Uncertainty and Macroeconomic Policies*

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Preliminary. Please do not circulate.

Abstract

We empirically investigate whether uncertainty is exogenous or endogenous, and how it affects the effectiveness of monetary and fiscal policies. Using a shock-restricted structural vector-autoregression model, we find that both real and financial uncertainty endogenously respond to macro policies and business cycle shocks. This is not an issue of identification scheme, but the joint dynamics of real activity, policies, and uncertainty. We also investigate the role of endogenous uncertainty in the propagation of policies through counter-factual study.

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1 Introduction

Following the seminal work by Bloom (2009), there has been vast literature on how uncertainty negatively affects economic activity (Bloom et al., 2018; Christiano et al., 2014; Choi, 2017). For instance, when uncertainty hikes, economic agents postpone their consumption or investment decisions and wait until uncertainty resolves to avoid a bad outcome hiding behind heightened uncertainty. Then, as a natural question stems from the previous studies, it has been widely analyzed whether the effects of monetary or fiscal policy depend on the level of economy-wide uncertainty, both theoretically and empirically. However, there has been little research on the interaction between uncertainty and macroeconomic policies. Most of previous research assumes that uncertainty is exogenously given or at least the most exogenous variable in the economy but it is a questionable assumption as private agents consider policy actions as major sources of economic uncertainty.

In this paper, we empirically investigate the joint dynamics of real and financial uncertainties, real activity, and monetary and fiscal policies. Our main findings are two folds. First, we show that both real and financial uncertainties endogenously respond to monetary and fiscal policy, and business cycle shocks using shock-restricted restrictions in Ludvigson et al. (2019). More importantly, it is an issue of considering the joint dynamics of policies and uncertainty, rather than the identification scheme. We also investigate the role of endogenous uncertainty in the propagation of policies through counter-factual study.

In addition, we also distinguish real and financial uncertainty following Ludvigson et al. (2019). There has been various ways to define uncertainty or uncertainty shock in the literature. Some researchers consider uncertainty as a concept which is originated from economic fundamentals such as productivity (Bloom et al., 2018; Christiano et al., 2014; Park, 2019; Gilchrist et al., 2014). On the other hand, other researchers argue that uncertainty affects the economy through financial markets and can be traced by indices describing financial market conditions such as stock market volatilities (Choi et al., 2018; Caggiano et al., 2014; Bekaert et al., 2013; Basu and Bundick, 2017). This discrepancy may confuse discussions among researchers and disturb separating causes and consequences of uncertainty. We separate real and financial uncertainty and examine how they interact with policy actions and real activity.

In this paper, we use a vector-autoregression (VAR) model with a modified identification scheme based on Ludvigson et al. (2019) to analyze the interactions between macroeconomic policies and different types of uncertainties. To investigate this, we first need the identification scheme which allows us to see whether uncertainty is endogenous or exogenous. To do this, our VAR analysis relies on Ludvigson et al. (2019). By considering additional restrictions and instruments, we identify fiscal spending shocks and monetary policy shocks. We find that a tighter monetary policy decreases both real and financial uncertainty in the medium-run while its short-run effects are not significant. On the other hand, an expansionary fiscal policy relieves real uncertainty but exacerbates financial uncertainty. Do we really need to consider endogenous responses of uncertainty to macroeconomic developments? To answer this question, we restrict coefficients in the model so that uncertainties only depend on their past terms as if they are exogenous. It turns out that real uncertainty is weakly linked to the other variables compared to financial uncertainty but incorporating endogenous feedbacks into the model seems more important for real uncertainty to analyze its impacts on the economy precisely. While the impacts of real uncertainty shocks are limited in the benchmark model, they become substantial when endogenous feedback channels are closed. In addition, we also find that ignoring endogenous feedbacks can exaggerate impacts of both monetary and fiscal policy. This suggests that it is necessary to consider endogenous feedback effects through uncertainty while evaluating macroeconomic policy effects.

Related Literature This paper is closely related to the uncertainty literature pioneered by Bloom (2009). The main difference between this paper and previous studies is that we investigate a model of endogenous uncertainty while previous ones consider uncertainty shocks which are independent to economic activity. Based on this assumption, the roles of uncertainty shocks as a business cycle driver(Bloom, 2009; Bloom et al., 2018; Christiano et al., 2014) or as a source of monetary(Castelnuovo and Pellegrino, 2018; Pellegrino, 2018b,0) and fiscal policy(Berg, 2017) asymmetry are analyzed.[1] To summarize, uncertainty shocks depress economic activity and dampen the effectiveness of monetary policy while they stimulate the effectiveness of fiscal policy. This paper differs from them as we track endogenous movements of uncertainty.

This paper is not the first paper to explore endogenous uncertainty. Bachmann and Moscarini (2011) document that negative first moment shocks can induce volatile and dispersed outcomes (uncertainty). Fajgelbaum et al. (2017) provide the novel framework of endogenous uncertainty through the social learning and show that vicious cycles can rise as decreased investments can reduce information flows which are necessary to remove uncertainty. Also, Guimaraes et al. (2016) study how fiscal policy affects aggregate economy through the confidence channel in the static model. In their model, an increased government spending signals more private investment hence it prevents a coordination failure which arises due to imperfect information about the fundamental. Bekaert et al. (2013) study a

[1]The relationships between confidence, which is a similar concept to uncertainty, and the effectiveness of fiscal policy have been studied in Bachmann and Sims (2012); Guimaraes et al. (2016).

similar topic to ours as they analyze how monetary policy affects risk appetite and uncertainty. They find that a lax monetary policy decreases uncertainty. Ours differs from them as we distinguish real and financial uncertainty and consider both monetary and fiscal policy. Carriero et al. (2018) is closely related to this paper. They also examine to what extend endogenous responses of macroeconomic (real) or financial uncertainty matter for macroeconomic dynamics. The results are quite similar to ours: macroeconomic uncertainty can be considered as exogenous but financial uncertainty is not. To our best knowledge, this is the first paper to show the propagation of both monetary and fiscal policy in the environment of endogenous uncertainty.

The rest of the paper is organized as follows. Section 2 introduces the empirical strategy which allows to investigates relationships between financial uncertainty and macroeconomic policies. section 3 explains the results obtained from our empirical analysis in details. Section 4 concludes the paper.

2 Empirical Framework

In this section, we explain the empirical strategy employed to analyze interactions between uncertainty and macroeconomic policies and their influences on real activity. Specifically, our baseline empirical model is mainly based on that in Ludvigson et al. (2019). Ludvigson et al. (2019) use a three-variable VAR model which consists of variables represent real uncertainty, real activity and financial uncertainty to show whether uncertainties rise in recessions are sources of business cycle or endogenous responses to it. In this paper, we extend their model to analyze the effects of monetary and fiscal policy. We use this state-of-the-art model as it is a utmost importance to carefully identify different types of uncertainties in a unified empirical framework to study the interactions among policies, real activity and uncertainty.

Precisely, we build a four-variable VAR model which includes real and financial uncertainty, real activity and policy variable. We analyze the impact of monetary and fiscal policy one by one by incorporating a policy variable representing monetary and fiscal activity in turn. The VAR model used in this paper is basically identified by the shock restriction method applied in Ludvigson et al. (2019) and originally proposed by Ludvigson et al. (2017). Among five structural shocks, real uncertainty, real activity and financial uncertainty are identified following the shock restriction provided in Ludvigson et al. (2019) while the monetary policy and government spending shock identification is also accompanied by other restriction methods such as the sign restriction proposed by Uhlig (2005) if necessary. We are going to make clear which restrictions are used shortly.

2.1 Data

In the baseline model, we use the monthly data from October 1980 (1980 Q3) to December 2018 (2018 Q4). For the quarterly frequency model, we use the corresponding quarterly data as shown in the parenthesis. To measure the real activity, we use estimated monthly real GDP[2] provided by two sources. First, we use monthly estimates of GDP provided by Mark Watson, which cover from January 1959 to June 2010, and Macroeconomic Advisers by IHS Markit, which include from January 1992 to August 2019.[3] We first check that the movements from two sources are almost the same for overlapped periods and the correlation is close to unity. Thus, we merge them with minor adjustments.

As the measures of real and financial uncertainties, we use the measures proposed in Jurado et al. (2015) and Ludvigson et al. (2019).[4] The measured uncertainties are closely related to forecasting errors. To better understand, let us define y_{jt}^C, a variable related to real (R) and financial (F) economy specified by the category indicator $C \in \{R, F\}$. Then, the h-period ahead purely unforecastable component of y_{jt}^C conditional on all information available at time t, $\mathcal{U}_{jt}^C(h)$ is formulated in this way:

$$\mathcal{U}_{jt}^C(h) \equiv \sqrt{\mathbb{E}\left[\left(y_{jt+h}^C - \mathbb{E}\left[y_{jt+h}^C | I_t\right]\right)^2 | I_t\right]} \tag{1}$$

where I_t represents the information set at time t. Then, the measured uncertainty U_{Ct} is the weighted sample average of $\mathcal{U}_{jt}^C(h)$. We use 1-month ahead forecast uncertainty as the benchmark variable following Ludvigson et al. (2019). Since the measured uncertainty indices are in monthly frequency, we take three-month average to convert them into quarterly data when incorporated in the quarterly frequency analysis.

As a variable which summaries monetary policy stance, we use the one-year government bond yield following Gertler and Karadi (2015). This variable is employed as the policy indicator as it is highly correlated with the monetary policy instrument, the Federal Funds Rate(FFR), but is not bounded by Zero lower bound during the sample period.[5] Based on the choice of monetary policy variable, the monetary policy shock which measures the unexpected changes in the stance of monetary authority is identified by introducing an

[2]While Industrial Production (IP) index is widely used in the literature for the monthly measure of real activity, we use the estimated monthly GDP as it is better to capture business cycle fluctuations.

[3]The data provided by Mark Watson is downloadable at http://www.princeton.edu/~mwatson/mgdp_gdi.html, and the later one is downloadable at https://ihsmarkit.com/products/us-monthly-gdp-index.html with details for estimation methodologies.

[4]Uncertainty indices are downloadable at Ludvigson's website: https://www.sydneyludvigson.com/data-and-appendixes. Data appendix which explains how to construct macro, real, and financial uncertainties is also available there.

[5]We also use the FFR and shadow rate proposed by Wu and Xia (2016) as the monetary policy indicator variable in a robust check exercise. The main results, however, remain unchanged.

auxiliary instrument variable. Specifically, the monetary policy news shock identified in Nakamura and Steinsson (2018) is employed as an instrument to help identify the monetary policy shock.

The primary source that summaries government spending in the literature is the real government expenditure item included in National Account and this variable is used for the quarterly frequency analysis. However, it is not available in monthly frequency. In this reason, we use alternative government expenditure measure for the monthly frequency analysis which comes from the outlays item included in the monthly treasury statement provided by the Bureau of Fiscal Services.[6]

As will be clear in the subsequent subsections, we use two external instruments S_{1t}, S&P 500 or Dow Jones Industrial Average, and S_{2t}, a real gold price, as in Ludvigson et al. (2019), to identify two kinds of uncertainty shocks.[7]

2.2 The Structural VAR (SVAR) and Identification

2.2.1 The model

Let X_t be the four-by-one endogenous variable. The reduced form VAR model can be expressed as

$$X_t = k_t + A_1 X_{t-1} + A_2 X_{t-2} + \cdots + A_p X_{t-p} + \eta_t \tag{2}$$

where $\eta_t \sim (0, \Omega)$ is the reduced form residual and k_t is the vector of exogenous variables including a constant, linear and quadratic time trends.[8] The lag order is chosen to be 6 and 4 for monthly and quarterly frequency but using more than 6 and 4 lags does not change the results.

The structural shocks e_t are related to the reduced form residuals as

$$\eta_t = H\Sigma e_t = Be_t \tag{3}$$

where $e_t \sim (0, \mathbf{I_k})$ and Σ is the diagonal variance matrix.

The endogenous variable is set as $X_t = (U_{Rt}, GDP_t, U_{Ft}, MP_t)'$ or $X_t = (U_{Rt}, GDP_t, U_{Ft}, G_t)'$ conditional on the policy variable of interest. U_{Rt}, GDP_t, U_{Ft}, G_t and MP_t denote real uncertainty, real GDP, financial uncertainty, government spending and monetary policy in-

[6]As the outlays is a nominal variable, it is adjusted by PCE price index first. Then, it is seasonally adjusted by X-13. To avoid volatile changes, the accumulated variable is used in the estimation.

[7]The data source for gold prices is as follows: https://www.macrotrends.net/1333/historical-gold-prices-100-year-chart.

[8]We also estimate the models with only constant and with constant and linear trend but the results are not affected by trend specifications.

dicator. The corresponding reduced form residuals $\eta_t = (\eta_{Rt}, \eta_{GDPt}, \eta_{Ft}, \eta_{MPt})'$ (or $\eta_t = (\eta_{Rt}, \eta_{GDPt}, \eta_{Ft}, \eta_{Gt})'$) can be related to to the structural shocks $e_t = (e_{Rt}, e_{Gt}, e_{GDPt}, e_{Ft}, e_{MPt})'$ (or $e_t = (e_{Rt}, e_{Gt}, e_{GDPt}, e_{Ft}, e_{Gt})'$) as below:

$$\begin{aligned}
\eta_{Rt} &= B_{RR}e_{Rt} + B_{RGDP}e_{GDPt} + B_{RF}e_{Ft} + B_{RMP}e_{MPt} \\
\eta_{GDPt} &= B_{GDPR}e_{Rt} + B_{GDPGDP}e_{GDPt} + B_{GDPF}e_{Ft} + B_{GDPMP}e_{MPt} \\
\eta_{Ft} &= B_{FR}e_{Rt} + B_{FGDP}e_{GDPt} + B_{FF}e_{Ft} + B_{FMP}e_{MPt} \\
\eta_{MPt} &= B_{MPR}e_{Rt} + B_{MPGDP}e_{GDPt} + B_{MPF}e_{Ft} + B_{MPMP}e_{MPt}
\end{aligned} \tag{4}$$

where B_{ij} is the element that belongs to B. A similar expression can be obtained for the analysis regarding fiscal policy. As is evident from the above relationships, identifying structural shocks corresponds to finding the solution for the matrix B. The standard covariance restrictions, which come from the covariance structure of η_t, provide $4 \times (4+1)/2 = 10$ equations in B and there are 16 unknowns in B. Hence, we need six additional restrictions to identify all structural shocks exactly. Therefore, it is not possible to exactly identify structural shocks without further identifying assumptions. In this paper, we do not pursue point-identification. Instead, the SVAR is set-identified by augmenting restrictions regarding properties that structural stocks are required to possess based on the reading of historical events as in Ludvigson et al. (2019).

2.2.2 Shock based restrictions

In what follows, we introduce additional identifying assumptions which is required to obtain the structural relationships among endogenous variables. The key idea here is that the resulting structural shocks e_t depend on the matrix B. Hence, by looking at the characteristics of candidate structural shocks, we can gather additional information that can be used to judge whether the candidate matrix B should be accepted or discarded.

External variable constraints. First, we augment external instrumental variables to provide more restrictions following Ludvigson et al. (2019). Specifically, the correlations between the external variables and uncertainty shocks are used to provide additional inequality constraints. The aggregate stock market return S_{1t} and the log difference in the real price of gold S_{2t} are required to satisfy the following restrictions:

$$\begin{aligned}
&i)\ corr(e_{jt}, S_{1t}) \leq 0, \ \ j = R, F \\
&ii)\ corr(e_{jt}, S_{2t}) \geq 0, \ \ j = R, F
\end{aligned} \tag{5}$$

The first constraint states that uncertainty shocks should be negatively correlated with the aggregate stock market returns. Similarly, the second one dictates that two uncertainty shocks are required to be positively correlated with the real price of gold.

In addition, we introduce two external instruments to help identify two policy variables. For the monetary policy shock, it is required to have minimal correlation $\bar{c}_{MP}$ with the monetary policy news shock identified in Nakamura and Steinsson (2018) (constraint iii). To provide an instrument which contains surprises regarding the government expenditure, we build a fiscal news variable following Caggiano et al. (2015). We also restrict that the identified government spending shock need to be correlated with the fiscal news variable (constraint iv).

$$\begin{aligned} iii)\ & corr(e_{MPt}, S_{3t}) \geq \bar{c}_{MP} \\ iv)\ & corr(e_{Gt}, S_{4t}) \geq \bar{c}_{G} \end{aligned} \tag{6}$$

Precisely, the fiscal news series is generated by summing the revisions of the real government expenditure over the forecast horizons reported in the Survey of Professional Forecasters (SPF) as follows:

$$news_t = \sum_{j=1}^{3} (E_t \Delta g_{t+j} - E_{t-1} \Delta g_{t+j}) \tag{7}$$

Since SPF is only available in quarterly frequency, we use the same value of the news shock within a quarter.

Event constraints. Event constrains restrict the behavior of the structural shocks based on the reading of the times throughout history. The idea is that the produced structural shocks should be consistent with our understanding of historical events, at least during times of special interest.

1. $e_{Ft_1}(B) > \bar{k}_1$ where t_1 is the period 1987:10(87Q4) of the stock market crash
2. $e_{Ft_2}(B) > \bar{k}_2$ or $e_{Rt_2}(B) > \bar{k}_3$ where t_2 =2008:09(08Q3)
3. $\sum_{j=t_3} e_{GDPt} < 0$ $t_3 \in [2007:12, 2009:06]$([07Q4,09Q2])
4. $e_{Rt_4} > 0$ and $e_{Ft_4} > 0$ at $t_4 = 2011:07$ or $t_4 = 2011:08$(11Q3)
5. There exists a $t_5 \in [2008:04, 2009:02]$([08Q2, 09Q1]) such that $e_{Gt_5}(B) > \bar{k}_4$

The above set of restrictions demands specific signs and sizes for the identified shocks. Firstly, the identified financial uncertainty shocks in October 1987 should be large, exceeding $\bar{k}_1$ standard deviations, and positive. Second, the identified financial or real uncertainty in September 2008 (the month of the Lehman collapse) be large and exceed $\bar{k}_2$ and $\bar{k}_3$ standard deviations above the mean. The third restriction requires that the cumulative GDP shocks during [2007:12,2009:06] period should be negative. That is, the sum of real activity shocks during the Great Recession may not exceed average. The fourth one states that both uncertainty shocks should be positive during the 2011 debt-ceiling crisis. Finally, the last condition implies that the identified government spending shocks should have large positive value in at least one month during [2008:04, 2009:02] period due to anticipating large fiscal supporting packages, such as American Recovery and Reinvestment Act signed into law in February 2009.

2.2.3 Implementation

The candidate solution $\hat{B}$ are obtained by following Ludvigson et al. (2019). Specifically, we initialize the solution to be the lower Choleski factorization of Ω and then rotating it by 3,000,000 random orthogonal matrices Q. We keep the resulting solutions only when all restrictions given above are satisfied.

One point is worth mentioning. Although no one solution is more likely than another, we can provide one exact solution, denoted 'max-C' solution, as reference solution to the model. 'max-C' solution is selected based on the correlations between instruments and structural shocks. That is, 'max-C' solution is the solution with the highest collective correlation $\sqrt{c(B)'c(B)}$. In the subsequent sections, we use 'max-C' solution as the reference result and pay more attention to this specific solution.

The specific numerical bounds for the correlation -$\bar{c}_1$, $\bar{c}_2$, $\bar{C}$ - and event constraints -$\bar{k}_1$, $\bar{k}_2$, $\bar{k}_3$, $\bar{k}_4$ - are set as below. We set the $\bar{c}_1$, $\bar{c}_2$, and $\bar{C}$ to be relatively less restrictive, with $\bar{c}_1 = 0.03$ and $\bar{c}_2 = 0.05$, for the individual correlations and $\bar{C} = 0.15$ for the collective correlation. These conditions imply that lower bounds of 3% and 5% absolute correlations between proxy instruments and both types of structural uncertainty shocks and between FFR shock instrument and monetary policy shock are maintained, with an average absolute correlation of 4%.[9] We set the parameters regarding the event constraints to $\bar{k}_1 = 4$, $\bar{k}_2 = 4$, $\bar{k}_3 = 2$, and $\bar{k}_4 = 3$. The numerical values for $\bar{k}_1$, $\bar{k}_2$ and $\bar{k}_3$ are borrowed from Ludvigson et al. (2019). For $\bar{k}_4 = 3$, we choose a sufficiently large value to capture the large scale fiscal

[9]The average absolute correlation is calculated by the root-mean-square-correlation $\sqrt{\frac{1}{4}c(B)'c(B)}$ following Ludvigson et al. (2019). We choose less restrictive value for this to accept more candidate solutions as our model is larger than theirs.

packages implemented during the Great Recession.

3 Results

In this section, we present the results derived from the SVAR model constructed in the previous section. First, the full impulse response functions are shown to gauge the effects of each structural shocks. In particular, we are interested in the responses of real and financial uncertainty to the government spending and monetary policy shock as there is little previous research on the roles of macro policies in shaping economic uncertainty. In addition, We revisit the issue related to the endogeneity of economic uncertainty and its implications on the propagation of the other structural shocks which has been widely studied in the literature. As mentioned before, we examine the effect of monetary and fiscal policy separately by including a policy variable one by one in the SVAR.

3.1 Identified structural shocks

Since the identification strategy heavily depends on the behavior of the identified structural shocks, it is meaningful to get a sense of the nature of the identified shocks. To do this, we depicts the time series and distributions of shocks produced in the max-C solution following Ludvigson et al. (2019).

Figure 1 shows the distribution of the identified real and financial uncertainty shocks. It clearly shows that the identified shocks are non Gaussian: they are negatively skewed and have fat tails. It gives a support for our empirical strategy which does not require Gaussian assumption.

Figure 2a and Figure 2b depict the time series of real and financial uncertainty. They move similarly but financial uncertainty is more volatile. In addition, it seems that the volatility of both series is time-varying, hence uncertainties are heteroskedasitic. Figure 2c and Figure 2d present the events that produce real or financial uncertainty shock which exceeds 2 standard deviations. Financial uncertainty exceeds 4 standard deviations in 1987 and 2008 due to Black Monday and the Global Financial Crisis (GFC) and 2 standard deviations around 1982 and 1998. Large real uncertainty shocks appear in the similar dates while the magnitudes are usually smaller than those in financial uncertainty.

3.2 Interactions between uncertainties and macro policies

Figure 3 depicts impulse responses of the monetary SVAR model. The first row shows responses of endogenous variables to the real uncertainty shock. Similar to Ludvigson et al.

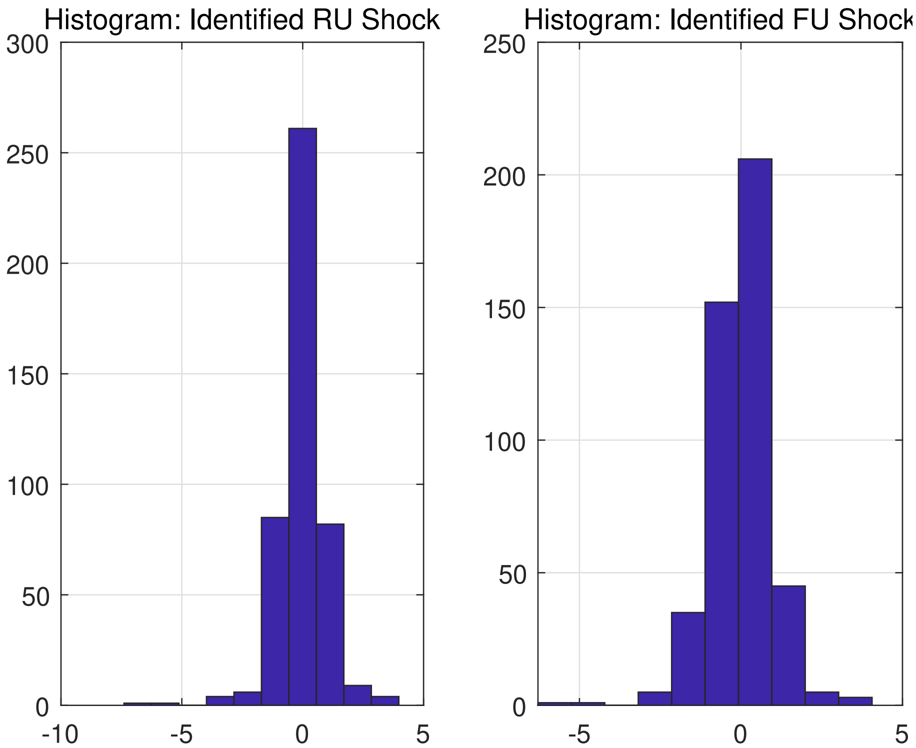
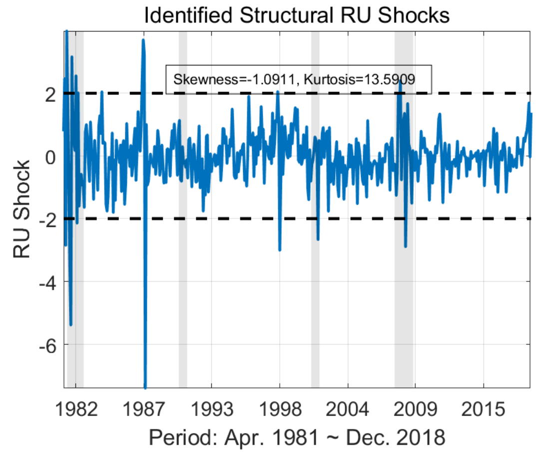


Figure 1: Distribution of identified shocks: The left panel shows the distribution of the identified real uncertainty shock and the right panel presents that of the financial uncertainty shock

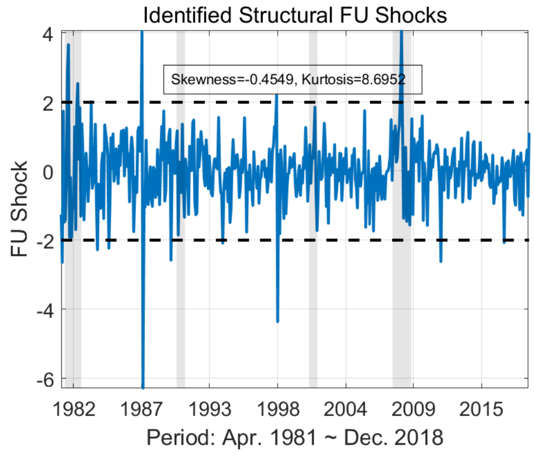
(2019), financial uncertainty hikes persistently as the real uncertainty shock hits the economy. In addition, a hike in real uncertainty has a significant consequence on real activity and, in turn, monetary policy. The impulse responses of GDP show that real activity becomes stronger and it leads to a contractionary monetary policy. This result is in line with that in Ludvigson et al. (2019) as they provide a result that real activity responds positively to real uncertainty, which is consistent with growth options theory which has raised the possibility that some forms of uncertainty can actually increase economic activity.[10] However, the response of real activity to the real uncertainty shock is somewhat different from that in Carriero et al. (2018). It can be attributed to differences in specifications, such as the way uncertainties are included in the model, as noticed in Ludvigson et al. (2019).[11] When real activity strengthens unexpectedly, real uncertainty tends to increase at the initial periods and rises in the medium-run periods. On the contrary, financial uncertainty decreases sharply for

[10]Growth options theory postulates that a mean-preserving spread in risk generated from an unbounded upside coupled with a limited downside can cause firms to invest and hire, since the increase in mean-preserving risk increases expected profits. Such theories were often used to explain the dot-com boom. See Pástor and Veronesi (2006), Segal et al. (2015) and Kraft et al. (2018).

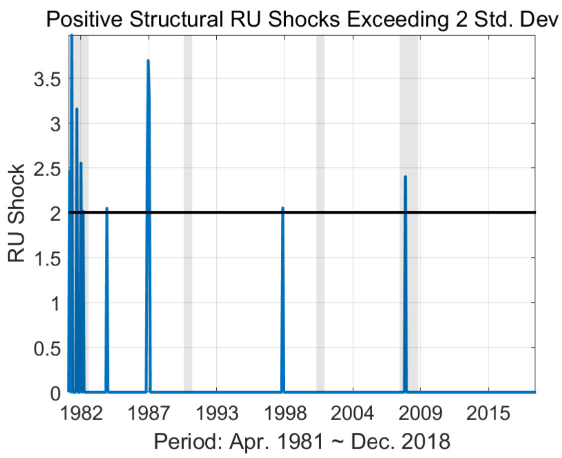
[11]As Carriero et al. (2018) do not consider both real and financial uncertainties in one framework, it may not be appropriate to compare the results directly.



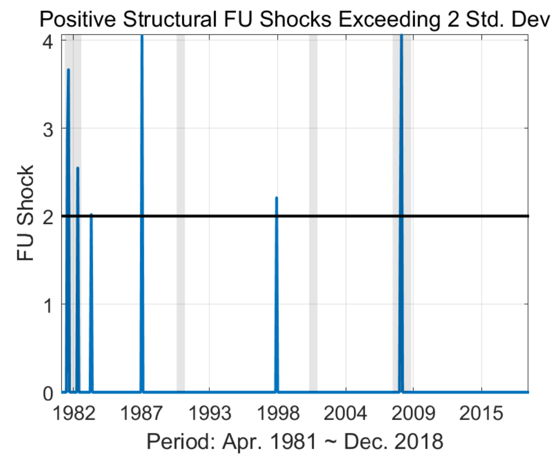
(a) RU Shock



(b) FU Shock



(c) Positively Large RU Shocks



(d) Positively Large FU Shocks

Figure 2: Time series of identified shocks: Figure 2a and Figure 2b depict the time series of the identified real and financial uncertainty shocks. Figure 2c and Figure 2d highlight shocks exceeding 2 standard deviations for real and financial uncertainty shocks, respectively.

about 30 months. While two uncertainties move in the opposite directions, the magnitude of response is more pronounced for financial uncertainty. Hence, this result suggests that employing a financial uncertainty measure such as VIX alone in analyses regarding the implications of economic uncertainty may be misleading. Finally, monetary policy gets tighter for 10 to 40 months following the positive GDP shock. This reaction can be understood as an ordinary monetary policy reaction to prevent an overhit.

The third row presents impulse responses to the financial uncertainty shock. Real uncertainty shows a positive hump-shaped response to the financial uncertainty shock. Combining the response of financial uncertainty to the real uncertainty shock, we can infer that these two types of uncertainties comove and are highly related. However, the responses of macro variables to these two types of uncertainty are quite different. This result emphasizes the

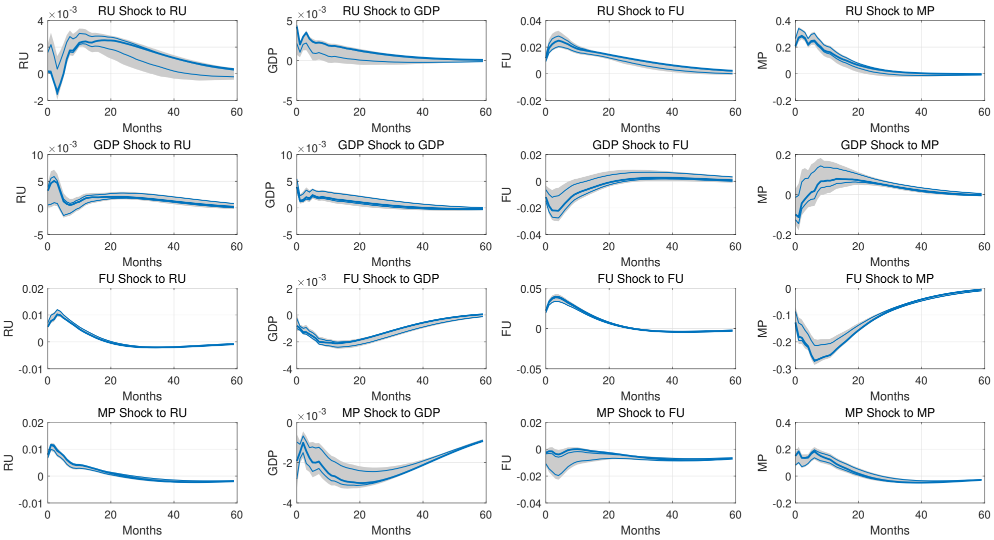


Figure 3: Impulse response functions of the monetary SVAR model: Shaded area and thin lines represent 90% and 68% confidence band respectively and solid lines represent the max-C impulse responses.

reason why it is necessary to distinguish different types of uncertainty while they move in a similar fashion. Next, a hike in financial uncertainty leads to a immediate decline in GDP. This result is in line with many previous studies which document that uncertainty drags real activities (Bloom, 2009; Caggiano et al., 2014; Christiano et al., 2014; Bloom et al., 2018). As the shock depresses real activity, a monetary accommodation follows to stimulate the economy in times of depression. The response of monetary policy to the financial uncertainty shock is in line with that of Bekaert et al. (2013): central banks conduct lax monetary policy following a hike in financial uncertainty. In addition, the reactions of monetary authority are also consistent with the results in Carriero et al. (2018).

The last row depicts the propagation of a positive monetary policy shock. A monetary tightening results in a slowdown of real activity as predicted by vast monetary literature (Christiano et al., 2005). Real and financial uncertainty show distinct reactions to the monetary policy shock. Real uncertainty increases substantially while financial uncertainty decreases persistently. It contradicts to the outcomes explored in Bekaert et al. (2013) as they predicted the opposite effects of monetary policy to financial uncertainty: a laxer monetary policy decreases financial uncertainty while this effect is not strong. It is noteworthy that their uncertainty measure is not comparable to ours as they built the uncertainty by decomposing an implied stock market volatility, which is a specific measure of financial uncertainty, into conditional variance('uncertainty') and the rest('risk aversion'). Furthermore, they find

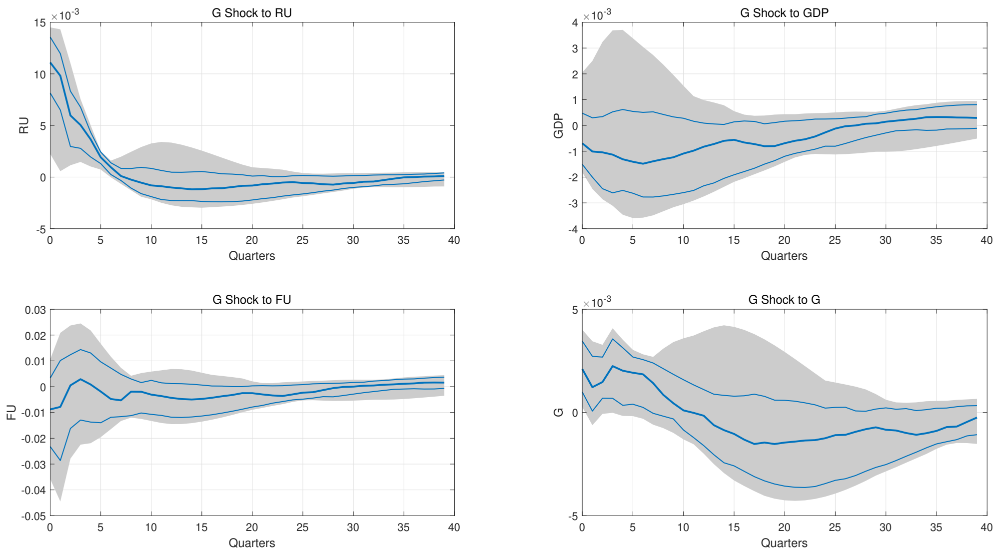


Figure 4: Impulse response functions of the fiscal SVAR model: Shaded area and thin lines represent 90% and 68% confidence band respectively and solid lines represent the max-C impulse responses.

that the degree of risk aversion is increasing in the monetary policy stance This result may be related to our result that real uncertainty moves in the same direction with monetary policy as a higher risk aversion leads to stronger wait-and-see behavior which prevails under higher real uncertainty. Our finding that financial uncertainty is decreasing in the policy rate may be attributed to unwinding financial stress or unbalances: by increasing the policy rate, monetary authority may prevent financial market from bearing more risk and piling up of financial unbalances or bubbles (Rajan, 2005; Ajello et al., 2019; Adrian et al., 2018). In sum, monetary policy seems to have a significant counter-cyclical effect in the short- to medium-run while it also affects building up of uncertainties. The latter result bears clear new policy implications. First, it is closely related to the view that a monetary authority needs to look after the financial cycle to prevent severe recessions caused by busts of the financial market (Adrian and Shin, 2008). The response of financial uncertainty hints that tightening monetary policy stance may reduce risk taking, relieve financial uncertainty and prevent creations of bubbles. However, risk management through conventional monetary policy should be carried out cautiously as it can also increase uncertainty related to real activities.

We then analyze the effects of expansionary fiscal policy using a quarterly fiscal SVAR model. Overall, fiscal policy does not seem to have significant effects on real activity nor uncertainty in equilibrium. As shown in Figure 4, the positive fiscal spending shock increases

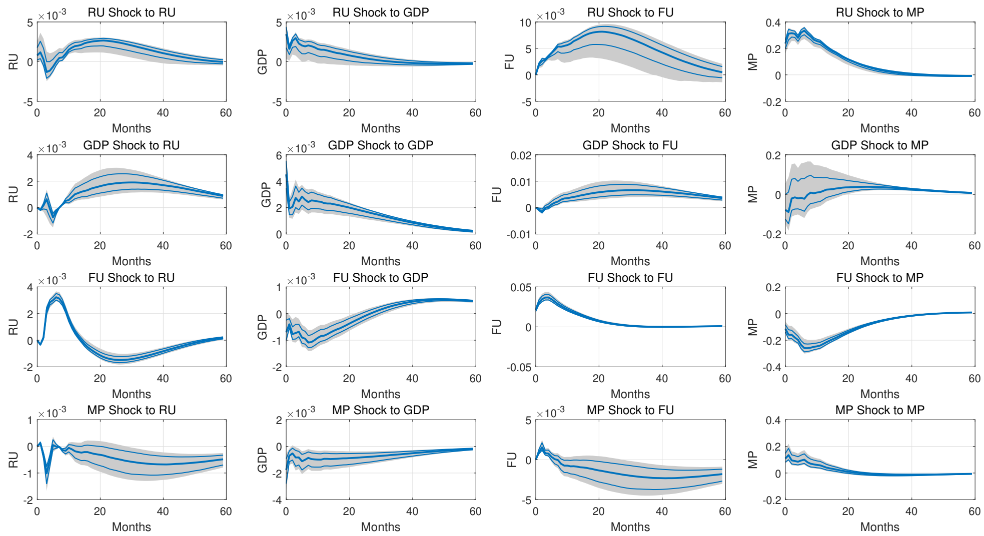


Figure 5: Impulse response functions of the monetary SVAR model when real and financial uncertainty do not respond endogenously: Shaded area and thin lines represent 90% and 68% confidence band respectively and solid lines represent the median impulse responses.

real uncertainty but it does not change financial uncertainty significantly. And the stimulus effect on GDP is not significant in our VAR system.

3.3 Role of endogenous responses of uncertainties

In this subsection, we analyze the importance of endogenous responses of uncertainties to policy shocks while conducting policy analyses. Specifically, we mute the endogenous responses of real and financial uncertainty caused by changes in the other endogenous variables. By doing this, we mimic the studies which examine the role of uncertainty shocks while assuming that the economic uncertainty is exogenous.[12] Then, we compare the results obtained from this subsection to those under benchmark model. Finally, we also show whether ignoring endogenous propagation of uncertainty can lead to different policy implications regarding the effectiveness of fiscal and monetary policy.

As a starting point, we examine the impulse responses after shutting endogenous propagation channels off. Precisely, the contemporaneous responses of both uncertainties to the other shocks are muted by restricting elements which govern contemporaneous responses in the matrix B. Figure 6 presents the impulse responses derived from this exercise.

Not surprisingly, it turns out that taking endogeneity into account is important for both

[12]Following Carriero et al. (2018), we say uncertainty is exogenous when it does not respond to the other economic shocks contemporaneously.

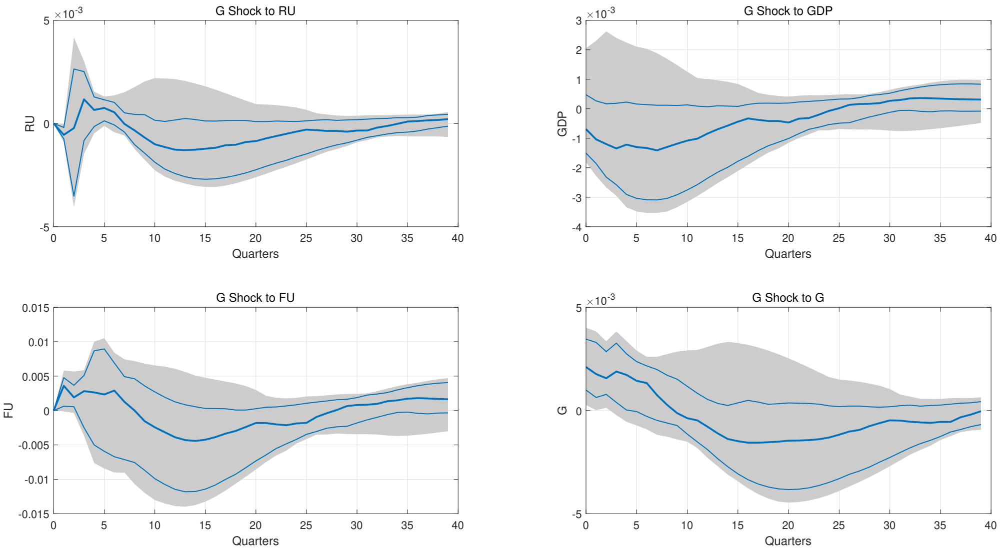


Figure 6: Impulse response functions of the quarterly fiscal SVAR model when real and financial uncertainty do not respond endogenously: Shaded area and thin lines represent 90% and 68% confidence band respectively and solid lines represent the median impulse responses.

real and financial uncertainty: some responses of real and financial uncertainty are qualitatively different from those obtained in the benchmark case. For instance, real uncertainty increases in the policy rate when the endogenous response channel is absent. Furthermore, financial uncertainty goes up following a positive GDP shock. In addition, while financial uncertainty resolves following a monetary tightening in a longer horizon, it hikes immediately after the shock arrives.

The above result that endogenous propagation channel is important for both real and financial uncertainty is somewhat different from the previous studies such as Ludvigson et al. (2019) and Carriero et al. (2018). The former states that endogeneity matters for real uncertainty but not for financial one while the latter documents the opposition. There are various possible explanations which may contribute to the discrepancy. Ours use different dataset, variables, sample period, model, identification scheme and so on. Among these factors, we point out one important feature which may create the distinct results for each study. First, Ludvigson et al. (2019) lacks a policy variable. As many discrepancies are related to the policy variable, including a policy variable in a model may generate distinct results. Second, Carriero et al. (2018) consider real and financial uncertainty in separate analyses. As is evident from Figure 3, two types of uncertainty are intertwined, hence omitting one may result in a biased outcome.

	Monetary: Contractionary & Fiscal: Expansionary		
Policy	Endogenous (A)	Exogenous (B)	(B-A)
Monetary	-0.013 (-0.030, -0.013)	-0.004 (-0.028, -0.007)	0.005 (-0.001, 0.009)
Fiscal	0.260 (-2.217, 7.585)	0.900 (-2.009, 6.002)	0.640 (-9.366, 2.945)

Table 1: Magnitudes of Macroeconomic Policy Effects: 20-month cumulative responses of GDP divided by 20-month cumulative responses of government spending or monetary policy rate. 68% confidence intervals are reported in parentheses.

Next, we turn to the role of endogenous channel on the effects of fiscal policy. The impact of fiscal policy is limited as shown in Figure 4. When the endogenous channel is shut off, the impact becomes more muted as presented in Figure 6. Precisely, real uncertainty no longer responds to the government spending shock. It once again emphasizes importance of considering endogeneity of uncertainty.

Finally, we examine how effectiveness of macro policies changes when engonegeity of uncertainty is overlooked. Table 1 compares the magnitudes of real effects generated by increases in government spending and the policy Rate. Precisely, we compute ratio of 20-month (quarter for fiscal policy) cumulative responses of monthly GDP to 20-month (quarter) cumulative responses of government spending or the monetary policy rate while allowing or not allowing endogenous feedbacks to uncertainties. The result reveals that ignoring endogenous feedbacks may understate the impacts of monetary policy while exaggerate that of fiscal policy. This suggests that it is required to consider endogenous feedback effects through uncertainty while evaluating macroeconomic policy effects. In addition, it also implies that endogeneity of uncertainty should be taken into account when analyzing state dependent effects of macroeconomic policies.

While monetary policy seems to be more potent when uncertainty is set to be endogenous, it is questionable whether the difference is significant. To this end, we estimate the distribution of the difference computed in possible solutions. Figure 7 shows the Kernel density estimate of the distribution. The vertical dotted line is located at zero. If monetary policy is indeed more potent when endogeneity of uncertainty is introduced, then more mass should be concentrated at the right-hand side of the vertical line. Although there is a substantial chance that monetary policy is more effective when endogeneity channel is closed, the model produces more effective monetary policy when endogeneity is allowed in more than 80% of time.

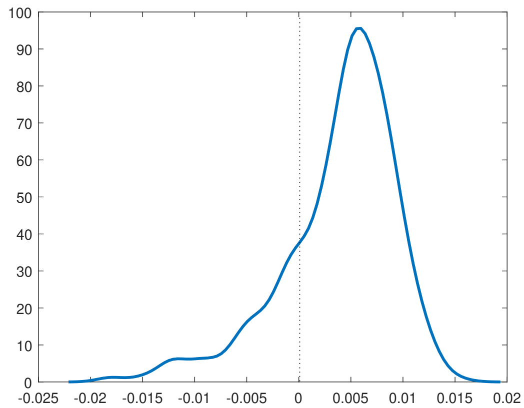


Figure 7: Kernel density estimate of the difference in responsiveness of GDP to a monetary policy shock between exogenous and endogenous uncertainty cases

3.4 Comparison with Bekaert et al. (2013)

Previous literature that studied the impact of economic policy on uncertainty is limited. One exception is Bekaert et al. (2013) which examines the effects of monetary policy on uncertainty. Specifically, they analyze how monetary policy affects risk appetite and uncertainty and find that a lax monetary policy decreases uncertainty. In this subsection, we compare our results with those obtained in Bekaert et al. (2013). It is not appropriate to compare their results directly with ours as they do not consider data after the GFC and stop their sample in 2007. Hence, we re-estimate the model using a shorter data sample which ends in December 2007 as in Bekaert et al. (2013) in this subsection.

Figure 8 contains the baseline results with a shorter sample excluding the period after the GFC. In this case, a tighter monetary policy heightens both real and financial uncertainty that is in line with the result derived in Bekaert et al. (2013). This result suggests the possibility that the nature of impacts of policies on uncertainty has been changed since the GFC. Hence, this calls for a more studies regarding the time-varying policy effects on uncertainty.

One additional difference which may possibly contribute to the discrepancy is the endogeneity of uncertainty in our model. Therefore, we conduct an analysis while shutting off the endogenous channel as in subsection 3.3. The results are summarized in Figure 9. The results reassure the above finding that two measures of uncertainty are increasing in the monetary policy rate.

Finally, one point is worth mentioning. Both Figure 8 and Figure 9 depict that real uncertainty depresses real activity significantly. This result hints the possibility that the impact of uncertainty on real activity has been changed substantially since the GFC. It also

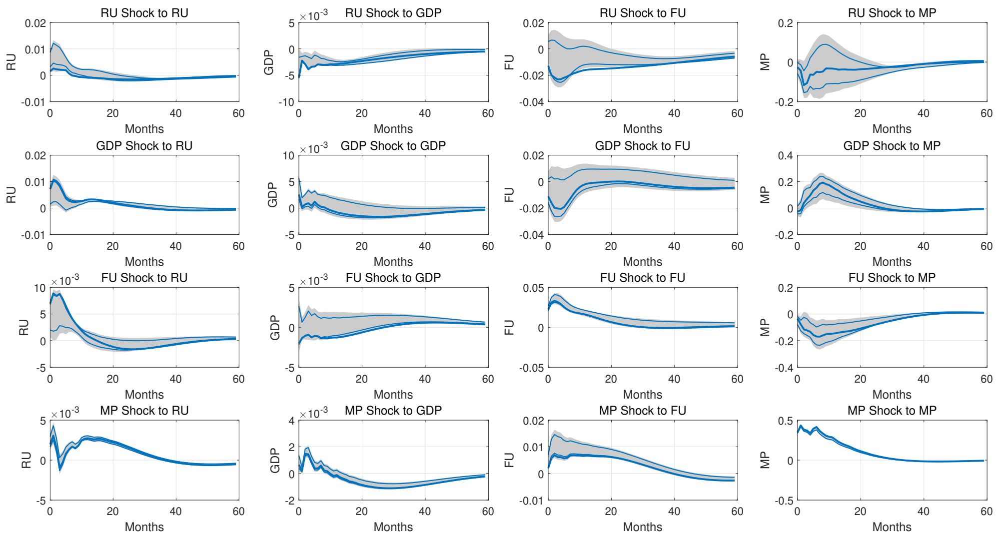


Figure 8: Comparison with Bekaert et al. (2013). Impulse response functions of the monetary SVAR model by Dec. 2007: Shaded area and thin lines represent 90% and 68% confidence band respectively and solid lines represent the max-C impulse responses.

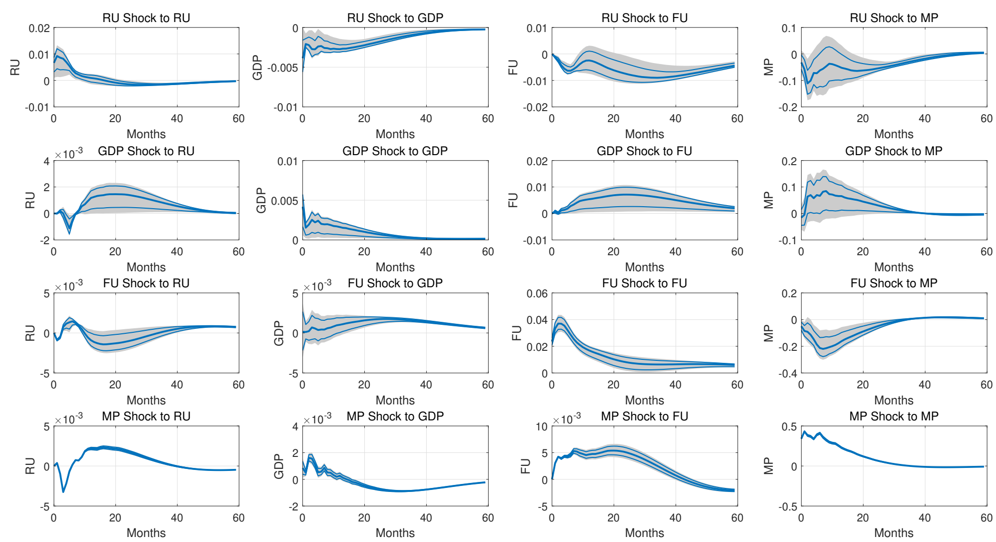


Figure 9: Comparison with Bekaert et al. (2013). Impulse response functions of the monetary SVAR model by Dec. 2007 without endogenous response of uncertainty: Shaded area and thin lines represent 90% and 68% confidence band respectively and solid lines represent the median impulse responses.

calls for further research regarding the time-varying effects of uncertainty on the economy.

4 Conclusion

In this research, we examine how monetary and fiscal policy affect the level of both real and financial uncertainty. While the economic influence of uncertainty has been widely studied after Bloom (2009), the economic force which drives uncertainty has been attracted relatively less attention. Specifically, while the role of uncertainty in shaping the (especially, monetary) policy effectiveness has been explored a lot, there is little research that analyzes the impacts of monetary or fiscal policy on economic uncertainty.

We find that monetary and fiscal policy have distinct effects on real and financial uncertainty. It turns out that monetary policy dampens financial uncertainty while it injects more uncertainty into the real sector. This result bears important policy implication and justifies active monetary policy that targets financial stability.

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