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Are the Effects of Monetary Policy Asymmetric in India? Evidence from a Nonlinear Vector Autoregression Approach

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ABSTRACT

Even though there exist quite a number of studies analysing the impact of monetary policy in India, none of these papers looks into the whether monetary policy has an asymmetric impact on the output and price level. In light of this, this paper uses Indian quarterly data for the period of 1960:Q2-2011:Q2 to test for nonlinearity in a standard monetary vector autoregression (VAR) model comprising of output, price and money, using an estimation strategy that is consistent with wide range of structural models. We find that positive and negative monetary policy shocks have an immediate short-lived and a delayed persistent asymmetric effect on output and price, respectively. In addition, we show that compared to a linear VAR, the nonlinear VAR has a bigger impact of a monetary policy shock on output and price. In general, we conclude that there are clear gains from modelling monetary policy using a nonlinear VAR framework.

Key words: Asymmetric effects, monetary policy, linear and nonlinear VAR, India

INTRODUCTION

The monetary policy framework in India has undergone series of transformations since the beginning of the planning period in 1951 (Mishra and Mishra, 2010). Therefore, understanding the response of goal variables (output and prices) to exogenous monetary policy shocks is essential for sustained economic growth in India. Determining whether monetary shocks have asymmetric effect is a key concern in macroeconomics (Weise, 1999). This is because a number of economic theories imply that monetary policy may have asymmetric effects based on the so-called "Keynesian" and "Classical" regions of the aggregate supply curve, the liquidity trap theory, credit constraint models and menu cost models, as observed by Morgan (1993), asymmetric wage indexation and price adjustment (Kandil, 1995) and asymmetric real rigidities in the form of irreversibility of investment (Abel and Eberly, 1994)[1]. Purely from a policy perspective, it is important to investigate if the monetary authority needs to change the money supply asymmetrically to contract and expand the economy.

Vector autoregressive (VAR) approach is one of the most commonly used methods of analysing the effects of monetary shocks. Barring a few[2], most studies generally use a linear VAR. These studies ignore the possibility of nonlinearities between the time series of economic variables which

[1]Refer to Weise (1999) for further details.

[2]Terasvirta and Anderson (1992), Garcia and Schaller (2002), Weise (1999), Karame and Olmedo (2002), Holmes and Wang (2000) and Rahman and Serletis (2010)

may arise due to structural breaks or regime changes. The main difference between the standard linear VAR and the nonlinear VAR is that the latter allows some coefficients to be state-dependant.

In this study, we estimate the asymmetric effects of monetary policy shocks in India using a logistic smooth transition vector autoregression (LSTVAR) as detailed in Weise (1999). Although, there are a number of studies on monetary policy impacts in India that used the VAR approach (Goyal and Pujari, 2005; Srimany and Samanta, 1998; Chowdhury, 2008; Ghosh, 2009; Kubo, 2009; Mallick and Sousa, 2009; Inoue, 2010; Mishra and Mishra, 2010; Patnaik, 2010). Although, none of these studies consider asymmetric effects or nonlinearities. Given this, the objective of this study is to analyze whether nonlinearities exist among the dynamic relationship between key macroeconomic variables and also, if monetary policy shocks tend to have an asymmetric effect on the output and price level of the Indian economy. Thus we contribute to monetary policy literature for India by considering asymmetry in a non-linear VAR framework[3].

ECONOMETRIC METHODOLOGY AND THE DATA

An unrestricted reduced-form, nonlinear vector autoregression following a smooth transition autoregressive form is used. The nonlinearity is based on the fact that the dynamic behaviour of time series depends on states or regimes of the variables. Terasvirta and Anderson (1992) used such a nonlinear model in a single equation framework, but here the LSTVAR is estimated in a multi-equation setting following Weise (1999)[4]. By ignoring moving average terms, our empirical LSTVAR model is given as:

$$X_t = X + A(L)X_{t-1} + (\theta_0 + \theta(L)X_{t-1})F(z_t) + u_t \tag{1}$$

where, X_t = $(y_t, p_t, m_t)'$ is the vector of endogenous variables with y_t being the growth rate of industrial production index, p_t is consumer production index inflation and m_t is growth rate of money supply which in turn is measured by M1. A(L) and θ(L) are pth-order polynomials in the lag operator. θ_t is interpreted as a technology shock with $E(\theta_t) = 0$. u_t is the residual. z_t is a "switching variable" that represents the state of the economy. $F(z_t)$ is a function which lies between zero and one with the two extremes values corresponding to two regimes.

We assume that $F(z_t)$ is a logistic function expressed by:

$$F(z_t) = \frac{1}{1+\exp\{-\gamma(z_t - c)\}} - \frac{1}{2} \tag{2}$$

The parameter c in Eq. 2 represents the threshold around which the dynamics of the model change. In the limit as z_t-c approaches minus infinity (plus infinity), $F(z_t)$ approaches zero (one). The parameter γ is the "smoothness" parameter. As γ approaches zero, $F(z_t)$ converges to a constant, the nonlinear terms become redundant and the model becomes linear. As γ approaches infinity the model becomes a threshold autoregression model. The model's dynamics change abruptly depending on whether z_t is greater than or less than the threshold value.

[3]For a recent set of studies dealing with monetary policy, see also, Javed and Sahinoz (2005), Ozturk (2006), Agbeja (2007), Saibu and Oladeji (2007), Berument *et al*. (2009), Ahortor and Olopoenia (2010), Mukherjee *et al*. (2011), Krishnapillai and Thompson (2012) and Simwaka *et al*. (2012)

[4]Weise (1999) for a detailed specifications and description of the methodology.

Note that, although, M2 or an interest rate variable is more commonly used as a stand-in for the monetary policy variable, M1 is found to have more desirable properties in the context of a three-variable monetary VAR, since it tends to avoid the so-called price puzzle, whereby prices tend to fall following a monetary expansion (Sims, 1992). The puzzle is usually resolved by including more variables such as the commodity price index, however, this tends to be impractical in our case, since the number of coefficients to be estimated in the LSTVAR model rises in proportion to the number of coefficients in the standard linear model. Hence, there is a virtue to working with a three variable VAR. The fact that we do not see the price puzzle, as will be seen below, using a VAR based on M1, suggests that monetary shocks are more successfully identified in a y-p-m ordered model.

There is a possibility, that one could reject linearity for this VAR because of time-dependent structural breaks. If non-linearity is solely due to structural breaks, the problem can be handled by including appropriate dummy variables, with deeper notions like asymmetric nominal rigidity can be ignored. For this reason each series, is filtered by regressing it on a constant, seasonal dummy variables, intercept dummies for the post 1991 (financial liberalization) and post 2007 (the "Great Recession") periods, a time trend and the time trend interacted with seasonal dummies. The order of differencing, the lag length, stability and cointegration in the VAR model are based on conventional tests.[5] Each of the filtered data series is stationary based on standard unit root tests, with log-levels of the industrial production, CPI and M1 containing unit roots. Since, it is well-known that the velocity of M1 is nonstationary and theory suggests no other cointegrating vector, the series are assumed not to be cointegrated-an assumption vindicated by the trace test proposed by Johansen (1991). The Schwarz information criterion suggested four lags. Given this, the benchmark model was estimated as a fourth-order VAR using the difference in the log of industrial production, the CPI and M1. Note that all data are obtained from the International Financial Statistics (IFS) database maintained by the International Monetary Fund (IMF) and covers the period of 1960:Q1-2011:Q1. Since, we use growth rates of the variables, our effective sample begins in 1960:Q2.

RESULTS AND DISCUSSION

We start off with a test of linearity performed on the baseline VAR. We test the null hypothesis H_0: $\gamma = 0$ against the alternative H_1: $\gamma>0$. As in Weise (1999), the tests of linearity employed here are based on a log-likelihood test of the null hypothesis. Based on the log-likelihood of the restricted and unrestricted models, we then obtain a Likelihood-Ratio (LR) test statistic. Based on the LR statistics for each equation and the entire system and the corresponding p-values, the switching variable for this study is found to be the third lag of the change in the rate of inflation, i.e., Δp_{t-3}. Note that we looked at the growth rate of industrial production, the rate of inflation, the change in the rate of inflation and the growth rate of M1, lagged one, two, three or four periods, as possible switching variables. All these variables are plausible candidates as suggested by theories on the asymmetric impact of monetary policy (Weise, 1999). In general, we found strong evidence against linearity in this standard VAR and in favour of the LSTVAR model.[6] However, whether this nonlinearity yields in economically meaningful asymmetry in the effects of monetary policy shocks must be determined by examining the dynamic effects of these shocks in the LSTVAR model. Thus, next we discuss a bit on the estimation strategy of the LSTVAR model.

[5]The details of these results are available upon request from the authors

The LSTVAR could be estimated using Full-Information Maximum Likelihood (FIML) techniques by imposing coefficient restrictions that set certain elements of A(L) and θ(L) equal to each other as in Terasvirta and Anderson (1992). However, imposing arbitrary coefficient restrictions is problematic because the results may be sensitive to which restrictions are imposed and the choice of restrictions cannot be guided by economic theory. In this study, the model is estimated using a two-stage procedure following Weise (1999). In the first stage, the threshold parameter, c is fixed at zero. In the second stage, the model is then estimated by OLS equation-by-equation using the value for c, allowing the smoothness parameter, γ to vary. The value of γ that minimizes the log of the determinant of the variance-covariance matrix of residuals from these regressions is used in the final regressions which in our case happens to be 3.51.

Once we have estimated the LSTVAR model, we are now ready to explore the asymmetric effects, if any, of a positive and negative monetary policy shock on the growth rate and inflation of the Indian economy. We use the impulse response functions for answering this question.[7] Monetary shocks are identified using the Cholesky decomposition, whereby the money equation is ordered last to ensure that money growth has no contemporaneous effect on inflation and output growth.[8] The same ordering is retained for the benchmark linear VAR model as well. The impulse response functions obtained from the LSTVAR model and the linear VAR model for a one-time (one standard deviation shock) to the growth rate of money supply, using the differences in log industrial production, consumer price index and M1, filtered for trends and structural breaks, are presented in Fig. 1. For the sake of comparability, we plot the responses of output growth and inflation to the negative shock by reversing the sign. The impulse response functions track the responses of the output growth and inflation from the linear and nonlinear VARs for over twenty quarters following the monetary policy shock.

The impulse responses, in general, do not tend to provide much evidence of asymmetry for the effects of positive and negative monetary policy shocks especially for the output growth, since, barring the initial two quarters where the positive shock has a bigger impact on the output growth relative to the negative shock, the responses lie virtually on top of one another. For the inflation, the negative shock has bigger effect compared to the positive shock post quarter four. Further, the effect on the inflation is quite persistent. Though, the effect starts to die off after the 10th quarter, it does not revert back to its initial level within twenty quarters as with the output growth. The linear model predicts weaker effects relative to the LSTVAR model for both output and inflation, though the effect on the inflation continues to be quite persistent as in the nonlinear case. So in general, there seems to be more evidence of asymmetry for a positive and negative monetary shock

[6]The evidence against linearity when the growth rate of M1 is used as the switching variable was found to be very weak. What was most striking was the fact that linearity was never rejected in the output equation when the growth rate of M1 was the switching variable. This, however, does not imply that shocks to money supply have symmetric effects. Positive and negative monetary policy shocks could have asymmetric effects due to the dynamic interactions of the model that uses other switching variables. By contrast, linearity was rejected in a number of specifications when output growth, inflation or the change in the rate of inflation acted as the switch variable, especially in the money equation. This result suggested that the monetary policy reaction function is asymmetric. There is hardly any evidence of non-linearity in the output equation though. Details of the Langrange Multiplier Tests for Linearity is available upon request from the authors.

[7]The technical details involved in obtaining the impulse response functions can be found in Weise (1999).

[8]Note that, in addition to this being the conventional ordering, this also allows us to avoid the problem that the contemporaneous relationships are state dependent under the assumption of heteroskedasticity, and hence, the Cholesky decomposition cannot be used. Thus, we do not identify output and inflation shocks

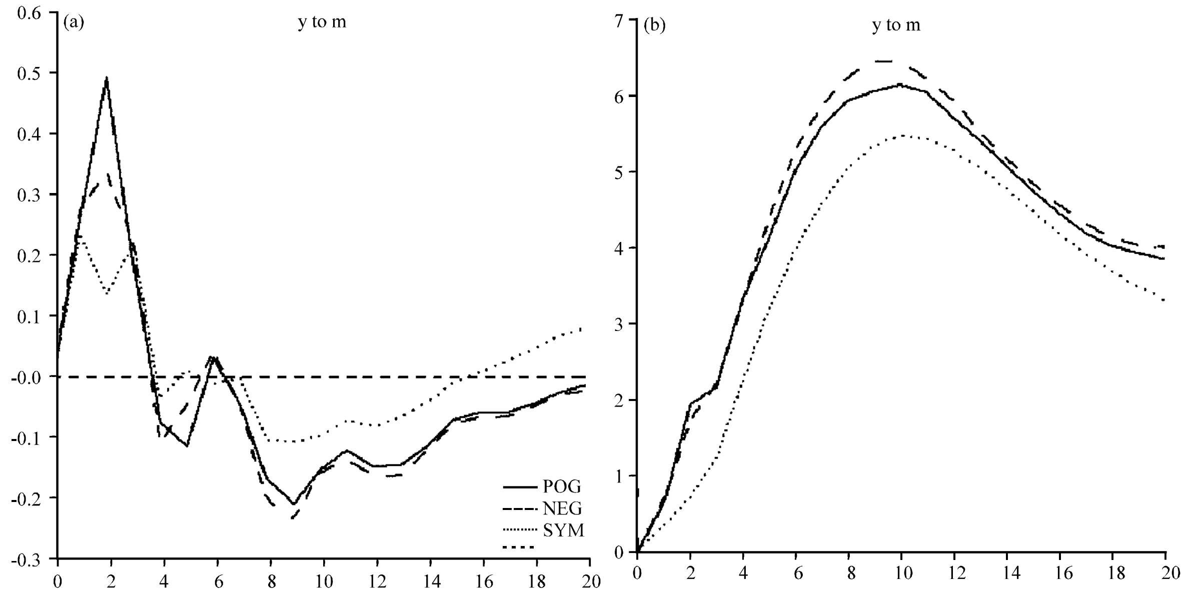

Fig. 1(a-b): Impact of a one standard deviation money supply growth rate shock (m) on output growth (y) and inflation (p) in linear and nonlinear VARs. POS (NEG) indicates the impulse responses for a positive (negative) money supply growth rate shock in the LSTVAR model; SYM indicates the impulse response from the linear VAR model for a money supply growth rate shock

for Indian inflation than on output growth, where the asymmetry is only restricted to the first few quarters. Unlike Weise (1999), who found no asymmetric effect of monetary policy for the US economy, our study does indicate that asymmetry is an important component of monetary decisions in India, especially with regards to the inflation rate. So, we indicate that the conclusions from the previous studies (Goyal and Pujari, 2005; Srimany and Samanta, 1998; Chowdhury, 2008; Ghosh, 2009; Kubo, 2009; Mallick and Sousa, 2009; Inoue, 2010; Mishra and Mishra, 2010; Patnaik, 2010) on monetary policy conducted for India might be inaccurate in their conclusions, since they fail to account for non-linearity.

CONCLUSION

The objective of this paper was to analyze if positive and negative monetary policy shocks affect the output growth and inflation asymmetrically for India. For this purpose, we estimated a three variable monetary VAR model comprising of output growth, CPI inflation and the growth rate of M1 using quarterly data covering the period of 1960:Q2 till 2011:Q2. The monetary policy shock was identified using the standard Cholesky decomposition. We found that, the evidence of asymmetric effect for the output growth is only limited to the first few quarters, where the positive monetary shock tend to have a bigger effect than the negative shock. For inflation, though, the differences in the effects of the positive and negative monetary policy shocks are much more visible, with the latter variety of shocks having a bigger impact after a year or so. Compared to the linear model, the non-linear model is found to produce stronger effects. Clearly then, there are gains from modelling monetary policy in a nonlinear set up for India, since money shocks have asymmetric effect on both growth and inflation, though slightly limited for the former. In addition, our results also highlight the fact, that if nonlinearities are not taken into account, we are likely to underestimate the effect of monetary policy on growth and inflation.

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