**Dynamic Effects of Monetary Policy Shocks on Macroeconomic Volatility in the United Kingdom[#]**

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**Abstract**

We use constant and time-varying parameters vector autoregressive models that allow the estimation of the impact of monetary policy shocks on volatility of macroeconomic variables in the United Kingdom. Estimates suggest that an increase in the policy rate by 1% is associated with a rise in unemployment and inflation volatility of about 10% on average, with peaks observed during episodes of local and global crises.

**Keywords:** Non-Linear SVAR, Stochastic Volatility, Monetary Policy Shock

**JEL Codes:** C32, E30, E40, E52

## 1. Introduction

There is widespread international evidence that uncertainty shocks can cause business cycle fluctuations (see for example, Bloom, 2014, 2017; Gupta et al., 2018, 2019, 2020; and references cited therein) and drive policy decisions (Christou et al., 2019a; Çekin et al., 2020). However, as recently pointed out by Ludvigson et al. (forthcoming) uncertainty is not necessarily exogenous, and hence what factors drive it is an important issue for the policymakers. In this regard, as shown empirically for the United States (US) by Mumtaz and Theodoridis (2020), (contractionary) monetary policy shock itself can lead to changes (increase) in uncertainty. Using a New-Keynesian model (with search and matching labour frictions and Epstein-Zin preferences), Mumtaz and Theodoridis (2020) point out that theoretically this is the case since these volatility effects are driven by the coexistence of agents' fears of unemployment and concerns about the (in) ability of the monetary authority to

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reverse deviations from the policy rule (with the impact magnified by the agents' preferences).

In this short note, we aim to analyse the same issue empirically for the United Kingdom (UK) – another major country in the global economic system, using structural vector autoregressions (SVAR) with stochastic volatility (extended to allow for feedback from the endogenous variables to the volatility). The decision to look at the UK was also motivated by the availability of long-span of consistent monthly data (particularly associated with unemployment rate), in our case 1960-2019, which is important to obtain reliable inferences, particularly from the time-varying framework, which can get overparameterized quickly when sample sizes are small, and hence provide statistically insignificant results. The relatively long sub-sample also allows us to provide a comparison of our work with that of Mumtaz and Theodoridis (2020), who used a similar post-World War II sample period of 1957-2007 for the US. But note unlike these authors, we look into the unconventional monetary policy shocks as well, by incorporating the zero lower bound situation in our sample period. While there exist papers that have analysed the impact of uncertainty shocks on macroeconomic variables and monetary policy for the UK (see for example, Redl, 2017; Christou et al., 2019b; for a review), to the best of our knowledge, this is the first attempt to study the impact of monetary policy shocks on the volatility of its macroeconomic variables. The remainder of the paper is organized as follows: Section 2 presents the data and methodology, while Section 3 discusses the results, with Section 4 concluding the paper.

## 2. Data and Methodology

Our study proceeds along two lines; one, estimating the level and volatility effects of monetary policy shocks on macroeconomic variables; two, adopting both constant parameter and time-varying parameter SVAR models denoted as CP-VAR and TVP-VAR respectively. Mumtaz and Theodoridis (2020) suggest that monetary policy uncertainties can drive volatilities in the variables and we can expect some feedback.

Thus, we define a vector of endogenous variables $z_t$ as $z_t = \left[ urate_t \ \inf_t \ prate_t \ tspread_t \right]'$ where the observables are unemployment rate ('urate'), inflation rate ('inf'), monetary policy rate ('prate') and term spread ('tspread'). Data for the UK on civilian unemployment rate, annual CPI inflation, an interest rate representing the policy instrument and the spread of 10 year government bonds over the three-month Treasury bill rate is derived primarily from the Main Economic Indicators (MEI) database of the OECD. The data is monthly and runs from 1960m1 to 2019m10, with the start and end dates being purely driven by data availability at the time of writing this paper. The first ten years are used as a training sample with estimation carried out over the period 1970m1 to 2019m10. Note that since our sample period involves the zero lower bound and unconventional monetary policy period, we use the three-month Treasury bill rate as the measure of monetary policy till 2008m12, and then the shadow short rate (SSR) of Wu and Xia (2016),[1] derived from a three-factor shadow rate term structure model (SRTSM), over the period of 2009m1 to the end of the sample period.

The CP-VAR and TVP-VAR for the level dynamic effects are among the observables and are respectively specified in Eq. (1) and Eq. (2) as follows:

$$z_t = c_0 + \sum_{i=1}^{p} \varpi_i z_{t-i} + \varepsilon_t \qquad (1)$$

$$z_t = c_{0,t} + \sum_{i=1}^{p} \varpi_{i,t} z_{t-i} + \varepsilon_t \qquad (2); \textit{for } t = 1,2,...T.$$

where $c_{0,t}$ is a 4x1 vector of time-varying coefficients of constants like its fixed counterpart ($c_0$); $\varpi_{i,t}$ are 4x4 matrices of time-varying coefficients of the lagged observables analogous to the constant coefficients, $\varpi_i$; $p$ is the optimal lag length of the VAR model chosen with Schwarz Information Criterion (SIC).

[1] The SSR is available for download from: https://sites.google.com/view/jingcynthiawu/shadow-rates?authuser=0.

We augment Eq. (2) to account for stochastic volatilities in endogenous variables and express dynamic relationships with the level of endogenous variables as follows:

$$z_t = c_{0,t} + \sum_{i=1}^{p} \varpi_{i,t} z_{t-i} + \sum_{j=1}^{q} \omega_j \tilde{h}_{t-j} + \zeta_t \qquad (3)$$

$$\tilde{h}_t = c + \rho \tilde{h}_{t-1} + \sum_{j=1}^{q} \delta_j z_{t-j} + v_t \qquad (4);\ \mathrm{E}(\varepsilon_t, v_t) = 0$$

where $\tilde{h}_t$ is the 4x1 vector of stochastic volatilities; $\zeta_t = \Omega_t^{1/2} \varepsilon_t$; the matrix of covariance residuals, $\Omega_t$ is decomposed as $\Omega_t = \Lambda^{-1} H \Lambda^{-1\prime}$ for $H$ being a diagonal matrix of orthogonalised volatility shocks and $\Lambda$ the matrix of contemporaneous effects.

The Eqs. (3) and (4) are specified to ensure feedbacks between level and volatilities of the observables with the presence of $\sum_{j=1}^{q} \delta_j z_{t-j}$ and $\sum_{j=1}^{q} \omega_j \tilde{h}_{t-j}$ in the specifications, in line with the study's objective.

The estimation process of the model parameters considers 5000 replications and 4000 burn-ins, leaving 1000 estimates from where the parameter values were averaged. The final VAR model was estimated with optimal lag length of 12 and lag 3 for the observables in both transition and volatility equations. From the resulting constant parameter and time-varying parameter models, we obtain impulse response functions for both the level and volatility responses of the observables to policy shocks as follows: sixty (60 months) forecast horizon, 100 model simulations and 500 retained Gibbs draws.

The monetary policy identification scheme uses contemporaneous sign restrictions, as originally developed by Uhlig (2005). We assume that a contractionary policy shock increases the short-term interest rate on impact and leads to a rise in unemployment and a fall in CPI inflation, so as to ensure that we do not encounter the "output and price puzzles", respectively. [2] In this regard, it must be emphasized that following Christiano et al. (1999, 2005), the number of studies examining the macroeconomic implications of monetary policy shocks has massively increased (Paul, 2020), with the debate on the exact identification of the monetary policy shock, besides the monetary policy instrument itself (Romer and Romer, 2004), still open among both scholars and policymakers (Nakamura and Steinsson, 2018a, b).

Keeping these issues in mind, we evaluate the various outcomes of the sign restrictions-based estimations in the subsequent section.

## 3. Results

In this section, we present empirical evidence on the first- and second-moments impact of a monetary policy shock, via the usage of impulse response functions (IRFs). In Figure 1, we document the results of the impulse responses for the CP-VAR model with stochastic volatility following a monetary policy shock. Subsequently, we present the same for the TVP-VAR model as an extension in Figure 2.

Figure 1 presents the impulse response to a contractionary monetary policy shock normalised to increase the short term interest rate by 100 basis points. The unemployment rate rises by about 0.35 percentage points at the three year horizon, though inflation does not display a significant impact, barring the first couple of months. Finally, the term spread falls by about 80 basis points on impact. The last three rows of the figure present the response of the unconditional volatility to this shock. It is clear from the figure that the volatility of all endogenous variables rises in response to this shock, but in a slightly delayed fashion. This is reflected in the measure of overall volatility, the log determinant of the covariance matrix of the endogenous variables which shows a significant increase between 3- to 24-month-ahead, with the

[2] Besides sign restrictions, studies have also used large-scale factors-augmented VARs or Bayesian VARs (see for example, Bernanke et al., (2005), Bańbura et al., (2010)) to solve the theoretically inconsistent results of the output and price puzzles following a monetary policy shock often observed in small-scale monetary VARs (Walsh, 2017). Note that, price and output puzzles relate to situations where both output and price level (or inflation rate) tends to increase initially, rather than decreasing immediately, following a contractionary monetary policy shock.

magnitude of the response of all the variables being quantitatively similar and around 10% (barring inflation variance, for which the effect is slightly lower) after 6 months following the shock.[3] Note that, this value is similar in comparison to the corresponding estimates for the US as obtained by Mumtaz and Theodoridis (2020).[4]

The time-varying impulse responses of volatility to a 1 unit monetary contraction (based on sign restrictions to identify the policy shock) are shown in Figure 2, with the impact on unemployment being exceptionally high in the 1990s, following the adoption of inflation targeting by the Bank of England, and also in the wake of the global financial crisis of 2007-2008 and the European sovereign debt crisis of 2010, and the Brexit vote in 2016. A similar picture also emerges for the inflation rate. More importantly, the impact on volatility remains positive and persistent throughout the sample period, with highest levels reached during the various recent global and local crises, as also observed for the US by Mumtaz and Theodoridis (2020).

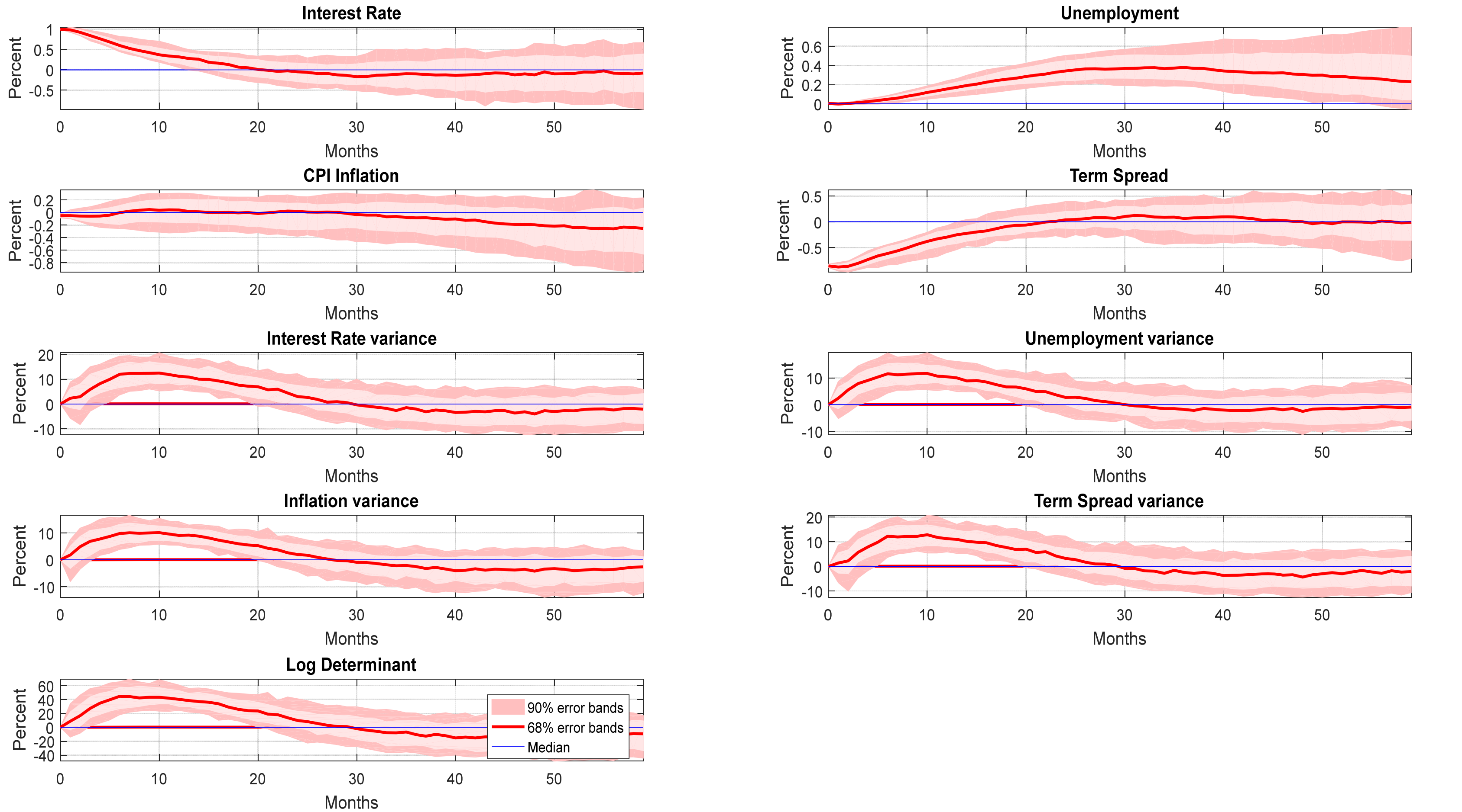
This observation of increased response of uncertainty to monetary policy shocks during episodes of crises for the UK can be explained by the same theoretical framework of Mumtaz and Theodoridis (2020) used for the US, which relies on a New Keynesian model, with search and matching labour frictions and Epstein-Zin preferences. The model predicts that volatility effects are driven by the coexistence of agents' fears of unemployment and concerns about the (in) ability of the monetary authority to reverse deviations from the policy rule with the impact magnified by the

[3] Based on the suggestion of an anonymous referee, we repeated our analysis by replacing the unemployment rate, with the year-on-year growth rate of the industrial production index (IPI), derived from the MEI database of the OECD over the period of 1961m1 to 2019m10. We found that our basic conclusion, complete details of which are available upon request from the authors, in terms of the contractionary monetary policy enhancing macroeconomic uncertainty continues to hold. Note that, we do not present these results explicitly in the paper to save space, and also because the explanation of the empirical results rely on a theoretical model of search and labor market frictions associated with unemployment and not industrial production, and hence ensures consistency across the theory and empirics.

[4] Based on the suggestion of an anonymous referee, we also identified the monetary policy shock based on a recursive (Cholesky) decomposition scheme, with the variables ordered as unemployment rate, inflation, policy rate, and the term-spread. The results from the recursive identification is presented in Figure A1 in the Appendix of the paper, and indicates that our basic results are qualitatively similar, but we do observe the existence of the "price puzzle", which in turn provides the empirical motivation for the sign-restriction approach in our context.

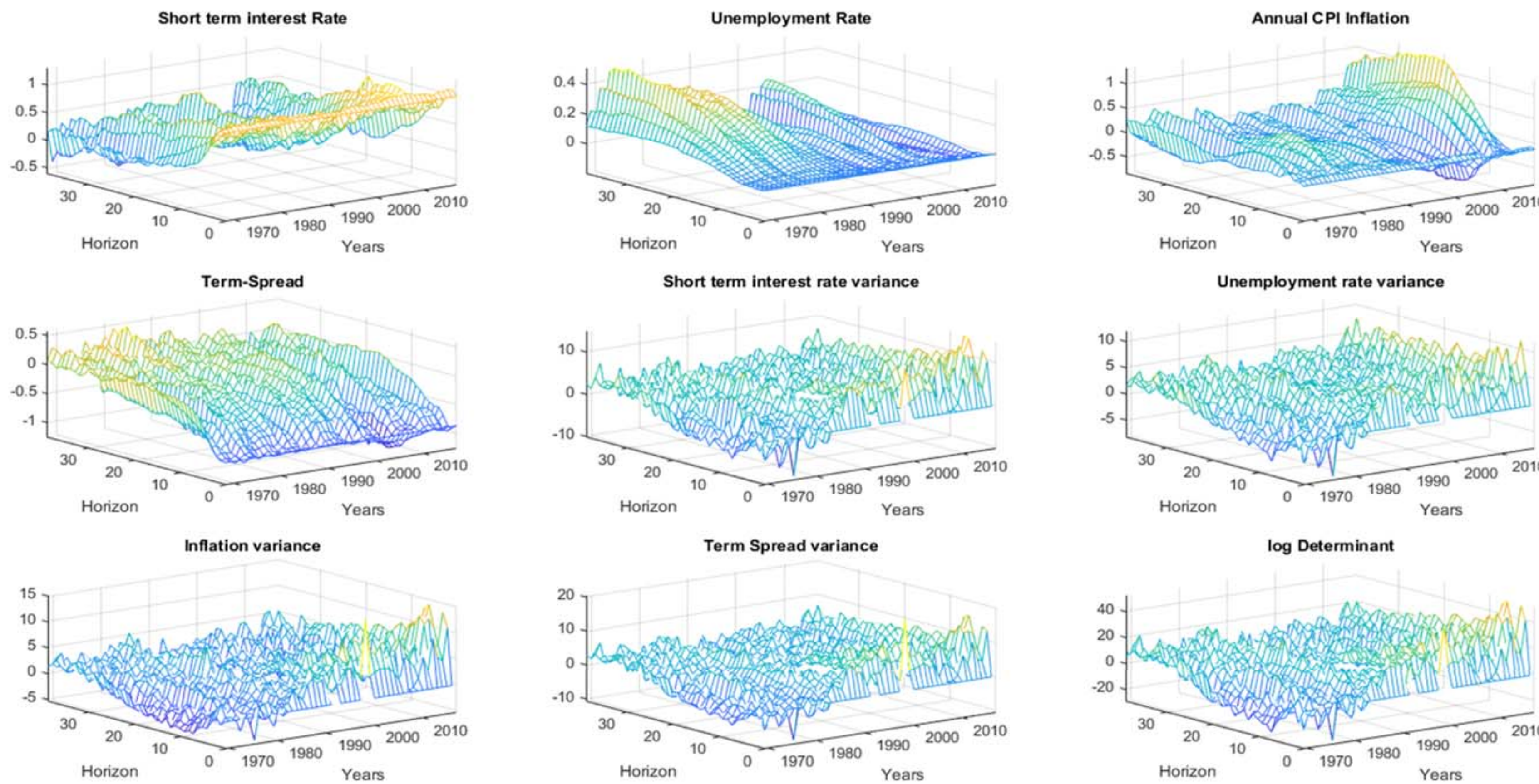
agents' preferences. Specifically speaking, agents in this economy price adverse shocks more heavily in 'bad times' when compared to 'good times', causing us to observe higher volatility due to monetary policy shocks when the economy faces recession and crises-like situations, as picked up the time-varying impulse responses in our empirical results for the UK.

**Figure 1: Sign-Restricted IRF Plots from the Constant Parameter VAR Model**




**Notes:** The solid line is the median. The light shaded area is the 68% error band while the dark shaded area is the 90% error band.

**Figure 2: Sign-Restricted IRF Plots from the Time-Varying Parameter VAR Model**




**Notes:** Plots correspond to posterior median impulse response. The impulse response is calculated every 12th month in the sample.

## 4. Conclusion

This study investigates the response of macroeconomic volatility of the UK to an unexpected increase in the monetary policy rate. For this purpose, we develop an empirical model that allows us to estimate the response of macroeconomic volatility to a monetary policy shock. The empirical model suggests that a 100 basis points increase in the policy rate causes unemployment and inflation volatility to rise by around 10% on average above its unconditional value, with peaks observed during the global financial and sovereign debt crises, and also in the wake of the Brexit vote. Our results imply that under episodes of heightened uncertainty, loose monetary policy can assist in reviving the economy by not only reducing unemployment in the UK, but by also reducing overall volatility associated with macroeconomic variables.

As part of future research, following Kirchner et al., (2010), one could analyse the driving factors behind the time-varying impulse responses for each variable at various forecast horizons based on regression analysis. In particular, with our results in line with the theory that the size of the impact of monetary policy on volatility is contingent on agents' fears of unemployment and concerns about the (in) ability of the monetary authority to reverse deviations from the policy rule in association with agents' preferences, we could test these theoretical propositions by obtaining appropriate empirical proxies for these parameters, and conducting estimations which would incorporate direct and interaction effects. Further, it would be interesting to extend our study to other developed and emerging markets, contingent on the availability of long span of data to ensure that we obtain robust inferences especially in the context of the time-varying framework. Moreover, one could also analyse the role of US monetary policy shocks, given its importance in affecting macroeconomic aggregates around the world (Iacoviello and Navarro, 2019), in impacting uncertainty of other economies over and above domestic monetary policy changes.

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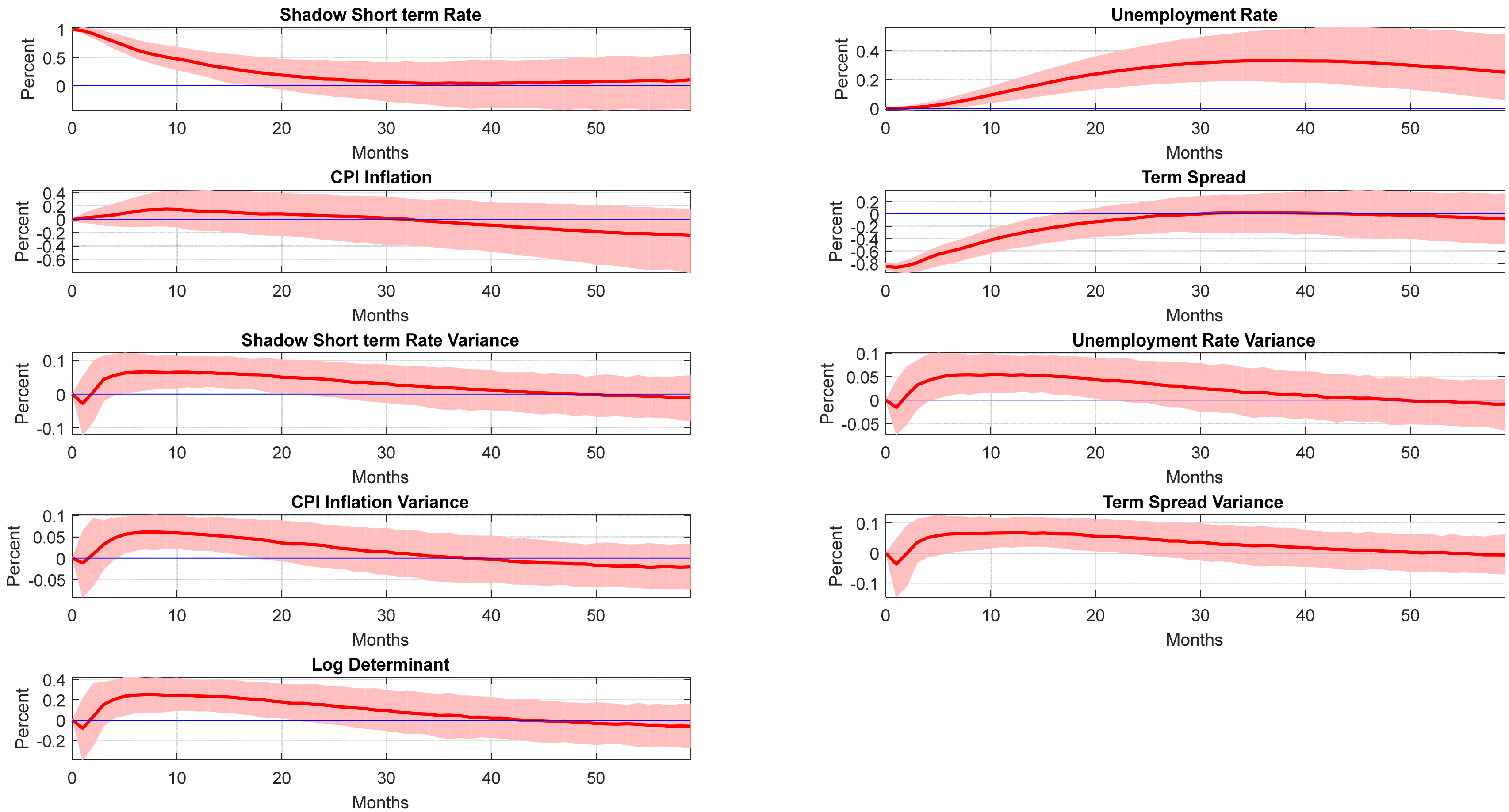
## Appendix:

### Figure A1: Cholesky Decomposition IRF Plots from the Constant Parameter VAR Model

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