for the ith call. Hence,

Theil U : $U_t = {RMSE_t}\Big/{RMSENCF_t}$ (3.14)

Theil's U (see Doan, 2013). is a unit free measurement used for comparing forecasting models. A value less than one (but not substantially less than one) indicates that we have a good forecasting model. Table 4 evaluates between the model with simple-sum M3 and Divisia M3, in

terms of the RMSE and Theil U statistics. We measure the 24- step ahead forecasts. Model with Divisia M3 records a lower RMSE and Theil U values, when compared with the model with simple-sum M3. The difference between the RMSE and Theil U also grows over time. This might be due because Divisia M3 facilitates longer-horizon forecasting.

	Table 4			
STEP	**RMSE (DM3)**	**RMSE (M3)**	**Theil U (DM3)**	**Theil U (M3)**
1	0.016817	0.016819	0.940706	0.940740
2	0.027940	0.027943	0.946547	0.946622
3	0.035328	0.035330	0.946943	0.947016
4	0.045093	0.045097	0.971017	0.971109
5	0.053015	0.053020	0.981338	0.981432
6	0.061130	0.061135	0.989332	0.989414
7	0.071596	0.071602	1.007960	1.008038
8	0.081620	0.081626	1.020525	1.020593
9	0.090237	0.090241	1.019690	1.019732
10	0.101070	0.101075	1.030261	1.030309
11	0.109619	0.109626	1.037362	1.037427
12	0.115920	0.115927	1.045357	1.045426
13	0.122422	0.122431	1.052918	1.052997
14	0.125861	0.125869	1.052831	1.052895
15	0.131126	0.131134	1.054369	1.054438
16	0.135009	0.135019	1.054615	1.054697
17	0.135963	0.135975	1.055324	1.055420
18	0.136028	0.136042	1.056076	1.056186
19	0.134683	0.134699	1.057102	1.057227
20	0.130837	0.130855	1.060035	1.060179
21	0.125023	0.125042	1.065176	1.065339
22	0.118077	0.118097	1.074508	1.074691
23	0.094337	0.094358	1.104058	1.104303
24	0.082902	0.082923	1.137938	1.138229

After analyzing both RMSE and Theil's U, we conclude two things: first, exchange rate forecasting model with money vis-à-vis no money does better and second, and exchange rate forecasting model with Divisia money vis-à-vis simple sum money does even better.

Our basic interest is to compare across the **models** with **no money** and **money** and of course between the **models** with **simple-sum monetary aggregate** and **Divisia monetary aggregate**. Our secondary set of interest is to compare across the simple-sum and Divisia monetary aggregate across different levels of aggregation. The simple-sum monetary aggregates that we

have are **M1, M3** and the Divisia monetary aggregates that we have used in our model are **DM2, DM3, and DL1**.

The forecast graphs (figures 11 and 12) are obtained through Gibbs Sampling on a Bayesian VAR with a "Minnesota" prior. The sequential likelihood ratio test selects 13 lags for the model for the given period. We hold back a part of the data to use for evaluating forecast performance. The graph forecasts 24 steps ahead with a +/- two standard error band using 2500 draws. The out of the sample simulations accounts for all uncertainty in forecasts: both the uncertainty regarding the coefficients (handled by Gibbs sampling) and the shocks during the forecast period (see Doan, 2012)

Figure 11

LER Forecast Comparison: Model without Money and Model with Divisia M3
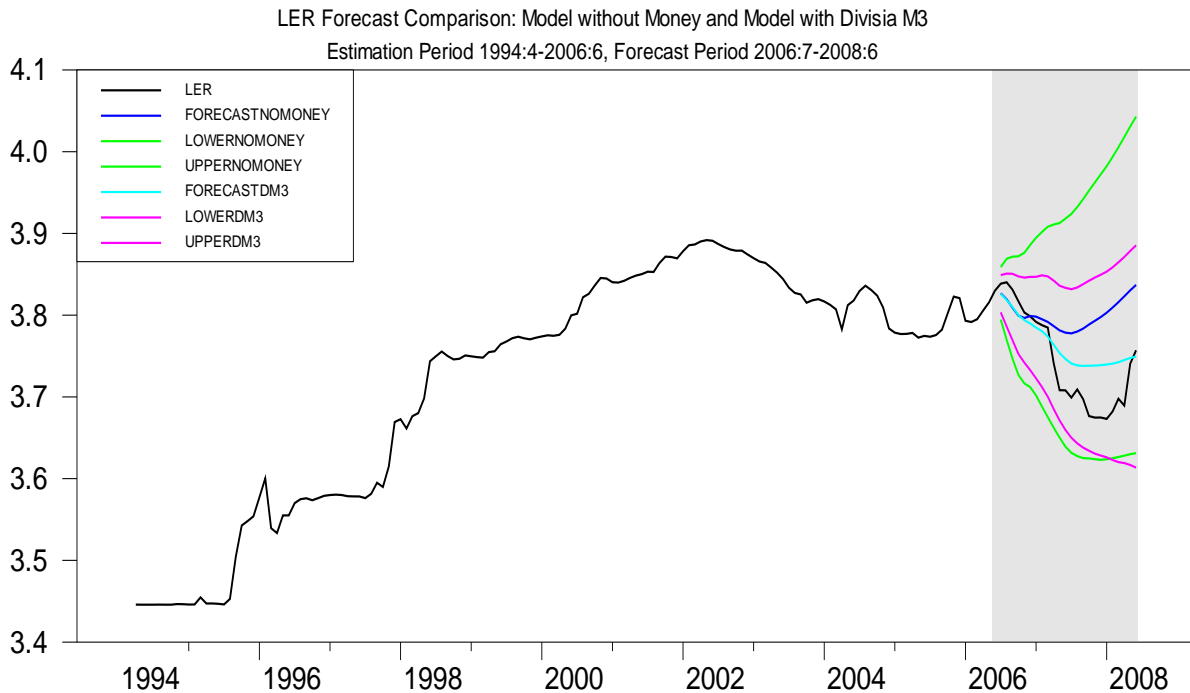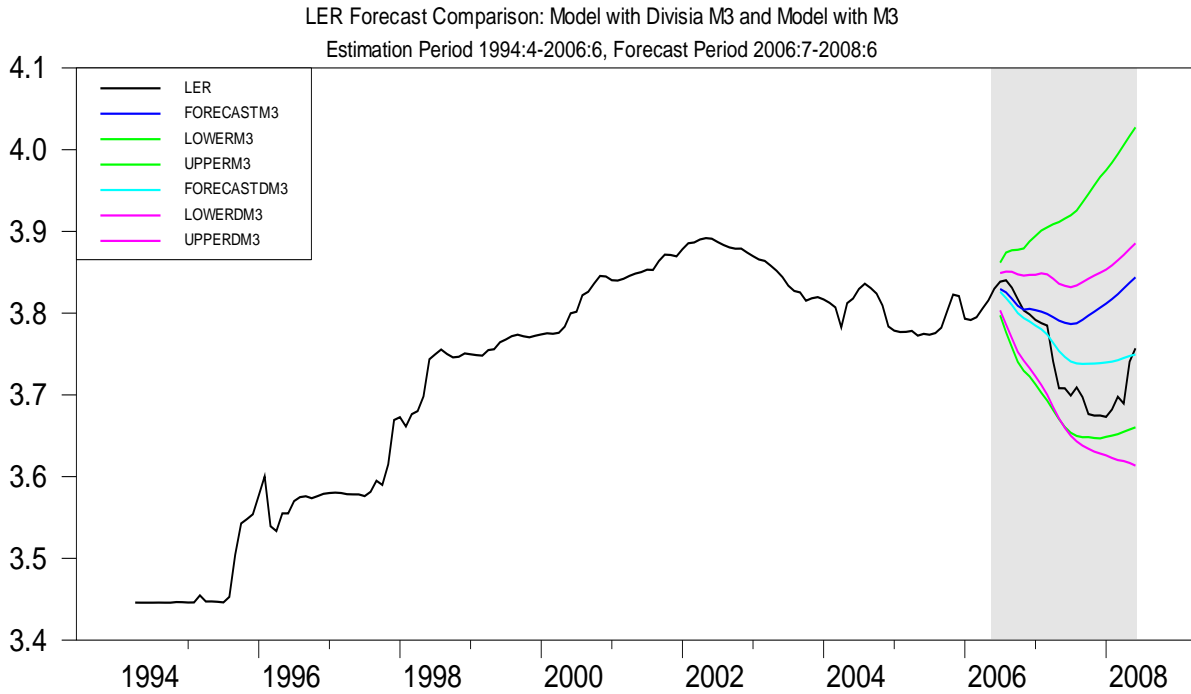Estimation Period 1994:4-2006:6, Forecast Period 2006:7-2008:6

Figure 11 represents the out of sample forecasting graph and compares between the model without money and model with the Divisia M3. The model forecast with Divisia M3 (represented in coral) stays closer to the actual log of exchange rate (LER) value (represented in black). The model forecast with no money is represented in blue, which clearly diverges from actual value over time. The forecast band for the model with Divisia M3 (represented in pink) lies within the forecast band for the model with no money (represented in green) implying that model with Divisia M3 can predict the exchange rate with greater precision.

Figure 12 represents the out of sample forecasting graph for log of exchange rate (LER) and compares between the model with simple-sum M3 and model with the Divisia M3. The model forecast with Divisia M3 (represented in coral) stays closer to the actual LER value (represented in black). The model forecast with simple-sum M3 (represented in blue) diverges from actual

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value over time. The forecast band for the model with Divisia M3 (represented in pink) is narrower compared to forecast band for the model with simple-sum M3 (represented in green), for the forecast horizon. This indicates a higher forecast accuracy in models with Divisia money compared to models with simple sum money. We have evaluated the relative performance of models using the out-of-sample forecasting graphs and RMSE, Theil U statistic. We conclude that model with Divisia M3 does better than model with simple-sum M3 and model with no money in forecasting exchange rates both in short-run and long-run. Moreover, this results holds robust to different forms of Divisia money available.

Figure 12

LER Forecast Comparison: Model with Divisia M3 and Model with M3
Estimation Period 1994:4-2006:6, Forecast Period 2006:7-2008:6

Section 4: Conclusion

In this paper, for the first time, we have applied the theoretically grounded and superior form of monetary aggregate, Divisia money in the exchange rate determination for India. We have also tried to compare across the models with money and no-money. This comparative analysis we felt was needed at a time when the role of money has been increasingly de-emphasized in macroeconomic models.

Our SVAR model was able to get rid of the price puzzle and the exchange rate puzzle. In order to claim this with confidence, we have compared the contemporaneous SVAR with the recursive model. In the recursive model, we have existence of both the price puzzle and the exchange rate puzzle. Even though there was little output-puzzle in the SVAR but we believe that for countries

like India, with maturing financial market, it might take some time for financial signals to get transmitted to the real sectors. In other words, the monetary transmission mechanism is still weak and delayed. The other relevant insight that we had from the variance decomposition analysis in our SVAR model is the role money plays in the model. We felt that money especially Divisia money rightly captures the information on flow of monetary services. In other words, we felt that money has a great informational role to play in our model. To achieve this we have compared how much of the exchange rate fluctuation is explained by the policy variable (rate of interest) in no-money models, models with the simple-sum monetary aggregate and models with the Divisia monetary aggregate.

We found that introduction of money added valuable information to the structure and policy rate could explain significantly more of the exchange rate fluctuation, compared to the no-money model. We also observed that in terms of the Divisia and simple-sum monetary aggregate, models with Divisia money did better. We not just had the opportunity to compare between simple-sum M3 and Divisia M3, but also across different levels of aggregation. (M1, M3, DL1, DM2, DM3) and different exogenous setups (model with Fed fund rate and World oil price, model with Fed fund rate and World commodity price). We also did the out-of-sample forecasting, across simple-sum monetary models and Divisia money models. Our results were analyzed and compared using the RMSE and Theil U statistics. In general, the inclusion of money lowered the RMSE values and Divisia M3 money model did fairly better than simple-sum M3 model. Also we have compared the forecasting results across different levels of monetary aggregation.

Finally, we did flip-flop analysis, where we had a nice pictorial representation of how much monetary policy in India is able to explain about the exchange rate movements, inflation and production; also how much of these variables can explain movements in the policy variable. Our results showed that during the estimation period 2000(1)-2008(1), monetary policy is able to explain most of the exchange rate fluctuation, followed by inflation and not much of the output movements are being explained by the policy variable. On the other hand, inflation is able to explain the most of the policy –variable changes, followed by exchange rate and output, switch over from time to time. This leads us to believe that the Central Bank of India had inflation-targets in mind, when it set up its policy rates.

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Appendix:

Table A Lag Selection Test						
Model	**Test for 7 vs 6 Lags**		**Test for 6 vs 5 Lags**		**Test for 5 vs 4 Lags**	
	χ^2	Significance Level	χ^2	Significance Level	χ^2	Significance Level
Model 1	38.49	0.8600	73.66	0.0129	57.88	0.1803
Model 2	38.24	0.8665	54.12	0.2854	69.43	0.0289
Model 3	53.00	0.3225	78.65	0.0046	64.76	0.0651
Model 4	39.09	0.8435	74.33	0.0113	58.11	0.1748
Model 5	49.71	0.4447	80.31	0.0032	70.37	0.0243
Model 6	44.88	0.6406	76.54	0.0071	52.27	0.3481
Model 7	34.42	0.9431	60.17	0.1316	67.10	0.0438
Model 8	55.08	0.2554	83.97	0.0014	60.16	0.1319
Model 9	45.68	0.6085	76.43	0.0073	52.45	0.3418
Model 10	53.62	0.3016	82.32	0.0020	65.89	0.0540