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Ansgar Belke and Pascal Goemans[1]

Uncertainty and Non-Linear Macroeconomic Effects of Fiscal Policy in the US: A SEIVAR-Based Analysis

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 plays 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.

JEL-Code: E62, E32, C32

Keywords: Government spending shocks; uncertainty; non-linear structural vector autoregressions; interacted VAR; generalized impulse response functions; endogenous uncertainty

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1 Introduction

The recent experience with the Great Recession in the US, which was accompanied by huge uncertainty in the real economy and the financial sector, has sparked a 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 prevalent in the economy.

How could the degree of uncertainty that the macroeconomy is facing influence its behavior? The early literature has emphasized a real-option channel of uncertainty for investment decisions (Bernanke, 1983, Dixit, 1989, Pindyck, 1991). Only recently, Bloom et al. (2018) have shown the importance of this channel in a general equilibrium model with non-convex adjustment costs in capital as well as labor and time-varying uncertainty: firms become more cautious in investing and hiring as uncertainty increases. In addition, the precautionary saving channel proposes that consumers lower their consumption expenditures and increase their savings as uncertainty surges (Challe et al., 2017, Leland, 1968, Lusardi, 1998). In line with these negative effects on private investment and private consumption, Leduc and Liu (2016) interpret uncertainty shocks as aggregate demand shocks. As summarized by Ramey (2011a), the effectiveness of fiscal policy depends strongly on the reaction of private spending. Therefore, it seems natural to evaluate the role of uncertainty for the effectiveness of government spending. Moreover, we in turn examine the effect of government spending on the level of uncertainty. As the effects may vary with the specific category of government spending, the effects of fiscal consumption, investment and research and development expenditures are scrutinized separately in addition to aggregate government spending.

To estimate a potential non-linearity in the transmission of fiscal spending shocks to output in the United States, we employ the Self-Exciting Interacted VAR (SEIVAR) model originally proposed by Pellegrino (2017) and Caggiano et al. (2017) in the field of monetary policy. This model augments an 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 macroeconomy for extreme deciles of the uncertainty distribution and enables us at the same time to control for a sufficient number of confounding factors such as the financing side of the government budget, monetary policy, financial frictions and private sector expectations.

We identify exogenous shocks to government spending 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 implementation lags in government spending such that private agents already adjust their behavior before the increase in government spending actually occurs (Ramey, 2011b). We follow Auerbach and Gorodnichenko (2012b), Klein and Linnemann (2019) 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 1960Q3 to 2017Q2. Besides macroeconomic uncertainty as propagated by Jurado et al. (2015), we also consider financial uncertainty (Ludvigson et al., 2015), indices of realized and implied stock market volatility following Bloom (2009) and Berger et al. (2019), the economic policy uncertainty index of Baker et al. (2016), a corporate bond spread as well as Michigan survey of consumer confidence data as a measure inversely related to uncertainty.

We obtain the following results. Firstly, we only find a statistically significant non-linearity when we consider general macroeconomic uncertainty. Secondly, significantly different effects of government spending on GDP occur in tranquil as opposed to 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 similarly to an uncertainty shock and reduces confidence in the economy. This in turn results in lower levels of personal

[1] Constructing impulse responses in non-linear VAR models is far from straightforward since many complexities arise in moving from linear to non-linear systems (Koop et al., 1996). In linear models, impulse responses are invariant to history, proportional to the shock size and symmetric in positive and negative shocks. However, in non-linear models, responses can depend on the magnitude and sign of the shock as well as on the histories of previous shocks.

consumption as well as private investment and leads us to observe a decline in economic activity. The aforementioned result remains valid if we control for fiscal anticipation. This prompts the question if we observe the rise in uncertainty during uncertain times because of a fiscal reaction to uncertainty. We order macroeconomic uncertainty first and shock this variable to scrutinize this issue of reverse causality. However, there is no evidence of a significant response of government spending, especially not in the short run. This mitigates our concerns about reverse causality.

The result of possible negative output effects of increased government during times of uncertainty has also been corroborated recently by Alloza (2018) using a different methodology and considering uncertainty as an endogenous variable in our SEIVAR. The key channel for our results seems to be consumer confidence. If we drop the corporate bond spread and consumer confidence from the set of our endogenous variables, we do not find significant state-specific effects of government spending shocks on output at longer horizons. Nevertheless, our result of a lower output response in times of heightened uncertainty persists in the first year after a shock.

However, the results slightly change if we consider a shorter sample period ranging from 1960Q3 to 2007Q3, the period before the Great Recession. In this case, government spending raises output and consumer confidence during tranquil times. However, the significant negative effect on GDP in uncertain times disappears for which we propose two explanations. Firstly, we loose roughly forty quarters of observations, making it more difficult to find statistical significant differences. Secondly, the Great Recession was characterized by high uncertainty, which is now dropped from our sample period so that the difference between tranquil and uncertain times diminishes and thus the state-specific effect. Nevertheless, we still find lower output responses during uncertain times within one year after the shock.

The remainder of the paper proceeds as follows: Section 2 reviews the recent literature on the state-dependent effectiveness of government spending increases with regard to uncertainty and the business cycle. Section 3 describes specific uncertainty measures used in the literature and sketches our empirical strategy. Our results are reported in section 4 while section 5 concludes.

2 Non-linear effects of fiscal spending - Review of the literature

Our paper is related to the literature dealing with non-linear effects of fiscal spending in general. Firstly, we will summarize the results of the very new literature dealing with uncertainty depending effects of fiscal policy. We will also review results on varying effects of fiscal policy over the business cycle since it is hard to empirically discriminate between uncertainty, as second order shocks, and the business cycle. This problem of discrimination 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 review 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 survey 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), Barro and Redlick (2011) and Ramey (2019) provide excellent reviews on both topics. We also do not review the literature on the effects of government spending 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, the literature comes to different conclusions about the uncertainty-related effectiveness of fiscal policy. Additionally, contributions vary in the empirical approach taken and the 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 households' confidence as a key variable for interpreting this result as agents become more pessimistic when an increase in government spending, even if intended to stabilize the economy, confirms their negative views about the economy.

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 (2019) 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 turns out to be larger in uncertain times.

Ricco et al. (2016) is more related to policy uncertainty instead of general economic uncertainty. The authors analyze how policy communication affects the propagation of fiscal shocks in a Bayesian TVAR where they use a newly constructed index of fiscal spending disagreement as the threshold variable. Large and positive output responses to government spending shocks occur if there is low disagreement between professional forecasters about future government spending. Conversely, periods of enhanced disagreement lead to more muted output responses.

The pioneering study investigating the possibly non-linear effects of fiscal spending over the business cycle is Auerbach and Gorodnichenko (2012b), who adopt a Smooth Transition (ST-) VAR to study regime-specific effects of fiscal spending. The authors 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 confirming their results are Auerbach and Gorodnichenko (2012a), who extend their sample to OECD countries and use local projections instead of the STVAR, Fazzari et al. (2015) who employ a TVAR and capital utilization as a business cycle threshold variable, and 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 positive business cycle effect into doubt. The study already mentioned above 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 state of the business cycle. Auerbach and Gorodnichenko (2012b) use a smooth transition function that includes the centered moving average of order seven 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) employ 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 discriminate between the states of the business cycle. Their study finds no evidence of larger multipliers when the economy is in a slack. In addition, they apply the Jordà method to the STVAR used by Auerbach and Gorodnichenko (2012b) and they show that the results in the latter depend on a simplifying assumption, i.e. that government spending shocks cannot change the business cycle state does not prove to be a good approximation in their sample. Importantly, relaxing this assumptions shrinks their estimated output multiplier.

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. We will use an econometric approach that fully takes into account the potential non-linearity between government spending and economic uncertainty and at the same time is parsimonious enough to control for a large set of confounding factors to be safeguarded against the potential problem of omitted variable bias.

3 Empirical strategy

In the following, we will explain various empirical proxies of uncertainty proposed by the literature, reveal differences between them, show their development over time as well as their empirical correlation. Section 3.2 elucidates our model and emphasizes some advantages of our approach compared to other methods used in the literature. It also explains the strategy for the identification of a structural government spending shock and provides statistical evidence in favor of the non-linear specification. Section 3.3 illustrates the calculation of impulse response functions in a non-linear world whereas section 3.4 explains the data used in estimations.

3.1 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. At a general level, uncertainty is typically defined as the conditional volatility of a disturbance that is unpredictable from the perspective of economic agents. Surges in uncertainty can depress hiring, investment or consumption if agents are subject to fixed costs or partial irreversibilities that lead to wait-and-see behavior of firms (e.g. Bernanke, 1983, Bloom et al., 2018, Dixit, 1989, Pindyck, 1991), precautionary savings if agents are risk averse (e.g. Challe et al., 2017, Leland, 1968, Lusardi, 1998) or if financial constraints tighten in response to higher uncertainty (e.g. Christiano et al., 2014, Gilchrist et al., 2014). On the other hand, an increase in future expected volatility can also raise expected profits when the loss is limited, thus leading to growth options and to higher research and development expenditures (e.g. Bar-Ilan and Strange, 1996). In addition, firms can invest to exploit good outcomes and to insure against bad outcomes in the future (Abel, 1983, Hartman, 1972, Oi, 1961). Various empirical proxies of uncertainty have been developed to grasp this amorphous concept since different channels might have channel-specific 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, however, the VIX is used instead.

The difference between them is that the VIX is based on the S&P 500 instead of the 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. [2] It has to be stressed that the focus of this measure is the degree of policy uncertainty prevalent 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.

Leduc and Liu (2016) propose a measure of uncertainty that is directly related to consumer confidence. They use consumer survey data from the University of Michigan relating to vehicle purchases and count the fraction of respondents that do not 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.[3] 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) use 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 from 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. Taking this as their starting point, 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 indexes, bond and stock market indexes as well as foreign exchange measures. Financial uncertainty, on the other hand, is the common variation of uncertainty relating to broad set of financial variables (Ludvigson et al., 2015).

[2] 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.

[3] An example is the possibility of a fiscal cliff the US economy faced in late 2012 that had the potential to trigger larger tax increases and government spending cuts when the VIX was very low but consumer uncertainty high (Leduc and Liu, 2016). See, for instance, Davig and Foerster (2018) for a deeper analysis of the effects of fiscal cliff uncertainty.

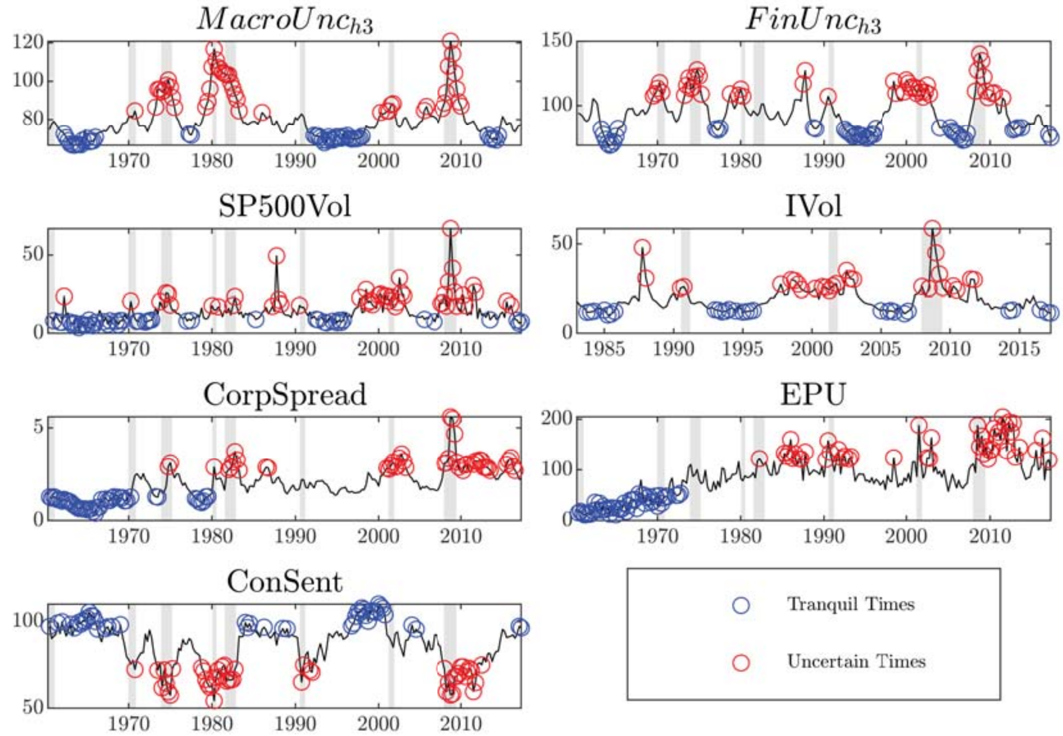

Figure 1: Different uncertainty measures over time

	$MacroUnc_{h3}$	$FinUnc_{h3}$	SP500Vol	IVol	CorpSpread	EPU	ConSent
$MacroUnc_{h3}$	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

Figure 2: Pairwise correlations between different uncertainty measures

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 the uncertainty measure determines which periods are classified as uncertain times. Macroeconomic uncertainty is high mainly during 1975 to 1985, the dotcom bubble at the beginning of the 20th century and the Great Recession. There is, however, no clear trend in uncertainty. Consumer confidence as an inversely proportional measure to uncertainty behaves in a similar fashion. Interestingly, the behavior of finance related uncertainty turns out to be very similar to those related to broad economic uncertainty, although differences in the respective empirical realizations occur at the beginning of the seventies and during the dotcom bubble. The increase in economic policy uncertainty and the corporate bond spread over time is also striking. 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 reviewed uncertainty measures and proposes a classification scheme. 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 index tries to capture policy and not general economic uncertainty. A distinction between realized stock market volatility and implied stock market volatility is nearly impossible 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 capture financial frictions but also policy related uncertainty. This is probably due to the inclusion of government bond yields in the spread.

[4] We define tranquil times as periods where the respective uncertainty measure is between the 0^{th} and the 20^{th} percentile of its empirical distribution. Uncertain times, accordingly, are periods between the 80^{th} and the 100^{th} percentile of the uncertainty distribution.

[5] This is probably a consequence of the use of quarterly data. We take quarterly averages of the respective uncertainty measures for our analysis since we are interested in the effects of fiscal spending and those variables are only available quarterly.

3.2 The Self-Exciting Interacted VAR

3.2.1 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) and Pellegrino (2017) 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 government spending variable and the uncertainty proxy:

$$\boldsymbol{y}_t = \boldsymbol{\alpha} + \boldsymbol{\gamma} \cdot t + \sum_{j=1}^{L} \boldsymbol{A}_j \boldsymbol{y}_{t-j} + \left[\sum_{j=1}^{L} \boldsymbol{c}_j g_{t-j} \cdot unc_{t-j} \right] + \boldsymbol{u}_t, \tag{1}$$

$$g_t = e_g' \cdot \boldsymbol{y}_t, \tag{2}$$

$$unc_t = e_{unc}' \cdot \boldsymbol{y}_t, \tag{3}$$

$$E(\boldsymbol{u}_t \boldsymbol{u}_t') = \boldsymbol{\Omega}, \tag{4}$$

where $\boldsymbol{y}_t$ 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. $\boldsymbol{A}_j$ denote the $(n \times n)$ matrices for each lag and $\boldsymbol{u}_t$ 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 $\boldsymbol{c}_j$. e_g and e_{unc} are selection vectors for the respective endogenous variable in $\boldsymbol{y}$, government spending growth and uncertainty. In other words, uncertainty and government spending are both treated as endogenous. It is important to note that the non-linearities captured by the interaction term are possibly affecting all endogenous variables. Hence they only capture the non-linearities in government spending induced by the historical level of uncertainty, but this non-linearity is allowed to affect all variables.

We estimate the model equation by equation with OLS.[7] The lag length L is determined by the

[6] The 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).

[7] This is possible since the model includes only predetermined regressors and, although non-linear in variables, is

Akaike information criterion and we impose the same number of lags for the linear and the non-linear parts of the SEIVAR. Bearing 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). Finally, 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 exhibits several advantages regarding our research question over alternative non-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 obliged to identify thresholds as in TVARs or to calibrate transition functions as in STVARs. The specific functional form in equations (1) to (4) has been chosen with an eye on parsimony and to avoid instability problems.

Second, unlike abrupt change models featuring regime-specific coefficients like TVARs, the SEIVAR is estimated exploiting the available sample periods. The latter 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 proves 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 (2019), 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) non-linear 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 estimated parameters can be biased due to other sources of non-linearities that we do not model.

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linear in parameters and does not depend on unobservable variables or nuisance parameters. In contrast to the most commonly used non-linear state-dependent models that reach non-linearity by combining two or more regime-specific linear VARs (e.g. Threshold VARs and Smooth Transition VARs), the Interacted-VAR is non-linear 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.).

[8] We also considered the Hannan-Quinn and Schwarz information criterion as a model selection device. However, they gave us an optimal lag length of one. This seemed too parsimonious to capture the dynamics in the data in this regard.

3.2.2 Identification and statistical motivation

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

$$\boldsymbol{y}_t = [govgr_t, gdpgr_t, taxgdp_t, rpolicy_t, unc_t, spread_t, consconf_t]',$$

where, respectively, the variables denote 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 3.4). 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 in Auerbach and Gorodnichenko (2012b) and Klein and Linnemann (2019). 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 employed when the research interest is in the effects of tax shocks on the economy as for example in Mertens and Ravn (2014) who use the data of Romer and Romer (2010) to identify anticipated and surprise tax shocks. On the one hand, it is less plausible that taxes do not respond to other shocks within the same quarter since they are often measured by tax revenues which increase during economic upturns 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 necessary in our context.

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[9] As 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.

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 it represents the one-step ahead forecast error of government spending.

In the following, 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 nests 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. Referring to the other uncertainty measures, we do not find significant non-linearities at the five percent level.[10] Nevertheless, we show the results for our baseline specification for all other uncertainty indicators in Figures 14 to 19 in section 6.4.

3.3 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 non-linear 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 $\boldsymbol{y}_t$ to a shock of size δ computed conditional on an initial history ω_{t-1} of observed histories of $\boldsymbol{y}$ is given by the following difference of conditional means:

$$\mathrm{GIRF}_{\boldsymbol{y}}(h, \delta, \omega_{t-1}) = E\left[\boldsymbol{y}_{t+h} | \delta, \omega_{t-1}\right] - E\left[\boldsymbol{y}_{t+h} | \omega_{t-1}\right] \tag{5}$$

[10] However, 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 highlights the use of general macroeconomic uncertainty. The latter thus seems to incorporate significant information in addition to consumer confidence and the spread.

GIRFs enable us to keep track of the dynamic responses of all 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. In computing GIRFs, we follow Kilian and Vigfusson (2011) and work with orthogonalized residuals to identify government spending shocks. The exact algorithm is described in section 6.2.

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 (2017) 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.

3.4 Data

We use quarterly U.S. macroeconomic data for a sample ranging from 1960Q3 to 2017Q2. The sample is restricted mainly by the availability of the uncertainty indicators (see section 3.1). Our specification closely follows Klein and Linnemann (2019) and the set of endogenous variables is $\boldsymbol{y}_t = [\text{govgr}_t, \text{gdpgr}_t, \text{taxgdp}_t, \text{rpolicy}_t, \text{unc}_t, \text{spread}_t, \text{consconf}_t]'$. 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 the University of Michigan consumer sentiment index. Details on data sources are given in Table 1.

Taxes are included to control for the financial side of government budget whereas we include the real policy rate to control for monetary policy. Several studies show that the conduct of monetary policy affects the macroeconomic impact of fiscal policy (e.g. Canova and Pappa, 2011, Davig and Leeper, 2011). The shadow rate is used to capture the effects of unconventional monetary policy during the zero lower bound. The spread variable is included to capture the degree of financial frictions prevalent in the economy. Fernández-Villaverde (2010) and Canzoneri et al. (2016) demonstrate in theoretical models that financial frictions should affect the economic reactions in response to government spending increases. The inclusion of the spread is based on the idea that a worsening of financial frictions should be reflected in an increase of the private bond interest rate as compared to a long-term bond rate, since the former as opposed to the latter incorporates the perceived risk of default on the part of private debtors. The inclusion of consumer confidence is based on Bachmann and Sims (2012), who find confidence to be an important channel in which fiscal policy innovations affect aggregate economic activity. 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 because there is no one to one relation between financial frictions, consumer confidence and uncertainty and the interaction between them might be important.

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

In this section, we provide empirical evidence in favor of 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 4.1, continue with a deeper analysis on the effects on GDP components in section 4.2 whereas section 4.3 deals with the issue of fiscal anticipation. We analyze potential channels that might drive our results in section 4.4 and section 4.5 considers the sample period prior to the Great Recession. Section 4.6 presents our results when the function of government expenditure is taken into account, as well as government spending multipliers.

4.1 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 in the estimation to levels. Uncertainty states are defined by macroeconomic uncertainty. So we obtain, as explained above, an average impulse response function to a government spending growth shock for each historical value of macroeconomic uncertainty in our sample. Those period specific generalized impulse response functions are shown in Figure 3. The results are as follows: 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 in response to a government spending 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 cannot be easily interpreted and do not capture statistical significance. Since we are interested in the effects of government spending during tranquil times as opposed to times of high uncertainty, we average our calculated impulse response functions over tranquil and uncertain times. Consistent with Bloom et al. (2007) and Pellegrino (2017), we assume the tranquil times state to be characterized by initial quarters with uncertainty around the first decile of its empirical distribution whereas uncertain times represent initial quarters around its ninth decile (a ten percentile tolerance band around the top and bottom deciles is used).[11] Conditioning responses on extreme events, rather than normal times, might be important in order not to confound similar states and hence miss empirical responses in favor of non-linearity (Caggiano et al., 2015).

Figure 4 plots the empirical impulse responses to a government spending growth shock of one percent along with 68% bootstrap confidence bands.[12] Some results are striking. First of all, a government spending shock in times of heightened uncertainty emerges in a different way and the type of government funding is regime-specific. During uncertain times, increased government spending is accompanied by declines in the tax-to-GDP ratio while we observe no significant reaction of taxes during tranquil times. Secondly, we observe a rise in uncertainty and a decline in consumer confidence during uncertain times. This results in a crowding-out of private spending, so large that the reaction of GDP becomes negative in the medium and long run. We obtain different results during times of low uncertainty. Herein, fiscal easing significantly reduces uncertainty in the medium run and boosts consumer confidence. This in turn results in a

[11] According to Pellegrino (2017), this definition allows both, each given state to feature a number of GIRFs large enough to obtain representative state-conditional responses and to have results that do not depend on exceptionally extreme observations. We deviate from the authors since we use a ten, instead of a five percentile, tolerance band that includes more extreme events. However, our results are robust to the use of five percentile tolerance bands.

[12] We 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 2.5^{th} and 97.5^{th} percentiles tends to be much larger than the number of draws required for the 16^{th} and 84^{th} percentiles (Kilian and Lütkepohl, 2017, p. 334f.).

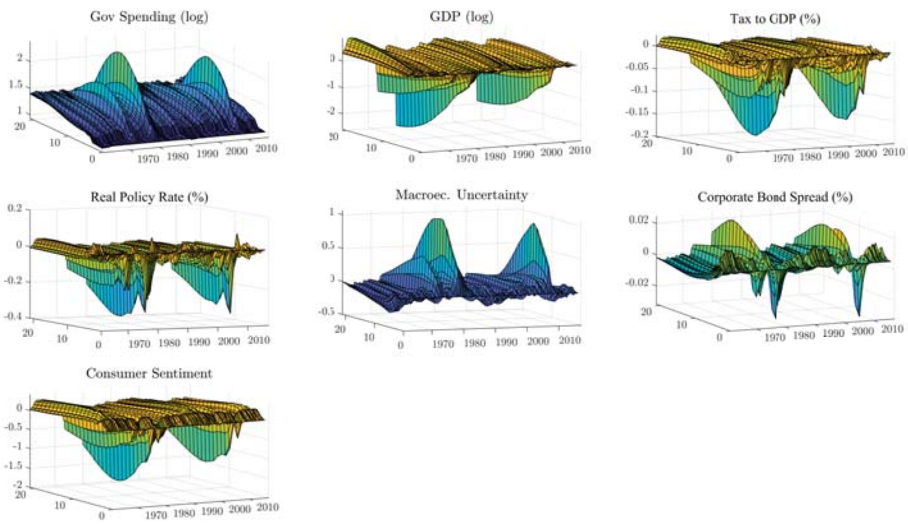

Figure 3: Generalized impulse response functions to an identified one percent government spending growth shock for each time period in the sample

positive output effect. Thirdly, the Fed behaves differently across states. On the one hand, there is almost no significant response of the real interest rate during times of low uncertainty. On the other hand, we observe a significant reduction in the real interest rate in times of heightened uncertainty, 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 specification where we included change in debt to GDP as a variable and considered inflation as well as the policy rate instead of the real interest rate. However, 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.[13] 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 potential issue is the question if our results are driven (only) by the most extreme histories. As positive 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 1$^{\text{st}}$ and 9$^{\text{th}}$ decile of the uncertainty distribution 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

[13]With three lags the original model includes 32 parameters to be estimated in each equation whereas the smaller model needs to estimate only 26 parameters.

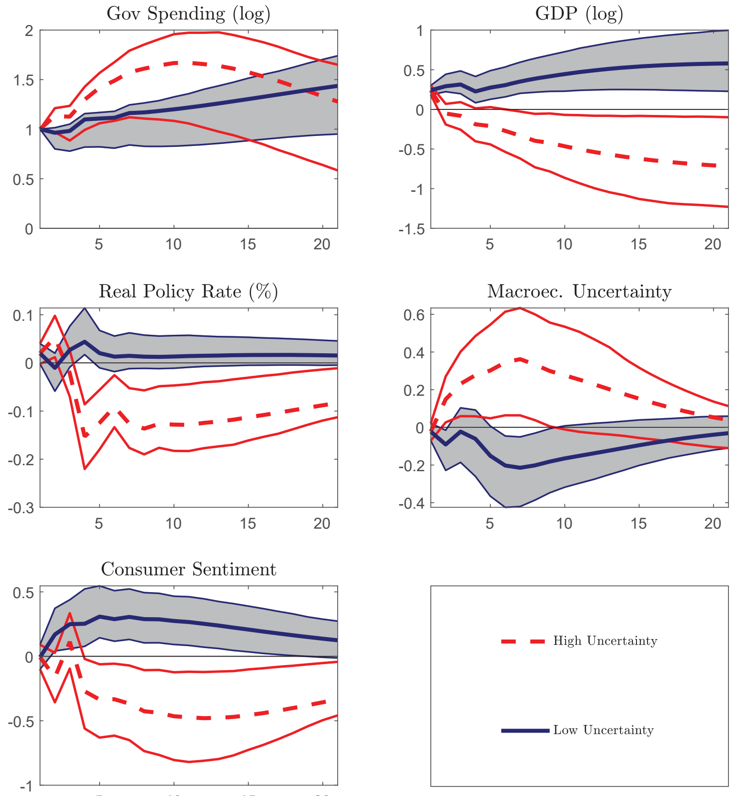

Figure 4: Impulse responses and 68% confidence intervals to a one percent government spending growth shock.
Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within the 80^{th} and 100^{th} percentile.

uncertain times behave very similarly to the responses to an uncertainty shock. This raises the question of whether our results are driven by reverse causality. In other words, do we find an increase in uncertainty because 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 observe an increase in financial frictions measured by the corporate bond spread, a reduction in consumer confidence as well as a contraction in aggregate demand. Those findings are in line with the theoretical underpinnings of alleged effects of uncertainty shocks. However, the results do not reveal a significant reaction of government spending in response to the uncertainty shock.

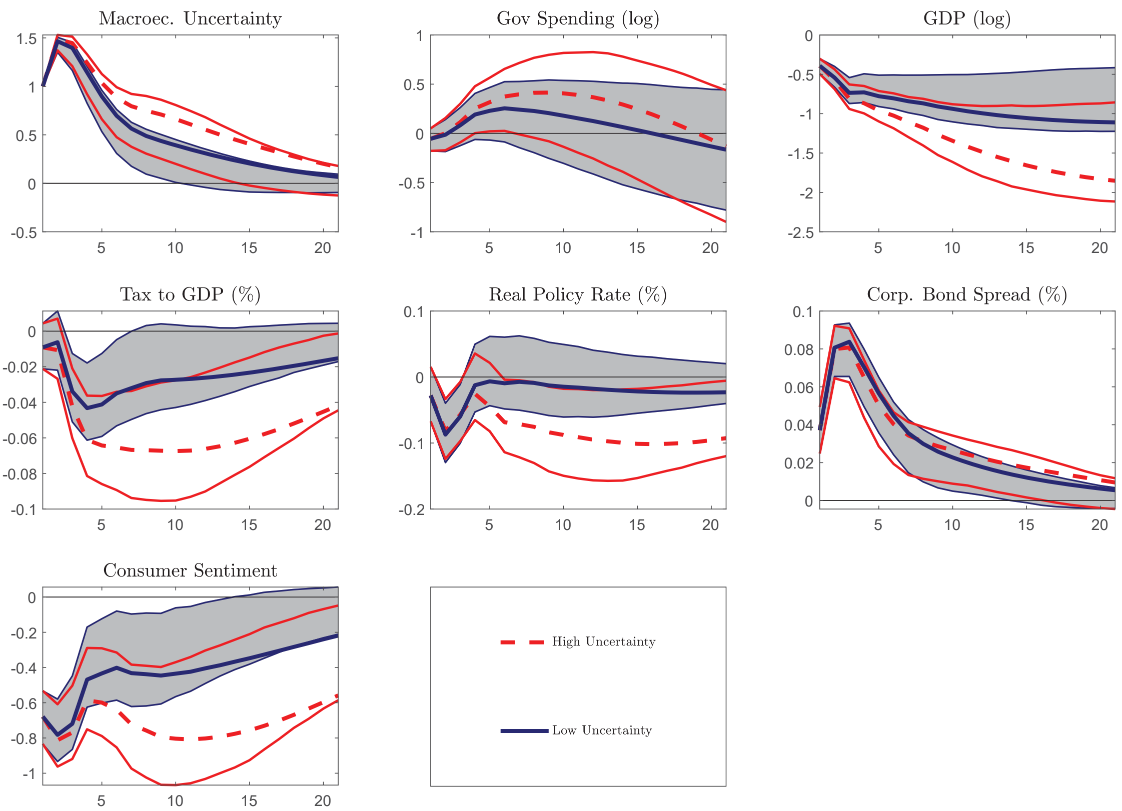

Figure 5: Impulse responses and 68% confidence intervals to a one index point shock in macroeconomic uncertainty.
Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within the 80^{th} and 100^{th} percentile.

4.2 The effects on private spending

In the following, 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. The model is estimated with three lags.

The results shown in Figure 6 are very similar to our baseline results. During uncertain times, a rise in macroeconomic uncertainty occurs in response to a government spending growth shock. Instead of stabilizing the economy, the government spending shock behaves similar to an uncertainty shock. Besides the usual crowding-out effect of fiscal spending, the rise in uncertainty seems to trigger the precautionary saving and real option channels. So we observe strong declines in personal consumption and private investment that we do not find during tranquil times. The financial frictions channel captured by the spread variable, however, plays no significant role.

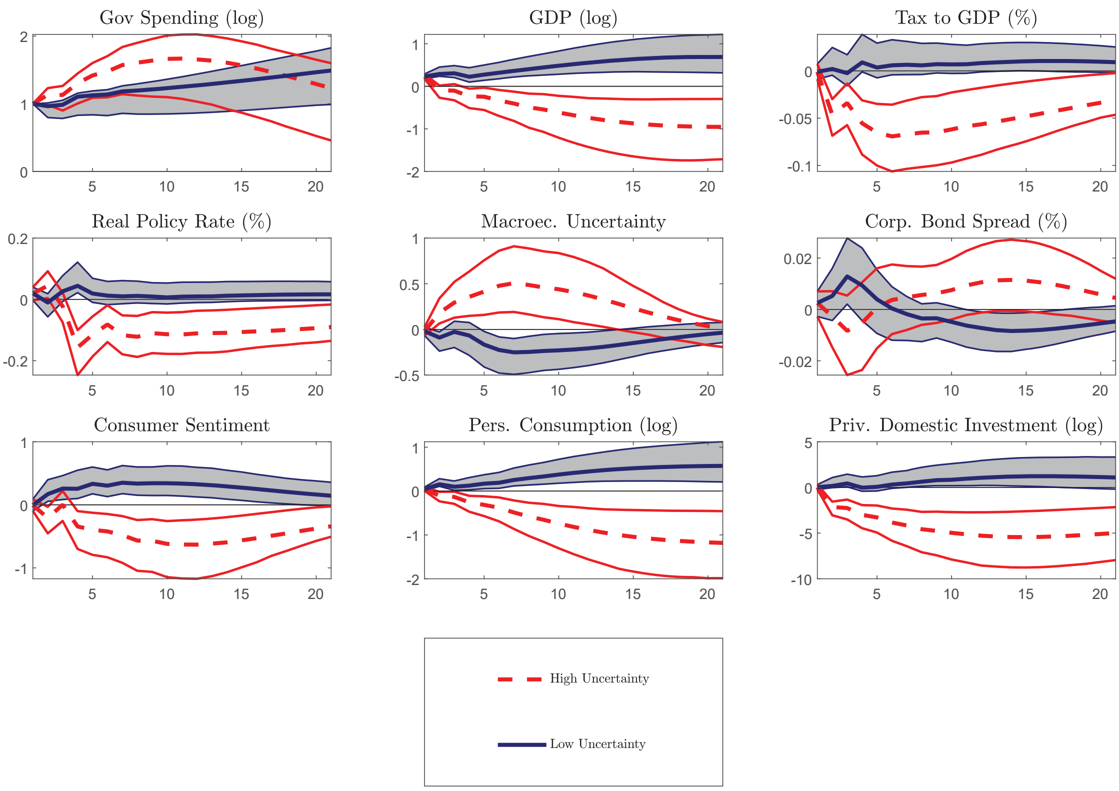

Figure 6: Impulse responses and 68% confidence intervals with private spending to a one percent government expenditure growth shock.
Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within the 80^{th} and 100^{th} percentile.

4.3 Controlling for fiscal anticipation

Are these findings just the result 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 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

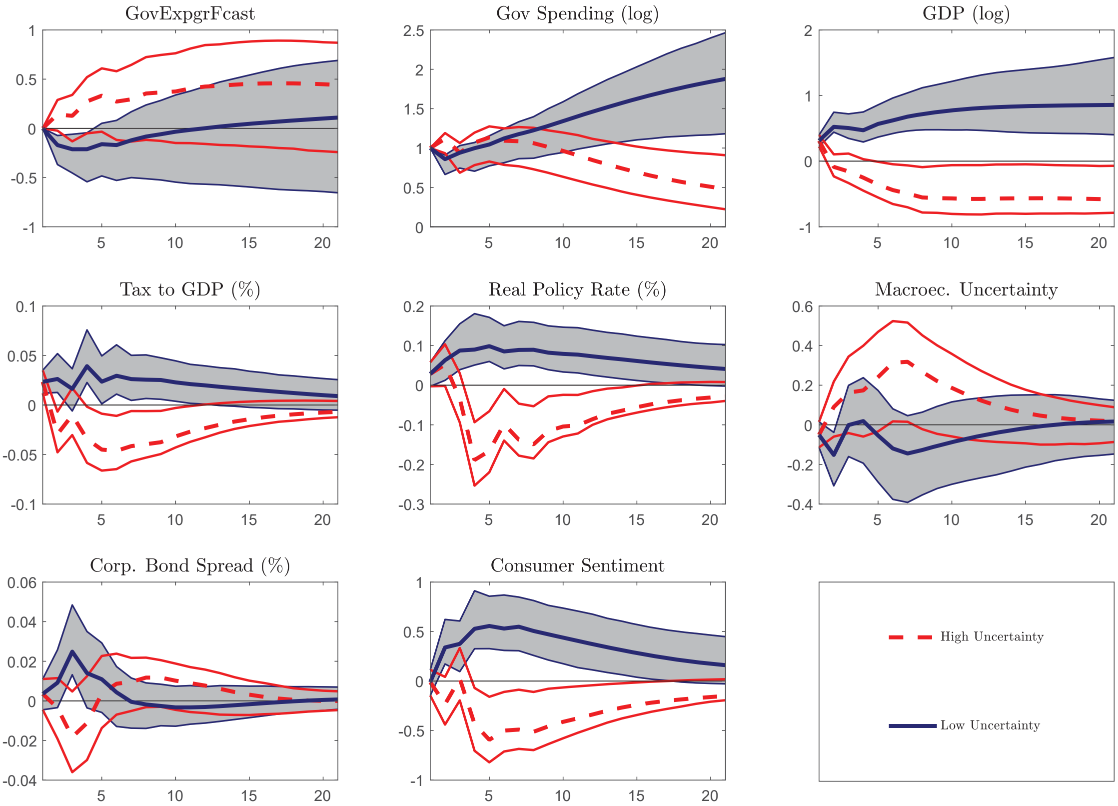

Figure 7: Impulse responses and 68% confidence intervals with control for fiscal anticipation to a one percent government spending growth shock when we account for fiscal anticipation.
Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th}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

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 (1966Q4–1981Q2) and the survey of professional forecasters (SPF, 1982Q3–2017Q3). We take the Greenbook data from Auerbach and Gorodnichenko (2012b) and augment them with the SPF data. Because the forecast variable limits the usable sample, the following estimation results are restricted to the period 1966Q4–2017Q3.

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.[14] The model is

[14]An alternative would be to use the defense news shock variable from Ramey (2011b). We do not follow this

estimated with three lags.

Figure 7 reveals that controlling for government spending forecasts 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.

4.4 The role of consumer confidence and corporate bond spread

In the following, we vary our specification to get a deeper look at the interaction between macroeconomic uncertainty, financial frictions and consumer sentiment as the latter two are sometimes used as uncertainty indicators. For this reason, we drop consumer sentiment and the corporate bond spread from our specification. The corresponding generalized impulse response functions are plotted in Figure 8. The left column shows the results if we drop consumer sentiment from our baseline specification while the central column shows the results omitting the spread variable from our specification. Both specifications are estimated with 3 lags according to the AIC. The right column shows the impulse responses if both variables are dropped. We estimate the latter including four lags.

The results we obtain are as follows. The tax-to-GDP ratio as well as the real policy rate behave very similarly to the responses in our baseline specification. However, substantial differences in the response of GDP, consumer sentiment and macroeconomic uncertainty occur compared to the results of the baseline specification in Figure 4 if the control for corporate bond spreads is neglected. Doing so would lead to different conclusions about the response of macroeconomic uncertainty in response to an increase in government purchases. In this case, macroeconomic uncertainty turns out to be decreasing in response to a government spending shock during times of heightened uncertainty. This is in stark contrast to our baseline specification and the left column of this figure where fiscal easing leads to a surge in uncertainty. In turn, the output effect becomes now positive and higher, although not significantly, than during tranquil times.

Nevertheless, a result that all our estimated specifications have in common, is a muted short-term output response during times of heightened uncertainty. This finding is in line with the precautionary savings and real-option channels. As is shown in the central column of Figure 8,

approach since the news variable has low predictive power for our sample that does not include WWII or the Korean War.

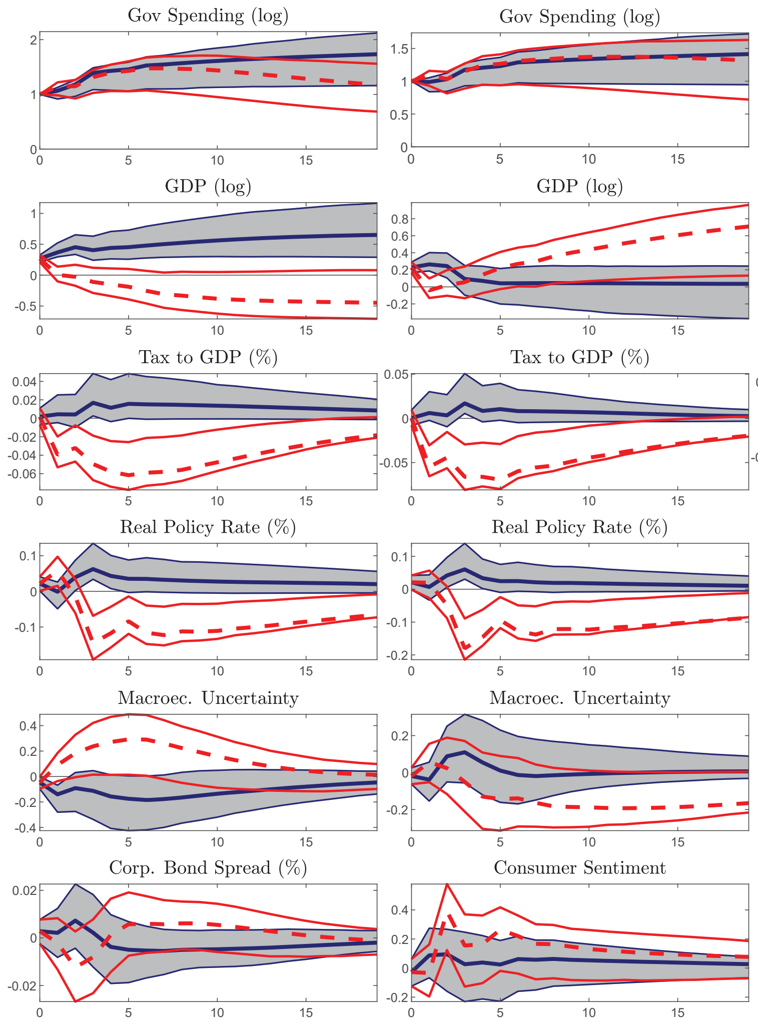

Figure 8: Impulse responses and 68% confidence intervals to a one percent government spending growth shock not including consumer sentiment (left column), the corporate spread (central column) and both of them (right column).
Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within the 80^{th} and 100^{th} percentile.

dropping the risk premium also alters the response of consumer sentiment. In this case, fiscal easing reinforces consumer confidence during times of heightened uncertainty. Those results are more in line with Bachmann and Sims (2012) who find that government spending might increase consumer sentiment during recessions.

These additional empirical results lead to the following conclusions. Firstly, it is important to include a large set of variables in the specification despite the loss in efficiency. The exclusion of potentially important variables, in our case the corporate bond spread, triggers the OLS estimation to suffer from omitted-variable bias and can even change the sign of the output response. In this regard, also the response of consumer sentiment turns out to be only marginally significant over a short period and ceases to be state-dependent. This underlines the usefulness of the SEIVAR in contrast to less parsimonious approaches like TVARS. Since the former is estimated exploiting the available sample periods while the latter splits the sample into numerous regimes according to a threshold variable, the former is able to include a larger set of (possibly) important variables (compare section 3.2.1). Secondly, the results make us feel legitimized to argue that we do not observe negative output responses in times of heightened uncertainty just because the economy is already in a slump. Note that we use the same histories for the definition of tranquil and uncertain times as in our additional estimations. While we do observe a medium- to long-term negative output response there, this is not the case in the more parsimonious specification. We conclude that the negative output effect in response to the fiscal easing is not just the result of being in uncertain times. In contrast, it is the result of uncertainty which has increased in response to fiscal policy. This is in line with typical crowding-out effects and common uncertainty transmission channels as reviewed above. This is also consistent with the literature stating that macroeconomic policy itself might induce uncertainty in the economy (Baker et al., 2016, Bi et al., 2013, Fernández-Villaverde et al., 2015).

4.5 Restricting the sample to the pre-Great Recession period

Are our results driven by specific periods as the recent Great Recession? It appears reasonable to think about a structural break in the relation between fiscal shocks and their output effect during this time. Indeed, using a non-parametric time varying coefficients VAR, Klein and Linnemann (2019) find the Great Recession to be characterized by uniquely large impulse responses of output to fiscal shocks. In order to scrutinize if our results are driven by this specific period, 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 using three lags. We display the resulting impulse responses in Figure 9.

Figure 9 shows a different picture than Figure 4. Fiscal easing still increases output and consumer confidence during tranquil times. However, the significant negative effect on GDP disappears for which we propose two explanations. Firstly, we lose roughly forty quarters of observations, such that it becomes harder to find statistically significant effects. Secondly, as Figure 1 reveals, the Great Recession has been a very uncertain period that is now dropped from our sample. Hence, the difference between tranquil and uncertain times diminishes and so does the state-specific effect. Nevertheless, there are also robust findings even for this shorter

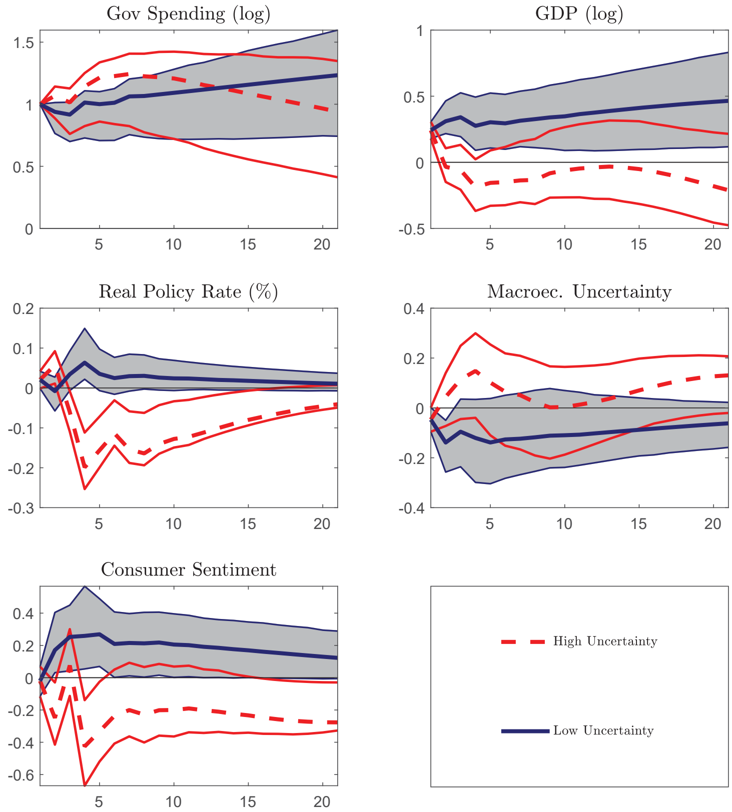

Figure 9: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when the sample ends before the Great Recession.
Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within the 80^{th} and 100^{th} percentile.

sample period. The GDP response 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.

4.6 Types of government spending and cumulative multipliers

In this section, we examine whether our results apply in the same way to all types of government spending. For this purpose, we follow Auerbach and Gorodnichenko (2012b) as well as Arčabić and Cover (2016) and investigate the effects of various components of our government spending variable separately. For this purpose, we consider shocks in the growth rate of consumption, gross investment, research & development (R & D) and national defense expenditures. The corresponding impulse response functions are plotted in Figure 10.

It turns out that government consumption has no significant effect on output but leads to lower

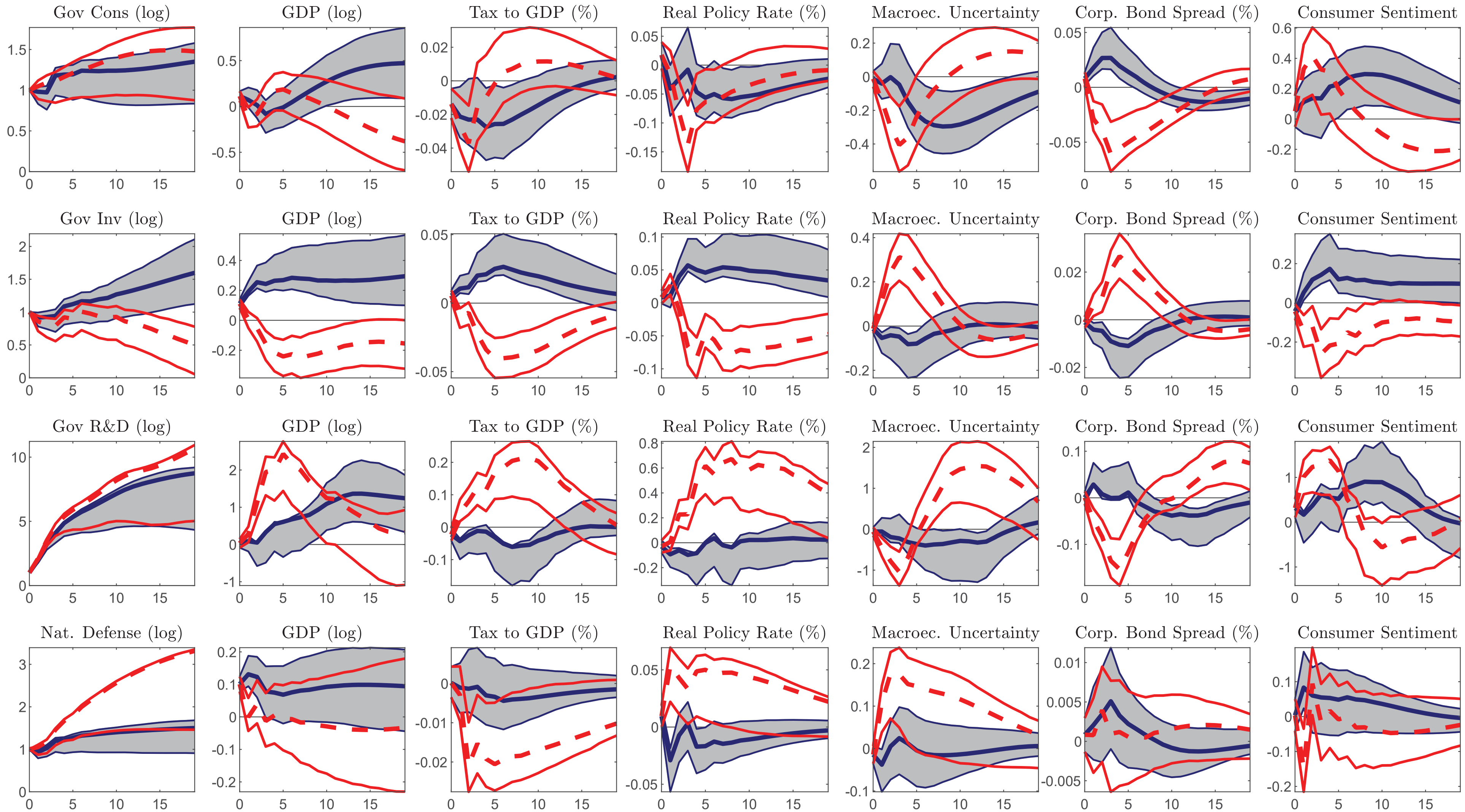

Figure 10: Impulse responses and 68% confidence intervals to a one percent spending growth shock for different types of government expenditures.
Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within the 80^{th} and 100^{th} percentile.

(higher) risk premia for corporations during tranquil (uncertain) times. In contrast, the results reveal state-specific effects if government investment expenditures are considered. During uncertain times, the debt-financed shock raises uncertainty, tightens financial frictions and diminishes consumer confidence. This results in a negative output effect. In tranquil times, the results are of the opposite direction. This pattern is actually puzzling, since we would have expected positive effects of government investment shocks because investments in infrastructure tend to result in higher future productivity and lead to larger incentives for increases in private spending.

In contrast to the results received so far, the impulse responses for R & D expenses underscore the effectiveness for fiscal stabilization politics. In that case, we find significant positive output effects in the short and medium horizon despite an increase in taxes to GDP. R & D increases 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 cut their research expenditures in times of high uncertainty, for example due to tighter financial frictions, fiscal research expenditures 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 of uncertainty (Bar-Ilan and Strange, 1996). If uncertainty is large and mean-reverting, the expected profit or technology increase induced by research effort can be larger. However, this effect is mitigated in the long run. Explanations for this are the sustained rise in taxes as well as the counteracting monetary policy. Both of them could also serve as explanations for the increase in uncertainty at longer horizons.

National defense expenditures only slightly affect the economy. Output does not react significantly during uncertain times and occurs to be marginally positively in the short run during tranquil times. In general, the confidence intervals turn out to be very large. From our point of view, the results emphasize the need to analyze effects for different types of government spending.

Figure 11 displays 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 type of multiplier measures the cumulative output gain relative to the accumulated government spending over a given horizon. Therefore, it incorporates the persistence of fiscal spending. Those cumulative multipliers are more informative for policymakers than the original fiscal multiplier proposed by Blanchard and

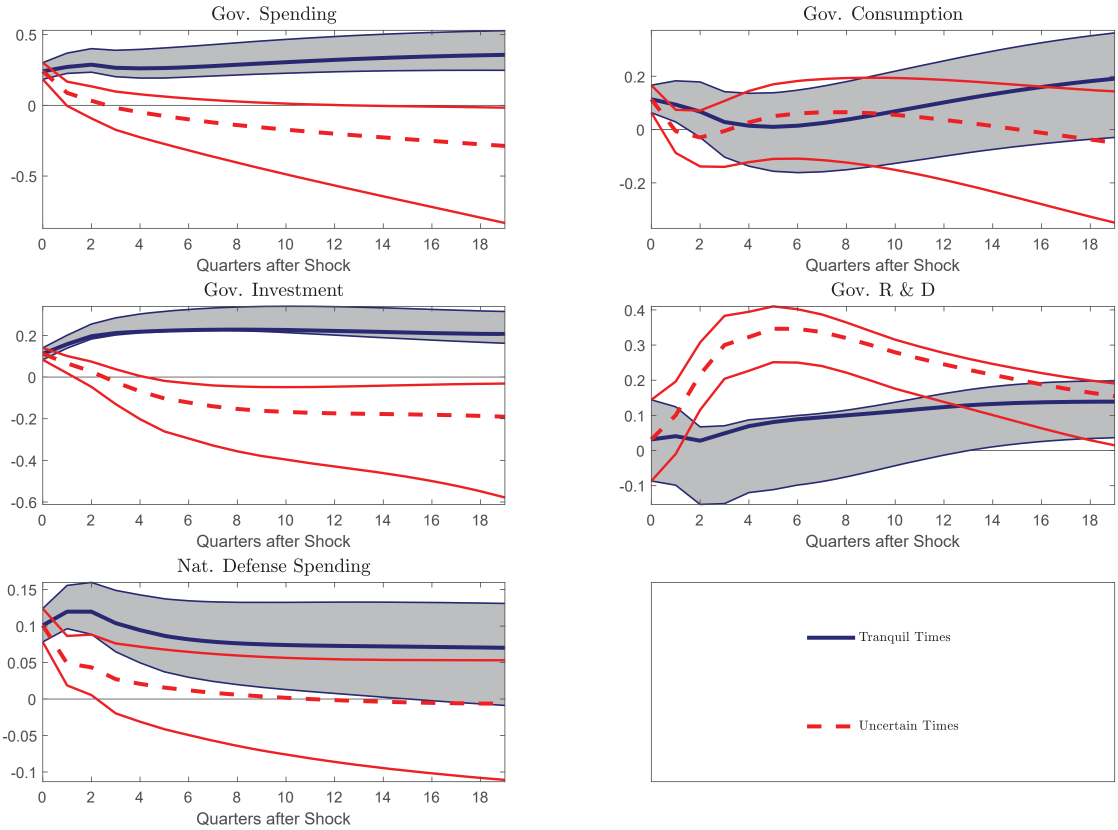

Figure 11: Cumulative government spending multipliers and 68% confidence intervals for different types of government spending.
Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within the 80^{th} and 100^{th} percentile.

Perotti (2002), that just 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.[15][16]

An inspection of Figure 11 reveals that the cumulative fiscal multiplier depends on the specific form of government spending. We find uncertainty-specific relative output gains for general government spending as well as for governmental investment and R & D programs. There is also a difference for defense expenditures, which are not significant. In addition, there is no state-specific gain for fiscal consumption. Overall, it can be stated that different types of government

[15]This multiplier was originally proposed by Mountford and Uhlig (2009) and 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.

[16]Note 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 derive dollar-to-dollar multipliers.

spending lead to relative output gains during tranquil times but turn out to have no statistically significant or contractionary effects on output during uncertain times. This challenges fiscal policy as a tool for the stabilization of the economy during times of heightened uncertainty. Instead of stabilizing the economy, the government seems to confirm private agents in their view that the economy is in a slack and raises uncertainty even more. The exception is governmental R & D programs which lower uncertainty, lead to higher confidence in the short term which result in relative output gains. This is the case even though the fiscal spending is tax-funded.

5 Conclusions

In our study, we have used a non-linear framework to study macroeconomic effects of fiscal spending shocks in the US during tranquil and uncertain times to take into account that uncertainty may react to fiscal spending.

We find evidence for the US 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 turns out to be contractionary during times of heightened uncertainty.

The empirical finding of negative output responses to positive government spending shocks are by far not uncommon in the literature. Among others, it also arises in settings of other types of non-linearities than considered in our paper (e.g. Corsetti et al., 2013). Instead of reducing uncertainty, the fiscal expansion appears to affect the macroeconomy similar to uncertainty shocks. Increasing uncertainty, working through precautionary saving and real option channels, turns a fiscal policy oriented at stabilization purposes into a contractionary one.

We come up with slight evidence in favor of a contractionary fiscal expansion[17] when we control for fiscal anticipation and different models of financing government expenditure, monetary policy, financial frictions, consumer confidence and different types of government spending. The point estimates of cumulative multipliers of government spending, government investment become negative in the long run. However, we would like to stress that these effects are at best

[17]This 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) and Alesina and Ardagna (2013). Nevertheless, we can not derive any evidence of an expansionary fiscal contraction in a stricter sense 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.

only slightly significant at the 68% level. According to our results, only governmental R & D expenditures can help to stabilize the economy.

The results change if we only consider periods before the Great Recession. In this case, the significantly contractionary effects of fiscal spending disappear, mainly due to two reasons. Firstly, the loss of roughly one fifth of our observations makes it more difficult to find statistical significant effects. Secondly, the Great Recession initiated a very uncertain time period that is not considered anymore. Hence, the difference between tranquil and uncertain times diminishes as does the state-specific effectiveness of fiscal policy. Nevertheless, the result that government spending has smaller short-run effects remains valid.

Our result that a government shock can act like an uncertainty shock in some circumstances is an innovative empirical finding in the realm of fiscal policy though backed by early analogous findings in the area of monetary policy. The most famous example in this regard is Milton Friedman's helicopter money allegory: "(T)he mere appearance of the helicopter might increase the degree of uncertainty anticipated by members of the community which in turn might change the demand for real cash balances" (Friedman, 1969). Friedman argues that this effect is especially relevant if information is scarce or noisy in times of high uncertainty. During these periods agents are concerned that the economy switches into a significant downturn which tends to reduce their future levels of income (Alloza, 2018). Analogously, a government spending shock during periods of enhanced uncertainty may thus simply confirm this pessimistic perspective. This, in turn, causes a decline in consumption and activity, especially if the private sector has ambiguity averse preferences (Alloza, 2018, Ilut and Schneider, 2014). Correspondingly, it has become a stylized fact that uncertainty can be caused and enhanced by endogenous drivers, as for instance by macroeconomic policy itself (Baker et al., 2016, Bi et al., 2013, Fernández-Villaverde et al., 2015).

Since we have also found prima facie evidence of an interaction between uncertainty, financial risk premiums and consumer sentiment in the transmission of government spending shocks, we are looking forward to new theoretical models that can explain our results in a more formal way. We leave this task to further research.

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6 Appendix

6.1 Data sources

Table 1: Data Description

Variable	Source/Construction	Quandl ID
(1) Real Gross Domestic Product	FRED	FRED/GDPC1
(2) Real Government Spending	FRED	FRED/GCEC1
(3) Federal Governmnent Current Receipts	FRED	FRED/FGRECPT
(4) Federal Government Current Transfers	FRED	FRED/W011RC1Q027SBEA
(5) Gross Domestic Product	FRED	FRED/GDP
(6) Government Taxes to GDP	((3)-(4))/(5)	
(7) Federal Government Credit Market Instruments	FRED	FRED/FGSDODNS
(8) State/Local Governments Credit Market Instruments	FRED	FRED/SLGSDODNS
(9) Government Debt to GDP	((7)+(8))/(5)	
(10) Gross Domestic Product Implicit Price Deflator (2012=100)	FRED	FRED/GDPDEF
(11) Effective Federal Funds Rate	FRED	FRED/FEDFUNDS
(12) Shadow Federal Funds Rate[1]	Wu and Xia (2016)	SHADOWS/US
(13) Corporate Spread: Moody's Seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity	FRED	FRED/BAA10YM
(14) Inflation	400*(log(GDPDEF$_t$)-log(GDPDEF$_{t-1}$))	
(15) Consumer Confidence	Michigan Survey of Consumers	UMICH/SOC1
(16) CBOE Volatility Index: VIX, Index, Daily, Not Seasonally Adjusted	FRED	FRED/VIXCLS
(17) S&P 500 (^GSPC) Historical Prices	Yahoo Finance	
(18) SP500Vol (quarterly average)	annualized monthly standard deviation of daily returns of (17)	
(19) monthly S&P 500 implied volatility (VIX) extended to 1983	Berger et al (2019)	
(20) Ivol (quarterly average)	composite series of (16) and (19)	
(21) Economic Policy Uncertainty[2]	policyuncertainty.com	
(22) Financial Uncertainty (h=3, then quarterly av., multiplied by 100)	Sydney Ludvigson's homepage	
(23) Macro Uncertainty (h=3, then quarterly av., multiplied by 100)	Sydney Ludvigson's homepage	
(24) Real Personal Consumption Expenditure	FRED	FRED/PCECC96
(25) Real Gross Private Domestic Investment	FRED	FRED/GPDIC1
(26) Greenbock Forecast for Real Government Spending Growth (1966:4-1981:2)	Auerbach & Gorodnichenko (2012)	
(27) Survey of Professional Forecasters Data for Real Government Spending Growth (1982:3-2017:3)	Federal Reserve Bank of Philadelphia	
(28) Government Consumption Expenditures[3]	FRED	FRED/A955RC1Q027SBEA
(29) Price Index: Government Consumption Expenditures (2012=100)	FRED	FRED/A955RG3Q086SBEA
(30) Real Government Consumption Expenditures	(28)/(29/100)	
(31) Government Gross Investment[4]	FRED	FRED/A782RC1Q027SBEA
(32) Price Index: Government Gross Investment	FRED	FRED/A782RG3Q086SBEA
(33) Real Government Gross Investment	(31)/(32/100)	
(34) Government Gross Investment: Research and Development	FRED	FRED/Y057RC1Q027SBEA
(35) Price Index: Government Gross Investment Research and Development (2012=100)	FRED	FRED/Y057RG3Q086SBEA
(36) Real Government Research and Development Expenditures	(34)/(35/100)	
(37) National Defense Consumption Expenditures and Gross Investment	FRED	FRED/FDEFX
(38) Price index: National defense (2012=100)	FRED	FRED/B824RG3Q086SBEA
(39) Real National Defense Expenditures	(37)/(38/100)	

1) For our variable policy rate, we splice the shadow rate for the period before and during the zero lower bound with the federal funds rate for the period after the zero lower bound. The quarterly data is obtained by taking averages.

2) Since the new economic policy uncertainty index is only available from 1985-2018 and the historical uncertainty index is available from 1900-2014, we combine them by normalizing the historical index to have the same mean and standard deviation as the new economic policy uncertainty index during the overlapping period. The quarterly data is obtained by taking averages.

3) Government consumption expenditures are services (such as education and national defense) produced by government that are valued at their cost of production. Excludes government sales to other sectors and government own-account investment (construction, software, and research and development).

4) Gross government investment consists of general government and government enterprise expenditures for fixed assets; inventory investment is included in government consumption expenditures.

6.2 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).

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

$$\text{GIRF}_{\boldsymbol{y},t}(h, \delta, \omega_{t-1}) = E\left[\boldsymbol{y}_{t+h} | \delta, \omega_{t-1}\right] - E\left[\boldsymbol{y}_{t+h} | \omega_{t-1}\right], \text{h} = 0,1,\ldots,\text{H} \tag{6}$$

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

1. Pick an initial condition $\omega_{t-1} = \{\boldsymbol{y}_{t-1}, \ldots, \boldsymbol{y}_{t-L}\}$, i.e. the historical values for the lagged endogenous variables at a particular date $t = L+1, \ldots, T$. 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 $\{\boldsymbol{u}_{t+h}\}^s$, h = 0,1,...,H = 19 , from the empirical distribution $d\left(\boldsymbol{0}, \hat{\boldsymbol{\Sigma}}\right)$ where $\hat{\boldsymbol{\Sigma}}$ 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 $\{\boldsymbol{u}_{t+h}\}^s$, simulate the evolution of the vector of endogenous variables over the following H periods to obtain the path $\boldsymbol{y}^s_{t+h}$ for $h = 0, 1, \ldots, H$. 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 $\{\boldsymbol{u}_{t+h}\}^s$, simulate the evolution of the vector of endogenous variables over the following H periods when a structural shock δ_t is imposed to $\boldsymbol{u}^s_t$. In particular, we Cholesky-decompose $\hat{\boldsymbol{\Sigma}} = \boldsymbol{C}\boldsymbol{C}'$, where $\boldsymbol{C}$ is a lower-triangular matrix. The structural innovations are then recovered as $\boldsymbol{\varepsilon}^s_t = \boldsymbol{C}^{-1}\boldsymbol{u}^s_t$. We add a quantity $\delta > 0$ to the scalar element of $\boldsymbol{\varepsilon}^s_t$ that refers to government spending, i.e. $\boldsymbol{\varepsilon}^s_{t,\text{gov}}$. We then move again to the residual associated with the structural shock $\boldsymbol{u}^{s,\delta}_t = \boldsymbol{C}\boldsymbol{\varepsilon}^{s,\delta}_t$ to proceed with simulations as in point 3. Call the resulting path $\boldsymbol{y}^{s,\delta}_{t+h}$.

5. Compute the difference between the previous two paths for each horizon and for each variable, i.e. $\boldsymbol{y}^{s,\delta}_{t+h} - \boldsymbol{y}^{s}_{t+h}$ for $h = 0, 1, \ldots, H$.

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. $\widehat{\mathrm{GIRF}}_{\boldsymbol{y},t}(h, \delta, \omega_{t-1}) = \{E[\boldsymbol{y}_{t+h}|\delta, \omega_{t-1}] - E[\boldsymbol{y}_{t+h}|\omega_{t-1}]\}_{h=0}^{19}$. If a given initial condition ω_{t-1} brings an explosive response (namely if this is explosive for most of the sequences of residuals drawn $\{\boldsymbol{u}_t\}^s$, 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 ω_{t-1} is classified to belong to the "tranquil times" state if unc_{t-1} is within a ten percentile 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 $\widehat{\mathrm{GIRF}}_{\boldsymbol{y},t}(\delta_t, \text{tranquil times})$ and $\widehat{\mathrm{GIRF}}_{\boldsymbol{y},t}(\delta_t, \text{uncertain times})$.

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

6.3 Generalized impulse response functions estimating a larger specification and using smaller tolerance bands for the definition of tranquil and uncertain times

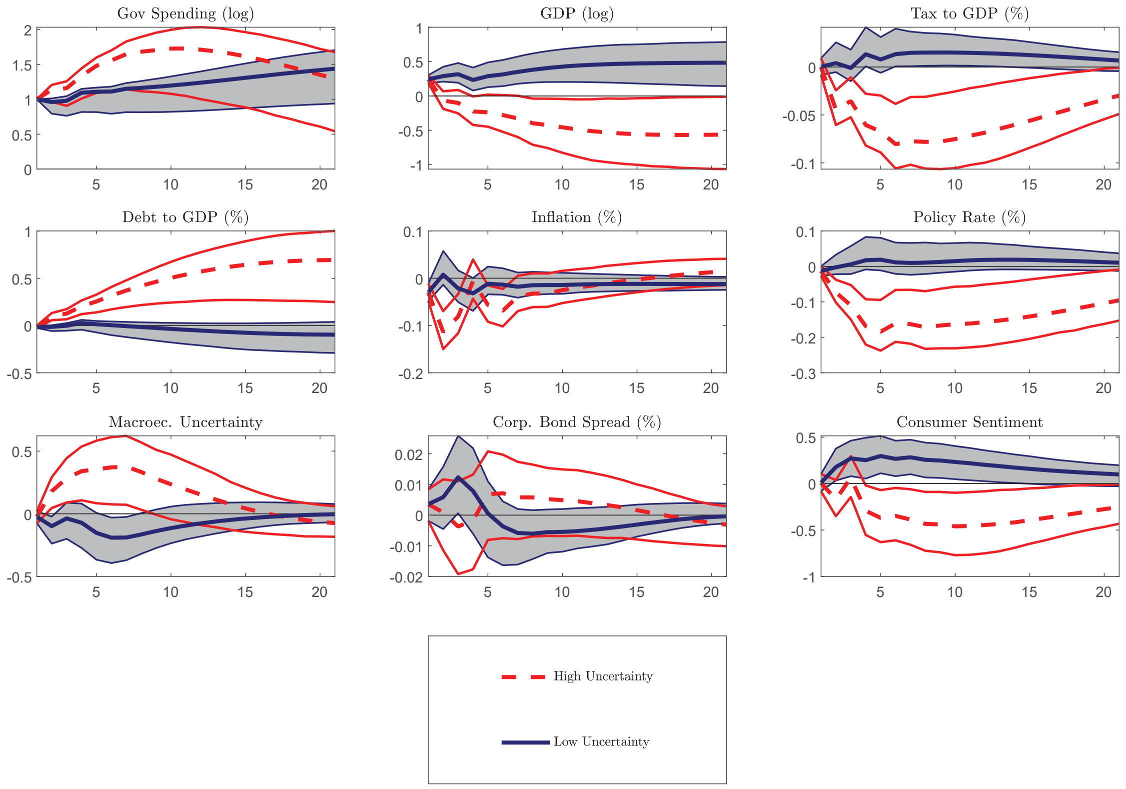

Figure 12: Impulse responses and 68% confidence intervals to a one percent government spending shock for our original specification

Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within in the 80^{th} and 100^{th} percentile.

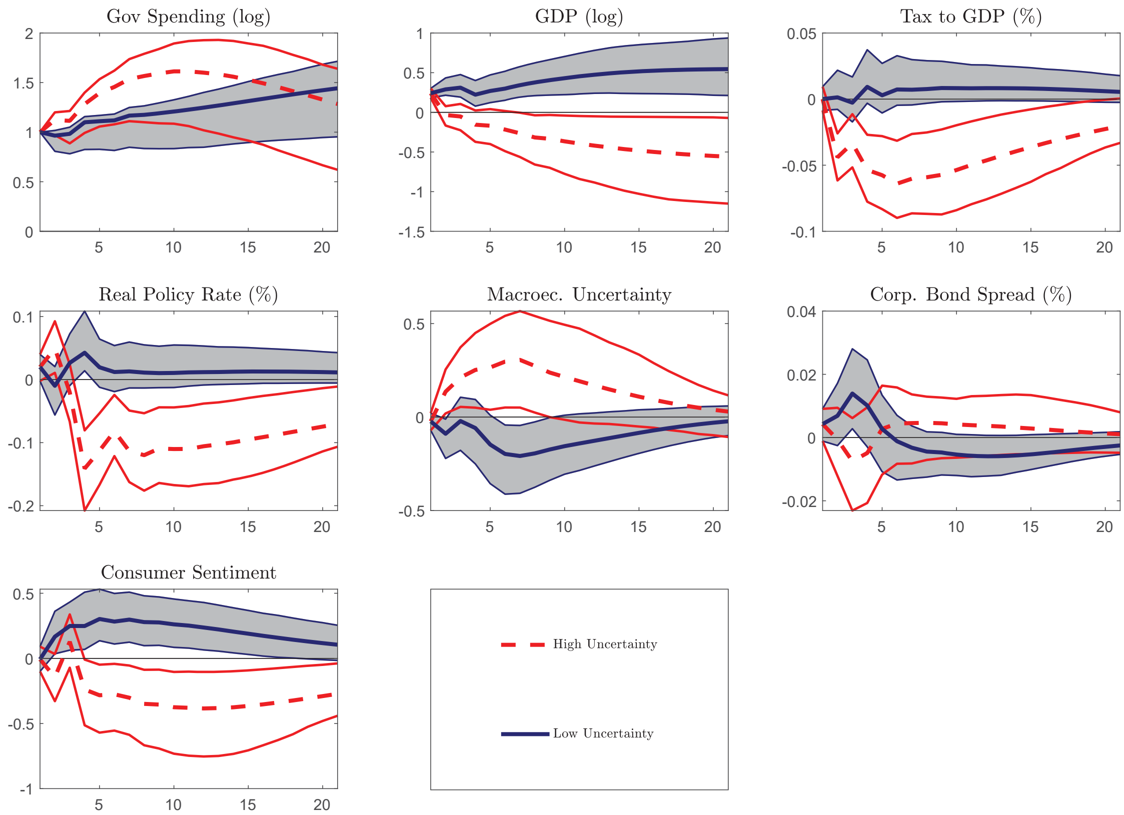

Figure 13: Impulse responses and 68% confidence intervals to a one percent government spending shock using smaller tolerance bands for the definition of tranquil and uncertain times
Note: Histories are classified as tranquil times if uncertainty corresponds to periods within the 5^{th} and 15^{th} percentile of the uncertainty distribution. Uncertain times are those periods located within the 85^{th} and 95^{th} percentile.

6.4 Generalized impulse response functions for the baseline specification using different uncertainty measures

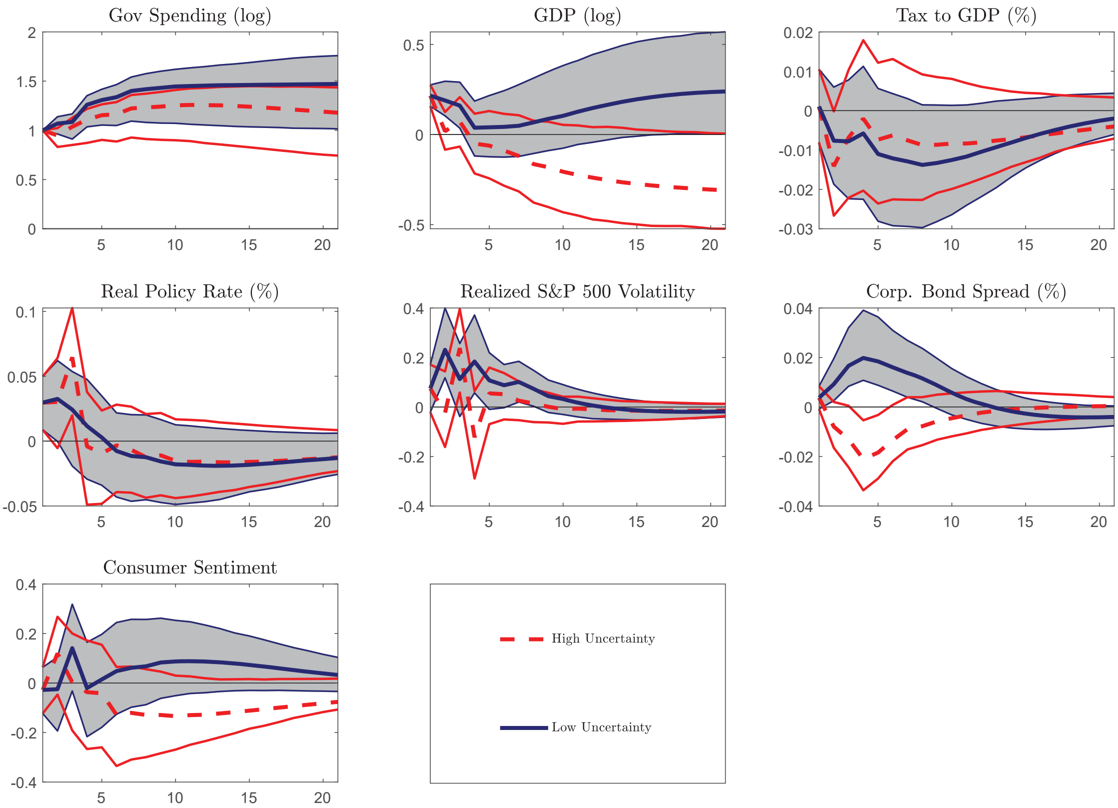

Figure 14: Impulse responses and 68% confidence intervals to a one percent government spending growth shock using annualized monthly standard deviation of daily S&P 500 returns as uncertainty proxy
Note: Histories are classified as tranquil times if uncertainty is located within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain periods are those located within the 80^{th} and 100^{th} percentile.

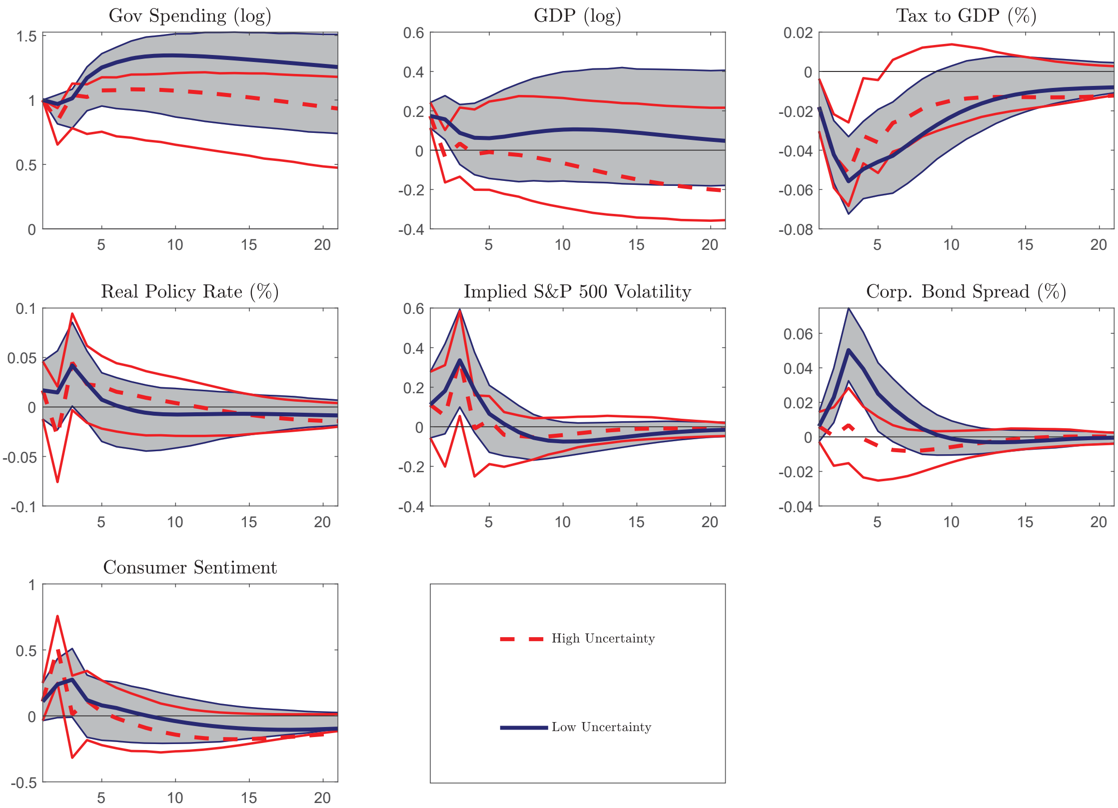

Figure 15: Impulse responses and 68% confidence intervals to a one percent government spending growth shock using implied volatility of daily stock market returns as uncertainty indicator
Note: Histories are classified as tranquil times if uncertainty is located within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain periods are those located within the 80^{th} and 100^{th} percentile.

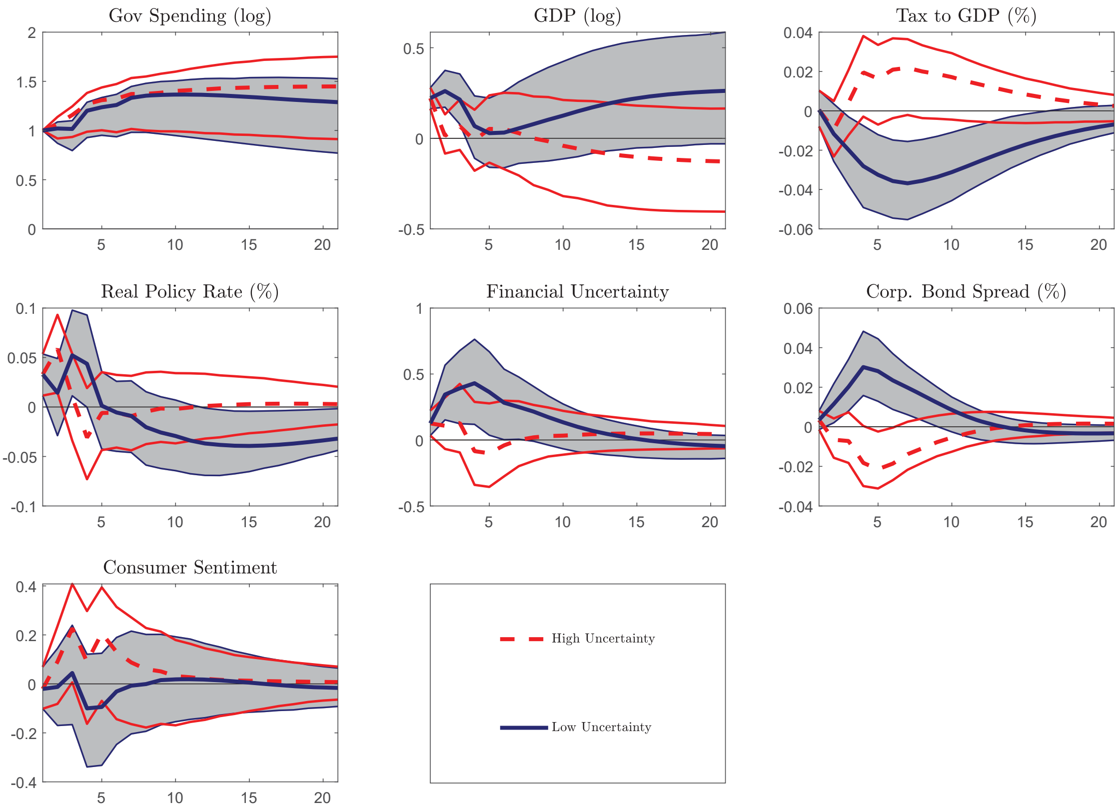

Figure 16: Impulse responses and 68% confidence intervals to a one percent government spending growth shock using financial uncertainty as uncertainty measure

Note: Histories are classified as tranquil times if uncertainty is located within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain periods are those located within the 80^{th} and 100^{th} percentile.

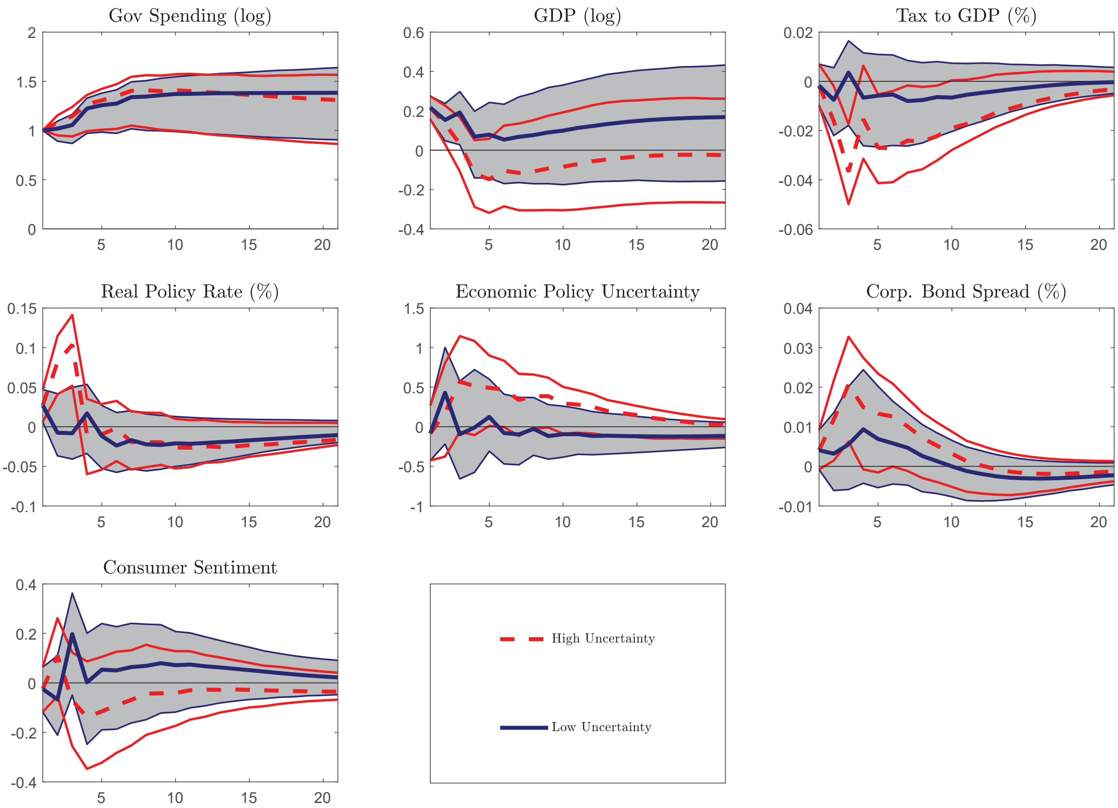

Figure 17: Impulse responses and 68% confidence intervals to a one percent government spending growth shock using economic policy uncertainty as uncertainty indicator

Note: Histories are classified as tranquil times if uncertainty is located within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain periods are those located within the 80^{th} and 100^{th} percentile.

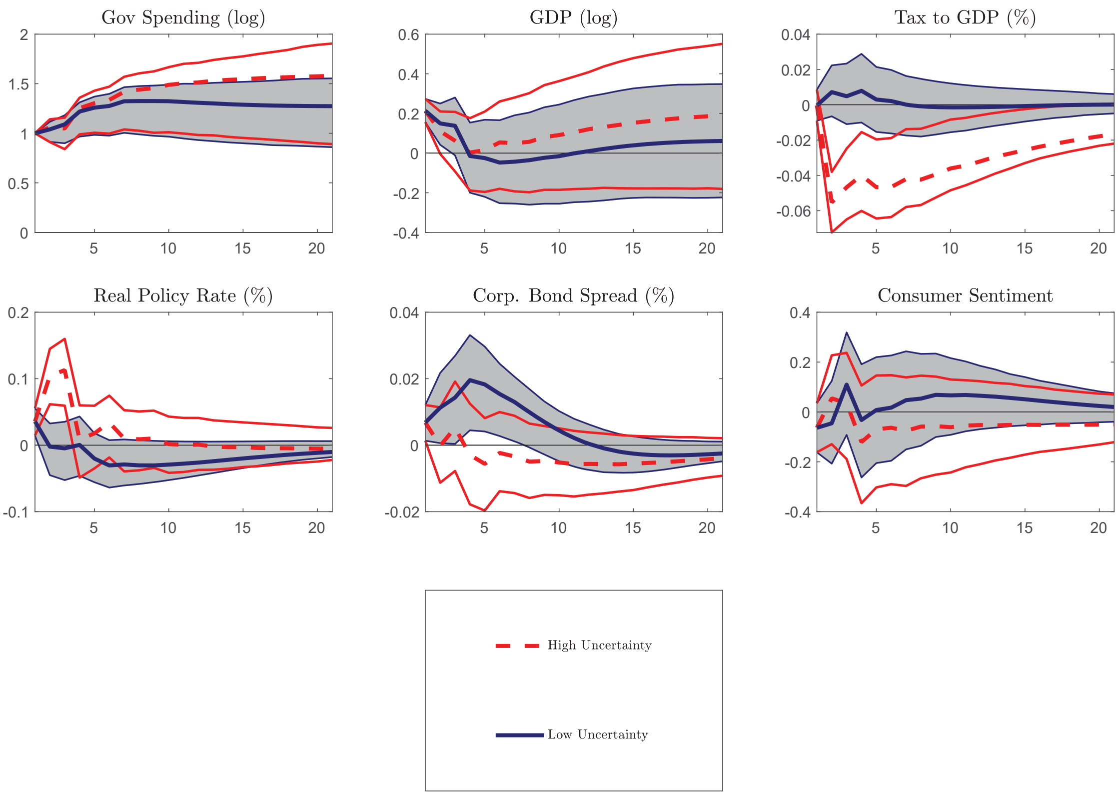

Figure 18: Impulse responses and 68% confidence intervals to a one percent government spending growth shock using corporate bond spread as uncertainty proxy
Note: Histories are classified as tranquil times if uncertainty is located within the 0^{th} and 20^{th} percentile of the uncertainty distribution. Uncertain periods are those located within the 80^{th} and 100^{th} percentile.

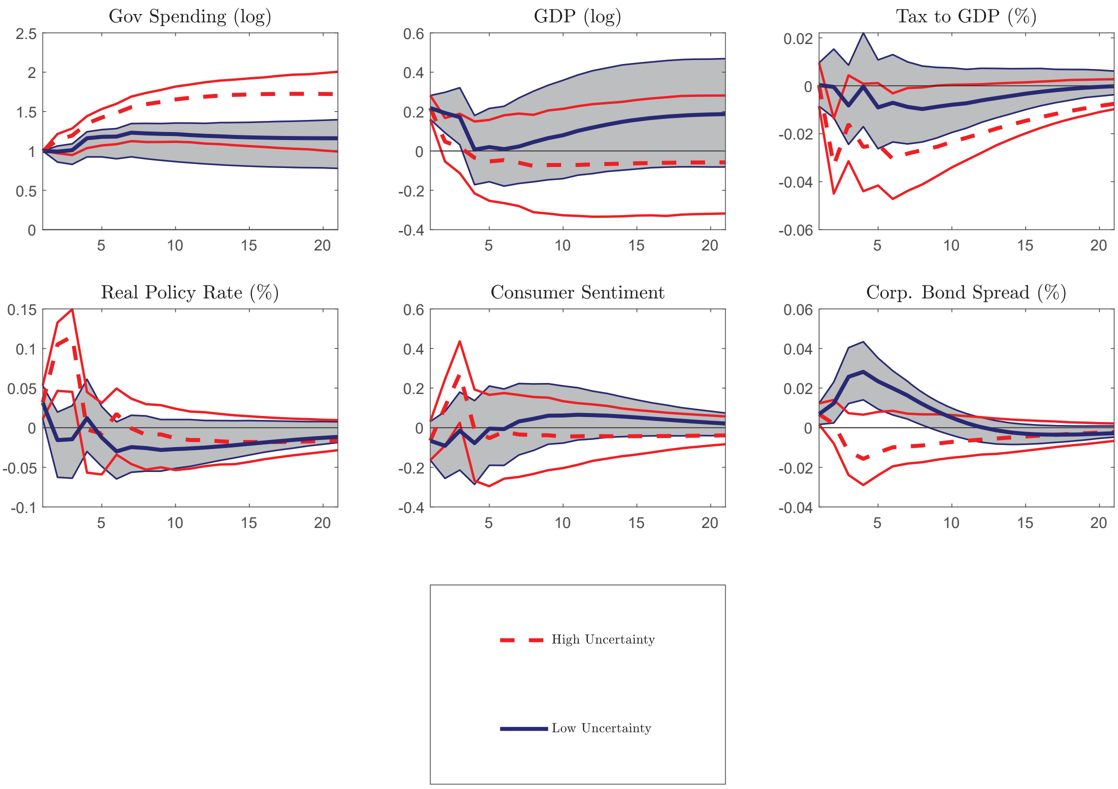

Figure 19: Impulse responses and 68% confidence intervals to a one percent government spending growth shock when we use consumer confidence as an inversely related uncertainty proxy
Note: Histories are classified as uncertain times if consumer sentiment corresponds to periods within the 0^{th} and 20^{th}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