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Uncertainty and non-linear macroeconomic effects of fiscal policy in the US: A SEIVAR-based analysis

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Abstract

We investigate whether the macroeconomic effects of government spending shocks vary with the level of uncertainty. Using postwar US data and a Self-Exciting Interacted VAR (SEIVAR) model, we find that fiscal spending has positive output effects in tranquil times but is contractionary during uncertain times. The endogenous reaction of macroeconomic uncertainty and consumer confidence play an important role in explaining the non-linear impact of government spending. In contrast to other types of government spending, research and development expenditures reduce uncertainty and have an expansionary effect on output during uncertain times.

Keywords: government spending shocks, uncertainty, non-linear structural vector autoregressions, interacted VAR, generalized impulse response functions, endogenous uncertainty
JEL classification: E62, E32, C32

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1 Introduction

The recent experience of the Great Recession in the US, which was accompanied by great uncertainty in the real economy and the financial sector, has sparked debate about the effect of uncertainty on macroeconomic outcomes. At the same time, an intense increase in government spending in advanced economies pushed the short-term effects of fiscal policy back on the macroeconomic research agenda. This coincidence naturally leads to the research question, if and how the effects of government spending vary with the degree of uncertainty in the economy.

How could the degree of uncertainty that the economy is facing influence its behavior? In a model with non-convex adjustment costs in capital as well as labor and time-varying uncertainty, Bloom et al. (2018) find a real-option channel of uncertainty: firms become more cautious in investing and hiring as uncertainty increases. Additionally, there is a precautionary saving channel (Bloom, 2014) where consumers lower their consumption expenditures and increase their savings as uncertainty surges. Following these negative effects on private investment and private consumption, Leduc and Liu (2016) interpret uncertainty shocks as aggregate demand shocks. As Ramey (2011a) states in her survey article, the effectiveness of fiscal policy depends strongly on the reaction of private spending. Therefore, we seek to evaluate the role of uncertainty for the effectiveness of government spending.

To estimate a potential non-linearity in the transmission of spending shocks to output in the United States, we employ the Self-Exciting Interacted VAR (SEIVAR) model used by Pellegrino (2018) and Caggiano et al. (2017) in the field of monetary policy. This model augments and otherwise standard VAR with an interaction term between government spending and uncertainty that is able to capture the uncertainty-varying effects of government spending on all endogenous variables. Accounting for the non-linearity of interest in this way leaves us with sufficient degrees of freedom to analyze the effects of government spending on the economy for extreme deciles of the uncertainty distribution and enables us at the same time to control for a sufficient number of confounding factors including fiscal finances, monetary policy, financial frictions and expectations of the private sector.

Exogenous shocks to government spending are identified using two alternative strategies. In the first case, exogenous variation in government spending is isolated using the exclusion restriction that the government, due to decision lags, cannot react within the same quarter to other shocks as proposed by Blanchard and Perotti (2002). The second one accounts for an implemen-

tation lag in government spending such that private agents already adjust their behavior before the increase in government spending actually occurs as stressed by Ramey (2011b). We follow Auerbach and Gorodnichenko (2012b), Klein and Linnemann (2018) and add data of professional forecasters to account for these expectations in our SEIVAR.

We obtain our main results from a SEIVAR model that includes government spending growth, real GDP growth, taxes to GDP, the real monetary policy rate, macroeconomic uncertainty, the corporate bond spread and the Michigan index of consumer sentiment. We construct generalized impulse response functions as proposed by Koop et al. (1996) accounting for an orthogonalized shock as in Kilian and Vigfusson (2011). The method is needed to fully account for the non-linearity in our system.¹ The model is estimated at the quarterly frequency over the period 1960:3 to 2017:2. Besides macroeconomic uncertainty propagated by Ludvigson et al. (2015), we also consider financial uncertainty from the same authors, indices of realized and implied stock market volatility as proposed by Berger et al. (2019), the economic policy uncertainty index from Baker et al. (2016), a corporate bond spread as well as Michigan survey of consumer confidence data as a measure inversely related to uncertainty.

The obtain the following results. Firstly, we only find a statistically significant non-linearity when we consider general macroeconomic uncertainty. Secondly, we find significantly different effects of government spending on GDP in tranquil and uncertain times. During periods of low uncertainty, government spending has positive output effects. However, this changes in uncertain times. According to our results, government spending acts like an uncertainty reduces confidence in the economy. This results in lower levels of personal consumption and private investment such we observe a decline in economic activity. This result remains valid if we control fiscal anticipation. Do we observe the increase in uncertainty during uncertain times because of a fiscal reaction to uncertainty? As a check against reverse causality, we order macroeconomic uncertainty first and shock this variable. We observe no significant response of government spending, especially not in the short run. This mitigates our concerns about reverse-causality. Similar results have been found recently by Alloza (2018) using a different methodology. The key channel for our results seems to be consumer confidence. When we drop the corporate bond spread and consumer confidence from the set of our endogenous variables, we do not find any

¹Constructing impulse responses in nonlinear VAR models is far from straightforward since many complexities arise when one moves from linear to non-linear systems as stated by Koop et al. (1996). In a linear model, the impulse responses are invariant to history, proportional to the shock size and symmetric in positive and negative shocks. In a nonlinear model, the response can depend differentially on the magnitude and sign of the shock as well as on the histories of previous shocks.

state-specific effect of a government spending shock on output.

However, the results slightly change if we consider the sample only up to 2007:3, the period before the Great Recession. In this case, government spending increases output and consumer confidence during tranquil times. However, the significant negative effect on GDP in uncertain times disappears. This can be the results of two circumstances. Firstly, we lose roughly forty quarters of observations such that it becomes harder to find statistical significant effects. Secondly, the Great Recession has been a very uncertain period that is now dropped from our sample such that the difference between tranquil and uncertain times diminishes and so does the state-specific effect. Nevertheless, our result of less effective government spending during uncertain times remains in the short run.

The remainder of the paper proceeds as follows: Section 2 gives a short review of the transmission channels of uncertainty on the economy while section 3 recaps the recent literature analyzing the effectiveness of government spending and especially those studies focusing on state-dependent effects of government spending. Section 4 describes specific uncertainty measures used in the literature and our empirical strategy. Our results are reported in section 5. Section 6 concludes.

2 A short recap of the uncertainty channels

We start with a short review of the theoretical working channels of uncertainty. The theoretical literature emphasizes two negative channels for uncertainty but also highlights a positive channel of influence. This review draws heavily on Bloom (2014).

A large body of theoretical literature about the effects of uncertainty focuses on "real options" (Bernanke, 1983, Brennan and Schwartz, 1985, McDonald and Siegel, 1986). The idea is that firms can see their investment choices as a series of options in the presence of adjustment costs: for example, a company thinks about investing in a new plant but is unsure about the future development of new more productive machines. It either can build the factory now with the available machines but has also the option to wait until the new and maybe a lot more productive machines are available - so it might prefer to wait until the new machines become available and avoid the costly mistake of being constrained with an ineffective machine. In the language of real options, the option value of delay for the company is high when uncertainty about the productivity of the future machines is high. In result, uncertainty makes firms cautious about actions like investment

and hiring, which adjustment costs can make expensive to reverse. Investment adjustment costs can be relevant for physical capital (a new adopted but already outdated technology must be used for some time) as well as for hiring decisions (hiring adjustment costs include recruitment, training and severance pay). Note that the real option channel relies on the ability to wait. For instance, if competitors are racing perhaps to be the first to patent a new idea or launch a new product, this option disappears.

Uncertainty might not only influence the behavior of companies but also change consumption decisions. When consumers decide on buying durables like housing or cars, they can usually delay purchases relatively easily (see f. i. Eberly (1994)). Uncertainty may influence the consumers decision especially if there is high uncertainty about their future income (Leland, 1968). A worker would probably increase his savings during a recession if there is a higher probability to become unemployed. Lusardi (1998) and Kazarosian (1997) provide evidence for the presence of such a precautionary saving channel. While being contractionary for an economy in the short run, the long-run effects are less clear. The reason is, at least in theory, lower consumption and greater saving may allow a rise in investment, which could then benefit long-run growth. However, as several recent papers have noticed, if prices are sticky (as New Keynesian models commonly assume), higher uncertainty shocks can lead to recessions in closed economies (where savings equal investments such that an increase in saving should induce higher investment) because prices do not fall enough to clear markets (see f. i. Leduc and Liu (2016)). The intuition is as follows: Uncertainty increases the desire of consumers to save, which should reduce interest rates and output prices, stimulating an offsetting rise in investment. However, if prices are sticky, this effect does not happen. The result is that prices and interest rates do not fall enough to encourage the neutralizing rise in investment so that output falls. This effect of uncertainty can be particularly damaging if interest rates are constrained at the zero lower bound as during the recent Great Recession.

Besides the production and consumer side uncertainty also affects the financial sector of the economy. Investors require a compensation for taking higher risks and because greater uncertainty leads to increasing risk premia, this should raise the cost of finance. Furthermore, uncertainty also increases the probability of default by expanding the size of left-tail default outcomes, raising the default premium and the aggregate deadweight loss of bankruptcy. This role of uncertainty in raising borrowing costs can influence the economy negatively as stressed in papers on the impact of uncertainty in the presence of financial constraints (Bai et al., 2011, Christiano

et al., 2014, Gilchrist et al., 2014).

In contrast to the channels above, uncertainty can potentially have a positive long-term economic effects. The "growth option" literature arguments that uncertainty can encourage investment if it increases the size of the potential prize. One example is Bar-Ilan and Strange (1996) who note that uncertainty can have positive effects on investment if firms might have long delays in completing projects, f.i. due to time-to-build or time-to-develop. Bloom (2014, p.166) illustrates this with a pharmaceutical company developing a new drug that recognizes a mean-preserving increase in demand uncertainty. The costs of bad draws (f.i. the drug turns out to be ineffective or unsafe) is limited because the firm can cancel the product losing only its sunk research and development costs. But good draws (the product turns out to be more useful and profitable than expected) are not constrained in this way. Hence, a rise in mean-preserving uncertainty means higher expected profit when the product goes to market. In conclusion, the firms incentives to conduct research increases with rising uncertainty.

After reviewing the theoretical channels of uncertainty, we pose the question of how this all relates to the effects of government spending on the economy. At first intuition, the real option channel might depress hiring of firms and private consumption, so reducing the typical crowding out effect of government purchases. In result, fiscal spending might be more effective during uncertain times. At the same time, the government spending shock might increase uncertainty in the economy or confirm agents expectations that times are bad. In this situation, private spending might fall very sharply resulting in a larger decline in private spending as opposed to a situation without the fiscal shock. To our point of view, it's far from clear how the uncertainty level impacts the effects of fiscal policy, so we continue with a review of the empirical literature on this topic.

3 Review of the literature

Our paper is related to the literature dealing with non-linear effects of fiscal spending. Firstly, we will recap the results of the very new literature dealing with uncertainty depending effects of fiscal policy. We will also review literary results on fiscal policy and the business cycle since it is hard to empirically discriminate between uncertainty, as second order shocks, and the business cycle. This leads Bloom et al. (2018) to classify recessions as the coincidence of a negative first order shock with a positive second order shock. We first recap the empirical literature on fiscal

spending and uncertainty. Since our paper is more related to this strand, we do so in more depth. We do not review the literature on linear effects of government spending or of tax shocks since our focus is on the non-linear effects of government spending. Ramey (2011a, 2019) provide excellent reviews on this. We also do not review the literature on government multipliers in times of high debt or the zero lower bound.

To the best of our knowledge there exist by now only very few contributions that empirically relate the effects of fiscal policy with uncertainty. Most importantly, they differ in their respective conclusions about the uncertainty-related effectiveness of fiscal policy. Additionally, they differ in the method and measures of uncertainty used as well as the country for which the effect of fiscal policy on the economy is estimated.

Alloza (2018) estimates the impact of government spending shocks during periods of high and low uncertainty and during periods of booms and recessions with U.S. data. He uses local projections à la Jordà (2005) and a threshold (T-) VAR where he implicitly assumes that a fiscal policy shock cannot influence the economy to transit from one state to the other. He finds positive output effects during times of low uncertainty but contractionary effects in periods of high uncertainty. He identifies household's confidence as a key variable for interpreting this result as agents become more pessimistic when a positive government spending shock, possibly to stabilize the economy, confirms their views about economic bad developments.

Another study in this vein is Arčabić and Cover (2016) who analyze the effectiveness of fiscal policy under different uncertainty regimes in the US with a TVAR model to endogenously estimate different uncertainty regimes. Contrary to Alloza (2018), they find larger effects of fiscal spending on the economy during periods of high uncertainty. Fiscal spending tends to crowd out private investment during periods of average or low uncertainty while they crowd-in private investment after some delay during periods of high uncertainty. They also find that various types of spending have different output effects: Government investment is more effective than government consumption. In addition, larger shocks do not have the same "dollar for dollar" effect on output as small shocks.

Berg (2017) examines the relationship between business uncertainty and fiscal policy effectiveness in Germany. As opposed to the papers mentioned above, he uses measures of business uncertainty that are derived from firm-level data. He finds only small impacts of increased uncertainty on the fiscal multiplier in the short run. However, the long-run multiplier is larger in uncertain times.

A paper more related to policy instead of general economic uncertainty is Ricco et al. (2016). They analyze how policy communication affects the propagation of fiscal shocks in a Bayesian threshold VAR where they use a new constructed index of fiscal spending disagreement as the threshold variable. The authors find a large and positive output response to government spending shocks if there is low disagreement between professional forecasters about future government spending. Conversely, periods of enhanced disagreement are characterized by muted output responses.

The pioneering study investigating the effects of fiscal spending over the business cycle is Auerbach and Gorodnichenko (2012b), who use a Smooth-Transition (ST-) VAR to study regime-specific effects of fiscal spending. They find large differences in the size of spending multipliers in recessions and expansions with fiscal policy being considerably more effective in recessions than during expansions. They also looked at more disaggregated fiscal spending variables and proposed to use data of professional forecasters to control for predictable components of fiscal shocks.

Other studies that confirm their results are Auerbach and Gorodnichenko (2012a), where they extend their sample to OECD countries and use local projections instead of the STVAR, Fazzari et al. (2015) who use a TVAR and capital utilization as the business cycle threshold variable, Caggiano et al. (2015) who use a STVAR together with generalized impulse response functions to allow for the endogenous transition from a state to another after a shock.

In contrast, there are also studies that put this business-cycle effect into doubt. The already mentioned study from Alloza (2018) finds that fiscal spending is contractionary during recessions. He explores the differences to Auerbach and Gorodnichenko (2012b) and highlights the importance of information used to determine the business cycle state. Auerbach and Gorodnichenko (2012b) use a smooth transition function that includes the centered moving of order 7 of the growth rate of real GDP, hence it includes knowledge about future development that is not in the information set of economic agents. Alloza (2018) shows that government spending has negative output effects during recessions when he uses their specification with only backward looking information.

Ramey and Zubairy (2018) use historical data spanning more than 120 years in the United States. They use the local projection method from Jordà (2005) to estimate the government spending effects on output and the unemployment rate to define the state of the economy. They find no evidence of large multipliers when the economy is in a slack. They also apply the Jordà method

to the STVAR used by Auerbach and Gorodnichenko (2012b). They show that the results in the letter depend on a simplifying assumption, government spending shocks cannot change the business cycle state, that is not a good approximation in their sample and that their recessions state multiplier estimates are smaller when that assumption is relaxed.

We can conclude that the literature on the state-specific effects of government spending on the economy comes to different results, varies in the method used for estimation and constructing the impulse responses. To the best of our knowledge, we will use an econometric method that has not been used to study the effects of fiscal policy in the US. We will explain the method and its advantages in the following section.

4 Empirical strategy

In the following, we will explain some empirical proxies of uncertainty, deal with differences between them, show their development over time and their empirical correlation. Section 4.2 explains our model and emphasizes some advantages of our approach compared to other methods used in the literature. It also explains the identification strategy of a structural government spending shock and provides statistical evidence in favor of the non-linear specification. Section 4.3 outlines the calculation of impulse response functions in a non-linear world whereas section 4.4 explains the data.

4.1 Measuring uncertainty

Uncertainty is an amorphous concept. Hence, not surprisingly, there is a lively discussion in the literature dealing with economic effects of uncertainty on how to measure this broad concept. While in theory distinguishable from risk as defined by Knight as a known probability distribution over a set of events whereas he defined uncertainty as peoples inability to forecast the likelihood of events happening, empirical work typically does not discriminate between those concept. At a general level, uncertainty is typically defined as the conditional volatility of a disturbance that is unpredictable from the perspective of economic agents. Increases in uncertainty, as reviewed in section 2, can depress hiring, investment or consumption if agents are subject to fixed costs or partial irreversibilities (real options), if agents are risk averse (precautionary savings) or if financial constraints tighten in response to higher uncertainty (financial frictions). On the other hand, an increase in future expected volatility can also increase expected profits

when the loss is limited, so leading to growth options and result in economic well-being. Various empirical proxies of uncertainty have been developed to grasp this amorphous concept since different channels might have distinguishable impacts on the economy.

The empirical literature starting with the seminal paper of Bloom (2009) began with using the VXO as a measure of economic uncertainty. The VXO is a measure of percentage implied volatility on a hypothetical at the money S&P100 option 30 days to expiration. Since the VXO is only available from 1986, Bloom (2009) used the realized monthly returns volatility calculated as the monthly standard deviation of the daily S&P 500 index normalized to the same mean and variance as the VXO index when they overlap from 1986 onward. He showed that this measure of uncertainty increased after major economic and political shocks. The underlying idea of this variable as a measure of uncertainty is that implied share-returns volatility is the canonical measure of uncertainty in financial markets. Sometimes, the VIX is used instead. The difference between them is that the VIX is based on S&P 500 instead of S&P 100. It has to be noted that an increase in the VIX is not only related to an increase in uncertainty. Bekaert et al. (2013) decompose the VIX into two components, a proxy for risk aversion and expected stock market volatility that is related to uncertainty. Very recently, Berger et al. (2019) showed the importance to distinguish between realized volatility, the arrival of large shocks today, as opposed to uncertainty defined as expected future volatility. We follow Berger et al. (2019) in our comparison of proxies and distinguish in our analysis between the two. Realized stock market volatility is measured as annualized standard deviation of daily SP500 returns over each month and stock market uncertainty IVol (implied volatility) is the VIX (available from 1990) spliced with their related measure of implied volatility (available from 1983).

Baker et al. (2016) take a different approach. They develop an index of economic policy uncertainty (EPU) based on newspaper coverage frequency. The index reflects the frequency of leading US newspapers that contain specific buzz-words relating to the economy, policy and uncertainty. Their standard EPU index is available from 1985 onward and based on ten leading newspapers but there exists also a historical index that is based on only six newspapers. The index in Figure 1 is a merged index that combines both of them. When merging them, we normalize the historical one to have the same mean and standard deviation as the standard one during the period where both of them are available. Importantly, the focus of this measure is the degree of policy uncertainty in the economy. Hence, the proxy does not rise if the economy faces a high uncertainty about future technological developments but low digression about policy actions.

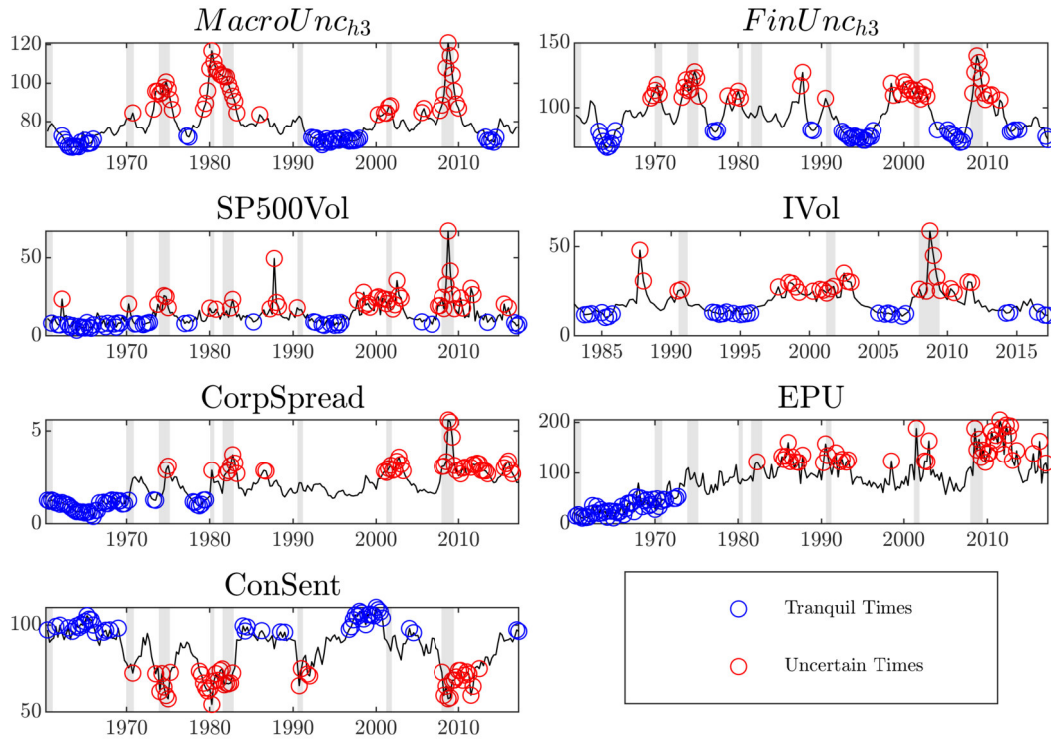


Figure 1: Different uncertainty measures over time

MacroUnc _{h3}	1						
FinUnc _{h3}	0.5828	1					
SP500Vol	0.5024	0.7185	1				
IVol	0.5641	0.839	0.9416	1			
CorpSpread	0.4835	0.4049	0.6084	0.6102	1		
EPU	0.2962	0.2416	0.4647	0.3519	0.7042	1	
ConSent	-0.6607	-0.3703	-0.3058	-0.268	-0.4383	-0.4305	1
	MacroUnc _{h3}	FinUnc _{h3}	SP500Vol	IVol	CorpSpread	EPU	ConSent

Figure 2: Pairwise correlations between different uncertainty measures

Another measure of uncertainty that is directly related to consumer confidence is proposed by Leduc and Liu (2016). They use survey of consumers data from the University of Michigan relating to vehicle purchases and count the fraction of respondents that don't buy cars or other durable goods over the next twelve month because the future is uncertain. They state that the VIX and their measure of consumer uncertainty are both counter-cyclical but react differently during specific events.² Their sample shows a correlation between the VIX/VXO and their consumer confidence related measure of uncertainty of only 0.24. We deviate from them as we focus on general consumer sentiment as an inversely related measure of consumer uncertainty.

In their analysis of uncertainty and the effectiveness of fiscal policy, Arčabić and Cover (2016) used the spread between Moody's seasoned Baa corporate bond yield and 10-year constant maturities treasury bonds yields as an alternative to the VXO. Intuitively firms might have to pay larger risk premia if uncertainty increases and so the spread.

Jurado et al. (2015) start with the premise that for making economic decisions, it is important whether the economy has become more or less predictable and not whether certain economic indicators as the ones mentioned before fluctuate more or less. As an alternative they exploit a data-rich environment to provide direct econometric estimates of time-varying macroeconomic and financial uncertainty. Macroeconomic uncertainty, on the one hand, is related to the common variation in uncertainty series that represent broad categories of macroeconomic time series. These cover real activity indicators, price indices as well as financial data.³ Financial uncertainty on the other hand is the common variation of uncertainty relating to broad set of financial variables.

Figure 1 displays the development of various uncertainty measures explained above over time. The blue dots indicate the periods that correspond to tranquil times whereas the red dots indicate uncertain times.⁴ Shaded areas correspond to NBER recession periods. It can be seen that the choice of uncertainty measure decides which periods are classified as uncertain times. Macroeconomic uncertainty is mainly high during 1975 to 1985, the dot com bubble at the beginning of the 20th century and the Great Recession. There is no clear trend in uncertainty. The behav-

²An example is the possibility of a fiscal cliff the US economy faced in late 2012 that could potentially trigger larger tax increases and government spending cuts where the VIX was very low but consumer uncertainty high.

³See Jurado et al. (2015, p. 1189)

⁴Tranquil times are defined as periods corresponding to the 10th percentile of respective proxy with a ten percent tolerance band. Uncertain times are classified around the 9th decile.

ior of consumer confidence as an inversely proportional measure to uncertainty is quite similar. Interestingly, the behavior of finance related uncertainty quite similar to those related to broad economic uncertainty. Interesting is also the increase in economic policy uncertainty and the corporate bond spread over time. All tranquil periods correspond to the start of our sample. Note also that uncertainty is at least partly persistent, such that periods often keep tranquil or uncertain for some quarters.

Figure 2 shows pairwise correlations between the different uncertainty measures and also serves as a classification. The strongest correlation exists between the financial sector related uncertainty measures: financial uncertainty, SP500Vol, IVol and the spread. In contrast, the smallest correlation is between economic policy uncertainty and the aggregate macroeconomic and financial uncertainties. This is no surprise since the EPU tries to capture policy and not general economic uncertainty. A distinction between realized stock market volatility and implied stock market volatility is almost not possible due to their high correlation of 0.94.⁵ Notably, there is a strong correlation between economic policy uncertainty and the corporate bond spread. Therefore, one could conclude that the spread does not only captures financial frictions but also policy related uncertainty. This is probably due to the included government bond yields in the spread.

4.2 The Self-Exciting Interacted VAR

Specification Our main research question is to investigate whether the real effects of government spending shocks depend on the level of uncertainty prevalent in the economy. With this in mind, we estimate a structural Self-Exciting Interacted VAR (SEIVAR) as proposed by Caggiano et al. (2017), Pellegrino (2018) with quarterly US-post-WWII data to capture the possible non-linear effect of government spending relating to uncertainty in a parsimonious manner.⁶ The SEIVAR augments an otherwise standard VAR with an interaction term including the govern-

⁵This is probably a consequence of our time aggregation. We take quarterly averages of the respective uncertainty measures since we are interested in the effects of fiscal spending and those variables are only available quarterly.

⁶The code used is based on the I-VAR toolbox published with Caggiano et al. (2017) that makes use of the VAR toolbox by Cesa-Bianchi (2015).

ment spending variable and the uncertainty proxy:

$$\mathbf{y}_t = \boldsymbol{\alpha} + \boldsymbol{\gamma} \cdot t + \sum_{j=1}^L \mathbf{A}_j \mathbf{y}_{t-j} + \left[\sum_{j=1}^L \mathbf{c}_j g_{t-j} \cdot \text{unc}_{t-j} \right] + \mathbf{u}_t \quad (1)$$

$$g_t = e'_g \cdot \mathbf{y}_t \quad (2)$$

$$\text{unc}_t = e'_{unc} \cdot \mathbf{y}_t \quad (3)$$

$$E(\mathbf{u}_t \mathbf{u}'_t) = \boldsymbol{\Omega} \quad (4)$$

where \mathbf{y}_t is the $(n \times 1)$ vector of endogenous variables, $\boldsymbol{\alpha}$ is the $(n \times 1)$ vector of constant terms, $\boldsymbol{\gamma}$ is the $(n \times 1)$ vector of constant slope coefficients for the linear time trend included. \mathbf{A}_j denote the $(n \times n)$ matrices for each lag and \mathbf{u}_t is the $(n \times 1)$ vector of error terms whose variance-covariance matrix (VCV) is $\boldsymbol{\Omega}$. The interaction term in brackets makes an otherwise standard VAR a SEIVAR model. The idea is to capture interactive effects of government spending g_t and uncertainty unc_t on the endogenous variables in the L $(n \times 1)$ vectors \mathbf{c}_j . e_g and e_{unc} are selection vectors for the respective endogenous variable in \mathbf{y} , government spending growth and uncertainty. In other words, uncertainty and government spending are both treated as endogenous. It is important to note that the nonlinearities captured by the interaction term are possibly affecting all endogenous variables. Hence they only capture the nonlinearities in government spending induced by the historical level of uncertainty but this nonlinearity is allowed to affect all variables.

We estimate the model equation by equation with OLS.⁷ We impose the same number of lags L for the linear and the nonlinear parts of the SEIVAR and choose the lag length based on the Akaike information criterion. Having in mind that serial correlation in the error terms would drive our OLS estimates to be inconsistent, we use a small sample test for residual autocorrelation of order one as in Edgerton and Shukur (1999). We increase the number of lags as long as the null of no autocorrelation in the errors cannot be rejected at the one percent level.⁸

The SEIVAR model presents several advantages for our research question over alternative non-

⁷This is possible since the model includes only predetermined regressors and, although nonlinear in variables, the model is linear in parameters and does not depend on unobservable variables or nuisance parameters. In contrast to the most commonly used nonlinear state-dependent models that reach nonlinearity by combining two or more regime-specific linear VARs (e.g. Threshold VARs and Smooth Transition VARs), the Interacted-VAR is nonlinear because of its interaction terms. Furthermore, the estimation with OLS is also efficient. Although the errors are correlated across equations, seemingly unrelated regressions would not be more efficient since all regressions have identical right-hand side variables (Enders, 2015, p. 290f.).

⁸We also considered the Hannan-Quinn and Schwarz information criterion. However they gave us an optimal lag length of one. This seemed too parsimonious to capture the dynamics in the data.

linear specifications that also feature an observed conditioning variable like Smooth-Transition (ST-)VARs and Threshold (T-)VARs.

First, the SEIVAR directly captures the non-linearity of interest, the interaction between government spending and uncertainty, without the need to estimate more parameterized and computationally intensive models. So we are not required to identify thresholds as in TVARs or to calibrate transition functions as in STVARs. The specific functional form in equations (1) to (4) was chosen in regards of parsimony and to avoid instability problems.

Second, unlike abrupt change models featuring regime-specific coefficients like TVARs, the SEIVAR is estimated on the full sample. This leaves us with sufficient degrees of freedom to precisely estimate empirical responses in different states of the world referring to extreme events of the uncertainty distribution. This is especially relevant in our case since we estimate a relatively large model to avoid the potential omitted-variable problem.

Third, in time-varying coefficient VARs as applied recently by Kirchner et al. (2010) and Klein and Linnemann (2018), time-varying impulse responses can not be directly connected to the source of non-linearity of our interest, i.e. the degree of uncertainty the economy is facing. By contrast, the SEIVAR enables us to analyze whether the (possibly) nonlinear macroeconomic response to a fiscal spending shock in the two regimes of interest is due to the relationship between uncertainty and fiscal policy or rather to different drivers. However, we admit that the parameters can be biased if there are other sources of nonlinearities that we don't model.

Identification and statistical motivation We identify a structural government spending shock from the vector of reduced form residuals imposing shock run restrictions following Blanchard and Perotti (2002). We order the vector of endogenous variables as follows:

$$\mathbf{y}_t = [\text{govgr}_t, \text{gdpgr}_t, \text{taxgdp}_t, \text{rpolicy}_t, \text{unc}_t, \text{spread}_t, \text{consconf}_t]'$$

where, in order, we have government spending growth, GDP growth, taxes to GDP, the real policy rate, a proxy of uncertainty, a corporate bond spread and consumer confidence (the variables are described in section 4.4). Hence we assume that the government, due to decision lags in the fiscal process, cannot react to other shocks within the same quarter. This identification approach is very common in the literature dealing with the effects of government spending shocks on the economy and is for instance used by Auerbach and Gorodnichenko (2012b), Klein and Linnemann (2018). Notice that all variables ordered after government spending are allowed to react during the same

quarter in response to a government spending shock but that the government is not allowed to react within the same quarter to other shocks. As a result, fiscal spending is allowed to influence the economic uncertainty level in the same period but not the other way around.⁹

Some readers might ask why we do not use instrumental variables to identify our structural government spending shock. Notice first that this approach is often conducted when the interest is in the effects of tax shocks on the economy as for example in Mertens and Ravn (2014) who use Romer and Romer (2010) data to identify anticipated and surprise tax shocks. On the one hand, it is less plausible that taxes are contemporaneous exogenous since they are often measured by tax revenues which increase during an economic upturn or decrease during times of slack. On the other hand, the administration needs time to decide on future spending so that government expenditures do not react contemporaneously to changes in economic activity as proposed by Blanchard and Perotti (2002). In fact Mertens and Ravn (2014, p. 10) show that the role of automatic stabilizers is negligible in the US such that government spending in the US does not react contemporaneously to economic conditions. Hence we conclude that the use of instruments is not needed.

Recently, the literature highlighted another reason against the use of instrumental variables to identify an exogenous government expenditure shock: instrument relevance - that is whether the proposed instrument is actually correlated with the variable it should explain. Ramey (2016) recognizes that many of the exogenous measures of fiscal spending shock are not very relevant instruments at all or in some subsamples. For instance, the military news variable introduced in Ramey (2016) is a weak instrument for the post 1954 period as are the alternative measures of defense news by Fisher and Peters (2010) and Zeev and Pappa (2017). In contrast, the Blanchard and Perotti (2002) shock is a strong instrument by construction, particularly at short horizons, since its is simply the one-step ahead forecast error of government spending.

Note that we, are interested in the effects of aggregate spending on the economy so that we don't take a cross-state approach as in Nakamura and Steinsson (2014). Their cross-sectional responses don't directly answer the research question at hand. As stressed by the authors, this is because states don't have to pay for spending since their government purchase shock is financed federally. In addition, their approach results in relative effects between states, there exist spillovers to other regions and monetary policy doesn't respond in cross-section. Moreover, their

⁹As a robustness check against reverse causality with respect to uncertainty, we order uncertainty first and find no evidence for a contemporaneous reaction of government spending in response to an uncertainty shock.

approach is also better if one is interested in the effects of an open economy (there is a lot of trade between US states) while the USA are a common example of a large closed economy. To the best of our knowledge there is also a lack of sectional uncertainty measures. Therefore it is not possible to distinguish the uncertainty level in local states which we would require to answer our research question.

We provide empirical evidence at the multivariate level in favor of non-linearity for our specification, in particular in favor of the SEIVAR model. Given that the model envelopes a linear VAR, we use a LR-type test for the null hypothesis of linearity versus the alternative of a SEIVAR-specification. For our baseline specification where we use macroeconomic uncertainty as our uncertainty measure, the null hypothesis of linearity is clearly rejected at the one percent level. For the others, we don't find significant nonlinearities at the five percent level.¹⁰ Nevertheless, we show the results for our baseline specification for all other uncertainty indicators in section 7.3.

4.3 Generalized impulse response functions

We quantify the uncertainty-regime-specific impact of government spending shocks via computing generalized impulse response functions (GIRFs) à la Koop et al. (1996). The reason is that in nonlinear systems, a single response does not completely characterize the dynamic effects of a shock. Instead, the effect depends on the sign, the size and the timing of the shock (Koop et al., 1996). Formally, the generalized impulse response at horizon h of the vector \mathbf{y}_t to a shock of size δ computed conditional on an initial history ω_{t-1} of observed histories of \mathbf{y} is given by the following difference of conditional means:

$$\text{GIRF}_{\mathbf{y}}(h, \delta, \omega_{t-1}) = E[\mathbf{y}_{t+h} | \delta, \omega_{t-1}] - E[\mathbf{y}_{t+h} | \omega_{t-1}] \quad (5)$$

GIRFs enable us to keep track of the dynamic responses of all the endogenous variables of the system conditional on the endogenous evolution of the value of the interaction terms in our framework. This is important for our analysis because an unexpected increase in government spending can influence uncertainty and has thereby the potential to change the uncertainty state.

¹⁰However this might be the result from our specification. Since we include consumer confidence and the corporate bond spread as explanatory variables, on the one hand the other measures of uncertainty might not add enough additional information such that the interaction term is not relevant enough anymore. On the other hand this emphasizes the use of general macroeconomic uncertainty. It seems to add something additional to the effects consumer confidence and the spread.

In computing GIRFs, we follow Kilian and Vigfusson (2011) and work with orthogonalized residuals to identify government spending shocks. The exact algorithm is given in Section 7.1.

An alternative would be to use the local projection approach proposed in Jordà (2005). Similar to GIRFs, this method allows estimated responses to implicitly incorporate the average evolution of the economy between the time the shock hits and the time shock effects are evaluated. We follow Pellegrino (2018) and do not use them here for three reasons. First, local projections are not as informative as GIRFs since they provide just the average reaction of the economy for each state while GIRFs allow us to obtain fully non-linear empirical responses for each given initial quarter in the sample. Second, they produce responses that are generally erratic and display oscillations at long horizons as discussed in Ramey (2012). Third, in our case they would suffer significantly from the issue of insufficient degrees of freedom to precisely estimate the empirical responses referring to the extreme deciles of the uncertainty distribution.

4.4 Data

We use quarterly U.S. macroeconomic data for a sample ranging from 1960:3 to 2017:2. The sample is restricted mainly by the availability of the uncertainty indicators. We already explained them in section 4.1. Our specification follows closely Klein and Linnemann (2018) and the set of endogenous variables is

$\mathbf{y}_t = [\text{govgr}_t, \text{gdpgr}_t, \text{taxgdp}_t, \text{rpolicy}_t, \text{unc}_t, \text{spread}_t, \text{consconf}_t]'$. Herein, govgr_t is the annualized growth rate of real government spending, gdpgr_t represents the annualized growth rate of real GDP, taxgdp_t is federal government receipts minus transfer payments as a fraction of GDP, rpolicy_t is the difference between the Wu and Xia (2016) shadow nominal Federal Funds Rate and inflation measured as the annualized quarterly growth rate of the GDP deflator, unc_t is our respective uncertainty indicator, spread_t represents the spread between Moody's seasoned BAA corporate bond yields and 10-year government bond yields, and consconf_t is an index of consumer confidence.

Some of these variables are chosen to control for the financial side of government budget (taxes) and for monetary policy (real policy rate). The shadow rate is used to capture the effects of unconventional monetary policy during the zero lower bound. We employ the spread as an indicator of the degree of financial frictions in the economy, and the consumer confidence variable because Klein and Linnemann (2018) found government spending to be much more effective during the Great Recession and those two variables seem to play a key role. As written above,

consumer confidence and the spread are also sometimes used as uncertainty proxies and their inclusion might result in a high degree of multicollinearity between the included variables. Nevertheless, we include them to grasp which uncertainty channel is important for the transmission of a government spending shock.

5 Government spending in tranquil vs. uncertain times: Empirical evidence

In this section, we provide empirical evidence for the hypothesis that the historical level of uncertainty has a significant effect on how the economy reacts to fiscal easing. We begin with the baseline results in Section 5.1, continue with a deeper analysis on the effects on GDP components in Section 5.2, check for the potential influence of fiscal anticipation in Section 5.3, analyze potential channels in Section 5.4 and look at cumulative fiscal multipliers for different types of government spending in Section 5.6.

5.1 Baseline results

We first estimate our SEIVAR over the full sample and then simulate generalized impulse response functions as described above. The model is estimated with three lags. For better readability, we transform the variables used as growth rates or changes in the estimation to levels. We define the uncertainty state with macroeconomic uncertainty. This gives us an average impulse response to a government spending growth shock for each historical value of macroeconomic uncertainty in our sample. We show these responses in figure 3. Firstly, this figure reveals some time variation in the response government spending as well as the other variables that is induced by the interaction term between government spending growth and macroeconomic uncertainty after a government growth shock. Secondly, we observe some time variation in the response of taxes to GDP as well as the central bank reaction. Thirdly, and maybe most importantly, we also observe some variation in the output effect that might be due to uncertainty and the related channels. However, these 3d impulse responses are hard to interpret and don't capture statistical significance. They do not directly reveal differences in between periods of high vs. low uncertainty. Therefore, we average our calculated impulse response functions over tranquil vs. uncertain times.

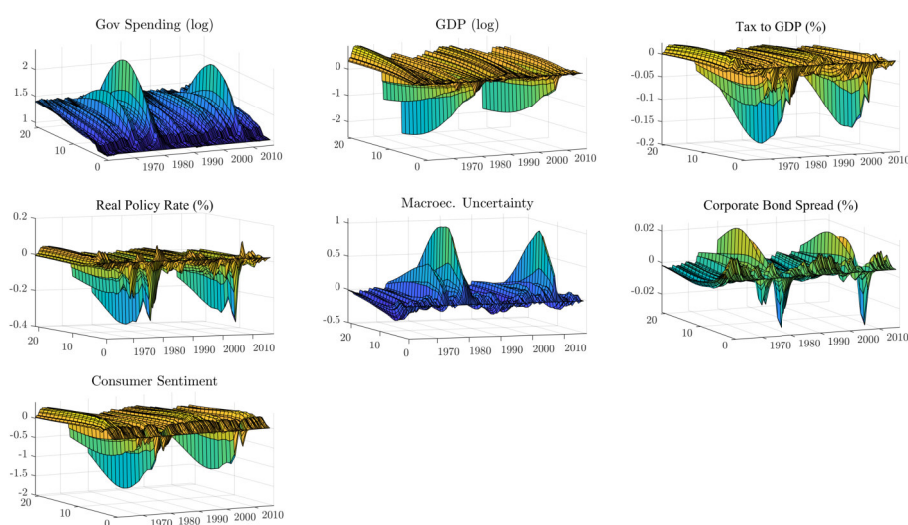


Figure 3: Generalized impulse response functions to an identified one percent government spending growth shock for each history in time

Figure 4 plots the empirical impulse responses to a government spending growth shock of one percent along with 68% bootstrap confidence bands.¹¹ Some results are striking: First of all, a government spending shock in the high uncertainty state emerges in a different way and the funding is regime-specific. During uncertain times, increased government spending is accompanied by a decrease in tax to GDP while there is no significant reaction of taxes during tranquil times. Secondly, fiscal spending is followed by an increase in uncertainty and lower consumer confidence in uncertain times. The result is a crowding-out of private spending, so large that the reaction of GDP becomes negative in the medium and long run. The responses in tranquil times are different. Here, the government spending shock significantly reduces uncertainty in the medium run and boosts consumer confidence. This results in a positive output effect. Thirdly, the central bank behaves differently across states. On the one hand, the real interest rate hardly reacts in quiet times. On the other hand, we see a significant reduction in the real interest rate in uncertain times, possibly to stabilize the economy and to prevent a disinflation resulting from the decrease in aggregate demand.

In an earlier version, we estimated a SEIVAR where we also considered the change in debt to GDP as a variable and used inflation as well as the policy rate instead of the real interest rate.

¹¹We use the 68% instead of the 95% confidence level since we estimate a relative large SEIVAR over a relative short sample. At the same time, the number of bootstrap draws required to accurately estimate the 2.5th and 97.5th percentiles tends to be much larger than the number of draws required for the 16th and 84th percentiles (Kilian and Lütkepohl, 2017, p. 334f.).

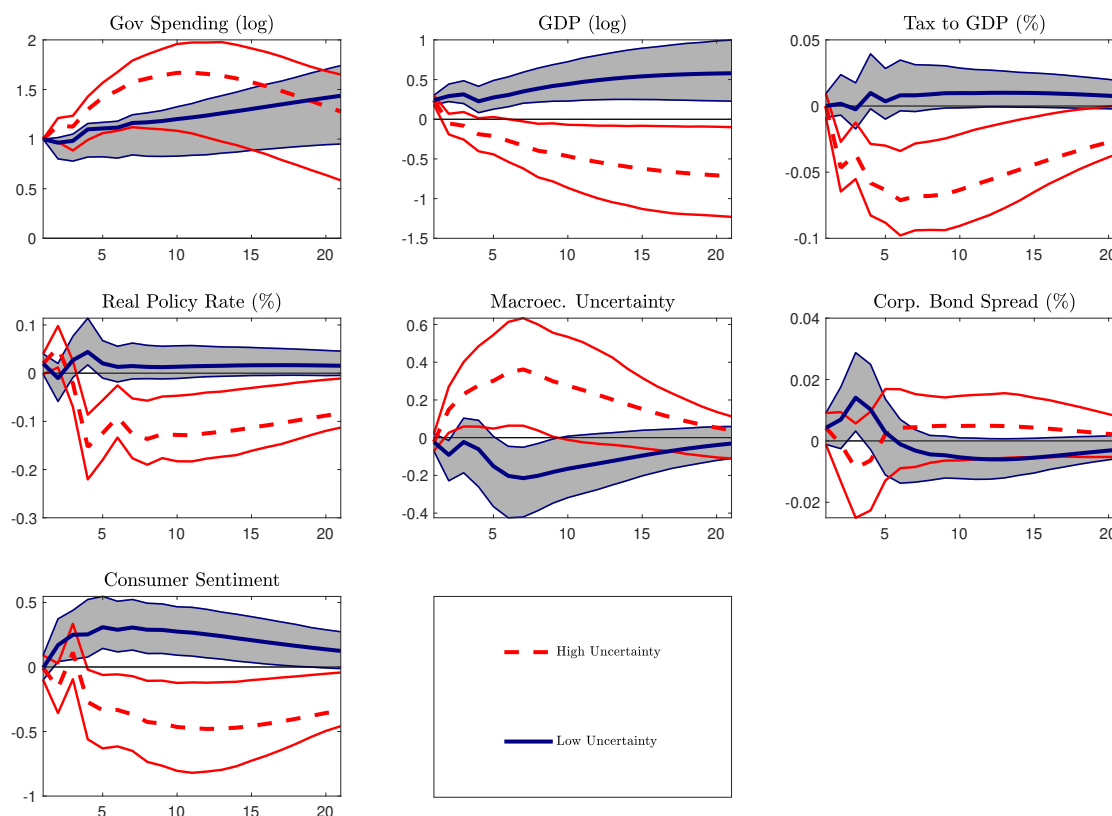


Figure 4: Impulse responses and 68% confidence intervals to a one percent government spending growth shock. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

We decided to change our specification because we have been confronted with issues of over-parameterization due to the large number coefficients to estimate in our system.¹² Figure 12 in the appendix shows that the results in the larger specification are very similar to our smaller model. This serves as a robustness check that our reduced model does not neglect important variables. Another issue is the question if our results are driven by the most extreme histories. As a check of this issue, figure 13 in the appendix shows that the results remain qualitatively the same if we use a five percent tolerance band around the 1st and 9th decile for the calculation of tranquil and uncertain times that doesn't include the most extreme events of the uncertainty distribution.

So far, we can conclude that the responses to a government spending growth shock during uncertain times are comparable to the responses to an uncertainty shock. This leads to the question of whether our results are driven by reverse causality. Do we see an increase in uncertainty be-

¹²With three lags the original model includes 32 parameters to estimate in each equation whereas the smaller model only needs to estimate 26 parameters.

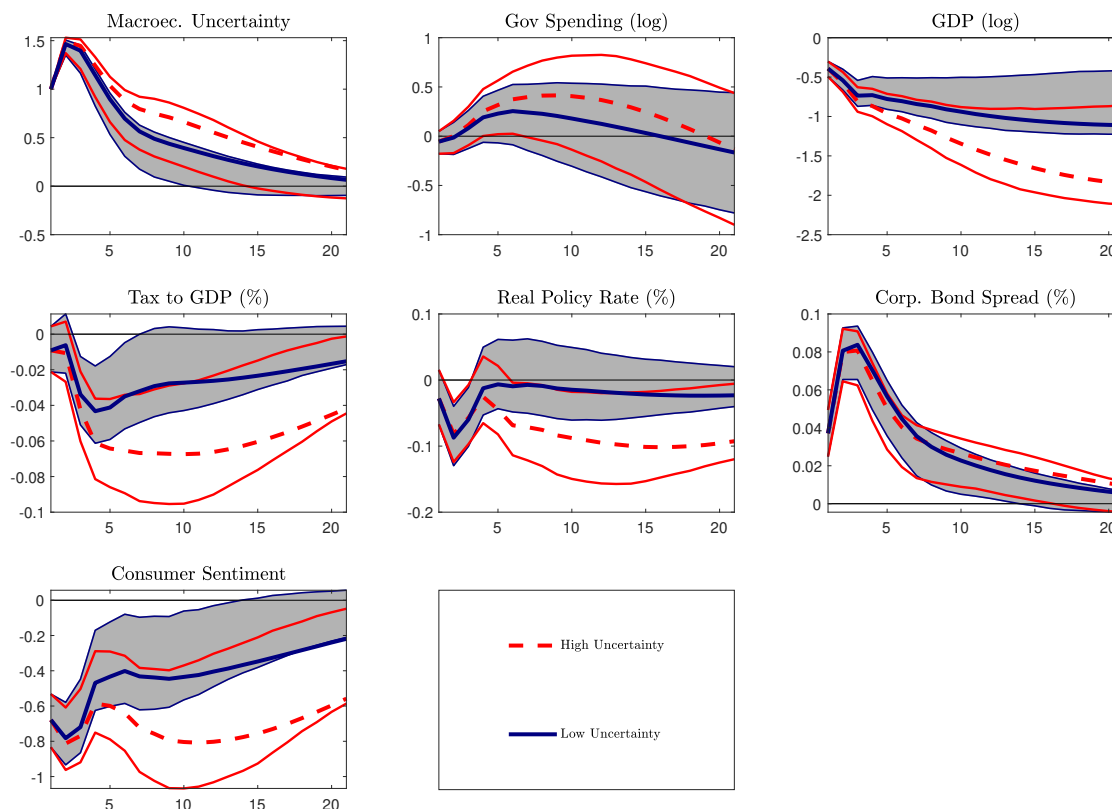


Figure 5: Impulse responses and 68% confidence intervals to a one index point shock in macroeconomic uncertainty. Histories are classified as tranquil times is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

cause government spending rises or as a result of the fiscal reaction to high uncertainty. We trace this question by arranging our uncertainty proxy as the first variable and analyze the impulse responses to an uncertainty shock. The results shown in figure 5 mitigate our reverse causality concerns. We see an increase in financial frictions measured by the corporate bond spread, a reduction in consumer confidence and a contradiction in aggregate demand. This is sensible in regard of section 2. But what we don't see is a significant reaction of government spending in response to an uncertainty shock.

5.2 The effects on private spending

As a next step, we have a deeper look at the responses of GDP components and include private spending in form of personal consumption and private domestic investment to our specification. We include both as growth rates in the estimation and transform the impulse responses to levels as before. We estimate the model with three lags.

Figure 6 tells a similar story as before. During uncertain times, we see a rise in macroeco-

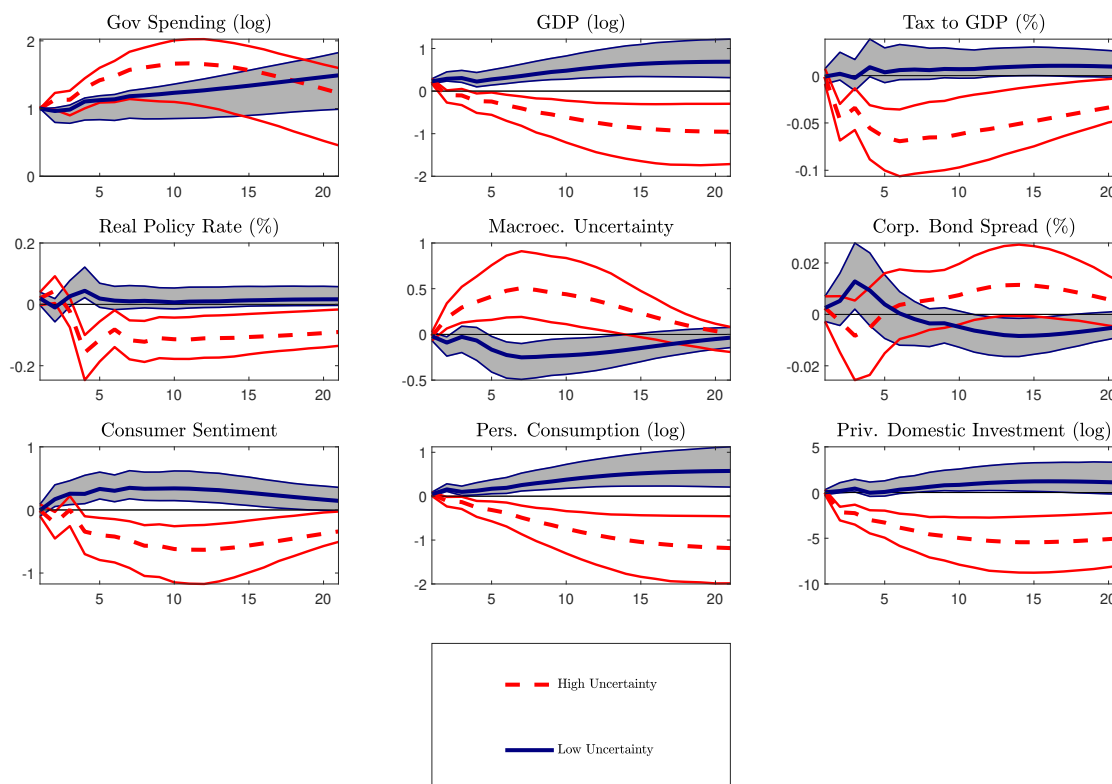


Figure 6: Impulse responses and 68% confidence intervals with private spending to a one percent government expenditure growth shock. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

economic uncertainty in response to a government spending growth shock. Instead of stabilizing the economy, the government spending shock acts very similar to an uncertainty shock during uncertain times. Besides the usual crowding out-effect of fiscal spending, the rise in uncertainty seems to trigger the precautionary saving and real option channel. This results in a strong decrease in personal consumption and private investment that we don't find during tranquil times. The financial frictions channel captured by the spread variable plays no significant role.

5.3 Controlling for fiscal anticipation

Are these results the figment of non-fundamental shocks? So far, we identified the unexpected structural fiscal shock via recursive orthogonalization of the reduced form residual variance-covariance matrix. Fundamental shocks can be recovered from past and present observed variables. In contrast, shocks are non-fundamental if they are not recoverable from present and past observations. one reason for the presence of non-fundamental shocks is the fact that economic agents use additional information in decision-making that is not fully reflected in the

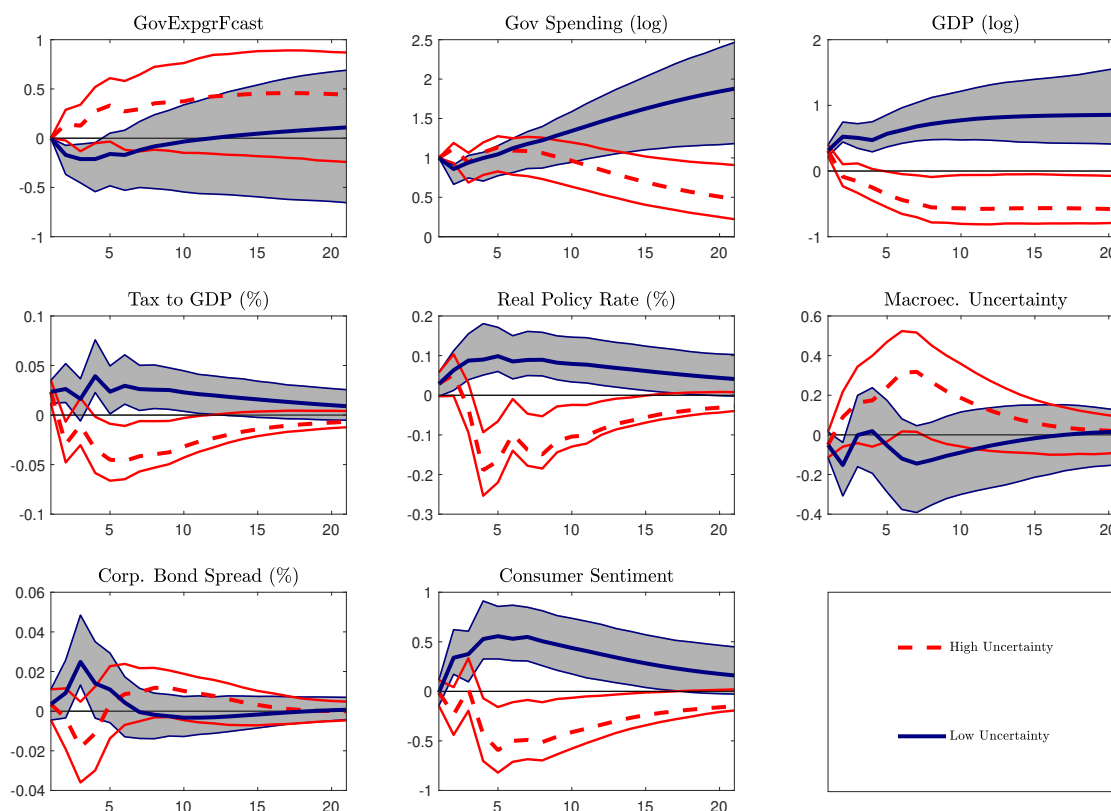


Figure 7: Impulse responses and 68% confidence intervals with control for fiscal anticipation to a one percent government spending growth shock when we account for fiscal anticipation. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

econometric specification of the VAR model (see Kilian and Lütkepohl, 2017, chap. 17). In our case, government spending could be anticipated by the private sector, such that the timing of fiscal shocks is incorrectly assessed by our econometric model. Ramey (2011b) emphasizes that neglecting anticipation effects can render impulse responses biased and proposes to include news/expectations about future fiscal policy to overcome this potential problem. Thus, we compare our baseline results with a specification that explicitly accounts for the issue of fiscal policy anticipation. We follow Auerbach and Gorodnichenko (2012b) and add real-time professional forecasts of government spending growth in front of our fiscal expenditure variable in the vector of endogenous variables. This is a spliced series of government spending forecasts provided by the Greenbook (1966:4-1981:2) and the survey of professional forecasters (SPF, 1982:3-2017:3). We take the Greenbook data from Auerbach and Gorodnichenko (2012b) and augment it with the SPF data. Because the forecast variable limits the usable sample, the following estimation results are restricted to the period 1966:4-2017:3. The unanticipated government spending growth shock is identified as the innovation to realized government spending growth. The change in

fiscal expenditure growth that is orthogonal to the respective expectation variable can then be interpreted as an unanticipated shock to government spending in the sense that it was not foreseen by professional forecasters.¹³ We estimate the model with three lags.

Figure 7 reveals that controlling for government spending forecast does not change qualitatively the results. We still find a state-dependent effect of a government spending growth shock on the economy. Hence, we decide to drop the forecast data for the rest of our analysis.

5.4 The role of consumer confidence and corporate bond spread

We now check what happens, if we drop consumer sentiment and the corporate bond spread from our specification. The corresponding generalized impulse response functions are plotted in Figure 8. We now estimate the model with four lags according to the AIC. Compared to our baseline specification, the following pattern emerges. Government spending growth shocks are accompanied by tax reductions in uncertain times whereas we observe an increase in tax to GDP during tranquil times. The monetary policy reaction turns out to be similar to the baseline but the output effect changes completely. There is now only a significant positive effect over the first year in tranquil times. What is even more remarkable is the now different GDP effect during uncertain times. Instead of being significant negative, the effect of an increase in government spending growth is now significant and positive in the long-run. Nevertheless the GDP significantly lower over the first year.

We feel legitimized to argue that the new results deliver evidence of a confidence channel in the transmission of fiscal policy changes. Accordingly, Bachmann and Sims (2012) show in a non-linear VAR that confidence rises following an increase in spending during periods of economic slack and that fiscal multipliers are much larger. In contrast, they find confidence to be irrelevant for the output multiplier during normal times. We support their results partly, at least. In the baseline specification, we are able to identify a different consumer confidence responses during tranquil and uncertain times. In uncertain times fiscal spending increases uncertainty and lowers consumer confidence. In tranquil times, the government expenses shock reduces macroeconomic uncertainty slightly but results in higher consumer confidence. We conclude that it is important to include consumer sentiment in the specification. Bachmann and Sims (2012) explanation that

¹³An alternative would be to use the defense news shock variable from Ramey (2011b). We do not follow this approach since the news variable has low predictive power for our sample that does not include WWII or the Korean War.

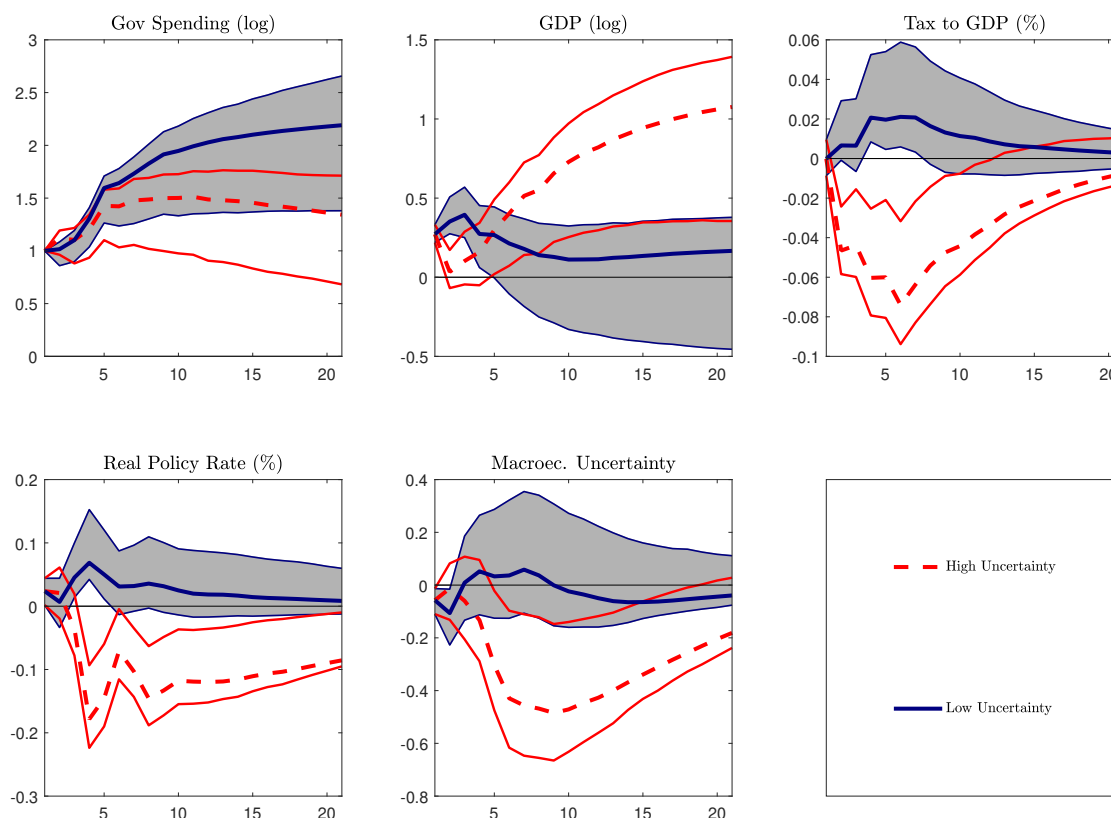


Figure 8: Impulse responses and 68% confidence intervals to a one percent government spending growth shock without consumer sentiment and corporate spread. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

consumer confidence is a proxy for expectations about future technological progress instead of a pure sentiment indicator could be an explanation why our output effect changes in the long-run when we exclude consumer confidence while the short-run effects remain. Nevertheless we are aware of the fact that we analyze a different model compared to our baseline specification and that the findings might not directly be related to the consumer confidence channel. Therefore, we plan to follow Bachmann and Sims (2012) in a future version and directly shut down the consumer confidence channel.

5.5 Restricting the sample to the period before the Great Recession

Are our results driven by very special circumstances as the recent Great Recession? It is not unreasonable to think about a structural break during this time. Indeed, in a non-parametric time varying coefficients VAR Klein and Linnemann (2018) find the Great Recession to be characterized by uniquely large impulse responses of output to fiscal shocks. To check if our results

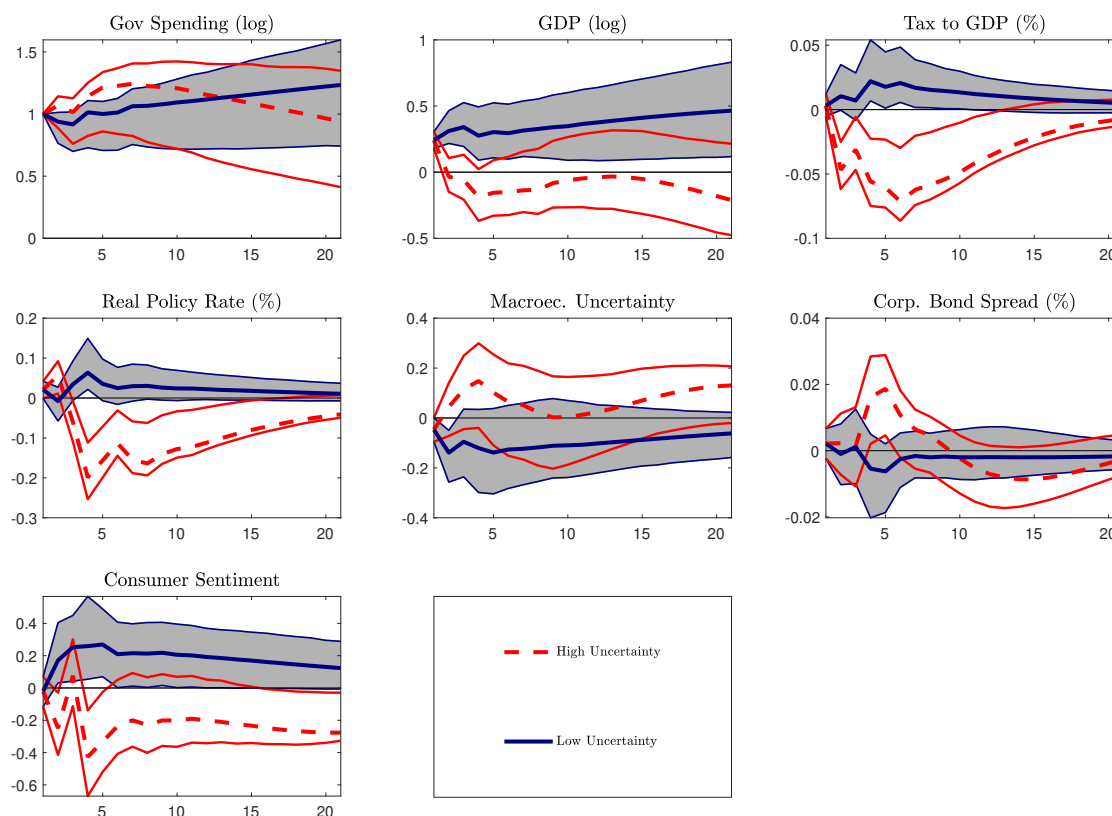


Figure 9: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when the sample ends before the Great Recession. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

are driven by this special time, we estimate the model in equations (1) to (4) again but consider only the period from 1960:3 to 2007:3. The model is estimated with three lags. We display the resulting impulse responses in Figure 9.

Figure 9 shows a different picture than Figure 4. The fiscal easing still increases output and consumer confidence during tranquil times. However, the significant negative effect on GDP disappears. This can be the result of two circumstances. Firstly, we lose roughly forty quarters of observations, such that it becomes harder to find statistical significant effects. Secondly, as can be seen from Figure 1 the Great Recession has been a very uncertain period that is now dropped from our sample. So the difference between tranquil and uncertain times diminishes and so does the state-specific effect. Nevertheless there are also findings that are robust to this check. The GDP effect is significantly lower in the short run during uncertain times. In addition, we find a significant reduction in consumer confidence and increase in financial frictions over some horizons.

5.6 Types of government spending and cumulative multipliers

In this section, we want to clarify if the output effect is similar for all types of government spending. For this purpose, we follow Auerbach and Gorodnichenko (2012b) and Arčabić and Cover (2016) and have a deeper look at the components of our government spending variable. We consider shocks in the growth rate of consumption, gross investment, research & development and national defense expenditures. The corresponding impulse response functions are plotted in Figure 10.

The results are as follows. Government consumption has no significant effect on output but leads to lower (higher) risk premia for corporations during tranquil (uncertain) times. For government investment, we find a clear state-effect. In uncertain times, an increase is debt-funded and comes along with tax cuts and leads to higher uncertainty, higher risk premia for businesses and lower consumer confidence. This results in a negative output effect. In tranquil times, the results are of the opposite direction. This result actually is puzzling, since we would have expected positive effects of government investment shocks. The reason is that investments in infrastructure might result in higher future productivity and lead to larger incentives for increases in private spending. Fortunately, the results for research & development expenses are promising for fiscal stabilization politics. Here, we find significant positive output effects in the short and medium horizon despite the increase in taxes to GDP. Such expenses result in lower short-run uncertainty, lower risk premia and higher consumer confidence in the short run. We propose two possible reasons for this. Firstly, if firms step cut their research expenditures in times of high uncertainty, f.i. due to tighter financial frictions, the fiscal research might be a replacement for private explorations although the composition of both might diverge in reality. The second is related to the growth-option channel explained above. If uncertainty is large and mean-reverting, the expected profit or technology increase induced by conducted research can be larger. However, this effect is mitigated in the long-run. This might be the result of the sustained rise in taxes as well as in the real policy rate. National defense expenditures hardly have an effect on the economy. Output does not react significantly in uncertain times and small positive in the short-run during tranquil times. In general, the confidence intervals are very large.

Figure 11 displays the cumulative fiscal multipliers for all types of government spending considered in this analysis. They are calculated following Ramey and Zubairy (2018) as $\frac{\sum_{i=1}^h \widehat{gdp}_h}{\sum_{i=1}^h \widehat{gov}_h}$ where \widehat{gov}_h is the log-level response of the respective government variable at horizon h and \widehat{gdp}_h represents the log-level GDP response at horizon h . This multiplier measures the cumulative

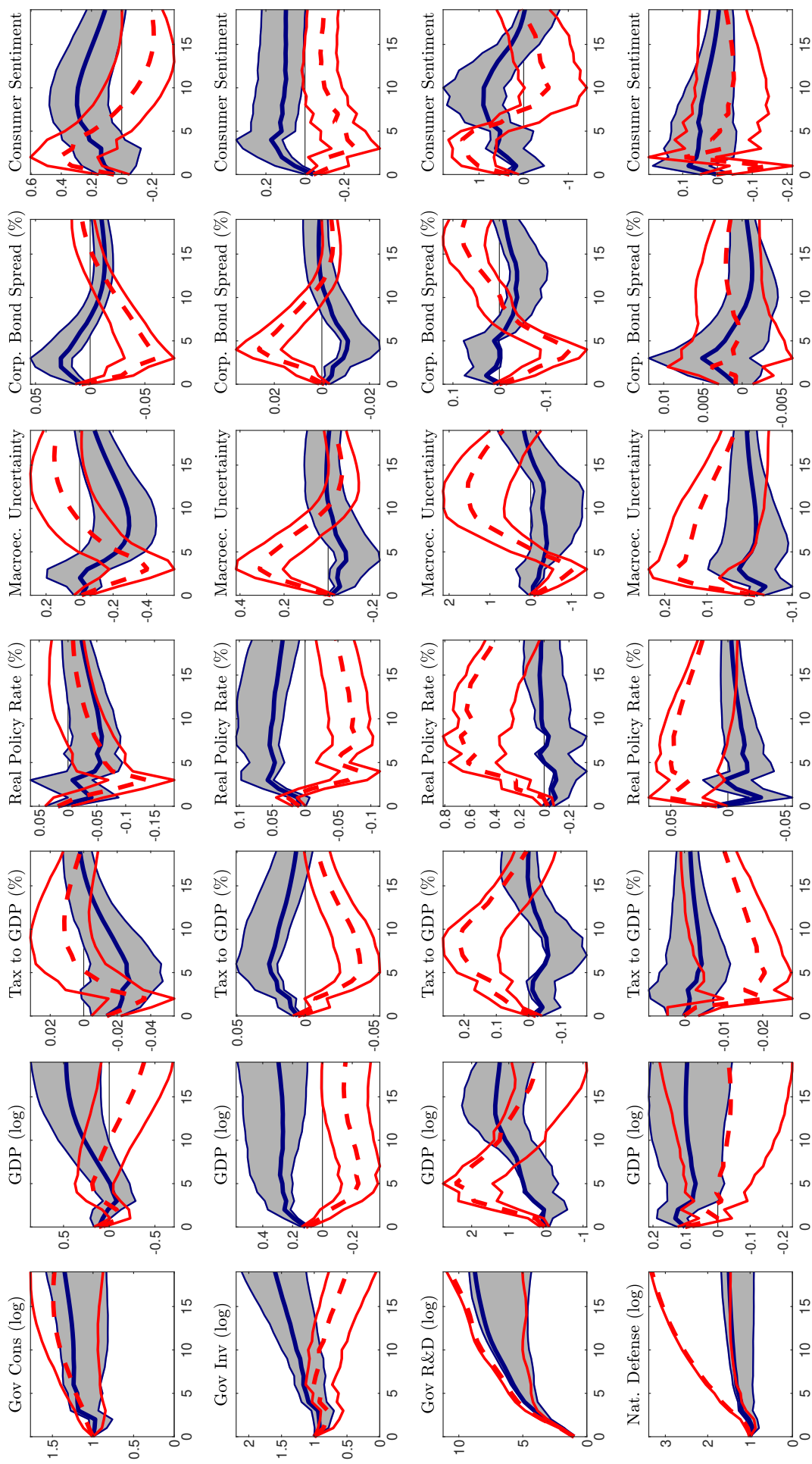


Figure 10: Impulse responses and 68% confidence intervals to a one percent spending growth shock for different types of government expenditures. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

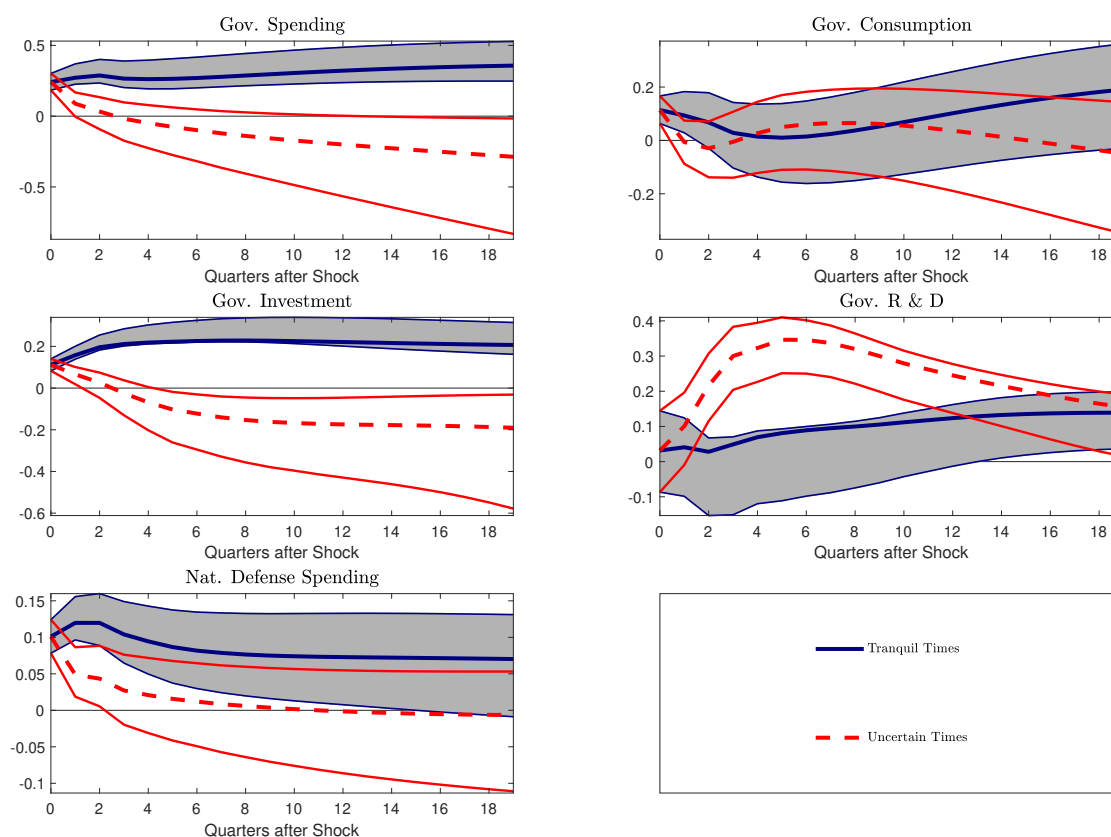


Figure 11: Cumulative government spending multipliers and 68% confidence intervals for different types of government spending. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

output gain relative to the accumulated government spending during a given horizon. Therefore, it incorporates the role played by fiscal spending persistence. Those cumulative multipliers are more informative for policymakers than the original fiscal multiplier in Blanchard and Perotti (2002), that focuses on the ratio between the peak of the output response and the impact response of government spending, because they account for the costs and benefits of the implementation of fiscal policy interventions.¹⁴¹⁵

Figure 11 depicts that the cumulative fiscal multiplier depends on the specific form of government spending. We find uncertainty-specific relative output gain for general government spending as well as for governmental investment and research & development expenses. There is also a difference for defense expenses but it's not statistically significant since the confidence inter-

¹⁴This multiplier was originally proposed by Mountford and Uhlig (2009), Uhlig (2010) who calculate a present value multiplier, using the long-run average interest rate to discount. Ramey and Zubairy (2018) use the simple cumulative multiplier because of its close relationship to the areas under the impulse responses. We follow the latter.

¹⁵Note that these are no dollar to dollar multipliers. Since government purchases and output effects are transformed to log-levels, the multipliers have to be scaled by the sample ratio of output to government spending to receive dollar to dollar multipliers.

vals overlap. We also find no state-specific gain for fiscal consumption. Overall, it can be stated that different types of government spending lead to a relative output-gain during tranquil times but have no statistical significant output-effect or is even contractionary during uncertain times. This questions fiscal policy as a tool for the stabilization of the economy during uncertain times. Instead of stabilizing the economy in uncertain times, the government seems to confirm private agents in their view that the economy is in a slack and rises uncertainty even more. The exception is governmental R & D. Those expenditures lower uncertainty and increase consumer sentiment in the short-run which results in a relative output gain. This is even the case though the fiscal spending is tax-funded.

6 Conclusion

We use a non-linear framework to study macroeconomic effects of fiscal spending shocks during tranquil versus uncertain times, taking into account that uncertainty may react to fiscal spending.

We find evidence that the output effects of fiscal spending vary with the level of macroeconomic uncertainty. An unexpected increase in government spending has significant positive output effects during tranquil times but is contractionary during times of high uncertainty. Instead of reducing uncertainty, a government spending shock appears to act very similar like an uncertainty shock. The increase in uncertainty triggers the precautionary saving and real option channels so strongly that a fiscal policy oriented at stabilization purposes becomes contractionary.

We find slight evidence in favor of a contractionary fiscal expansion¹⁶ when we control for fiscal anticipation and government finance as well as monetary policy as well for different types of government spending. The point estimates of cumulative multipliers of government spending, government investment become negative in the long run. But we would like to stress that this evidence is at best only slightly significant at the 68% level. In our sample, only governmental research and development expenditures can help to stabilize the economy.

The results change if we let our sample end before the Great Recession. In this case, the contractionary effects of fiscal spending disappear. This can be due to two circumstances. Firstly, the loss of roughly a fifth of our observations makes it more difficult to find statistical significant

¹⁶This term hints at the literature on an expansionary fiscal contraction that has been popularized by Giavazzi and Pagano (1990) and has been analyzed systematically by Barry and Devereux (2003). Nevertheless, we can not derive evidence for an expansionary fiscal contraction from our results since we analyzed expansionary fiscal policy in a non-linear model where impulse responses are not symmetric in positive and negative shocks.

effects. Secondly, the Great Recession initiated a very uncertain period that is now dropped from our sample. Hence, the difference between tranquil and uncertain times diminishes as does the state-specific effect. Nevertheless the result that government spending has smaller short-run effects remains.

To our point of view, the result that a government shock can act like an uncertainty shock in some circumstances is an interesting finding. Although we have find circumstantial evidence for an important role of consumer sentiment in the transmission, we are looking forward to new theoretical models that can explain our results in a more formal way.

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Knight (1921)

7 Appendix

7.1 Computation of generalized impulse response functions

This section documents the algorithm employed to compute the GIRFs and their confidence intervals. The algorithm follows Koop et al. (1996) with the modification of considering an orthogonal structural shock as in Kilian and Vigfusson (2011).

The theoretical GIRF of the vector of endogenous variables \mathbf{y}_t , h periods ahead, for a starting condition $\omega_{t-1} = \{\mathbf{y}_{t-1}, \dots, \mathbf{y}_{t-L}\}$ and a structural shock of size δ_t in period t can be expressed following Koop et al. (1996) as:

$$\text{GIRF}_{\mathbf{y},t}(h, \delta, \omega_{t-1}) = E[\mathbf{y}_{t+h} | \delta, \omega_{t-1}] - E[\mathbf{y}_{t+h} | \omega_{t-1}], h = 0, 1, \dots, H \quad (6)$$

where $E[\cdot]$ represents the expectation operator. The algorithm to estimate the state-conditional GIRF is the following:

1. Pick an initial condition $\omega_{t-1} = \{\mathbf{y}_{t-1}, \dots, \mathbf{y}_{t-L}\}$, i.e. the historical values for the lagged endogenous variables at a particular date $t = L + 1, \dots, T$. This set includes the values for the interaction terms since both interaction variables are modeled as endogenous.
2. Draw randomly with repetition a sequence of n -dimensional residuals $\{\mathbf{u}_{t+h}\}^s$, $h = 0, 1, \dots, H = 19$, from the empirical distribution $d(\mathbf{0}, \hat{\Sigma})$ where $\hat{\Sigma}$ is the estimated residual variance-covariance matrix. In order to preserve the contemporaneous structural relationships among variables, residuals are assumed to be jointly distributed, so that we draw all n residuals together for period t .
3. Conditional on ω_{t-1} , on the estimated model equations (1) to (4) and using $\{\mathbf{u}_{t+h}\}^s$, simulate the evolution of the vector of endogenous variables over the following H periods to obtain the path \mathbf{y}_{t+h}^s for $h = 0, 1, \dots, H$. s denotes the dependence of the path on the particular sequence of residuals used.
4. Conditional on ω_{t-1} , on the estimated model equations (1) to (4) and using $\{\mathbf{u}_{t+h}\}^s$, simulate the evolution of the vector of endogenous variables over the following H periods when

a structural shock δ_t is imposed to \mathbf{u}_t^s . In particular, we Cholesky-decompose $\hat{\Sigma} = \mathbf{C}\mathbf{C}'$, where \mathbf{C} is a lower-triangular matrix. The structural innovations are then recovered as $\boldsymbol{\varepsilon}_t^s = \mathbf{C}^{-1}\mathbf{u}_t^s$. We add a quantity $\delta > 0$ to the scalar element of $\boldsymbol{\varepsilon}_t^s$ that refers to government spending, i.e. $\boldsymbol{\varepsilon}_{t,\text{gov}}^s$. We then move again to the residual associated with the structural shock $\mathbf{u}_t^{s,\delta} = \mathbf{C}\boldsymbol{\varepsilon}_t^{s,\delta}$ to proceed with simulations as in point 3. Call the resulting path $\mathbf{y}_{t+h}^{s,\delta}$.

5. Compute the difference between the previous two paths for each horizon and for each variable, i.e. $\mathbf{y}_{t+h}^{s,\delta} - \mathbf{y}_{t+h}^s$ for $h = 0, 1, \dots, H$.
6. Repeat steps 2-5 for $S = 500$ different draws from the empirical residuals and then take the average across s . During this computation, the starting quarter $t - 1$ does not change. In this way, we obtain a consistent point estimate of the GIRF for each given starting quarter in our sample, i.e. $\widehat{\text{GIRF}}_{\mathbf{y},t}(h, \delta, \boldsymbol{\omega}_{t-1}) = \{E[\mathbf{y}_{t+h}|\delta, \boldsymbol{\omega}_{t-1}] - E[\mathbf{y}_{t+h}|\boldsymbol{\omega}_{t-1}]\}_{h=0}^{19}$. If a given initial condition $\boldsymbol{\omega}_{t-1}$ brings an explosive response (namely if this is explosive for most of the sequences of residuals drawn $\{\mathbf{u}_t\}^s$, in the sense that the response of the variable shocked diverges instead than reverting to zero), it is discarded and not considered for the computation of state-conditional responses at the next step. Note that this stability condition is imposed on the GIRF in the original form of variables that is used in estimation and not in the transformed form that is plotted where GIRFs for variables modeled as growth rates or changes are transformed to level responses.
7. These history-dependent GIRFs are then averaged over a particular subset of initial conditions of interest to produce the state-dependent GIRFs. For this, an initial condition $\boldsymbol{\omega}_{t-1}$ is classified to belong to the "tranquil times" state if unc_{t-1} is within a 5-percentiles tolerance band from the bottom decile of the empirical uncertainty distribution and to the "uncertain times" state if unc_{t-1} is within the same band around the top decile of the uncertainty distribution. In this way, we obtain the $\widehat{\text{GIRF}}_{\mathbf{y},t}(\delta_t, \text{tranquil times})$ and $\widehat{\text{GIRF}}_{\mathbf{y},t}(\delta_t, \text{uncertain times})$.
8. Confidence bands around the point estimates obtained in point 7 are computed through bootstrap. In particular, we simulate $R = 1999$ datasets statistically equivalent to the actual sample and for each of them the interaction terms are constructed coherently with the simulated series. Then, for each dataset, (a) we estimate the SEIVAR and (b) implement steps 1-7. In implementing this procedure this time, the starting conditions and variance-covariance matrix used in the computation depend on the particular dataset r used, i.e.

ω_{t-1}^r and $\hat{\Sigma}^r$. The 16th and 84th percentiles of the resulting distribution of state-conditional GIRFs are taken to construct the confidence bands.

7.2 Robustness checks

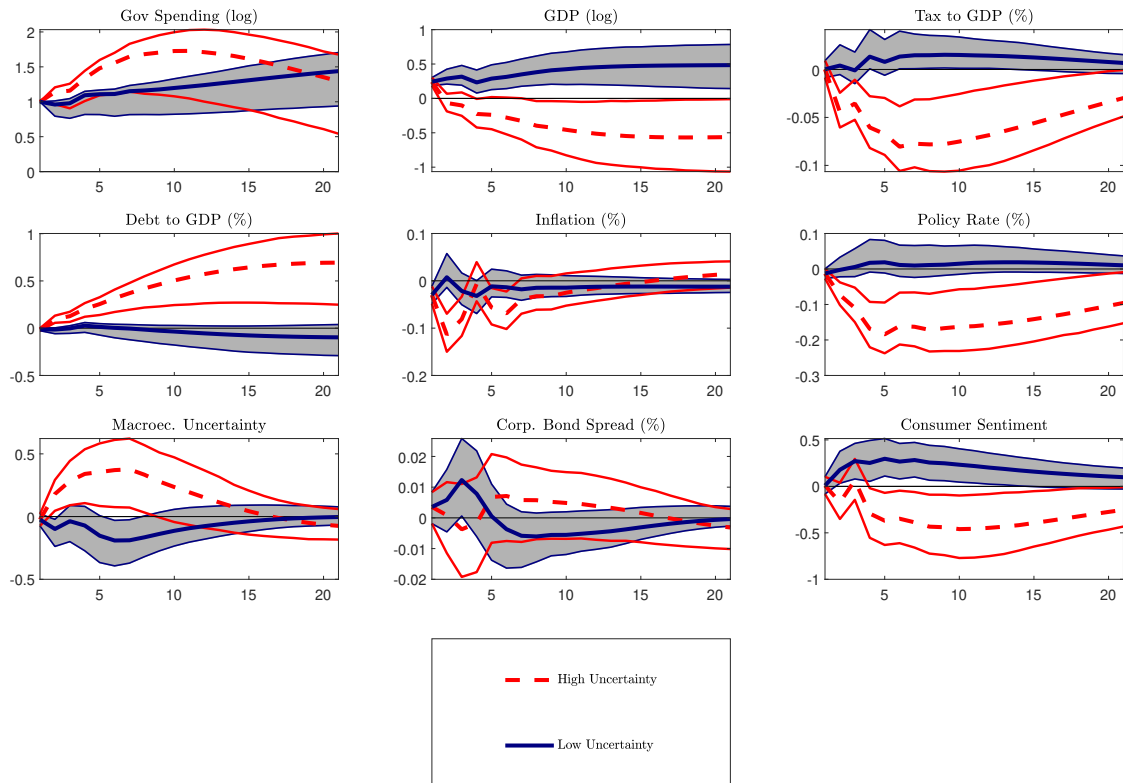


Figure 12: Impulse responses and 68% confidence intervals to a one percent government spending shock for our original specification. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

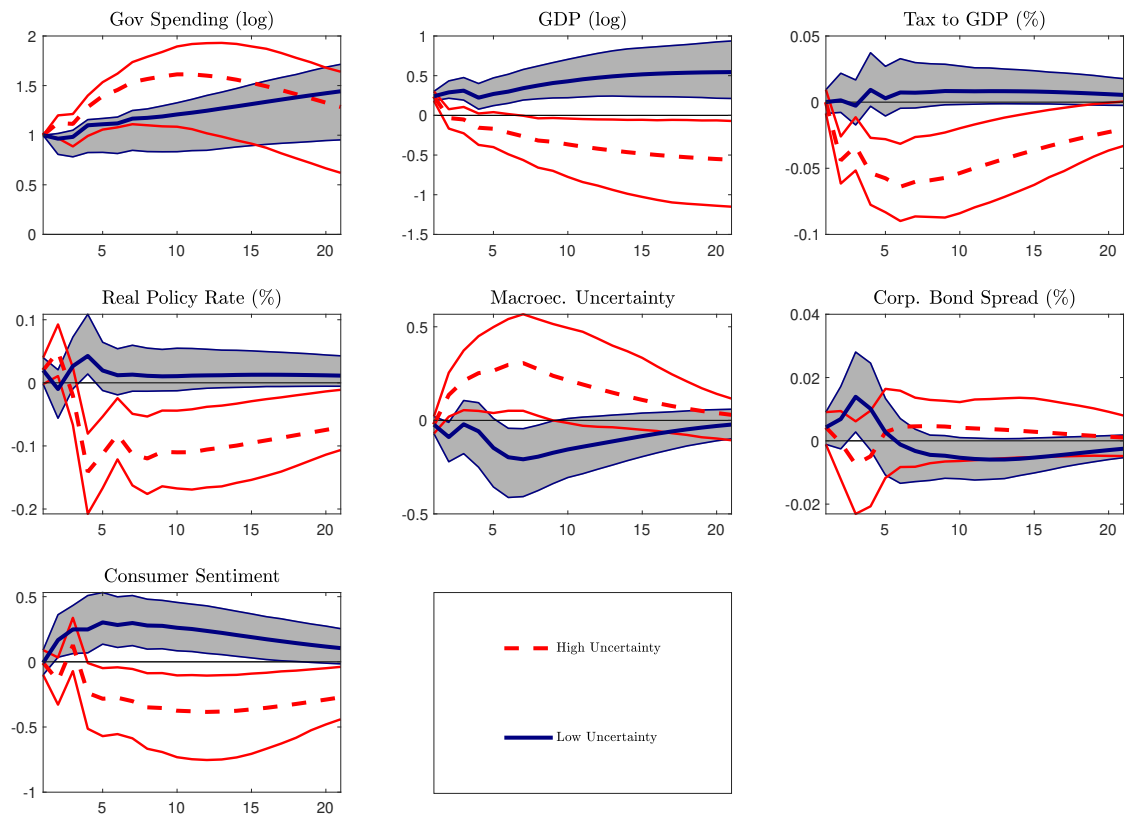


Figure 13: Impulse responses and 68% confidence intervals to a one percent government spending shock with smaller tolerance bands. Histories are classified as tranquil times if uncertainty is between the 5th and 15th percentile of the uncertainty distribution. Uncertain times are between the 85th and 95th percentile.

7.3 Results for different uncertainty measures

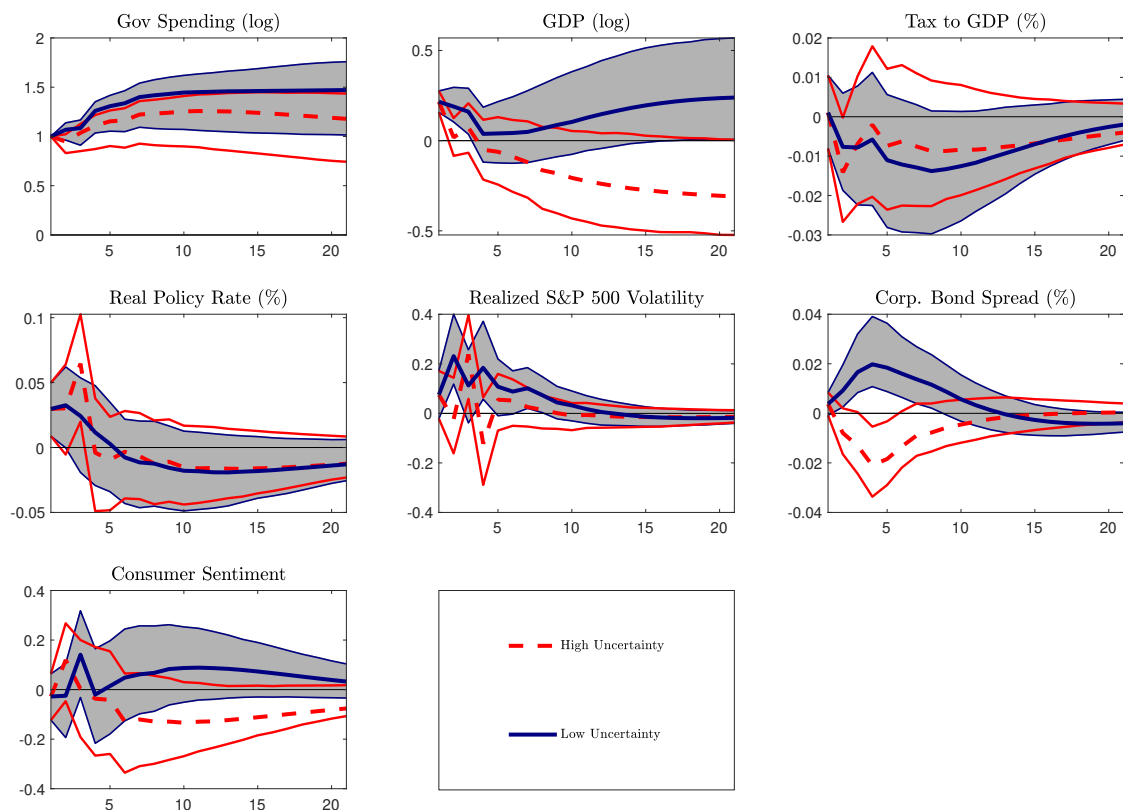


Figure 14: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when we used annualized monthly standard deviation of daily S&P 500 returns as uncertainty indicator. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

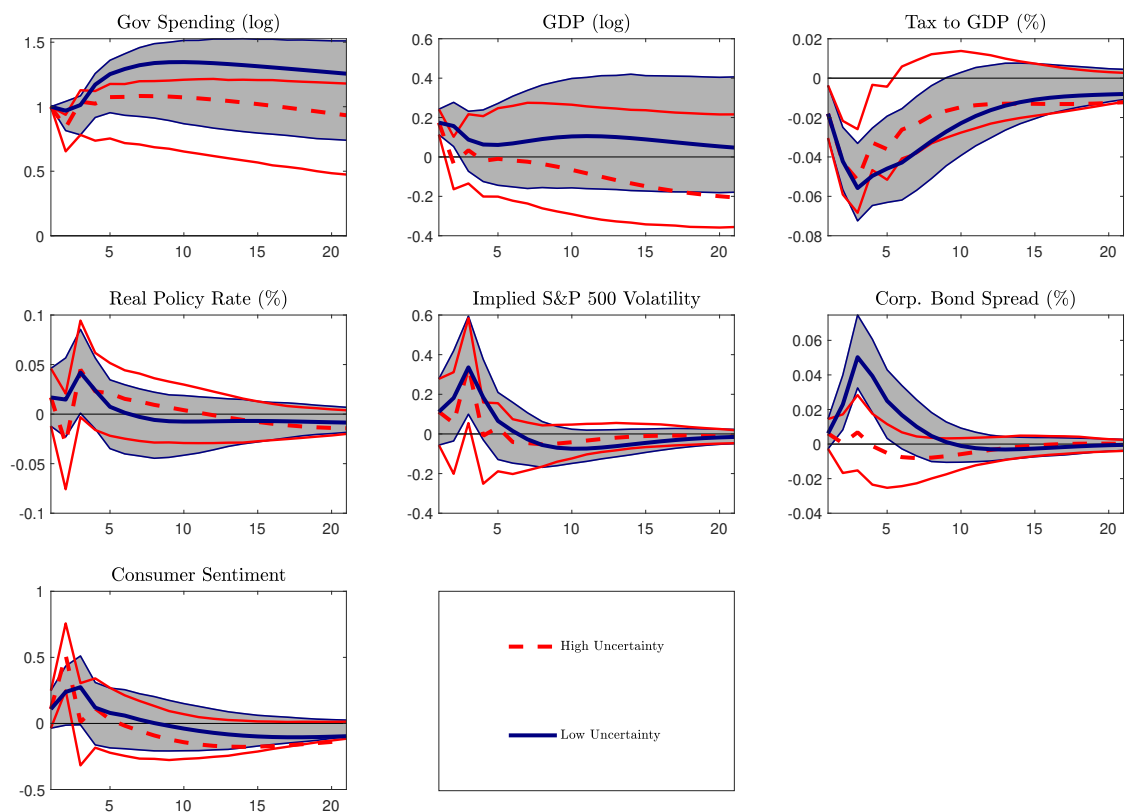


Figure 15: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when the use implied volatility of daily stock market returns as uncertainty indicator. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

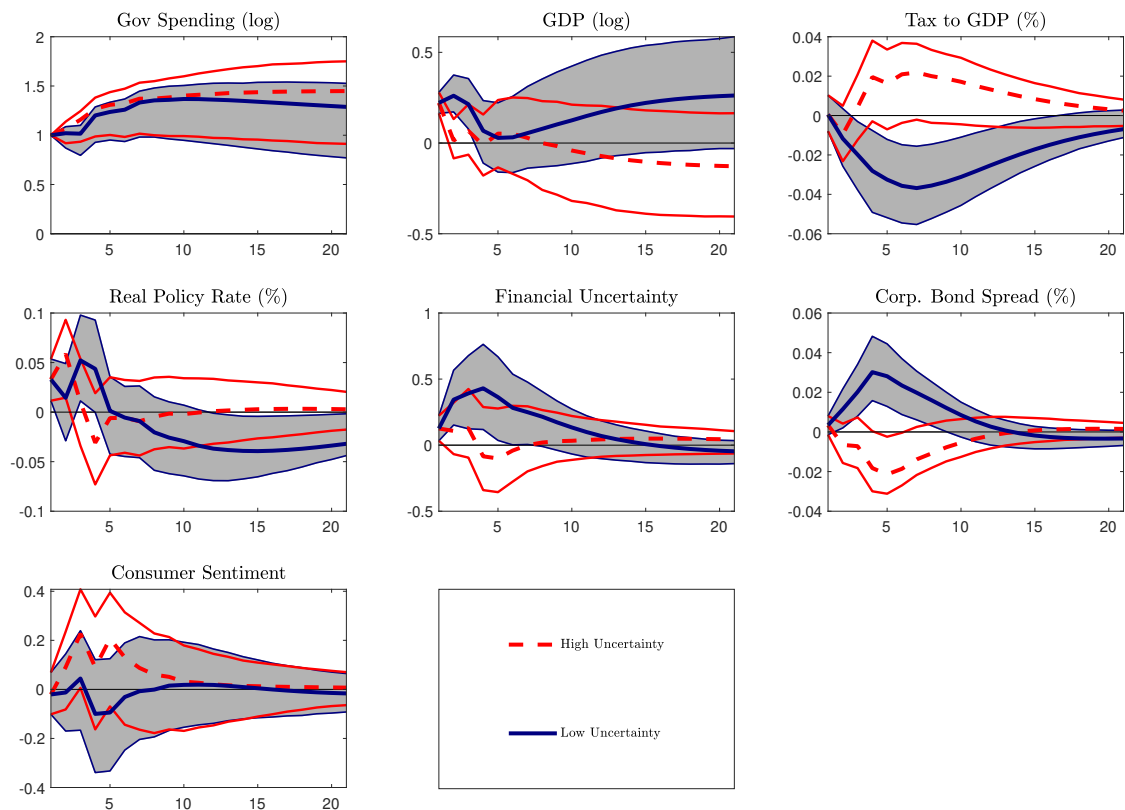


Figure 16: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when we use the financial uncertainty indicator. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

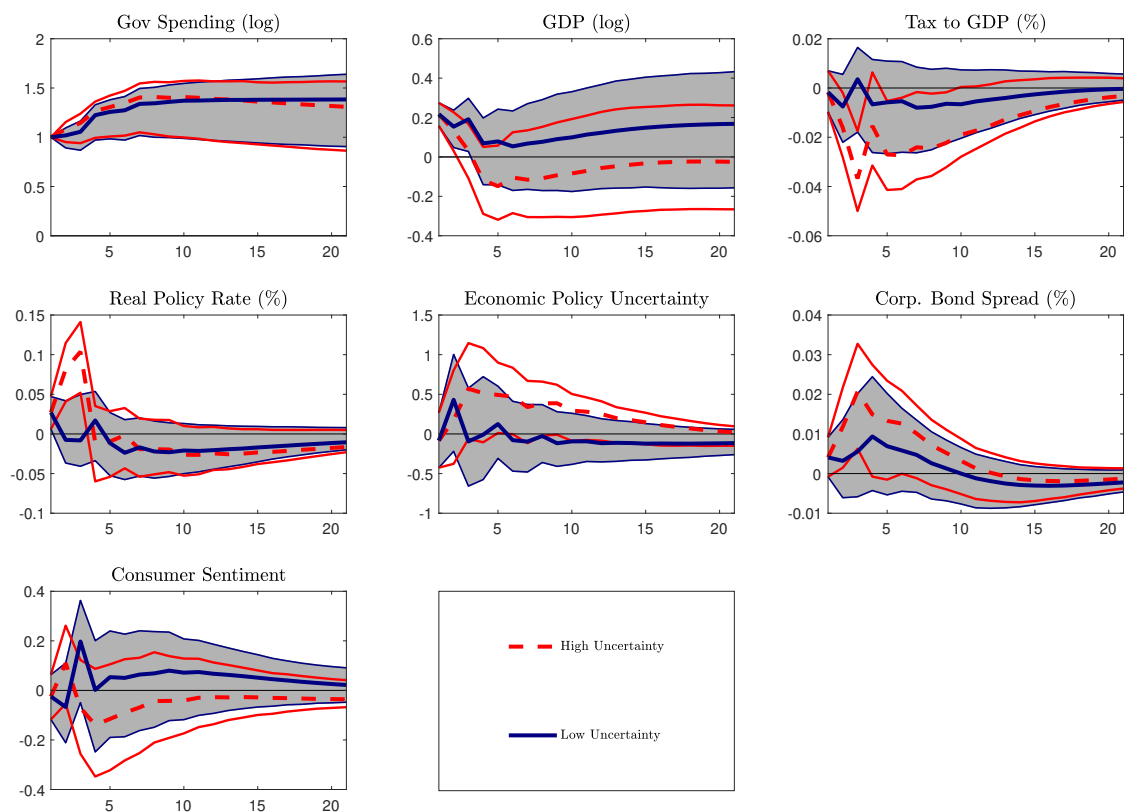


Figure 17: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when we use economic policy uncertainty. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

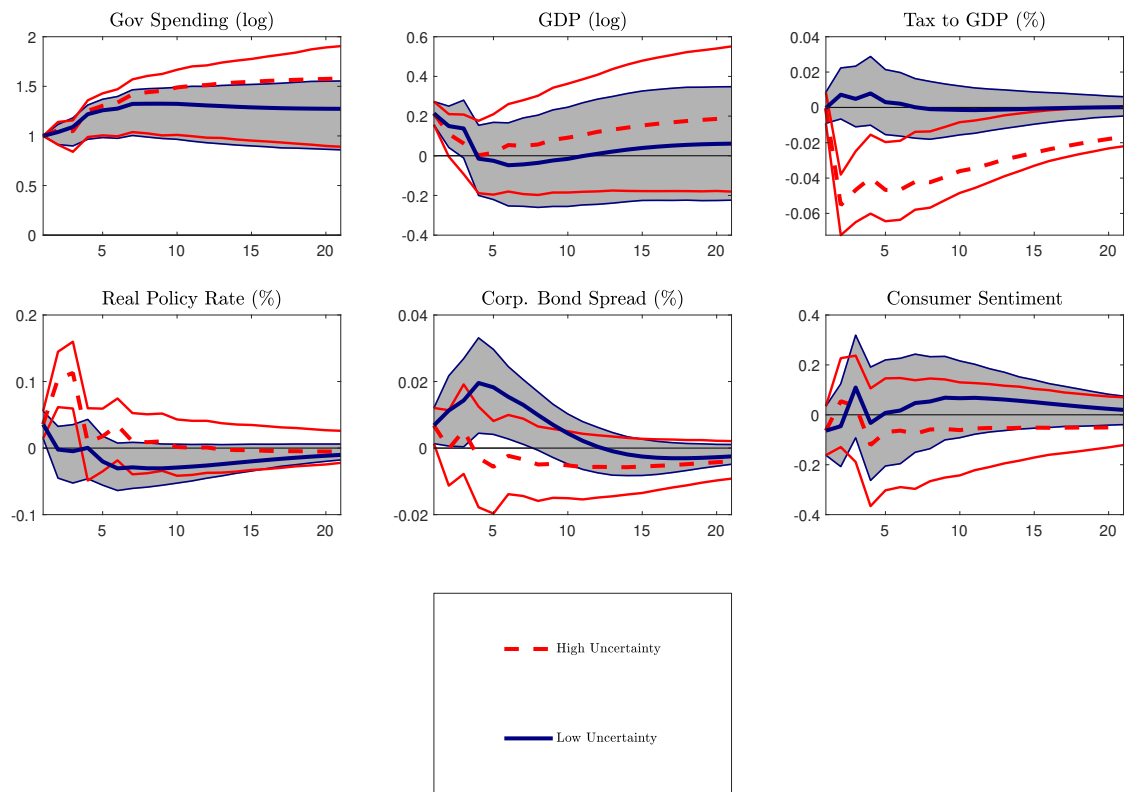


Figure 18: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when we use corporate bond spread as uncertainty proxy. Histories are classified as tranquil times if uncertainty is between the 0th and 20th percentile of the uncertainty distribution. Uncertain times are between the 80th and 100th percentile.

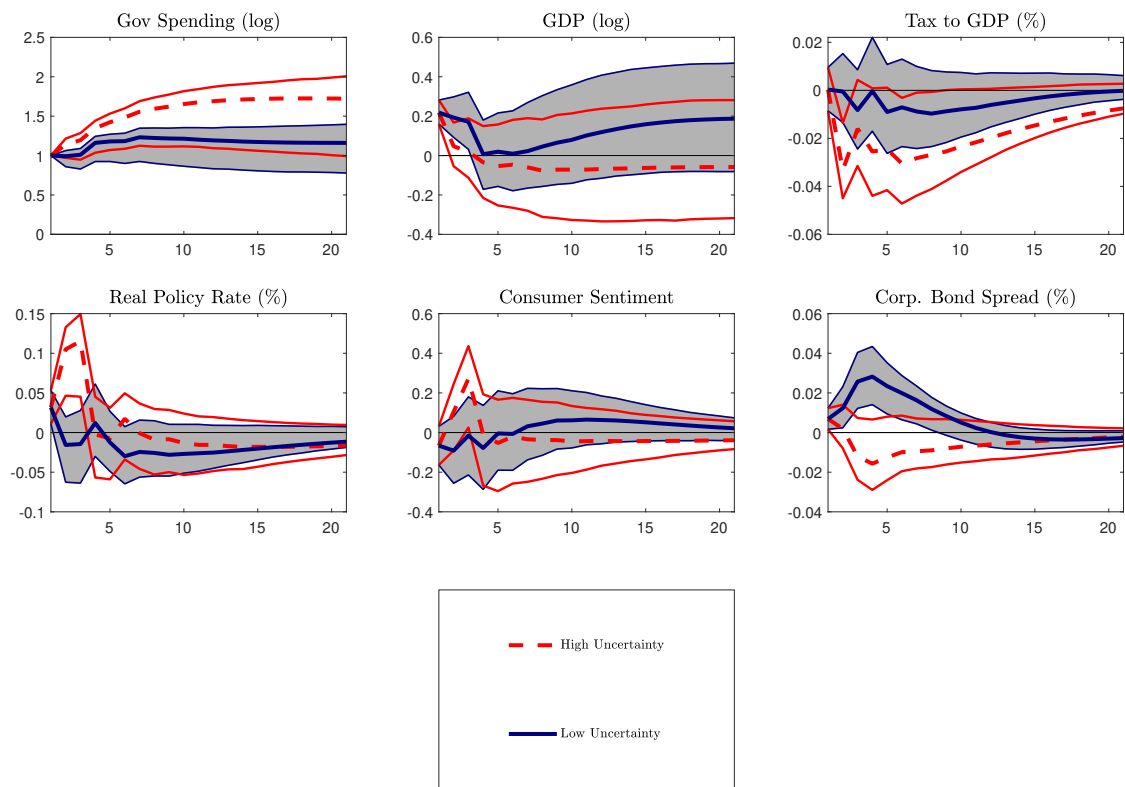


Figure 19: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when we use consumer confidence as an inversely related uncertainty proxy. Histories are classified as uncertain times if consumer sentiment is between the 0th and 20th percentile of its empirical distribution. Tranquil times are between the 80th and 100th percentile.