Monetary Transmission to Stock Market in India: A Regime Switching Approach

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In this paper an attempt has been made to study the impact of monetary policy on stock market in India. Our analysis suggests that monetary policy affect stock market as the coefficients of call money rate residual and narrow money residual (obtained from a vector auto regression) is significant and as expected. Indian stock market reflects the bull and bear phase as identified in literature. More importantly the impact of monetary policy on stock market is quite strong in case of bear phase in comparison to bull phase.

Keywords: Stock Market, Bull and Bear, Markov Regime Switching

Introduction

James Tobin's seminal 1969 Journal of Money, Credit and Banking paper established the Idea of Tobin's Q (Market Value/Replacement Value of Capital stock). He argued that "financial policies" could play a crucial role in altering Tobin's Q, the market value of a firm's assets relative to their replacement costs. Tobin emphasized that; in particular, monetary policy can change this ratio.

Tobin (1969,1978) established what we call the assets Price channel of monetary transmission. Tobin's (1978) argued that a tightening of monetary policy, which may result from an increase in inflation, lowers the present value of future earning flows (because of higher discount rate) and hence depresses equity markets. Ever since the seminal paper by Bernanke and Blinder (1992), the Federal funds rate has been the most widely used measure of monetary policy. The interest rate instrument has been widely used to examine the relationship between monetary policy and stock returns. The question that arises is how a tightening of monetary policy can be measured, since monetary policy may be endogenous in that central banks might react to developments in stock markets and there is a possibility that the increase in interest rate is expected by market participants and such increase is not going to affect stock prices as they have been already factored in Pricing the stock. The point is to find the unanticipated movement in interest rate and use the same to find the impact on stock market.

The same argument can be used for using monetary aggregates as monetary policy indicator. Considerable progress has been made in this respect. Rigobon and Sack (2002, 2003) develop a methodology that exploits the heteroskedasticity present in financial markets to identify monetary

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policy shocks, while Kuttner (2001) and Bernanke and Kuttner (2003) derive monetary policy shocks through measures of market expectations obtained from federal funds futures contracts. Another way of finding the measure of monetary policy tightening or easiness may be the residual of policy rate from a vector auto-regression and it has been used in this paper (Shiu-Sheng Chen 2007) .

Rozeff (1974) presents evidence that increases in the growth rate of money raises stock returns. Black (1987), on the other hand, argues that monetary policy cannot affect interest rates, stock returns, investment, or employment. Boudoukh, Richardson, and Whitelaw (1994) state that whether monetary policy affects the real economy, and whether its effects are quantitatively important, remain open questions.Rigobon and Sack (2003) show that the causality between interest rates and stock prices may run in both directions. After accounting for this endogeneity, they find a significant monetary policy response to the stock market.

Using money aggregate data as a measure of money supply, some empirical studies agree that stock returns lag behind changes in monetary policy; for instance, see Keran (1971), Homa and Jaffee (1971), and Hamburner and Kochin (1972). In contrast, Cooper (1974), Pesando (1974), Rozeff (1974), and Rogalski and Vinso (1977) show that there is no significant forecasting power of past changes in money. Thorbecke (1997) and Patelis (1997) demonstrate that shifts in monetary policy help to explain U.S. stock returns.

Conover, Jensen, and Johnson (1999) show that foreign stock returns generally react both to local and U.S. monetary policy. Furthermore, cyclical variations in stock returns are widely reported in the literature. Particularly, bull and bear markets have been explicitly identified in Maheu and McCurdy (2000), Pagan and Sossounov (2003), Edwards, Gomez Biscarri, and Perez de Gracia (2003), and Lunde and Timmermann (2004). In case of distinct bull and bear phase it’s expected that non-linear framework is more suitable for examining the impact of monetary policy on stock return. And the question arises, that is monetary policy have different impacts on stock returns in bull and bear markets? The class of models in which there exist agency costs of financial intermediation (finance constraint) asserts that when there is information asymmetry in the financial market, agents may behave as if they are constrained financially. Moreover, the financial constraint is more likely to bind in bear markets. Hence, a monetary policy may have greater effects in bear markets. See Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). In this paper our objective is to study the impact of monetary policy on stock market. The paper extends the linear framework in a non-linear framework using the markov regime-switching model on the lines of Hamilton (1989) to account for the distinct impact of monetary policy in bull and bear phase of market.

Data and Methodology

The monthly data from 2001 May till Feb 2013 has been used in our analysis. Sensex represent the stock market and monthly return of the same has been used for measuring the impact of monetary policy on stock return. Repo rate, Reverse Repo Rate and call money rate has been used as monetary policy indicator. The unanticipated component of monetary policy has been obtained from a vector-autoregression model (VAR). For details of Vector Auto Regression see the Appendix A. VAR has Interest rate, Natural Log of Index of Industrial Production, Natural Log of consumer price Index and natural Log of Exchange rate as exogenous variable. Later we use reserve money, narrow money and broad money growth instead of interest rate and similarly find the unanticipated component of monetary growth and we see their impact on stock market return. Residuals are given in Appendix C.

The basic model is $r_t^* = \delta + \beta z_t + \varepsilon_t$

Where r_t^* is monthly stock return and z_t is residual from vector auto-regression. Later we estimate the same model in regime switching framework using a Matlab Package developed by Marcelo Perlin (2012). For details of Markov Regime switching framework see appendix B.

Result and Analysis

The result given in Table: 1 and Table: 2 suggest that stock market return responds to unanticipated movement in call money rate and narrow money significantly. One percent unanticipated movement in call rate leads to more than one percent change in stock return and one percent unanticipated change in narrow money leads to around half percent change in stock return. The result with reserve money and broad money are as expected but not significant. The result with repo and reverse repo has sign opposite to as expected. This could be because of feed back rule associated with repo rate and reverse repo rate, which may not be so timely.

Table: 1: Regression of Sensex Return with residual obtained from respective VAR

	MMR	Repo	ReRepo
β	-1.290*	1.756	2.310
	(-2.56)	(0.69)	(0.74)
δ	1.473**	1.473**	1.473**
	(2.82)	(2.76)	(2.76)
N	139	139	139
t statistics in parentheses			
="* p<0.05	** p<0.01	*** p<0.001"	

Table: 2: Regression of Sensex Return with residual obtained from respective VAR

	Reserve Money	**Narrow Money**	**Broad Money**
β	0.0227	0.516**	0.671
	(0.20)	(2.72)	(1.63)
δ	1.492**	1.492**	1.492**
	(2.77)	(2.85)	(2.80)
N	138	138	138
t statistics in parentheses			
="* p<0.05	** p<0.01	*** p<0.001"	

In order to identify the bull and bear phase in the Indian stock Market we estimated a constant expected return model (Eq.1) in regime switching framework. In our estimation we have allowed the constant of regression and variance of the error term to vary in the two phases. For details on markov regime switching framework see the appendix B. The estimation has been done by a Matlab package developed by Marcelo Perlin (2012)[1]. Result obtained from estimation of

$$r_t^* = \delta_{s_t} + \varepsilon_{s_t} \qquad \text{Eq.1}$$

Gives evidence of two regimes in Indian Stock Market (Table: 1). One having higher return and lower variance and other having lower return (negative) and higher variance. Figure: 1 clearly depicts the so-called bull and bear phase. As we can see that since May 2001 till Dec 2007 Indian Stock market was in bull phase (State 1). For two years it remained in bear phase (State 2) till Dec 2010 and from Jan 2011 onwards it's again in bullish phase. The ratio of bull and bear phase is 6:1. As argued above to test whether the impact of monetary policy is different in two phases the basic model was estimated in markov regime switching framework after adding residual of call money rate and narrow money rate as explanatory variable (Eq.2). We allowed the coefficient of call money rate and narrow money rate residual to vary in the two phases. The constant and variance of the error term is also allowed to vary.

$$r_t^* = \delta_{s_t} + \beta_{s_t} z_t + \varepsilon_{s_t} \qquad \text{Eq.2}$$

Table: 1

		State 1	State 2
Variance		25.177034	109.691612
Constant		1.697	-0.1962
Duration		72.64	12.17
Transition	P_{11}	0.99	P_{21} 0.08
Probability	P_{12}	0.01	P_{22} 0.92

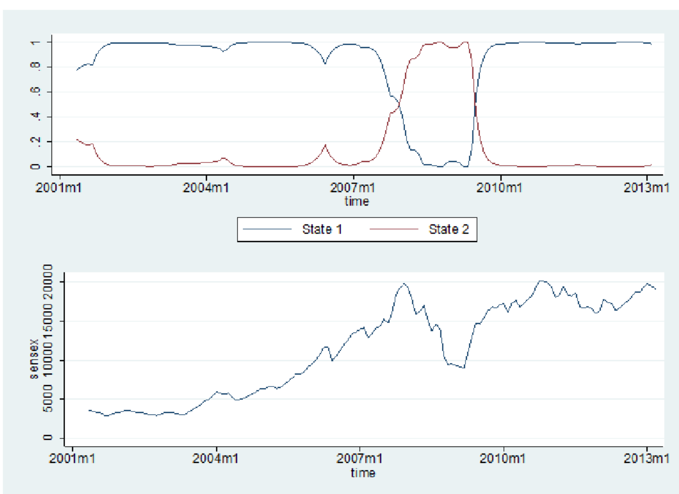


Figure: 1

[1] For details http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1714016

The output of regression obtained from call money rate residual is given in Table: 2 and we can easily identify the bull and bear phases. The ratio of bull and bear phase is approximately 6:1. The coefficient of call money rate is negative in both the phase. But the impact of call money rate is quite higher in bear phase almost four times of that in bull phase. This indicates the asymmetry in interest rate transmission to stock market as argued above.

Table: 2: Regression with Call Money Residual

		State 1	State 2
Variance		21.870789	93.236276
	δ	2.006	-0.593
	β	-0.9018	-3.6896
Duration		33.93	6.36
Transition	$\mathbf{P_{11}}$	0.97	P_{21}0.16
Probability	$\mathbf{P_{12}}$	0.03	P_{22}0.84

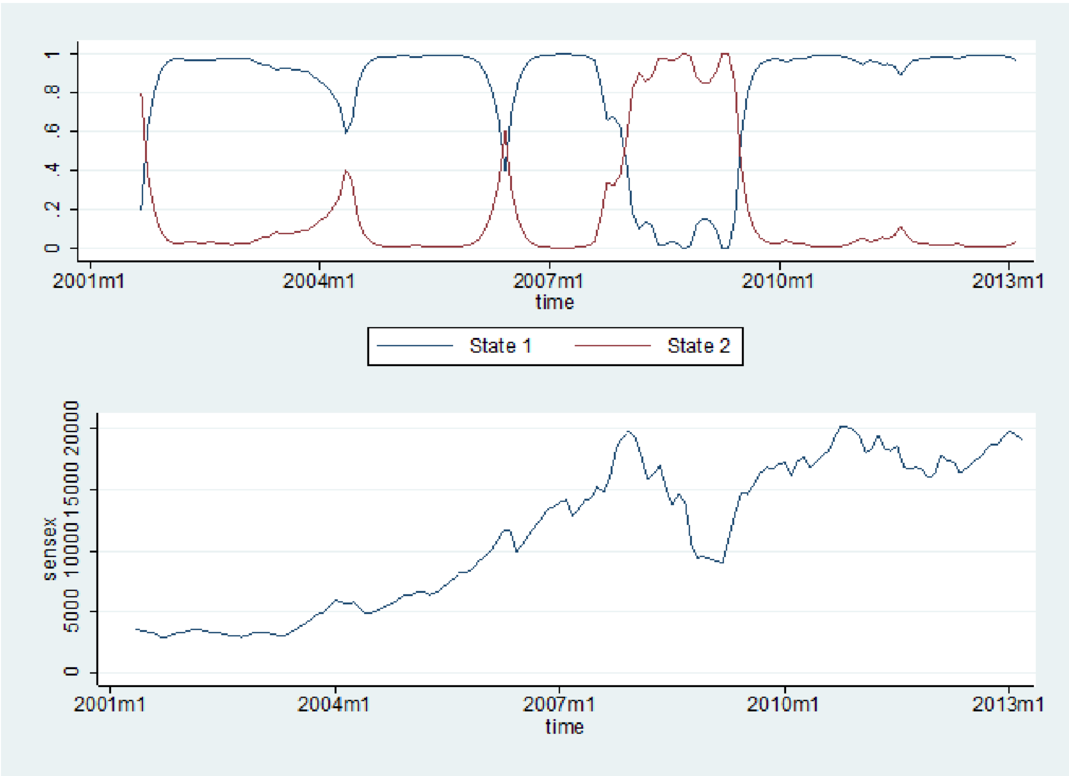


Figure: 2

The regression output (Table: 3) with narrow money residual also identifies regimes with higher and lower (although positive) returns. As expected the impact of narrow money residual is positive. An increase in money supply leads to higher stock return. But what is significant is the impact of narrow money residual in bear phase, which is quite higher than in comparison to bull phase.

Table-3: Regression with Narrow Money Residuals

		State 1	State 2
Variance		22.49186	92.209014
	δ	1.8768	0.3949
	β	0.3103	0.9452
Duration		35.42	6.69
Transition	$\mathbf{P_{11}}$	0.97	P_{21}0.15
Probability	$\mathbf{P_{12}}$	0.03	P_{21}0.85

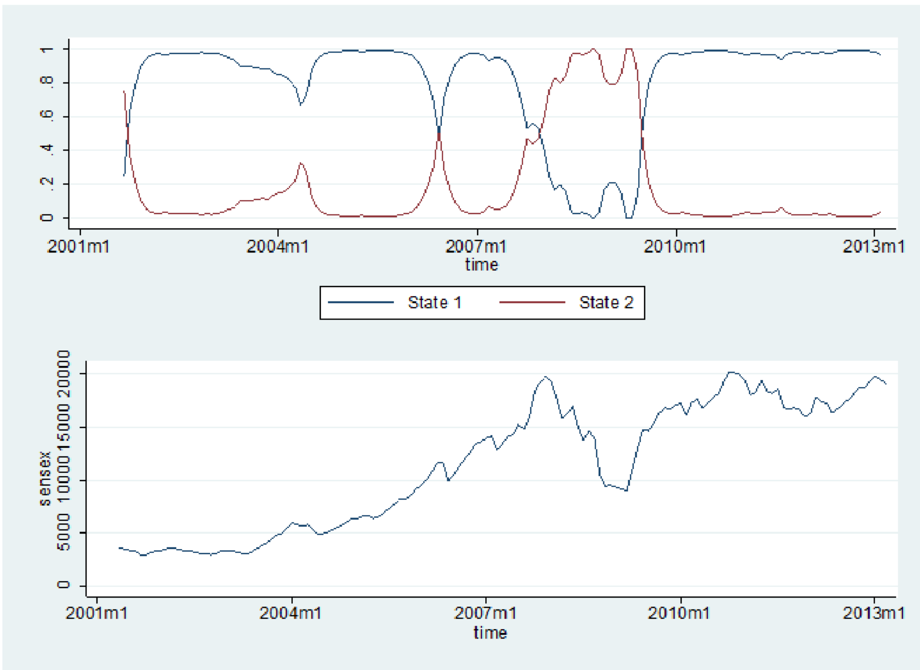


Figure: 3

Conclusion

Our analysis suggests that monetary policy affect stock market as the coefficients of call money rate and narrow money residual is significant and as expected. Indian stock market reflects the bull and bear phase as identified in literature and discussed above. More importantly the impact of monetary policy on stock market is quite different in two phases. The impact is quite strong in case of bear phase in comparison to bull phase.

Appendix A

The VAR model is a multi-equation system where all the variables are treated as endogenous. There is thus one equation for each variable as dependent variable. Each equation has lagged values of all the included variables as dependent variables, including the dependent variable itself. Since there are no contemporaneous variables included as explanatory, right-hand side variables, the model is a reduced form. Thus all the equations have the same form since they share the same right-hand side variables. This kind of VAR model is called reduced from VAR.

Say, we have two variables: GDP, y, and the money supply, m, the VAR model will be:

$$y_t = a_1 y_{t-1} + \ldots + a_k y_{t-k} + a_{k+1} m_{t-1} + \ldots a_{k+1+n} m_{t-n} + e_t^y$$

$$m_t = b_1 y_{t-1} + \ldots + b_k y_{t-k} + b_{k+1} m_{t-1} + \ldots b_{k+1+n} m_{t-n} + e_t^y$$

The two endogenous variables y and m are also the explanatory variables in lagged form. How many lags to put in is an empirical matter, that is decided at the estimation stage using lag length criteria AIC, BIC and others. The estimation can be done using OLS method.

Appendix B
Markov Regime Switching Process

Consider the following process replicated by a variable (I). The variable has a mean that is dependent on state and we have assumed two states.

$$y_t = \mu_{S_t} + e_t \qquad \text{(I)}$$

The same can be shown using different state mean. The variance remains same in two sates.

$$y_t = \mu_1 + e_t \text{ when } S_t = 1 \qquad \text{(II)}$$

$$y_t = \mu_2 + e_t \text{ when } S_t = 2 \qquad \text{(III)}$$

$$e_t = N(0, \sigma^2_{S_t}) \qquad \text{(IV)}$$

If we know the point where state change i.e. if the state can be determined the above equation can be replace with (V) and can be estimated using simple ordinary least square technique.

$$y_t = \mathrm{m}_1 \mathrm{D}_{1t} + \mathrm{m}_2 (1-\mathrm{D}_{1t}) + \mathrm{e}_t \qquad \text{(V)}$$

$$\mathrm{D}_{1t} = 1 \text{ When } S_t = 1$$

$$\mathrm{D}_{1t} = 0 \text{ when } S_t = 2$$

For a markov regime-switching model, the transition of states isstochastic (and not deterministic). This means that one is never surewhether there will be a switch of state or not. But, the dynamics behindthe switching process is know and driven by a transition matrix. The probability of state at any point of time depends upon the state one time before.

$$\Pr[s_t|s_1, s_2, \ldots, s_{t-1}] = \Pr[s_t|s_{t-1}]$$

$$\Pr[s_t|s_1, s_2, \ldots, s_{t-1}] = \Pr[s_t|s_{t-1}] \qquad \text{(VI)}$$

Probability of moving from state *j* to state *i*:

$p_{ij} = P[s_t = i | s_{t-1} = j]$ (VII)

This matrix will control the probabilities of making a switch from onestate to the other. It can be represented as

$$P = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{N1} \\ p_{12} & p_{22} & \cdots & p_{N2} \\ \vdots & \vdots & \cdots & \vdots \\ p_{1N} & p_{2N} & \cdots & p_{NN} \end{bmatrix}$$

$$\sum_{j=1}^{N} p_{ij} = 1 \quad \text{where} \quad i = 1,2,\ldots,N \quad \text{and} \quad 0 \le p_{ij} \le 1$$

This kind of problem can be estimated using maximum likelihood method as demonstrated below

$$y_t = \mu_{S_t} + e_t \qquad \text{(VIII)}$$

$$e_t = N(0, \sigma^2_{S_t}) \qquad \text{(IX)}$$

$$S_t = 1, 2$$

The log likelihood of this model is given by:

$$lnL = \sum_{t=1}^{T} ln(\frac{1}{\sqrt{2\pi\sigma^2}} e^{(-y_t - \mu s_t / 2\sigma^2)}) \quad \text{(X)}$$

For the previous specification, if all of the states of the world were know, that is, the values of are available, then estimating the modelby maximum likelihood is straightforward. All you need is to maximize Equation (X) as a function of parameters μ_1 μ_2 $\sigma_1^2$and σ_2^2 . Is shouldbe clear by now that this is not the case for a markov switching model,where the states of the world are unknown.In order to estimate a regime switching model where the statesare not know, it is necessary to change the notation for the likelihoodfunction. Considering $(f(y_t \vdots S_t = j, \psi)$ as the likelihood functionfor state j conditional on a set of parameters (), then the full loglikelihood function of the model is given by:

$$lnL = \sum_{t=1}^{T} ln \sum_{j=1}^{2} (f(y_t \vdots S_t = j, \psi) \Pr(S_t = j)) \qquad \text{(XI)}$$

Which is weighted average of likelihood function weighted by the probability of the state. The question is that if the probabilities are not observable we can't apply the log likelihood function. The idea that we use is of Hamilton filter, starting from any arbitrary probability at t=0 we can find conditional probability of the two states at t=0 and the same is given below

$$Pr(S_0 = 1 \vdots \psi_0) = \frac{1 - p_{11}}{2 - p_{11} - p_{22}}$$

$$Pr(S_0 = 2 \vdots \psi_0) = \frac{1 - p_{22}}{2 - p_{11} - p_{22}} \qquad \text{(XII)}$$

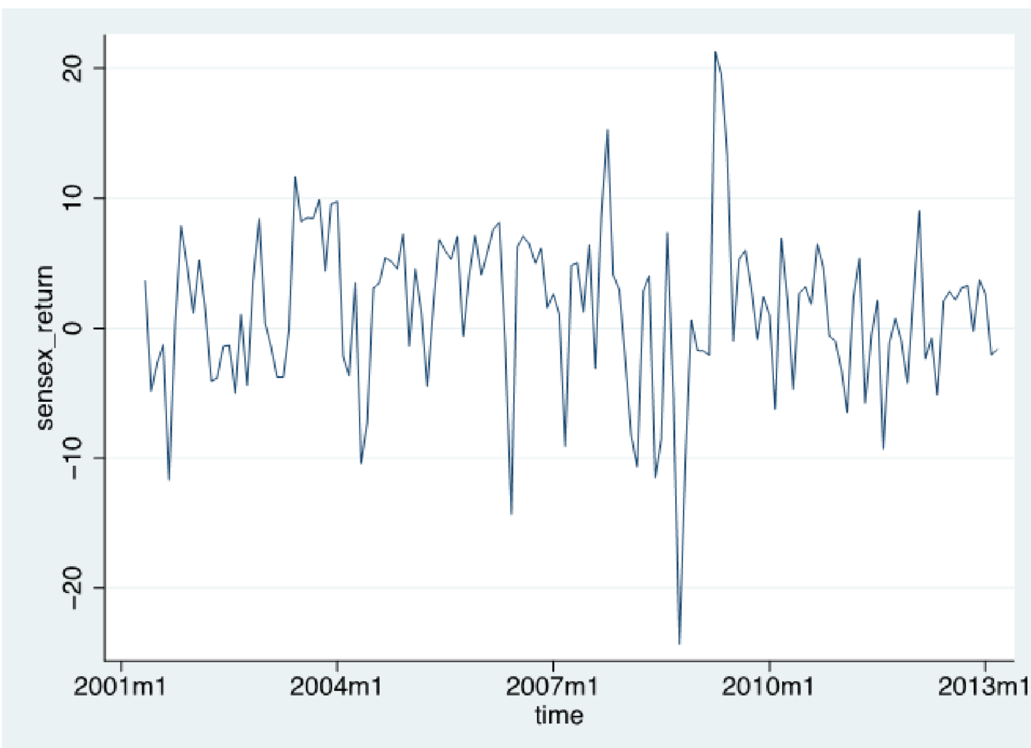
Extending the idea we can find the probability of being in state j at given the information till time t-1

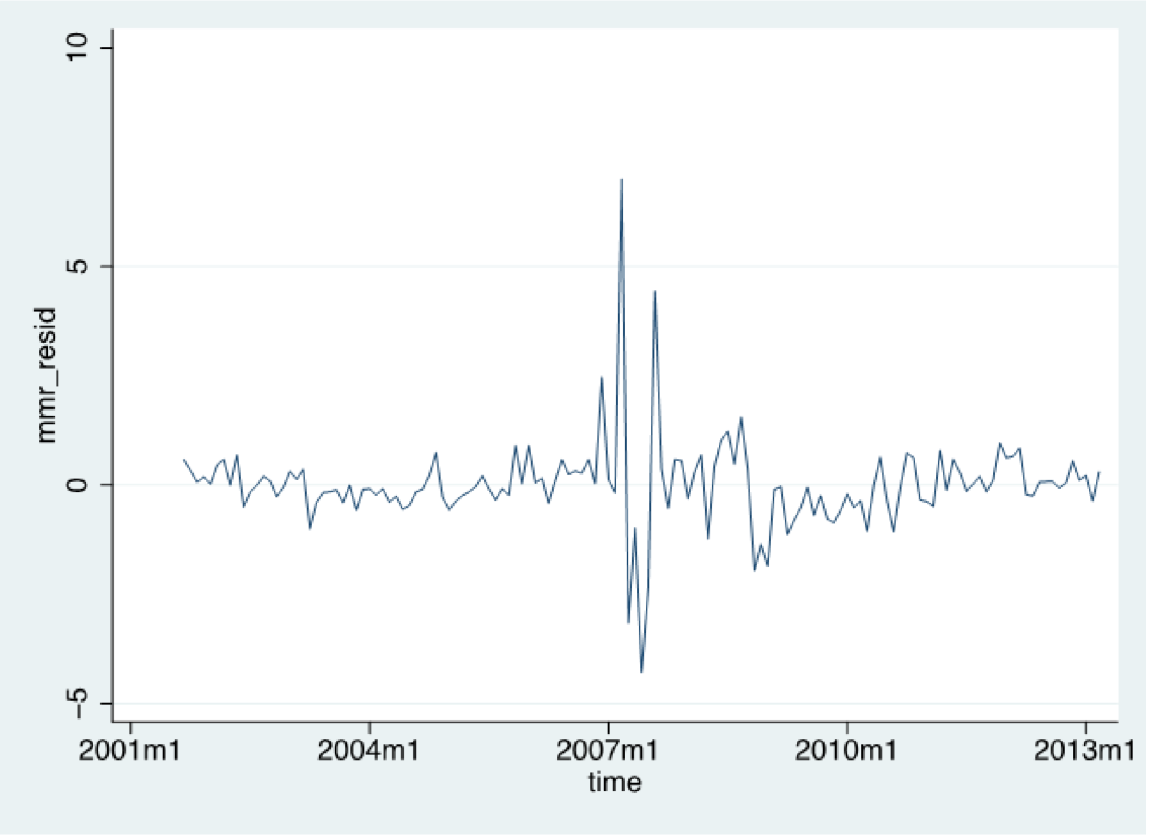
$$Pr(S_t = j \vdots \psi_{t-1}) = \sum_{i=1}^{2} \quad p_{ji}\ Pr(S_{t-1} = i \vdots \psi_{t-1})$$

$$Pr(S_t = j \vdots \psi_t) = \frac{(f\left(y_t \vdots S_t = j, \psi_{t-1}\right)\ Pr(S_t = j \vdots \psi_{t-1}))}{\sum_{j=1}^{2} \quad f\left(y_t \vdots S_t = j, \psi_{t-1}\right)\ Pr(S_t = j \vdots \psi_{t-1}))}$$

$$lnL = \sum_{t=1}^{T} ln \sum_{j=1}^{2} (f(y_t \vdots S_t = j, \psi)\, \Pr(S_t = j))$$

Appendix C

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mmr_resid
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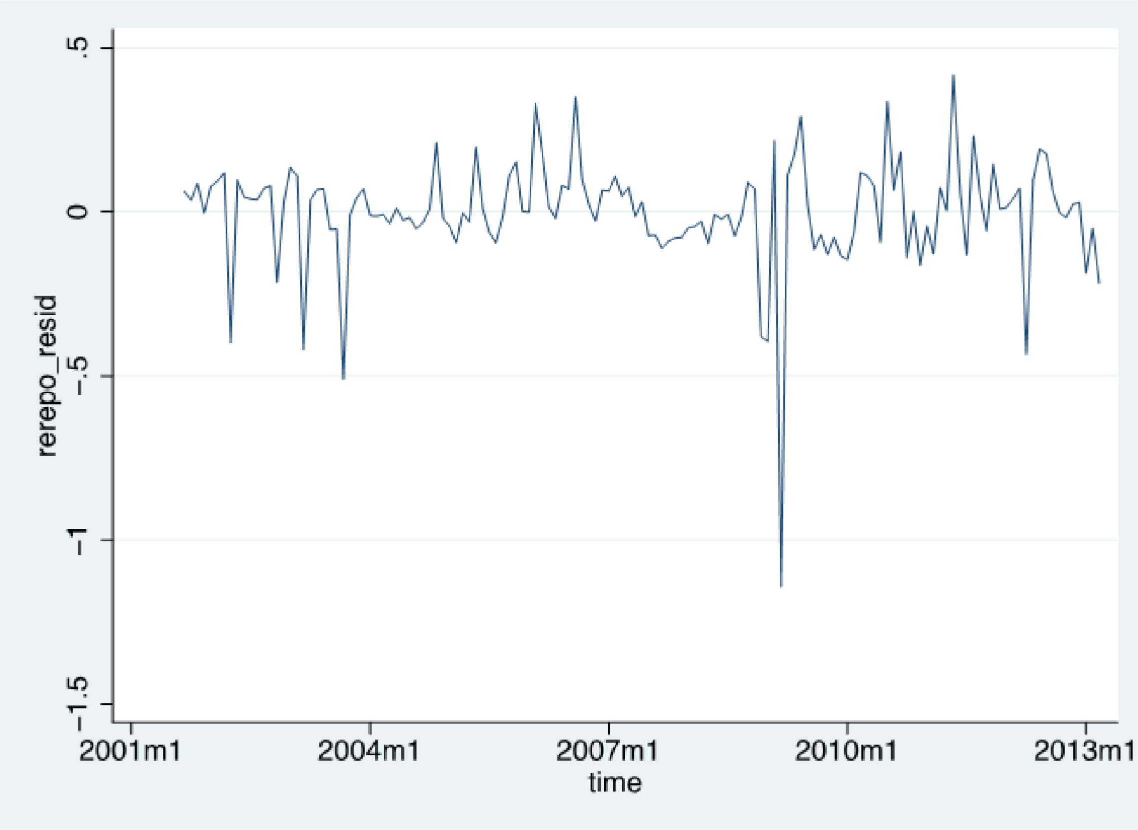
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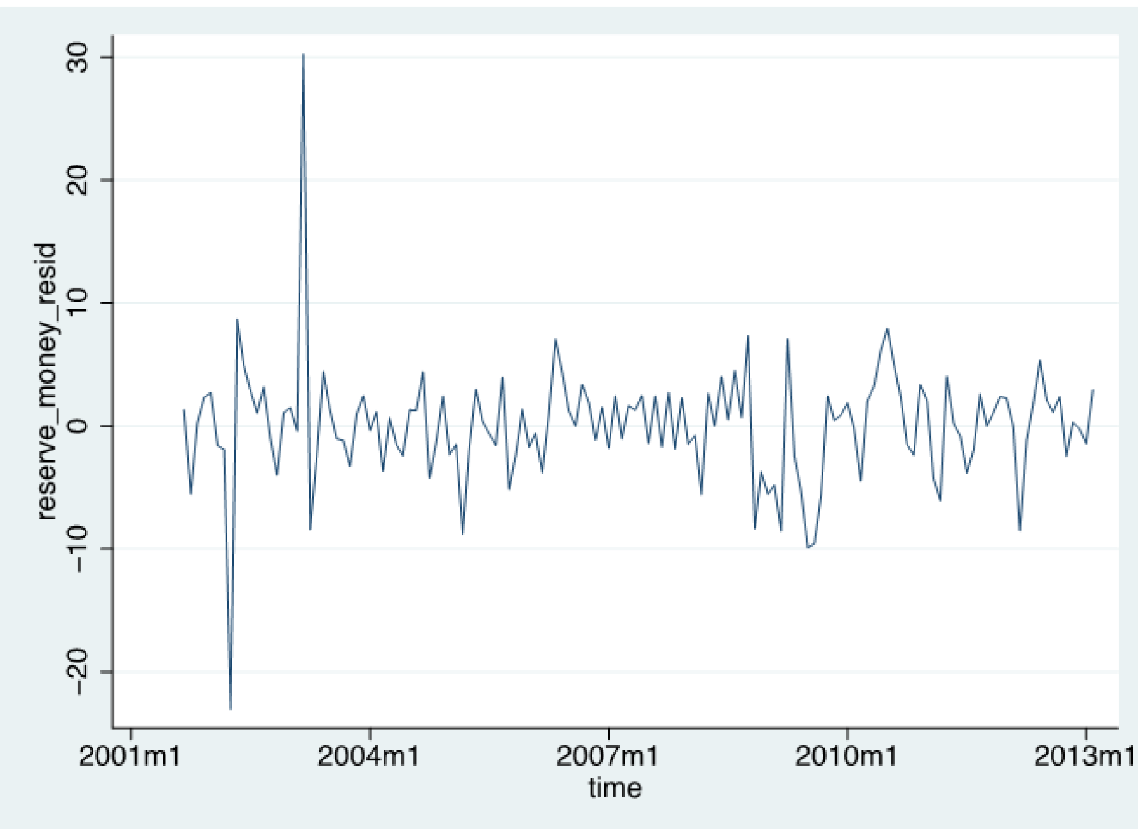
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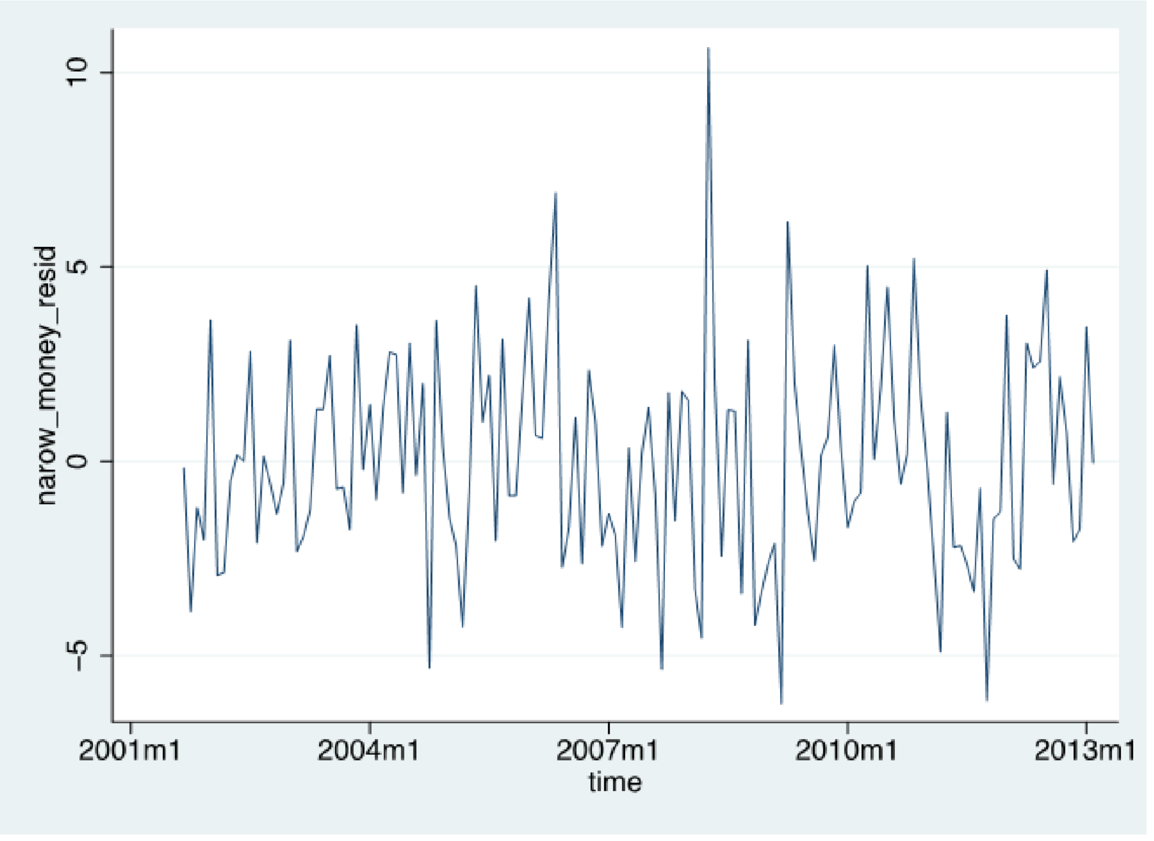
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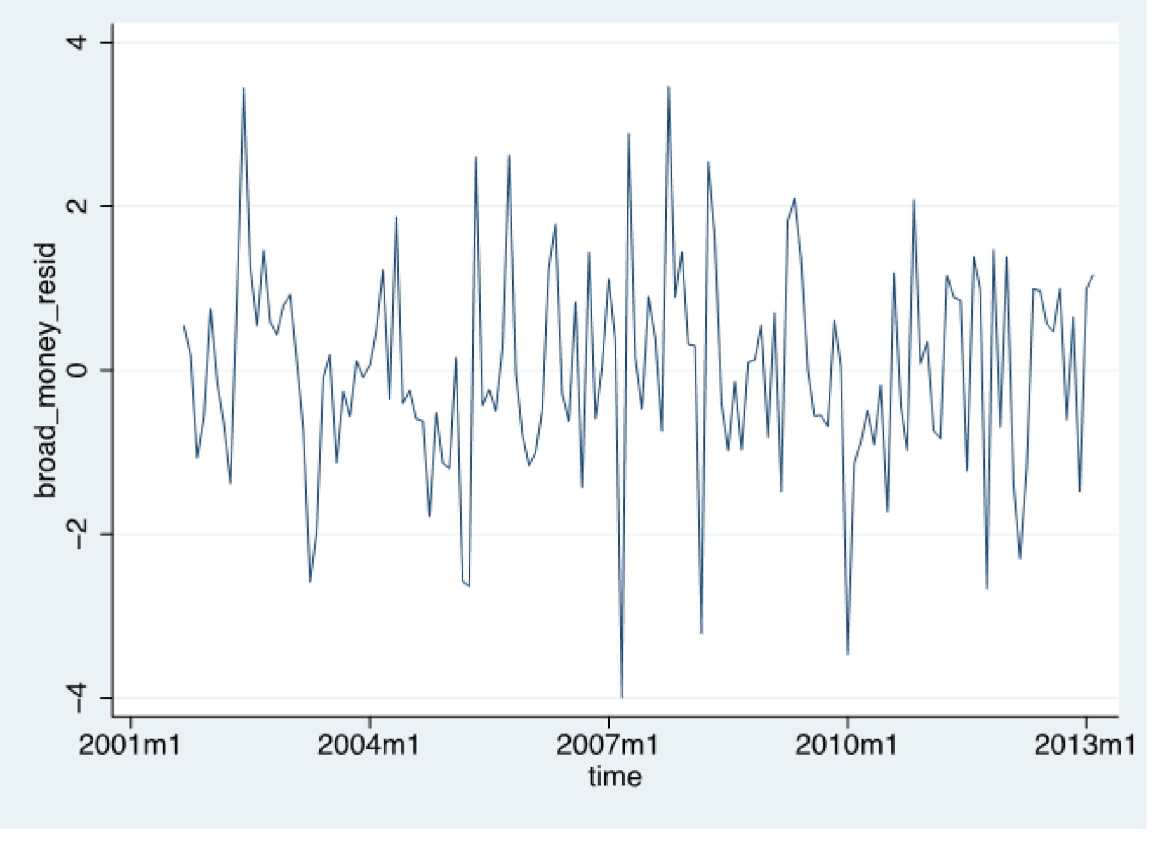
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2004m1
2007m1
2010m1
2013m1
time

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