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The Effects of Monetary Policy on Output and Inflation in India: A Time-varying Approach

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Abstract

The study investigates whether the effects of monetary policy shocks on output and inflation have changed over time in India. By estimating a Time-varying Parameter Vector Autoregression model, we find substantial variations in the effects of monetary policy shock on both output and inflation. The impulse responses reveal that the effect of monetary policy shocks on inflation has weakened over time, while on output, it has strengthened. Our results also suggest that the adoption of the inflation-targeting framework has been beneficial in moderating inflation volatility.

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1. Introduction

The conduct and operating procedures of monetary policy in India have changed substantially from the last couple of decades. The Reserve Bank of India (RBI) adopted the multiple indicator approach in 1998 by replacing the monetary targeting to transmit signals to the market through various instruments such as cash reserve ratio, open market operation, and bank rate. Later in 2000, to modulate liquidity in the economy, the Liquidity Adjustment Facility (LAF) was introduced. In this mechanism, the RBI set a corridor where the liquidity was injected at repo rate (ceiling) and absorbed at reverse repo rate (floor), respectively. Since then, the RBI uses the repo rate as the main monetary policy instrument to influence output and inflation in the economy. In 2014, RBI introduced a new Consumer Price Index (CPI) by replacing the Wholesale Price Index (WPI) as the economy's new nominal anchor. Subsequently, in June 2016 RBI formally adopted flexible inflation targeting (FIT) framework where the monthly annualized CPI inflation rate targeted at 4% with upper and lower bound of 6% and 2%, respectively. The changes in the conduct of monetary procedure over the years, along with occurrences of global disturbances such as the Global Financial Crisis (GFC), oil shocks, etc., brings changes in the structural relationship among the variables, which in turn alter the impact the monetary policy shocks on macroeconomic variables over time (Cogley and Sargent 2005).

Previous studies largely estimated the traditional Structural Vector Autoregression (SVAR) model to investigate the dynamic impact of monetary policy shocks on macroeconomic variables. Examples include but are not limited to Bernanke and Blinder (1992), Sims (1992), Camarero, Ordónez and Tamarit (2002), and Suzuki (2008). However, most of the macroeconomic variables observed to have a drift in their data generating process, and their volatility process may not be time-invariant. Therefore, examining dynamic interaction among variables in a traditional SVAR setup characterized by parameter constancy and homoscedastic variance may result in inconsistent and inefficient estimates, which in turn could lead to biased inference (Nakajima 2011). In this regard, the Time-varying Parameter Vector Autoregression (TVP-VAR) proposed by Primiceri (2005) circumvent this issue by allowing the model's parameter and variance-covariance matrix to vary with respect to time, thereby enabling the researcher to trace the time-varying relationship among variables. After the influential work of Primiceri (2005), many recent empirical studies have investigated the time-varying impact of monetary policy on macroeconomic variables by employing TVP-VAR model for various countries and reported substantial time variation. For example, Nakajima (2011) for Japan, Franta, Horváth, and Rusnak (2014) for the Czech Republic, Poon (2018) for Malaysia, Tiwari, Chai and Chang (2019) for China, Çatik and Akdeniz (2019) for Turkey and Finck (2019) for Euro area.

In the Indian context, studies that evaluate the effects of monetary policy on macroeconomic variables are largely based on the traditional SVAR framework (e.g., Singh and Kalirajan 2007, Aleem 2010, Paramanik and Kamaiah 2014, Arora 2018 and Bhoi *et al.* 2017). These studies found contractionary monetary policy is effective in reducing output and inflation. To the best of our knowledge, Mohanty and John (2015) and Kumar and Dash (2020) are the only studies that employed time-varying models to address the time-varying impact of monetary policy on aggregate and disaggregate inflation dynamics. Both studies reported a positive shock to the policy rate is effective in reducing the inflation rate. Kumar and Dash (2020), by estimating Time-varying Parameter Factor Augmented Vector Autoregression

(TVP-FAVAR) model, reported improvement in aggregate inflation response to monetary policy shocks over time. These studies, however, used WPI-based inflation for their analysis. As mentioned earlier, the RBI targets CPI-based inflation for maintaining price stability in the economy. Therefore, it is essential to investigate whether monetary effective in reducing CPI-based inflation. Besides, the effects of monetary policy on output and inflation might have improved or worsened in due course of time, which needs to be answered. Considering these points, we re-investigate the impact of monetary policy shock on output and inflation in India in a TVP-VAR model with stochastic volatility.

The remainder of the paper is organized as follows: Section 2 describes the data and their sources. In Section 3, we briefly outlined the TVP-VAR methodology. Section 4 presents the empirical results, and in Section 5, we conclude our study.

2. Data and sources

The study uses monthly data spanning from January 2001 to March 2020 on the Real Gross Domestic Product (RGDP), CPI, and Call Money Rate (CMR). The data period is restricted due to the availability of data on the new CPI. Data on new CPI is available from 2011 onwards. Data prior to 2011 have been backcasted by RBI by using the CPI for industrial workers until January 2001 for empirical purposes, which is freely available on their official website. All other variables are sourced from the Handbook of Indian Statistics published by the RBI and its various publications. Following previous studies in the Indian context (Singh and Kalirajan 2007, Paramanik and Kamaiah 2014, Mohanty and John 2015, Bhoi *et al.* 2017, and Kumar and Dash 2020), we proxy inter-bank CMR as a proxy for the short-term policy rate. Since RGDP is not available on a monthly basis, one can use the Index of Industrial Production (IIP) as a proxy for monthly output. However, IIP represents a small proportion of RGDP in India. Hence, it may not be suitable for a proxy for monthly output in the economy. To overcome this problem, we convert quarterly RGDP into monthly by employing the Chow and Lin (1971) method. In doing so, we used IIP as a reference series. The Census X13-ARIMA method was employed to deseasonalized the data wherever needed.

3. The TVP-VAR model

Following Primiceri (2005), we adopted a TVP-VAR model with stochastic volatility. The methodology is explained as follows:

Consider a VAR model of the following form:

$$AY_t = \sum_{i=1}^{s} F_i Y_{t-1} + u_t \qquad (1)$$

where Y_t is $k \times 1$ vector of endogenous variables, $A, F_1, \dots, F_n$ are matrices of coefficients, s is the number of lags in the VAR model. Pre-multiplying equation (1) with A^{-1} , the reduced form of the equation can be written as:

$$Y_t = \sum_{i=1}^{s} \beta_i Y_{t-1} + A^{-1} \Omega \varepsilon_t \qquad (2)$$

where $\beta_i = A^{-1} F_i$, $V(\varepsilon_t) = I_n$ and Ω is a diagonal matrix.

Defining $X = I_n \otimes [Y_t, Y_{t-1}, \dots, Y_{t-s}]$, where $\otimes$ is Kronecker product, Eqn. (2) can be written as:

$$Y_t = \beta X_t + A^{-1} \Omega \varepsilon_t$$

The TVP-VAR model can be defined as,

$$Y_t = \beta_t X_t + A_t^{-1} \Omega_t \varepsilon_t \quad (3)$$

where matrices β_t , A_t^{-1} and Ω_t are time-varying. Further, these coefficients are modeled as

$$\beta_t = \beta_{t-1} + v_t$$

$$\alpha_t = \alpha_{t-1} + \xi_t$$

$$log\ \sigma_t = log\ \sigma_{t-1} + \eta_t$$

where β_t and the elements of matrices A_t i.e., α_t are modeled as a random walk process, and the standard deviation (σ_t) modeled as a geometric random walk process. The variance-covariance matrix of innovations v_t , ξ_t , η_t is given as:

$$V = var\left(\begin{bmatrix} \varepsilon_t \\ v_t \\ \xi_t \\ \eta_t \end{bmatrix}\right) = \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & \sum_\beta & 0 & 0 \\ 0 & 0 & \sum_\alpha & 0 \\ 0 & 0 & 0 & \sum_\sigma \end{bmatrix}$$

where I_n is an identity matrix and $\sum_\beta$, $\sum_\alpha$ and $\sum_\sigma$ are positive definite matrices.

Considering the main objective of our study and following the previous studies in the Indian context, we focus on the interest rate channel. We include only three key macroeconomic variables, i.e., output growth, inflation, and policy rate, in the following order in the TVP-VAR model.

$$Y_t = f(y_t, inf_t, prate_t)$$

where y_t and, inf_t are output growth rate and inflation rate, respectively. $prate_t$ denote monetary policy rate. We apply Cholesky decomposition to identify the structural shocks in the model. In particular, $prate_t$ is allowed to get affected by shock in output growth and inflation contemporaneously[1].

4. Empirical results and discussion

Before estimating the model, we conduct a battery of unit root tests. For that purpose, we employed the Dickey-Fuller Generalized Least Square (DFGLS) (Elliott *et al.* 1996) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) (Kwiatkowski *et al.* 1992) tests. At initial, we found the natural logarithm of RGDP and CPI to follows I (1) process. We converted RGDP and CPI into year-on-year growth rates to measures output growth rate and inflation rate[2], respectively. The unit root test results indicate that all variables under consideration are stationary at level (see Table 1). Figure 1 shows a visual plot of all variables. Next, we proceed further to estimate our model.

A lag length of 2 was chosen based on the Akaike Information Criterion (AIC). The TVP-VAR model was then estimated under a Bayesian approach with the revised Markov chain Monte Carlo algorithm proposed by Neigro and Primiceri (2015). For that purpose, we used the initial 40 data points to calibrate our model priors' distributions[3]. We sampled 11000 observations via Gibbs sampler, of which initial 1000 were discarded in burn-in.

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[1] Previous studies in the Indian context have followed similar ordering (see Aleem 2010; Bhoi *et al.* 2017)

[2] In India, the RBI measures inflation as year-on-year growth rate of CPI. Both RGDP and CPI are at base year 2012.

[3] We used data-based prior. See Primiceri (2005) for a detail on calibrating models priors.

To examine the varying effects of monetary policy, we plotted the median impulse response of output and inflation to a 1% increase in policy rate for different dates (see Figure 2). The responses of output growth observed to be negative and show substantial variations across dates. As can be seen, the responses have improved in the post-GFC dates (2011M1, 2016M1) and are observed to be larger in magnitudes, especially after the adoption of FIT in 2016. This suggests that the adoption of FIT might have enhanced the effect of monetary policy shocks on output.

The responses of inflation observed to be positive at the beginning up to 6 to 7 months for all dates; after that, the responses turn out to be negative. This implies some presence of "*price puzzle*[4]." This is consistent with the finding of Paramanik and Kamaiha (2014), and Bhoi *et al.* (2017) for India. Both studies reported positive response of inflation to a contractionary monetary policy shock. From the figure, it can be observed that contractionary monetary policy is more effective in reducing inflation prior to the adoption of FIT, i.e., the response of inflation to a positive shock to policy rate is larger in magnitudes before the adoption of FIT. Comparing the relative effectiveness of monetary policy shocks on output and inflation, the effect on the former has become stronger over time, whereas on the latter, it has weakened. This evidence is in contrast to the finding of Kumar and Das (2020). They found improvement in the response of aggregate inflation to contractionary monetary policy shocks over time. The difference in the results might be due to the methodology and aggregate inflation measures used. The varying responses of output and inflation might be attributed to the structural changes in the underlying relationship caused by changes in the conduct and operating procedure of monetary policy and the occurrence of global disturbances. Our findings concerning the response of output and inflation to monetary policy shocks are broadly consistent with the findings of previous studies in the Indian context (Singh and Kalirajan 2007, Aleem 2010, Bhoi *et al.* 2017 and Kumar and Dash 2020).

We have also reported a different set of impulse responses[5] of output and inflation for the pre-FIT and post-FIT periods (see Figure 3). It can be observed that the response of output in terms of magnitude is larger in the post-FIT period (2018M1) relative to the pre-FIT period (2007M1, 2010M1). At the same time, the response of inflation has less in the post-FIT period relative to the pre-FIT period. In other words, the response of output has improved after the adoption FIT framework, while that of inflation has worsened.

For robustness check, we have plotted the output and inflation responses for alternative dates (see Figure 4). As can be observed, output responses to a positive shock to the policy rate are negative. The responses of output are varying over time and observed improvement after the GFC. Responses of inflation, on the other hand, have lessened in magnitude over time. We also re-estimate our model by ordering the policy rate in the first position in the Cholesky decomposition. We did not find much difference in the responses of output and inflation[6] to monetary policy shocks.

The stochastic volatilities of output, inflation, and policy rate are plotted in Figure 5. The volatility of output growth has increased moderately during the crisis episodes; after that, it increases until 2011, then it declines continuously till 2018. Towards the end (after 2018), the volatility has increased significantly due to the slowdown in the economy. The volatility of inflation was low in the pre-crisis episodes. It suddenly increased during crisis episodes due to

[4] A case where price level rises in response to a positive shock to policy rate (Sims 1992).

[5] The author would like to thank the editor and reviewer for this suggestion.

[6] We do not present the results of impulse responses as the responses of output and inflation were found almost similar.

the GFC; after that, it was nearly stable until 2013, then it has significantly declined. After the adoption of FIT, it further declines until 2018. This implies that the adoption of FIT has helped in reducing the volatility of inflation. Volatility of inflation has increased towards the end due to the fluctuation in the prices of food items and global crude oil. The volatility of the policy rate has increased dramatically during the crisis episodes; after that, it was stable.

Table.1. Results of unit root test (At level)

Variable	DFGLS	KPSS
y_t	-3.71**	0.343
inf_t	-2.29**	0.387*
$prate_t$	-3.76***	0.355*

Note:

1. *, ** and *** denotes test statistics are significant at 10%, 5% and 1% level, respectively.
2. The null hypothesis for the DFGLS test is “series is non-stationary” whereas that for the KPSS test is “series is stationary”.

Source: Author’s calculation

5. Conclusion

The study estimates a TVP-VAR model to answer two crucial questions. 1) Are the effects of monetary policy on inflation and output have changed over time? 2) Has monetary policy becomes less effective in India? From the impulse responses, we find that output growth and inflation's responses to contractionary monetary policy shocks are negative and have changed substantially over-time. The effect of monetary policy on inflation has weakened over time, whereas it has become stronger on output. The stochastic volatilities of output and inflation have changed significantly during the estimation period. The changing volatility of inflation suggests that the adoption of FIT has helped in reducing the volatility of inflation. Overall, our study suggests that RBI can efficiently use the call money rate as an operating target of monetary policy to affect the output and inflation level in the economy.

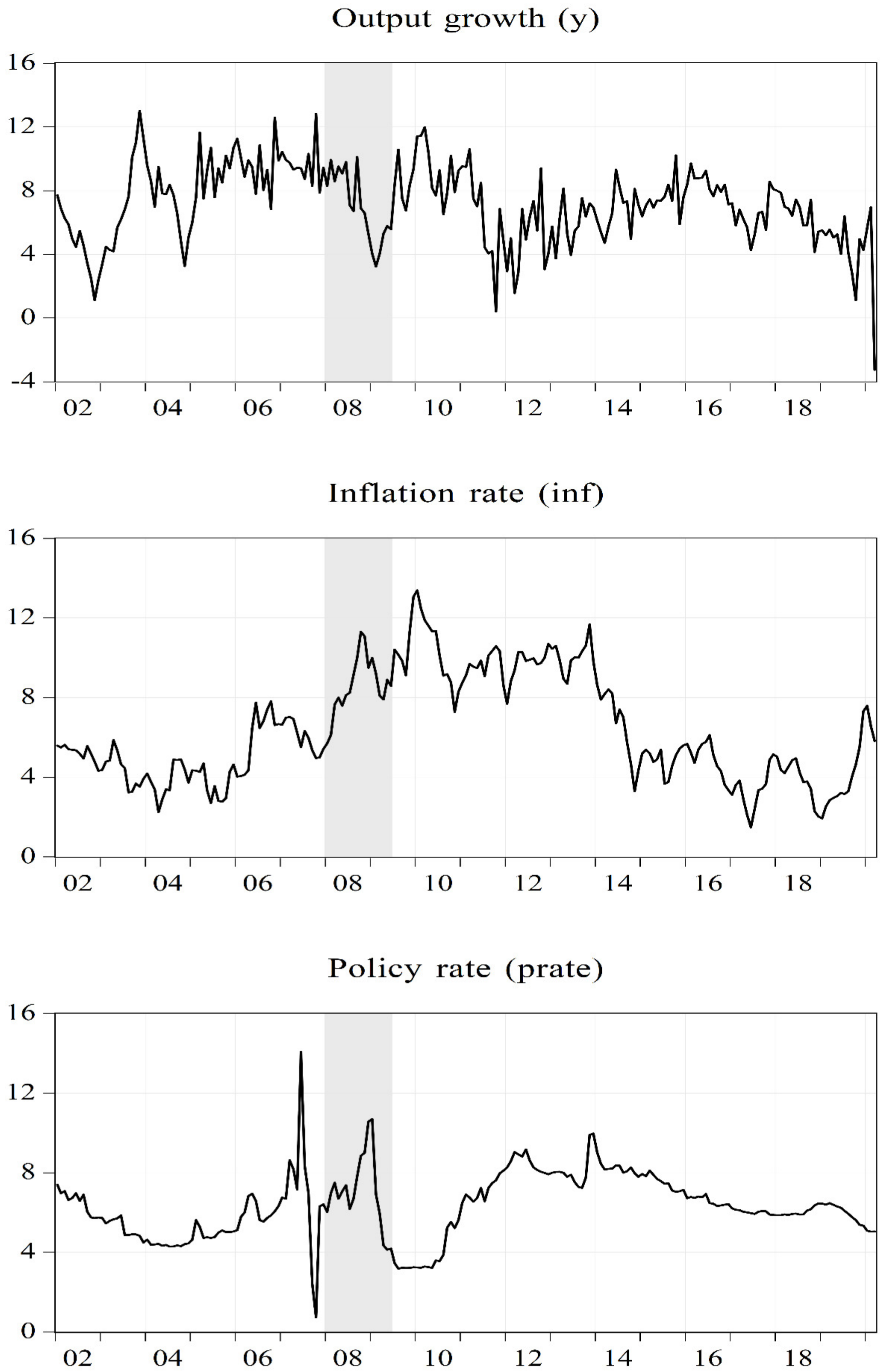

Figure 1. Plot of output growth, inflation rate, and policy rate. The shaded area represents GFC episodes

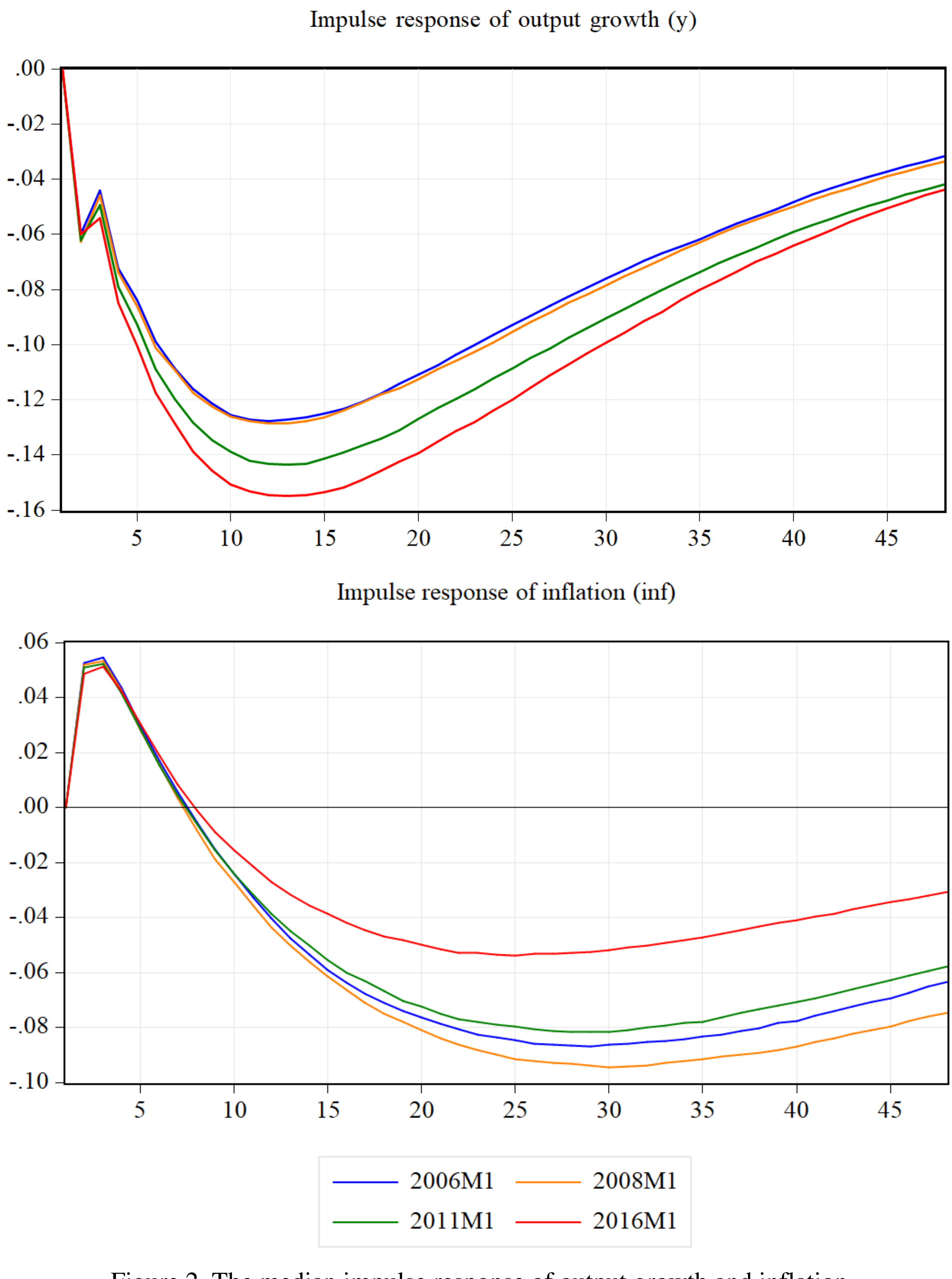

Figure 2. The median impulse response of output growth and inflation
Source: Author’s estimation

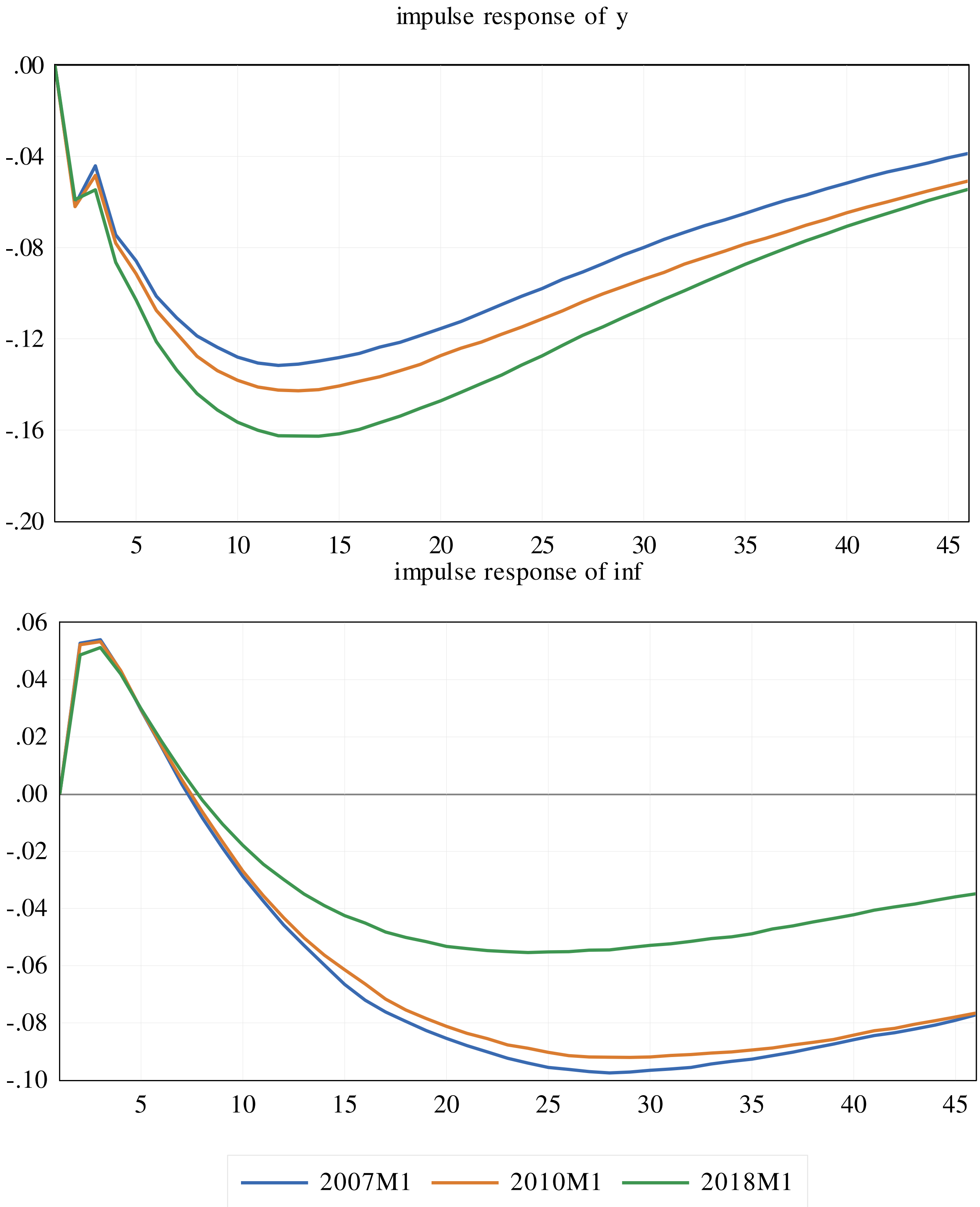

Figure 3. Median impulse response of output and inflation to policy rate for pre-FIT (2007M1, 2010M1) and post-FIT (2018M1) period

Source: Author’s estimation

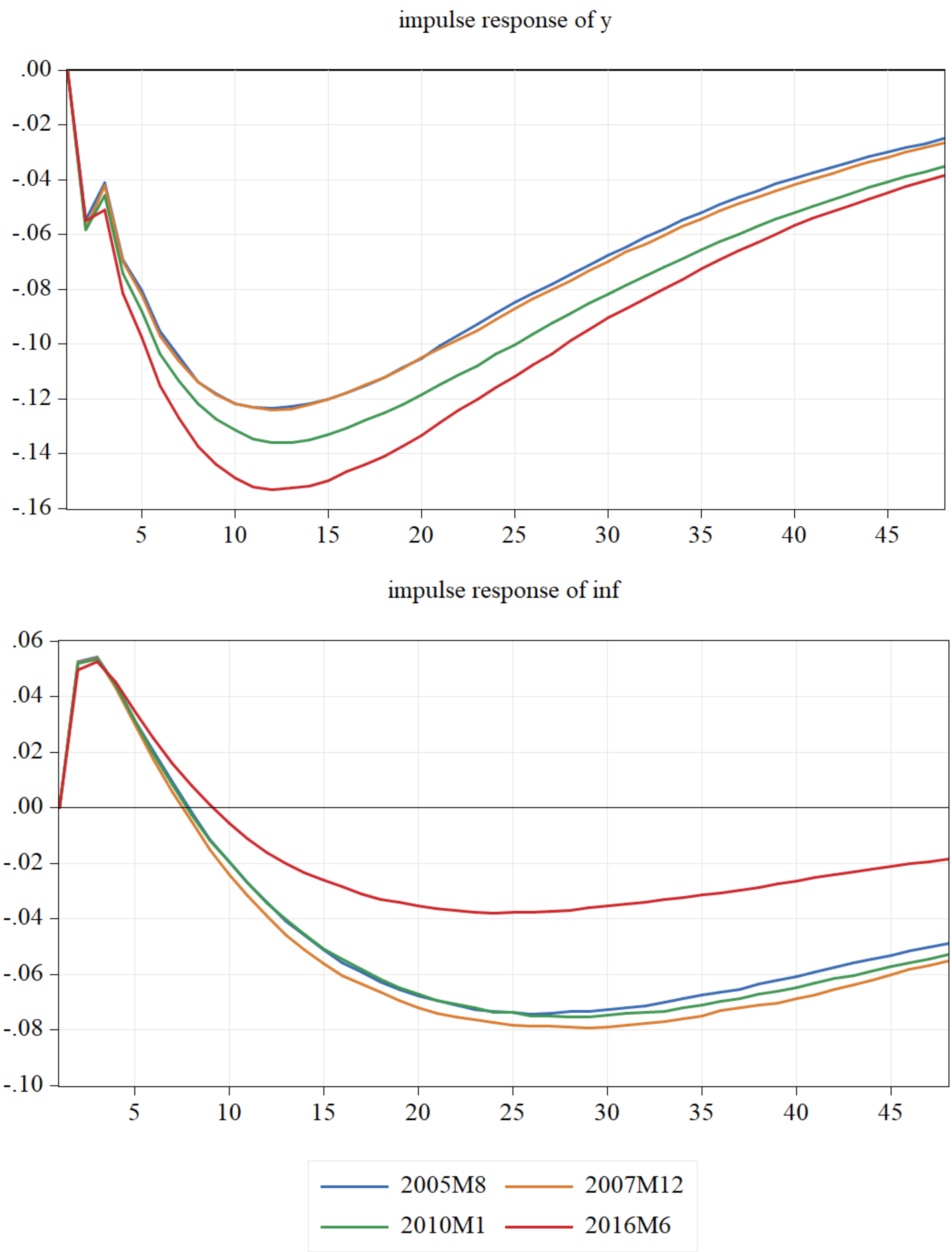

Figure 4. The median impulse response of output growth and inflation (for alternative dates)

Source: Author's estimation

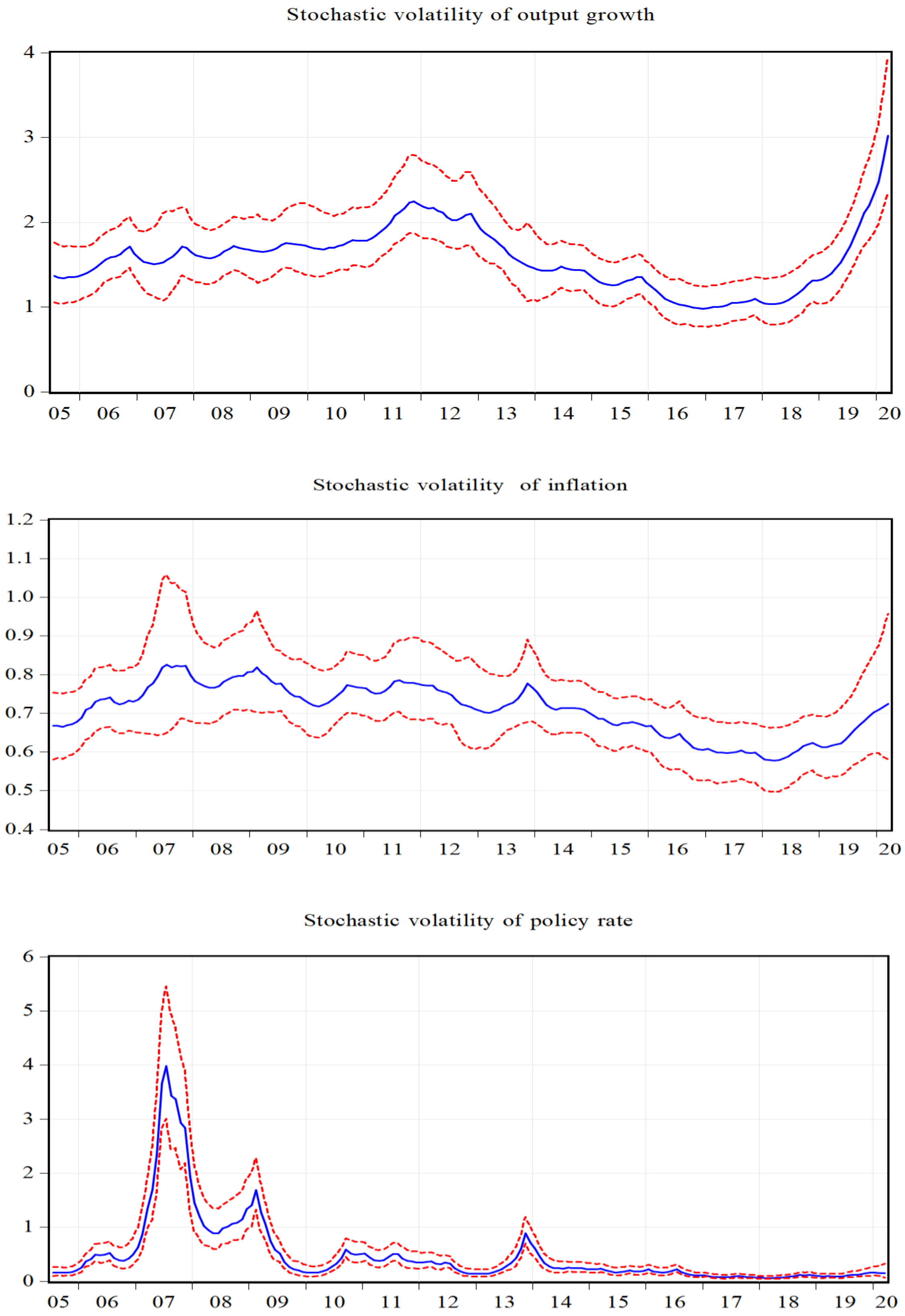

Figure 5. Stochastic volatilities of variables with 68% confidence band

Source: Author’s estimation

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