Uncertainties under monetary tightening and easing shocks and different market states

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Abstract

We examine the impact of monetary policy shocks on monetary policy and stock market uncertainties, testing for asymmetric responses to tightening/easing shocks, business cycle phases, and stock market volatility regimes. To identify monetary shocks, we use a theoretical vector autoregressive model of the US economy that accounts for the interconnectedness between monetary policy and the stock market. Then, with local projections, we estimate the uncertainty responses to such shocks. Our findings suggest that monetary policy holds promising potential as a countercyclical tool to reduce uncertainties, through easing policies in recessions and tightening policies in expansions or tranquil stock market regimes.

JEL classification*:* E32; E44; E52

Keywords: business cycle; monetary policy; shocks; stock market; uncertainty; volatility

1. Introduction

Uncertainty can affect the injections and withdrawals made by economic agents into the circular flow of income, which have multiplier and accelerator implications for the growth of the economy and stock market. Several studies relate uncertainty, in its different forms, to macroeconomic and financial performance. Recently, Husted *et al.* (2020) emphasise the negative link between monetary policy uncertainty (MPU) and investment, Ko and Lee (2015) point out the negative relationship between economic policy uncertainty and stock prices, and Mao and Huang (2022) find that climate policy uncertainty reduces green innovation by increasing credit constraints. In addition, others, such as Dai and Zhu (2023), show the dynamic risk spillovers among economic policy uncertainty, commodity markets, and financial sectors.

In this paper, we address three interconnected research questions: what are the effects of monetary policy (MP) shocks on uncertainties related to monetary policy and the stock market? Do tightening and easing shocks incite asymmetric uncertainty responses? Are MP shocks consistent across all states of the economy and the stock market? Given the strong linkages between MP actions and uncertainties associated with MP and the stock market, the answers to these questions are particularly important to central bankers for policy appraisal purposes and for investors to gauge the impact of policy related news on uncertainty levels. Yet, discrepancies exist around exactly how MP movements affect uncertainties. For instance, Bekaert *et al.* (2013) show that monetary easing decreases risk aversion and uncertainty in the stock market. However, Funashima (2022) finds such expansionary monetary shocks increase MPU, while contractionary monetary shocks yield negligible effects, and argue that unanticipated monetary easing can counter-intuitively depress stock prices through an elevated environment of uncertainty. We contribute to this line of research by explicitly analysing the link between MP actions (including tightening and easing shocks) and the stock market, in terms of both MPU and stock market uncertainty (SMU).

Another contribution of our work, is that we consider whether such relationships change over the business cycle and volatility regimes in the stock market. The unanticipated nature of MP shocks enables us to explore the response of uncertainty across business cycle and stock market states. Interestingly, the analysis of all well-known MP shocks in the literature, such as those of Romer and Romer (2004) or the more recent of Jarociński and Karadi (2020), reveals that both tightening and easing shocks occur over time, without being particularly clustered around certain periods. Thus, predicting the performance of macroeconomic and financial variables, during different conditions in the economy and stock market, remain revolving empirical research issues. In particular, the potency of MP in recessions compared to expansions is uncertain (Tenreyro and Thwaites, 2016). Moreover, since changes in macroeconomic activity are a key determinant of stock returns, the latter becomes more complex to predict when the economy is in recession because macroeconomic indicators themselves become harder to forecast in such times (Hamilton and Lin, 1996). Furthermore, although stock market volatility is important for predicting macroeconomic volatility, the converse has historically been less convincing and given rise to the so-called *volatility puzzle* (Schwert, 1989). Finally, considering whether asymmetric responses exist across business cycle phases and volatility regimes in the stock market is key given the importance of the relationship between uncertainty and the business cycle, as addressed in Bloom (2014), and between business and financial cycles, as recently documented in Yan and Huang (2020). Interestingly, the former suggests that uncertainty increases in recessions and decreases in booms, since usually shocks hitting output also increase uncertainty. Additionally, Bloom (2014) explains that in recessions (booms), lower (higher) economic growth naturally induces an environment of more (less) uncertainty.

As a third contribution, given the problem of appropriately identifying MP shocks at the zero lower bound (see, e.g., Basu and House, 2016; Ramey 2016), we provide a solution to capture quantitative easing injections within policy rate innovations. Thus, we overcome the endpoint sample constraint faced in numerous empirical studies, including Funashima (2022), and extend the sample beyond the pre-Great Recession era to include more recent data. To do this, we augment the structural vector autoregression (SVAR) suggested in Bjørnland and Leitemo (2009), which facilities the identification of conventional MP shocks in a model that permits the interaction between policy rates and the stock market (Gambacorta *et al.*, 2014), by replacing the federal funds rate series with shadow short rates (SSR). Krippner (2020) explains that SSR estimates are generated regressors to proxy policy interest rates that reflect unconventional MP actions.

2. Methods and data[1]

Our empirical procedures consist of two steps. In the first step, we estimate the SVAR suggested in Bjørnland and Leitemo (2009) to obtain MP shocks in a model that embraces the interconnectivity between the stock market and the policy rate. Their SVAR consists of a combination of short and long run restrictions. The short run restrictions are indicated by the zero elements positioned in the contemporaneous 5x5 matrix in Eq. (1):

[1] Replication files available at https://anonymous.4open.science/r/Replication-Files---FRL-DFBE/.

$$\begin{bmatrix} q_t \\ p_t \\ c_t \\ s_t \\ r_t \end{bmatrix} = B(L) \begin{bmatrix} S_{11} & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & S_{45} \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_t^q \\ \varepsilon_t^p \\ \varepsilon_t^c \\ \varepsilon_t^s \\ \varepsilon_t^r \end{bmatrix} \qquad \text{Eq. (1)}$$

where the left-hand-side of the equation is a vector of macroeconomic variables - Z_t in Eq. (2) below. Here, q_t is the log of the US industrial production (IP) index[2], detrended using a two year (24 month) seasonal differencing filter, which is considered a robust measure for removing unit roots and isolating the cyclical component of most time series of interest in economics and finance (Hamilton, 2021). p_t is the annual percent change in the consumer price index (CPI) (2015 = 100)[3]. c_t is the annual change in the log of the S&P GSCI commodity index[4]. s_t is the returns on the real S&P 500 index[5], where returns are computed as the logarithmic-difference of the real stock price index times 100, and where deflation is done using the CPI (2015 = 100). r_t is the detrended SSR[6], where the cyclical component of interest is decomposed in a similar manner to IP to induce stationarity. By using the SSR in place of the federal funds rate, we can accommodate unconventional MP activity within this macroeconomic framework.

On the right-hand-side of Eq. (1), $B(L)$ is a (5x5) convergent matrix polynomial in L, where L is the lag operator, such that $B(L) = \sum_{j=0}^{\infty} B_j L^j$ in the moving average representation of the VAR model (ignoring deterministic terms) in Eq. (2):

$$Z_t = B(L)v_t \qquad \text{Eq. (2)}$$

where v_t is a (5x1) vector of reduced-form iid residuals, with a positive-definite covariance matrix. Writing the underlying orthogonal structural disturbances (ε_t) as linear combinations of the innovations (v_t), such that $v_t = S\varepsilon_t$, where S is the contemporaneous 5x5 matrix specified in Eq. (1), Eq. (2) can be expressed as structural shocks in Eq. (3):

$$Z_t = C(L)\varepsilon_t \qquad \text{Eq. (3)}$$

[2] Retrieved from https://fred.stlouisfed.org/series/INDPRO in June 2022.
[3] Retrieved from https://fred.stlouisfed.org/series/CPALTT01USM661S#0 in June 2022.
[4] Retrieved from the Bloomberg Terminal in June 2022.
[5] Retrieved from https://uk.finance.yahoo.com/ in June 2022.
[6] Retrieved from https://www.ljkmfa.com/visitors/ in June 2022. See Krippner (2013) for details on the SSR framework.

where $C(L) = B(L)S$. The structure of the short run matrix in Eq. (1) implies that the stock market and MP variables are able to immediately react to all variables in the system but can affect macroeconomic variables, such as output and prices, with a delay. However, an additional long run restriction to reflect the neutrality of MP on the stock market is imposed, which is achieved by setting the infinite number of relevant lag coefficients in $\sum_{j=0}^{\infty} C_{45,j}$, suggested by Eq. (3), equal to zero. Hence, for the subsequent modelling that will be done in the second step, ε_t^r is the identified MP shock of interest[7].

Following Bjørnland and Leitemo (2009), we use monthly data and ensure the five variables admitted into the VAR are stationary. Our period of analysis runs from 1997m3 to 2019m12. For this, we require data from 1995m1 for the SVAR model, which is based on the availability of the SSR series. Then, 24 months are required to apply the detrending filter on the IP and SSR series. Furthermore, 2 months are lost to prime the SVAR model. In the second step, for estimating IRFs using LPs, we terminate the sample prior to the COVID-19 pandemic. Based on the KPSS tests (see Kwiatkowski et al., 1992), with intercept and intercept and trend variants, we fail to reject the null hypothesis of stationarity at the 5% level of significance, for all the series described in the vector on the left-hand-side of Eq. (1) ($\equiv Z_t$ in Eq. 2). Moreover, an optimal lag length of two months is determined for the VAR based on the Schwarz information criterion and this model satisfies the stability condition, such that no inverse roots of the AR characteristics polynomial lie outside the unit disc.

In the second step, we use newspaper-based MPU and SMU indices[8], which are measured following the approach of Baker *et al*. (2016), and estimate the impulse response functions (IRFs) of these uncertainties to the MP shock estimated in the first step. We do this using the local projections (LP) approach of Jordá (2005), smoothing the IRFs following the smooth LP approach of Barnichon and Brownlees (2019). The basic LP estimation takes the form:

$$y_{t+h} = c + \beta_h \epsilon_t^{mp} + \gamma_h' x_t + \varepsilon_{t+h} \qquad \text{Eq. (4)}$$

[7] ε_t^s is a stock market shock, while the other uncorrelated structural shocks in the ε_t vector on the right-hand-side of Eq. (1) remain uninterpreted.

[8] For consistency with Funashima (2022), the chosen MPU index data are based on Access World News, retrieved from https://www.policyuncertainty.com/equity_uncert.html in July 2022. Daily SMU index data are retrieved from https://www.policyuncertainty.com/monetary.html in July 2022 and computed as monthly averages.

$$h = 0, \ldots H$$

where y_{t+h} is a given uncertainty variable (MPU or SMU) h periods ahead, c is a constant, ϵ_t^{mp} is the MP shock, x_t is a vector of control variables, ε_{t+h} is the residual, and β_h, for h = 0, ..., H, represents the IRFs of MPU (SMU) at time *t* + *h* to the MP shock at time *t*.

To test business cycle and stock market asymmetries, the baseline specification, following Funashima (2022), which is consistent also with the specification of Tenreyro and Twaites (2016), becomes:

$$y_t = c + \beta_{t-h}^{R}\epsilon_{t-h}^{R} + \beta_{t-h}^{E}\epsilon_{t-h}^{E} + \gamma_h' x_{t-h} + \varepsilon_t \text{ Eq. (5)}$$

where ϵ_{t-h}^{R} (ϵ_{t-h}^{Turb}) represents the shocks in recessions (or in a turbulent stock market volatility regime), $\epsilon_{t-h}^{E}(\epsilon_{t-h}^{Tran})$ represents the shock in expansions (or in a tranquil stock market volatility regime), $\epsilon_t^{mp} = \epsilon_{t-h}^{R}\left(\epsilon_{t-h}^{Turb}\right) + \epsilon_{t-h}^{E}\left(\epsilon_{t-h}^{Tran}\right)$, and x_{t-h} represents the control vector.

We determine phases of the US business cycle, occurring in our sample, identified by the National Bureau of Economic Research[9]. For volatility regimes in the US stock market, we follow Mahadeo *et al.* (2022) and adopt the so-called practitioner's rule where VIX values that exceed 20 are characterised as being in the turbulent volatility regime. The VIX series[10] is especially appropriate for our analysis, as the stock market variable from the SVAR model in our first step is the real S&P 500 returns and the VIX measures near term implied volatility from price inputs of the S&P 500 index options.

Plotting the identified MP shock over the different market states, as shown in Figures 1 and 2, further reveals the motivation of our empirical exercise. For instance, it is possible to observe the fact that easing and tightening shocks do not always go in the expected direction, with unanticipated easings (tightenings) taking place in periods of expansion (recession). It is also straightforward to see that unanticipated easings and tightenings are evenly distributed across stock market regimes.

[9] Retrieved from https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions in July 2022.
[10] Retrieved from https://fred.stlouisfed.org/series/VIXCLS in July 2022

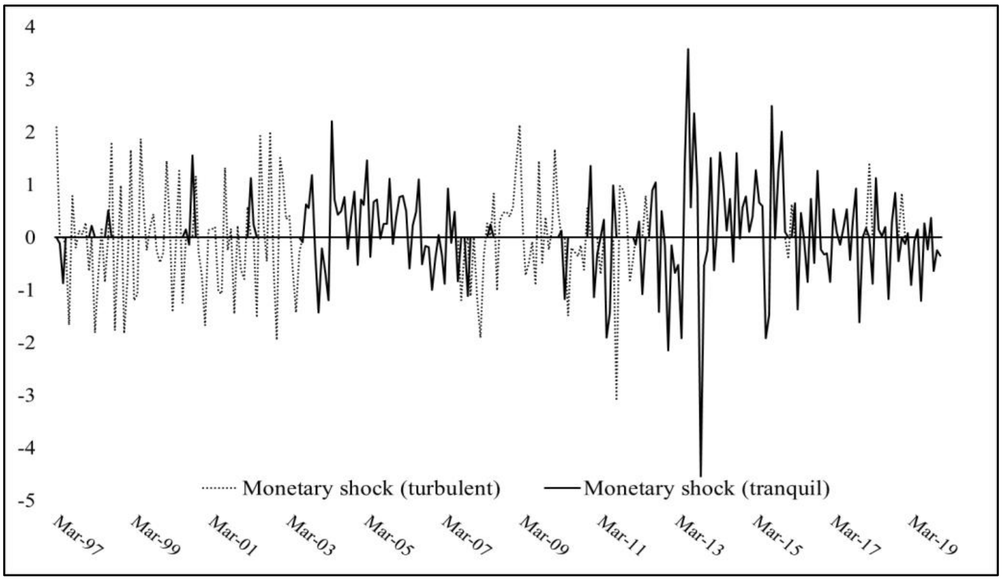


Figure 1. Monetary policy shock across stock market volatility regimes.

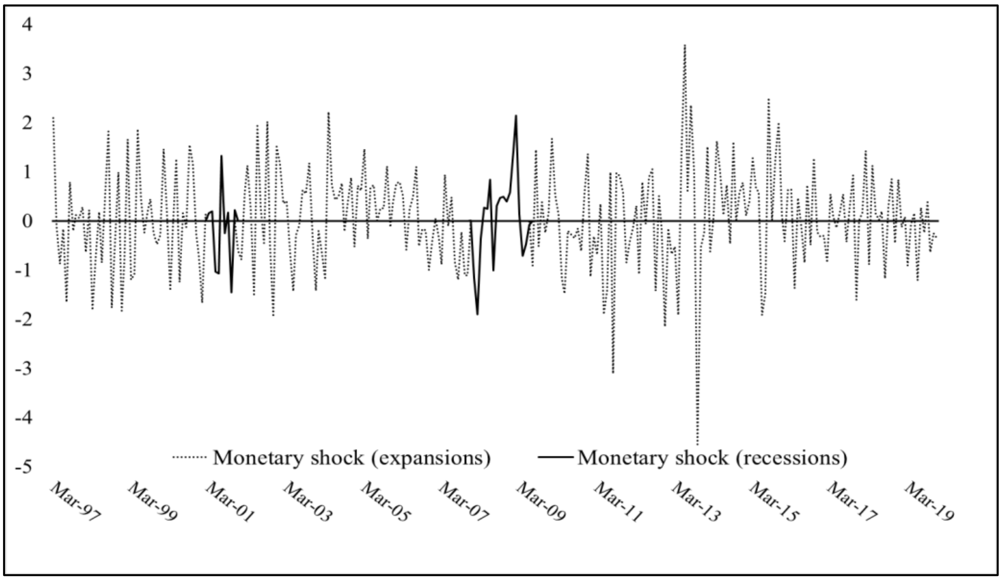


Figure 2. Monetary policy shock across business cycle phases.

3. Results and discussion[11]

Since the shape and magnitude of the IRFs for both variables are similar, in this section, we simply refer to MPU and SMU as 'uncertainty'. In panel A of Figure 3, it is possible to find the IRFs of MPU and SMU to a one-standard deviation MP shock, and to both tightening and easing shocks. The clearest

[11] Replication files available at https://anonymous.4open.science/r/Replication-Files---FRL-DFBE/.

result is the decreasing response of uncertainty after a MP tightening, which peaks around a year subsequent to the shock. This short-run reduction in uncertainty is consistent with the findings of Bekaert *et al*. (2013). However, while they find uncertainty increases in the medium and long-term, our results suggest an initial reduction followed by a non-significant behaviour. Easing shocks display a non-significant response in the level specification, but uncertainty increases in the first differences of logs specification[12]. This increase, instead, is consistent with the results of Funashima (2022).

In panel B of Figure 3, holding the disentangled sign (i.e., easing/tightening) of the MP shocks constant, we report the responses across business cycle phases and stock market regimes. Stock market regimes do not appear to play a significant role: MP shocks reduce uncertainty in tranquil times and increase it in turbulent periods, but responses are not robust to the specification in first differences[13]. The analysis of business cycle phases suggests: MP shocks reduce uncertainty in recessions, while triggering a non-significant or erratic response in expansions.

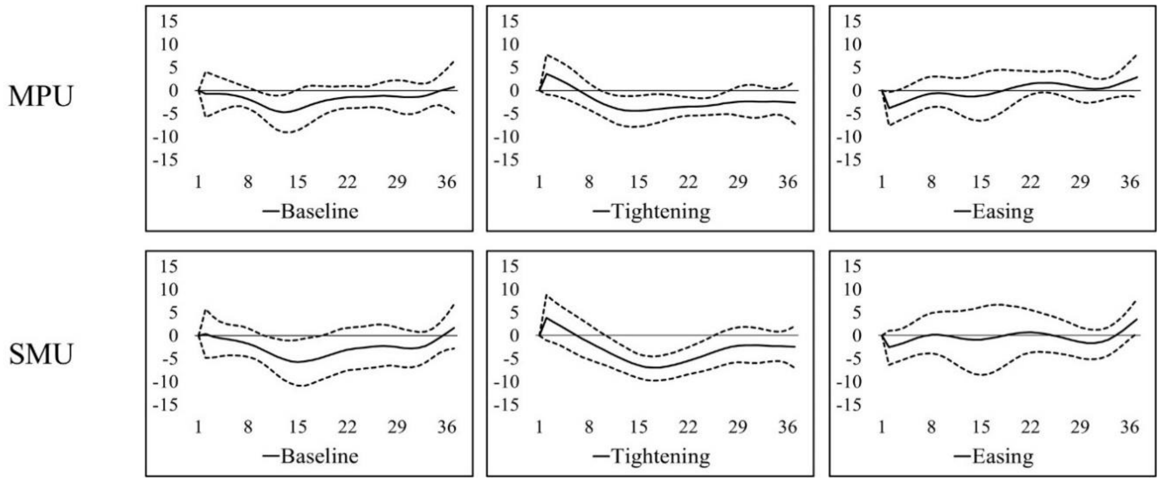
The most interesting results appear in panels C and D of Figure 3, which combines the response of uncertainties in market states in panel B with disentangled monetary tightening and easing shocks. A significant and robust result across all specifications tested is that tightening shocks reduce uncertainty in tranquil regimes and expansions, while the response in turbulent periods and recessions in not robust. This is clearly indicative of the high effectiveness of contractionary monetary policy shocks in times of expansion, as pointed out by Tenreyro and Twaites (2016) who show that tightening shocks have a clear effect in booms by reducing consumption and investment. Our results complement the existing literature by providing an insight into transmission mechanism of monetary policy shocks through the uncertainty channel.

Easing shocks, instead, seem to increase uncertainty in tranquil times and expansions, displaying some weak significant IRFs. Additionally, when analysing easing shocks in recessions and turbulent times, the most unambiguous result is that easing shocks reduce uncertainty in recessions, but only around one year after the shock and thereafter giving rise to an erratic movement. Again, in turbulent periods the

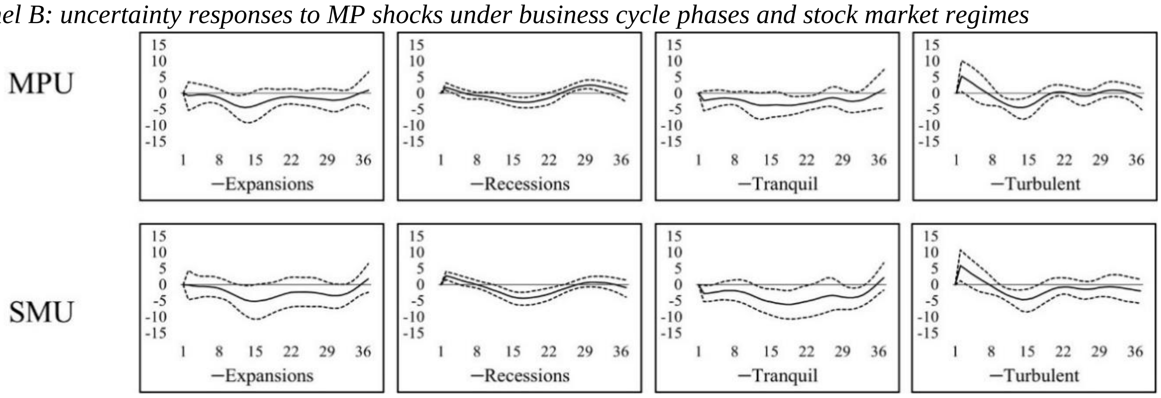
[12] Robustness checks are included in the appendix and/or available upon request.
[13] Ibid

response is not robust across alternative specifications. The lagged and erratic response in recessions indicates that monetary policy is less straightforward in recessions, once again showing consistency with the findings of Tenreyro and Twaites (2016).

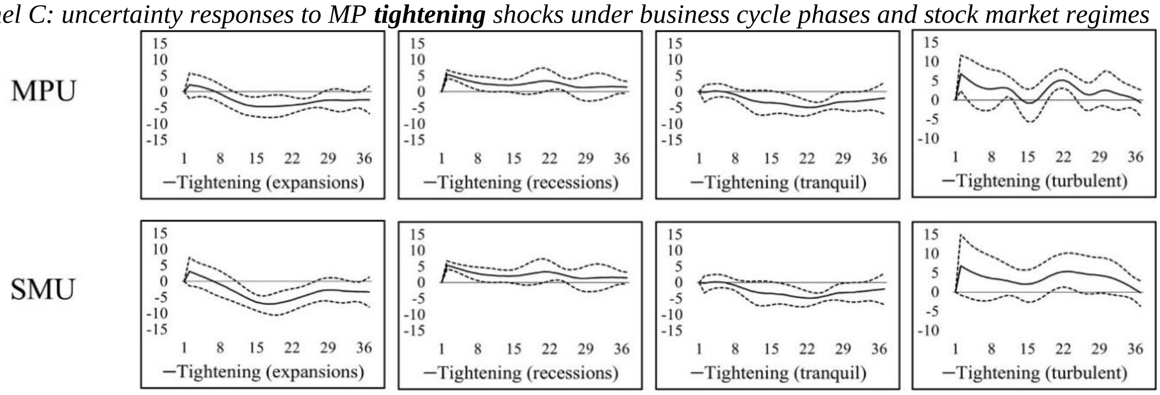
Panel A: uncertainty responses to MP tightening and easing shocks



Panel B: uncertainty responses to MP shocks under business cycle phases and stock market regimes



Panel C: uncertainty responses to MP ***tightening*** *shocks under business cycle phases and stock market regimes*



*Panel D: uncertainty responses to MP **easing** shocks under business cycle phases and stock market regimes*

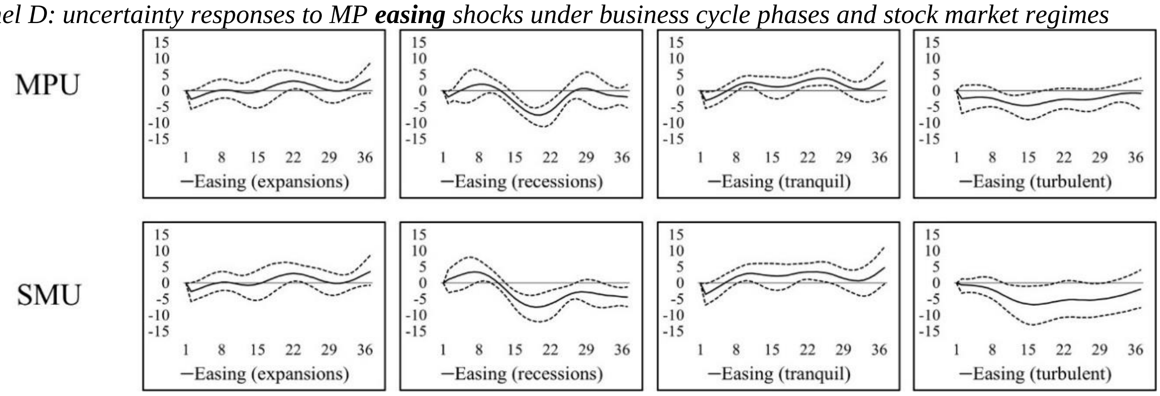


Figure 3. Uncertainty IRFs to a one-standard-deviation MP shock.
Notes: the solid black line reports the cumulated response for the first 36 months for the log level specification augmented with a linear trend. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

Interestingly, Eickmeier *et al*. (2016) analyse the effects of monetary shocks in tranquil and turbulent times, finding them to be more effective in the former than in the latter due to the fact that changes in the interest rate in a low volatility environment is more effective at changing credit conditions. The changes in uncertainty, certainly, are an important driver through which credit conditions change. Our results are consistent with tightening monetary policy shocks being more effective in tranquil times, but not with easing shocks further pushing the economy in times of low volatility, at least not through the reduction of uncertainty. This latter result could be a consequence of the fact that easing shocks are not expected in tranquil periods, and unexpected surprises, as pointed out by Jarociński and Karadi (2020), may convey additional information that offset the expected results and, in the case of our results, increases uncertainty.

4. Robustness checks[14]

The response of the MPU and SMU are robust to all the checks listed below:

1. Stochastic trends: in order to treat potential unit roots, we complemented the estimation in levels with an estimation in first differences. In addition, we also tested a specification in levels without trend assuming stationary data.

[14] Ibid.

2. Controls: we tested several sets of control variables. In particular, we added lags of the MP shock following the order of autocorrelation suggested by the autocorrelation function, lags of the dependent variable following Tenreyro and Twaites (2016) - three months, a dummy for the Great Recession period, and a linear time trend in the log level specification.

5. Conclusion

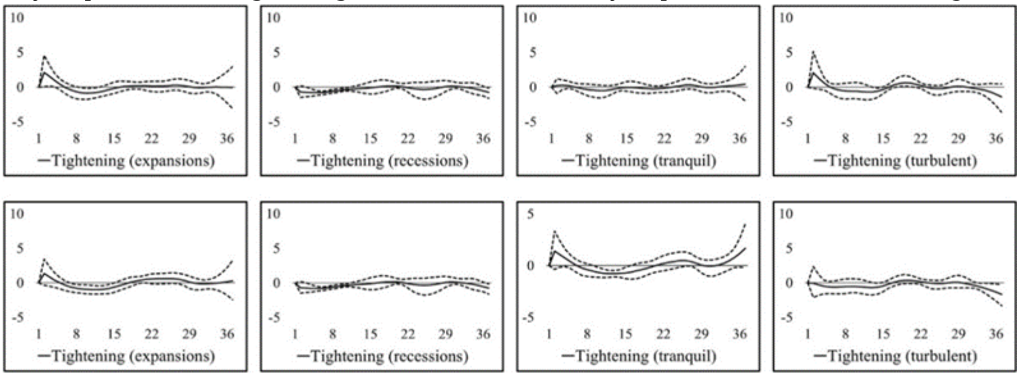
We examine whether monetary policy shocks propagate greater uncertainties regarding monetary policy and the stock market. From a structural vector autoregression model of the US economy, we identify monetary policy shocks and use smooth local projections to estimate the responses of monetary policy and stock market uncertainties to such shocks. Key contributions of our work include assessing whether there exist asymmetric uncertainty responses to tightening and easing shocks, and whether business cycle phases and stock market volatility regimes matter in this context.

Our main findings indicate that monetary tightening shocks reduce uncertainties, while easing shocks would either increase them or play a negligible effect. Across stock market volatility regimes and business cycle phases, we find tightening shocks reduce uncertainty in tranquil times and in expansions, while the responses in turbulent times and in recessions are not robust across empirical specifications. Easing shocks, instead, increase uncertainty in tranquil times and expansions, reduce it in recessions after a year or so, and display non-robust responses in turbulent periods.

Altogether, we broaden the research of Funashima (2022) by studying stock market volatility regimes and business cycle asymmetries. In particular, we find that easing shocks increase uncertainties, especially in tranquil regimes and expansions, while the response is less clear when it is not business cycle or volatility regime dependent. Moreover, we show that easing shocks could reduce uncertainty in recessionary phases. Tightening shocks, which Funashima found to be non-significant (or to only marginally reduce uncertainty), would reduce uncertainty, but particularly so in tranquil and expansionary periods. These results suggest that monetary policy holds promising potential as an effective countercyclical tool to reduce uncertainties, through easing polices in recessions and tightening policies in expansions or tranquil stock market volatility regimes.

Appendix: robustness checks – results with the first difference of logs specification

Panel E: uncertainty responses to MP ***tightening*** *shocks under business cycle phases and stock market regimes*



Panel F: uncertainty responses to MP ***easing*** *shocks under business cycle phases and stock market regimes*

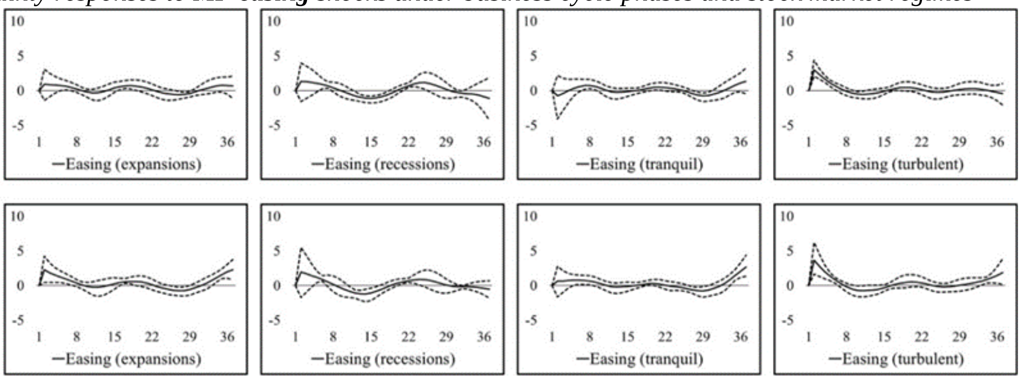


Figure A.1. Uncertainty IRFs to a one-standard-deviation MP shock.
Notes: the solid black line reports the point response for the first 36 months for the first difference of logs specification. The remainder of Figure 1 notes apply.

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