Fiscal Volatility Shocks and Economic Activity

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October 10, 2013

Abstract

We study the effects of changes in uncertainty about future fiscal policy on aggregate economic activity. First, we estimate tax and spending processes for the U.S. that allow for time-varying volatility. We uncover strong evidence of the importance of this time-varying volatility in accounting for the dynamics of tax and spending data. We then feed these processes into an otherwise standard New Keynesian business cycle model estimated to the U.S. economy. We find that fiscal volatility shocks can have a sizable adverse effect on economic activity and inflation, in particular when the economy is at the zero lower bound of the nominal interest rates. An endogenous increase in markups accounts for about half of the contraction.

Keywords: Dynamic economies, Uncertainty, Fiscal Policy, Monetary Policy.

JEL classification numbers: E10, E30, C11.

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"The recovery in the United States continues to be held back by a number of other headwinds, including still-tight borrowing conditions for some businesses and households, and – as I will discuss in more detail shortly – the restraining effects of fiscal policy and fiscal uncertainty."
July 18, 2012, Ben S. Bernanke.

Policymakers and business leaders alike see the U.S. economy buffeted by larger-than-usual uncertainty about fiscal policy. As illustrated by a number of prolonged struggles at all levels of government in recent years, there is little consensus among policymakers about the fiscal mix and timing going forward.[1] Will government spending rise or fall? Will taxes rise or fall? And which ones? And when will it happen?

In this paper, we investigate whether all of this increased uncertainty about fiscal policy has a detrimental impact on economic activity (hereafter, and following the literature, we use the term "uncertainty" as shorthand for what would more precisely be referred to as "objective uncertainty" or "risk"). We first estimate fiscal rules for the U.S. that allow for time-varying volatility in their innovations while keeping the rest of the parameters constant. In particular, we estimate fiscal rules for capital and labor income taxes, consumption taxes, and government expenditure as a share of output. We interpret the changes in the volatility of the innovations in the fiscal rules as a representation of the variations in fiscal policy uncertainty. A key feature of our specification of the fiscal rules is that we clearly distinguish between fiscal shocks and fiscal volatility shocks. Thus, we will be able to consider shocks to fiscal volatility that would not have a contemporaneous effect on taxes or government expenditure as a share of output. Another important characteristic of our fiscal rules is that the changes in fiscal uncertainty are only temporary. This is a deliberate choice as we already know from the work of Bi, Leeper and Leith (2013) and others that permanent changes in policy have important effects on economic activity. Our goal is to investigate a different

[1] As regards the uncertain outlook created by the current political gridlock, a notorious example is the current debate about the funding of Obamacare. Other cases were the unending discussion of the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010, which was signed into law only shortly before the Bush tax cuts and the extension of federal unemployment benefits would have expired, the discussion surrounding the federal debt limit in 2011 that witnessed the U.S. sovereign debt downgraded by S&P, or the starkly different platforms in the 2012 presidential election. With regard to concerns by businesses, the Philadelphia Fed's July 2010 Business Outlook Survey is suggestive of heightened fiscal uncertainty as well: of those firms that saw their demand fall, 52 percent cited "Increased uncertainty about future tax rates or government regulations" as one of the reasons. Fiscal uncertainty is, in recent years, repeatedly mentioned by respondents to the Fed's Beige Book. Finally see the indicator constructed by Baker, Bloom and Davis (2011).

question: the response of the economy to a temporary increase in fiscal policy uncertainty.

In a second step, we feed the estimated rules into a New Keynesian model, variants of which have been demonstrated to capture the properties of U.S. business cycles (Christiano, Eichenbaum and Evans (2005)). The model serves as a useful starting point both for analyzing the effects of fiscal uncertainty and for outlining –through counterfactuals– some of the implications for monetary policy. We estimate the model to match observations of the U.S. economy. We then compute impulse response functions (IRFs) to a fiscal volatility shock (to be defined precisely below) by employing third-order perturbation methods to solve for the equilibrium. By using the estimated rules, we assume that the economy is temporarily subjected to higher fiscal uncertainty, but that the processes for taxes, government spending as a share of output, and uncertainty follow their historical behavior.

Our main findings are as follows. First, there is a considerable amount of time-varying volatility in tax and government spending as a share of output processes in the U.S. The evidence overwhelmingly supports the view that explicitly modeling time-varying volatility is crucial in any empirical investigation of fiscal policy in the U.S.

Second, fiscal volatility shocks reduce economic activity: aggregate output, consumption, investment, and hours worked drop on impact and stay low for several quarters. Most of the effect works through larger uncertainty about future tax rates on capital income. Endogenous markups are central to the mechanism. On the one hand, because of nominal rigidities, prices cannot fully accommodate the drop in demand triggered by precautionary behavior. On the other hand, fiscal volatility shocks make future marginal costs and demand harder to predict, which means that firms stand to lose more by setting relatively low prices. This leads firms to bias their prices upward. Fiscal volatility shocks are therefore "stagflationary": Inflation rises on impact while output falls. We provide VAR evidence of the mechanism at hand by showing that, empirically, output falls and markups rise after a fiscal volatility shock.

Third, we measure that the effect on output of a fiscal volatility shock is 0.14 percent, roughly equivalent to the effect of a one-standard-deviation contractionary monetary shock identified in VAR studies (a 30-basis-point increase in the federal funds rate).

Fourth, when the economy is at the zero lower bound (ZLB) of the nominal interest rates, such as it

is the case for the U.S. right now, the effects of a fiscal volatility shock are particularly large: output drops 1.7 percent and investment 7.9 percent. The reason is that, at the ZLB, the real interest rate cannot fall to ameliorate the contractionary effect of a fiscal volatility shock, as it happens when the economy is outside the ZLB.

Quantitatively, we explore the effects of large fiscal volatility shocks, namely, a two-standard-deviation innovation shock. However, the size of the shock is in line with the volatility literature. Bloom (2009) uses a similar-sized shock to the volatility of idiosyncratic productivity and Basu and Bundick (2011) evaluate the impact of about a doubling in the standard deviation of TFP and demand preference shocks. The key is not to think about fiscal volatility shocks as a main source of business cycle fluctuations every quarter, but as an important one from time to time (for instance, every decade or so).

In this paper, we evaluate one possible incarnation of the notion of fiscal uncertainty. In particular, we estimate fiscal rules for the U.S. that allow for temporary and smooth changes in the standard deviation of their innovations while keeping the rest of the fiscal rules parameters constant. Other scenarios could be possible. First, we could allow for changes in regimes on either the standard deviation of the innovations or the rest of the fiscal rules parameters. We believe that the former would provide results similar to the ones reported in the paper and that, given the dimensionality of our problem and that we analyze temporary changes, it would be difficult to handle the latter. In the literature, Bi, Leeper and Leith (2013) study a world in which the initial level of debt is high and can be permanently consolidated through either future tax increases or spending cuts. They explore how beliefs about the distribution of future realizations of these one-sided risks affect economic activity. The main difference is that they consider permanent changes in policy, while we want to focus on temporary ones. Davig and Leeper (2011) estimate Markov-switching processes for a monetary rule and a (lump-sum) tax policy rule. Using a simple New Keynesian model, they analyze the outcomes of government spending shocks in different combinations of regimes (see also Davig and Leeper (2007)). A nice feature of that paper is that the authors are able to implement changes in monetary and fiscal regime away from the active monetary/passive fiscal policy regime. They are able to do that because they consider a small three-equation model without capital (which, in comparison, plays a fundamental role in our results).

As a second alternative, we could investigate fiscal rules with time-varying parameters other than the standard deviation of their innovations. Although this route is a promising research program, we view our choice as a complementary scenario and as a required step before exploring time-varying parameters in fiscal policy rules.

To the best of our knowledge, our paper is the first attempt to fully characterize the dynamic consequences of fiscal volatility shocks. At the same time, our work is placed in a growing literature that analyzes how other types of volatility shocks interact with aggregate variables. Notable examples include Basu and Bundick (2011), Bloom (2009), Bloom et al. (2012), Justiniano and Primiceri (2008), and Fernández-Villaverde et al. (2011). As a novelty with respect to these papers, our work focuses on the effects of fiscal volatility shocks. In addition, we focus on a monetary business cycle model, highlighting that this dimension is central to the transmission of fiscal volatility shocks even without non-convexities.[2]

Our work has connections with several other literatures. First, our paper is related to the literature that assesses how fiscal uncertainty affects the economy through long-run growth risks, such as Croce, Nguyen and Schmid (2012). In comparison with that work, we focus on time-separable preferences and we abstract from long-run risks or financial frictions. In addition, agents in our paper have complete knowledge about the probability distribution of future outcomes. We do so to demonstrate that, even with these much more restrictive assumptions, higher tax uncertainty may depress economic activity. It would be trivial, for instance, to incorporate recursive preferences into our analysis and to make our results stronger. Our choice of time-separable utility functions, though, makes our argument more transparent. Second, there are indirect links with another strand of the literature that focuses on the (lack of) resolution of longer-term fiscal uncertainty. Davig, Leeper and Walker (2010), for example, focus on uncertainty about how unfunded liabilities for Social Security, Medicare, and Medicaid would be resolved through taxation, inflation, or reneging on promised transfers.

The remainder of the paper is structured as follows. Section 1 estimates the tax and spending processes that form the basis for our analysis. Section 2 discusses the model and section 3 its estimation and solution. Sections 4 to 7 report the main results, VAR evidence, and a number

[2] After circulating a draft of this paper, we were made aware of related work by Born and Pfeifer (2011), who are also concerned with increased fiscal policy uncertainty.

of robustness exercises. We close with some final comments. Several appendices present further details and a large number of additional robustness analysis.

1 Fiscal Rules with Time-Varying Volatility

This section estimates fiscal rules with time-varying volatility using taxes, government spending, debt, and output data. The estimated rules will later discipline our quantitative experiments by assuming that past fiscal behavior is a guide to assess current behavior.

There are, at least, two alternatives to our approach. First is the direct use of agents' expectations. This will avoid the problem that the timing of uncertainty that we estimate and the actual uncertainty that agents face might be different. Unfortunately, and to the best of our knowledge, there are no surveys that inquire about individuals' expectations with regard to future fiscal policies. A second alternative would be to estimate a fully fledged business cycle model using likelihood-based methods and to smooth out the time-varying volatility in fiscal rules. The sheer size of the state space in that exercise makes this strategy too challenging for practical implementation.

1.1 Data

We build a sample of average tax rates and spending of the consolidated government sector (federal, state, and local) at quarterly frequency from 1970.Q1 to 2010.Q2 (see appendix A for details). The tax data are constructed from NIPA as in Leeper, Plante and Traum (2010). Government spending is government consumption and gross investment, both from NIPA. The debt series is federal debt held by the public recorded in the St. Louis Fed's FRED database. Output comes from NIPA.

We use average tax rates rather than marginal tax rates. The latter are employed by Barro and Sahasakul (1983). Since the tax code for income taxes is progressive, we may underestimate the extent to which these taxes are distortionary. Assuming that marginal income tax rates, in terms of persistence and volatility, display characteristics similar to those of the average tax rates, we would then undermeasure the effect of fiscal volatility shocks. Unfortunately, the update of the Barro-Sahasakul data provided by Daniel R. Feenberg[3] only covers income weighted average marginal tax

[3] `http://users.nber.org/ taxsim/barro-redlick/current.html`

rates and, as we will see in our quantitative exercises, we are particularly interested in the evolution of capital income tax rates by themselves.

1.2 The Rules

Our fiscal rules model the evolution of four policy instruments: government spending as a share of output, $\tilde{g}_t$, and taxes on labor income, $\tau_{l,t}$, on capital income, $\tau_{k,t}$, and on personal consumption expenditures, $\tau_{c,t}$. For each instrument, we postulate the law of motion:

$$x_t - x = \quad \rho_x(x_{t-1} - x) + \phi_{x,y}\tilde{y}_{t-1} + \phi_{x,b}\left(\frac{b_{t-1}}{y_{t-1}} - \frac{b}{y}\right) + \exp(\sigma_{x,t})\varepsilon_{x,t}, \quad \varepsilon_{x,t} \sim \mathcal{N}(0,1), \tag{1}$$

for $x \in \{\tilde{g}, \tau_l, \tau_k, \tau_c\}$, where $\tilde{g}$ is the mean government spending as a share of output and τ_x is the mean of the tax rate. Above, $\tilde{y}_{t-1}$ is lagged detrended output, b_t is public debt (with $\frac{b}{y}$ being the mean debt-to-output ratio), and y_t is output. Equation (1) allows for two feedbacks: one from the state of the business cycle ($\phi_{\tau_x,y} > 0$ and $\phi_{\tilde{g},y} < 0$) and another from the debt-to-output ratio ($\phi_{\tau_x,b} > 0$ and $\phi_{\tilde{g},b} < 0$). This structure follows Bohn (1998).

The novelty of equation (1) is that it incorporates time-varying volatility in the form of stochastic volatility. Namely, the log of the standard deviation, $\sigma_{x,t}$, of the innovation to each policy instrument is random, and not a constant, as traditionally assumed. We model $\sigma_{x,t}$ as an $AR(1)$ process:

$$\sigma_{x,t} = \left(1 - \rho_{\sigma_x}\right)\sigma_x + \rho_{\sigma_x}\sigma_{x,t-1} + \left(1 - \rho_{\sigma_x}^2\right)^{(1/2)}\eta_x u_{x,t},\ u_{x,t} \sim \mathcal{N}(0,1). \tag{2}$$

In our formulation, two independent innovations affect the fiscal instrument x. The first innovation, $\varepsilon_{x,t}$, changes the instrument itself, while the second innovation, $u_{x,t}$, determines the spread of values for the fiscal instrument. We will call $\varepsilon_{x,t}$ an innovation to the fiscal shock to instrument x and $\sigma_{x,t}$ a fiscal volatility shock to instrument x with innovation $u_{x,t}$.

The $\epsilon_{x,t}$'s are not the observed changes in the fiscal instruments, but the deviations of the data with respect to the historical response to the regressors in equation (1). Thus, the $\epsilon_{x,t}$'s capture both explicit changes in legislation and a wide range of fiscal actions whenever government behavior deviates from what could have been expected given the past value of the fiscal instruments, the stage of the business cycle, and the level of government debt. Indeed, there may be non-zero $\epsilon_{x,t}$'s even in

the absence of new legislation. Examples include changes in the effective tax rate if policymakers, through legislative inaction, allow for bracket creep in inflationary times, or for changes in effective capital income tax rates in booming stock markets.

The parameter σ_x fixes the average standard deviation of an innovation to the fiscal shock to instrument x, η_x is the unconditional standard deviation of the fiscal volatility shock to instrument x, and ρ_{σ_x} controls its persistence. A value of $\sigma_{\tau_k,t} > \sigma_{\tau_k}$, for example, implies that the range of likely future capital tax rates is larger than usual. Variations of $\sigma_{x,t}$ over time, in turn, will depend on η_x and ρ_{σ_x}. A positive fiscal volatility shocks to a fiscal instrument captures greater-than-usual uncertainty about the future path of that instrument. Stochastic volatility intuitively models such changes while only introducing two new parameters for each instrument (ρ_{σ_x} and η_x).

1.3 Estimation

We estimate equations (1) and (2) for each fiscal instrument. We set the means in equation (1) to their average values. Then, we estimate the rest of the parameters following a Bayesian approach by combining the likelihood function with flat priors and sampling from the posterior with a Markov Chain Monte Carlo (see appendix B for details). Output is detrended with the Christiano-Fitzgerald band pass filter. The non-linear interaction between the innovations to fiscal shocks and their volatility shocks is overcome with the particle filter as described in Fernández-Villaverde, Guerrón-Quintana and Rubio-Ramírez (2010).

Table 1 reports the posterior median for the parameters along with 95 percent probability intervals. Both tax rates and government spending as a share of output are quite persistent. The posterior also provides overwhelming evidence that time-varying volatility is crucial; see the positive numbers in the row "η_x". Except for labor income taxes, deviations from average volatility last for some time -see the row "ρ_{σ_x}"- although that persistence is not identified as precisely as the persistence of the fiscal shocks. Evaluated at the posterior median, the half-life of the fiscal volatility shocks is 0.6 quarter for the labor tax, 1.5 quarters for the consumption tax, 2.6 quarters for the capital tax rate, and 9.6 quarters for government spending.

To gauge these numbers, let us focus on the estimates for capital income taxes in the third column in table 1. The innovation to the capital tax rate has an average standard deviation of 0.70 percentage

Table 1: Posterior Median Parameters

	Tax rate on			Government
	Labor	Consumption	Capital	Spending
ρ_x	0.99 [0.975,0.999]	0.99 [0.981,0.999]	0.97 [0.93,0.996]	0.97 [0.948,0.992]
σ_x	-6.01 [-6.27,-5.75]	-7.09 [-7.34,-6.78]	-4.96 [-5.29,-4.66]	-6.13 [-6.49,-5.39]
$\phi_{x,y}$	0.031 [0.011,0.055]	0.001 [0.000,0.005]	0.044 [0.004,0.109]	-0.004 [-0.02,0.00]
$\phi_{x,b}$	0.003 [0.00,0.007]	0.0006 [0.00,0.002]	0.004 [0.00,0.016]	-0.008 [-0.012,-0.003]
ρ_{σ_x}	0.31 [0.06,0.57]	0.65 [0.08,0.91]	0.76 [0.47,0.92]	0.93 [0.43,0.99]
η_x	0.94 [0.73,1.18]	0.60 [0.31,0.93]	0.57 [0.33,0.88]	0.43 [0.13,1.15]

Note: For each parameter, we report the posterior median and, in brackets, a 95 percent probability interval.

point ($100 \exp(-4.96)$). A one-standard-deviation fiscal volatility shock to capital taxes increases the standard deviation of the innovation to taxes to $100 \exp(-4.96 + (1 - 0.76^2)^{1/2} 0.57)$, or to 1.02 percentage points. Starting at the average tax, after a simultaneous one-standard-deviation innovation to the rate and its fiscal volatility shock, the tax rate jumps by about 1 percentage point (rather than by 0.70 percentage point, as would be the case without the fiscal volatility shock). The half-life of the change to the tax rate is 20 quarters ($\rho_{\tau_k} = 0.97$).

Conditional on the posterior medians, figure 1 displays the evolution of the smoothed fiscal volatility shocks, $100 \exp \sigma_{x,t}$, for each fiscal instrument. Since the numbers on the y-axis are percentage points of the respective fiscal instrument, the figure shows by how many percentage points a one-standard-deviation fiscal shock would have moved that instrument at different points in time. For example, we estimate that a one-standard-deviation fiscal shock would have moved the capital tax rate by anywhere between more than 2 percentage points (in 1976) or 0.4 percentage point (in 1993). Periods of fiscal change coincide with times of high fiscal policy uncertainty as during the fiscal overhauls by Bush senior and Clinton. While these bursts of volatility happened in an expansion, fiscal volatility is typically higher during recessions. Also, the fiscal volatility shocks during the latest recession is commensurate with the one that prevailed in the early 1980s. In sum, fiscal policy in the U.S. displays quantitatively significant time-varying volatility.

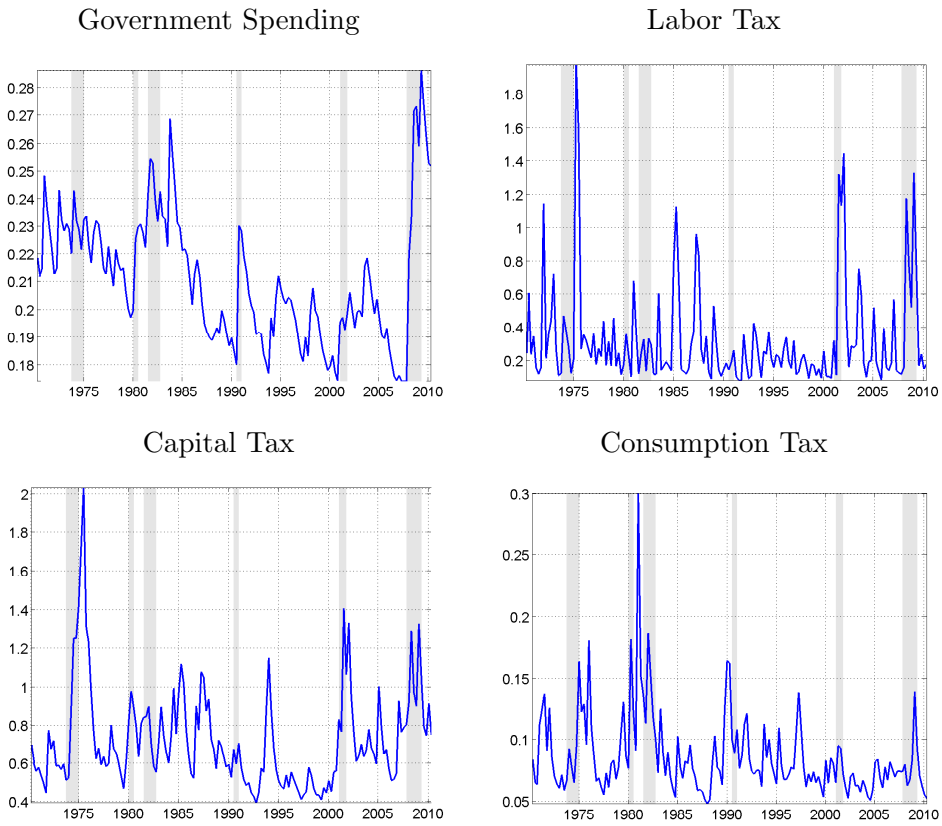


Figure 1: Smoothed fiscal volatility shocks to each instrument, $100 \exp \sigma_{x,t}$

Note: Volatilities expressed in percentage points.

1.4 Robustness of Estimation

Since the estimates of η_x and ρ_{σ_x} are key for the results in sections 4 and 6, we asses the sensitivity of our estimates with respect to alternative detrending mechanisms and measures of economic activity. Summing up these experiments, we find our estimates of η_x and ρ_{σ_x} to be consistently robust. Thus, we can consider that these parameters are structural in the sense of Hurwicz (1962). Table 2 reports the new results for the case of capital income taxes. We present the comparison only for this instrument because section 4 will argue this is the only instrument for which volatility shocks have sizable effects. The first row (label 0) replicates the results reported in column "Capital" of table 1. Row I shows results if we detrend output using the HP filter. Row II contains our findings when output is introduced contemporaneously into the estimation:

$$\tau_{k,t} - \tau_k = \quad \rho_{\tau_k}(\tau_{k,t-1} - \tau_k) + \phi_{\tau_k,y} y_t + \phi_{\tau_k,b}\left(\frac{b_{t-1}}{y_{t-1}} - \frac{b}{y}\right) + \exp(\sigma_{\tau_k,t})\varepsilon_{\tau_k,t},\ \varepsilon_{\tau_k,t} \sim \mathcal{N}(0,1)\,.$$

Row III reports the findings when we use the log of civilian employment (CE160V) detrended with a band pass filter in lieu of output. Row IV shows the estimates when we use output gap (the difference between output and CBO's potential output) as our measure of economic activity.

It may also be the case that the rules do not fully account for endogeneity when the economy is buffeted by large shocks (since lagged output may be a poor forecaster of today's output). Thus, we reestimate our rules using the Philadelphia Fed's ADS current business conditions index (Aruoba, Diebold and Scotti (2009)) as our measure of economic activity. This index tracks real business conditions at high frequency by statistically aggregating a large number of data series, and, hence, it is a natural alternative to detrended output. We estimate three new versions of the fiscal rule: (V) with the value of the ADS index at the beginning of the quarter, (VI) with the value of the ADS index in the middle of the quarter, and (VII) with the value of the ADS index at the end of the quarter. To the extent that fiscal and other structural shocks arrive uniformly within the quarter, the ADS index with different timings incorporates different information that may or may not be correlated with our fiscal measures. If endogeneity were an issue, our estimates of η_x and ρ_{σ_x} whould be sensitive to the timing of the ADS index. The results in table 2 line up with those in table 1 and we conclude that the estimates of η_x and ρ_{σ_x} are stable across the presented alternatives. The parameter $\phi_{x,y}$ is different when we use the ADS index, since detrended output and the ADS index are measured in different units.

1.5 Comparison with Alternative Indexes of Policy Uncertainty

Contemporaneously with us, Baker, Bloom and Davis (2011) have built an index of policy-related uncertainty. We call it the BBD index. This index weights the frequency of news media references to economic policy uncertainty, the number of federal tax code provisions set to expire in future years, and the extent of forecaster disagreement over future inflation and federal government purchases. The correlation of the BBD index with our our smoothed series of the volatility of capital income taxes (as before, the most relevant of our series) is 0.35. The correlation is significant at a 1 percent level. We find these positive correlations between two measures generated using such different approaches reassuring and corroborating independent evidence that our approach captures well the movements in fiscal policy uncertainty that agents face in the U.S.economy.

Table 2: Posterior Median Parameters – Robustness of Estimation

	Volatility Parameters			Fiscal Rule Parameters		
	σ_{τ_k}	$\rho_{\sigma_{\tau_k}}$	η_k	ρ_{τ_k}	$\phi_{\tau_k,y}$	$\phi_{\tau_k,b}$
0	−4.96 [−5.29,−4.66]	0.76 [0.47,0.92]	0.57 [0.33,0.88]	0.97 [0.93,0.996]	0.044 [0.004,0.109]	0.004 [0.00,0.016]
I	−4.96 [−5.27,−4.64]	0.76 [0.49,0.93]	0.58 [0.32,0.89]	0.96 [0.92,0.99]	0.04 [0.003,0.11]	0.005 [0.000,0.015]
II	−4.97 [−5.27,−4.66]	0.77 [0.48,0.93]	0.57 [0.33,0.88]	0.97 [0.92,0.99]	0.05 [0.004,0.12]	0.004 [0.001,0.014]
III	−4.95 [−5.24,−4.66]	0.77 [0.46,0.93]	0.55 [0.32,0.89]	0.97 [0.93,0.99]	0.04 [0.002,0.14]	0.005 [0.000,0.016]
IV	−4.96 [−5.24,−4.62]	0.74 [0.44,0.92]	0.56 [0.32,0.88]	0.96 [0.92,0.99]	0.037 [0.004,0.08]	0.004 [0.000,0.013]
V	−5.01 [−5.29,−4.62]	0.75 [0.44,0.94]	0.57 [0.44,0.79]	0.95 [0.91,0.98]	0.003 [0.002,0.005]	0.003 [0.001,0.01]
VI	−4.97 [−5.22,−4.72]	0.69 [0.20,0.91]	0.47 [0.25,0.77]	0.96 [0.92,0.99]	0.003 [0.001,0.004]	0.003 [0.001,0.01]
VII	−4.96 [−5.25,−4.64]	0.77 [0.49,0.93]	0.53 [0.39,0.75]	0.96 [0.93,0.99]	0.002 [0.001,0.003]	0.004 [0.001,0.014]

Notes: Row I is the specification with HP-filtered output, II is the specification with BP-filtered contemporaneous output, row III with the value of BP-filtered employment for 1970.I-2010.I, and finally row IV reports the results with the output gap. Row V is the specification with the value of the ADS index at the beginning of the quarter, row VI with the value of the ADS index in the middle of the quarter, and row VII with the value of the ADS index at the end of the quarter. For each parameter, the posterior median is given and a 95 percent probability interval (in parentheses).

For completeness, we check whether movements in the BBD index either lead or lag changes in our measure of fiscal policy uncertainty. Table 3 shows that our measure leads by two quarters, when the correlation is 0.44. It is also useful to analyze partial correlations. Both indexes are countercyclical and could be jointly driven by the cycle. Thus, analyzing their partial correlation, conditional on a measure for the cycle (we use HP-filtered output), is most helpful. It turns out that the partial correlation is almost identical to the unconditional one, 0.36 versus 0.35. Finally, we highlight that the correlation between the indexes improves dramatically since 1995. The unconditional correlation moves from 0.35 to 0.56 and the conditional one from 0.36 to 0.58.

Table 3: Lead/Lag Correlation: $Corr(\sigma_{k,t}, \sigma_{bbd,t+k})$

k	−4	−3	−2	−1	0	1	2	3	4
	0.18	0.25	0.32	0.38	0.35	0.39	0.44	0.43	0.42

Notes: $\sigma_{k,t}$ is our measure. $\sigma_{bbd,t}$ is BDD index. k refers to the number of quarters ahead.

2 Model

Motivated by our previous findings, we build a business cycle model to investigate how the estimated processes for fiscal volatility affect the economy. We do so by including fiscal policy in a New Keynesian model in the spirit of Christiano, Eichenbaum and Evans (2005). This model is a natural environment for our goal because it has been shown to fit many features of the U.S. business cycle and it forms the basis for much applied policy analysis.

2.1 Household

In the following, capital letters refer to nominal variables and small letters to real variables. Letters without a time subscript indicate steady-state values. There is a representative household with a unit mass of members who supply differentiated types of labor $l_{j,t}$ and whose preferences are separable in consumption, c_t, and labor:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t d_t \left\{ \frac{(c_t - b_h c_{t-1})^{1-\omega}}{1-\omega} - \psi \int_0^1 \frac{l_{j,t}^{1+\vartheta}}{1+\vartheta} dj \right\}.$$

Here, $\mathbb{E}_0$ is the conditional expectation operator, β is the discount factor, ϑ is the inverse of the Frisch elasticity of labor supply, and b_h governs the habit formation. Preferences are subject to an intertemporal shock d_t that follows $\log d_t = \rho_d \log d_{t-1} + \sigma_d \varepsilon_{dt}$, where $\varepsilon_{dt} \sim \mathcal{N}(0,1)$.

The household can invest in capital, i_t, and hold government bonds, B_t, that pay a nominal gross interest rate of R_t in period $t+1$. The real value of the bonds at the end of the period is $b_t = B_t/P_t$, where P_t is the price level. The real value at the start of period t (before coupon payments) of bonds bought last period is $b_{t-1}\frac{R_{t-1}}{\Pi_t}$, where $\Pi_t = \frac{P_t}{P_{t-1}}$ is inflation between $t-1$ and t.

The household pays consumption taxes $\tau_{c,t}$, labor income taxes $\tau_{l,t}$, capital income taxes $\tau_{k,t}$ and lump-sum taxes Ω_t. The capital tax is levied on capital income, which is given by the product of the amount of capital owned by the household k_{t-1}, the rate of utilization of capital u_t, and the rental rate of capital $r_{k,t}$. There is a depreciation allowance for the book value of capital, k_{t-1}^b. Finally, the household receives the profits of the firms in the economy $\digamma_t$. Hence, the household's

budget constraint is:

$$\begin{aligned}&(1+\tau_{c,t})c_t + i_t + b_t + \Omega_t + \int_0^1 AC_{j,t}^w dj \\ &= (1-\tau_{l,t})\int_0^1 w_{j,t} l_{j,t} dj + (1-\tau_{k,t})\, r_{k,t} u_t k_{t-1} + \tau_{k,t}\delta k_{t-1}^b + b_{t-1}\frac{R_{t-1}}{\Pi_t} + \digamma_t.\end{aligned} \tag{3}$$

where the real wage for labor of type j, $w_{j,t}$, is subject to an adjustment costs:

$$AC_{j,t}^w = \frac{\phi_w}{2}\left(\frac{w_{j,t}}{w_{j,t-1}} - 1\right)^2 y_t,$$

scaled by aggregate output y_t. We prefer a Rotemberg-style wage setting mechanism to a Calvo setting because it is more transparent when thinking about the effects of fiscal volatility shocks. In a Calvo world, we would have an endogenous reaction of the wage (and price) dispersion to changes in volatility that would complicate the analysis without delivering additional insight.[4]

A perfectly competitive labor packer aggregates the different types of labor $l_{j,t}$ into homogeneous labor l_t with the production function:

$$l_t = \left(\int_0^1 l_{j,t}^{\frac{\epsilon_w - 1}{\epsilon_w}} dj\right)^{\frac{\epsilon_w}{\epsilon_w - 1}},$$

where ϵ_w is the elasticity of substitution among types. The homogeneous labor is rented to intermediate good producers at real wage w_t. The labor packer takes the wages $w_{j,t}$ and w_t as given.

The law of motion of capital is $k_t = (1-\delta(u_t))\, k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t$ where $\delta(u_t)$ is the depreciation rate that depends on the utilization rate according to

$$\delta(u_t) = \delta + \Phi_1(u_t - 1) + \frac{1}{2}\Phi_2(u_t - 1)^2. \tag{4}$$

We assume a quadratic adjustment cost $S\left[\frac{i_t}{i_{t-1}}\right] = \frac{\kappa}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2$, which implies $S(1) = S'(1) = 0$ and $S''(1) = \kappa$, and that Φ_1 and Φ_2 are strictly positive.

To keep the model manageable, our representation of the U.S. tax system is stylized. However, we incorporate the fact that, in the U.S., depreciation allowances are based on the book value of capital and a fixed accounting depreciation rate rather than on the replacement cost and economic

[4] We will solve the model non-linearly. Hence, Rotemberg and Calvo settings are not equivalent. In any case, our choice is not consequential. We also computed the model with Calvo stickiness and we obtained similar results.

depreciation. Since our model includes investment adjustment costs and a variable depreciation depending on the utilization rate, the value of the capital stock employed in production differs from the book value of capital used to compute tax depreciation allowances.[5] To approximate these allowances, we assume a geometric depreciation schedule, under which in each period a share δ of the remaining book value of capital is tax-deductible. For simplicity, this parameter is the same as the intercept in equation (4). Thus, the depreciation allowance in period t is given by $\delta k_{t-1}^b \tau_{k,t}$, where k_t^b is the book value of the capital stock that evolves according to $k_t^b = (1-\delta)k_{t-1}^b + i_t$.

2.2 Firms

There is a competitive final good producer that aggregates the continuum of intermediate goods:

$$y_t = \left(\int_0^1 y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{5}$$

where ε is the elasticity of substitution.

Each of the intermediate goods is produced by a monopolistically competitive firm. The production technology is Cobb-Douglas $y_{it} = A_t k_{it}^{\alpha} l_{it}^{1-\alpha}$, where k_{it} and l_{it} are the capital and homogeneous labor input rented by the firm. A_t is neutral productivity that follows:

$$\log A_t = \rho_A \log A_{t-1} + \sigma_A \varepsilon_{At},\ \varepsilon_{At} \sim \mathcal{N}(0,1) \text{ and } \rho_A \in [0,1).$$

Intermediate good firms produce the quantity demanded of the good by renting labor and capital at prices w_t and $r_{k,t}$. Cost minimization implies that, in equilibrium, all intermediate good firms have the same capital-to-labor ratio and the same marginal cost:

$$mc_t = \left(\frac{1}{1-\alpha} \right)^{1-\alpha} \left(\frac{1}{\alpha} \right)^{\alpha} \frac{w_t^{1-\alpha} r_{k,t}^{\alpha}}{A_t}.$$

The intermediate good firms are subject to nominal rigidities. Given the demand function, the monopolistic intermediate good firms maximize profits by setting prices subject to adjustment

[5] The U.S. tax system presents some exceptions. In particular, at the time that firms sell capital goods to other firms, any actual capital loss is realized (reflected in the selling price). As a result, when ownership of capital goods changes hands, firms can lock in the economic depreciation. In our model all capital is owned by the representative household and, hence, we abstract from this margin.

costs as in Rotemberg (1982) (expressed in terms of deviations with respect to the inflation target Π of the monetary authority). Thus, firms solve:

$$\max_{P_{i,t+s}} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \frac{\lambda_{t+s}}{\lambda_t} \left(\frac{P_{i,t+s}}{P_{t+s}} y_{i,t+s} - mc_{t+s} y_{i,t+s} - AC^p_{i,t+s} \right)$$

$$\text{s.t. } y_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon} y_t,$$

$$AC^p_{i,t} = \frac{\phi_p}{2} \left(\frac{P_{i,t}}{P_{i,t-1}} - \Pi \right)^2 y_{i,t}$$

where they discount future cash flows using the pricing kernel of the economy, $\beta^s \frac{\lambda_{t+s}}{\lambda_t}$.

In a symmetric equilibrium, and after some algebra, the previous optimization problem implies an expanded Phillips curve:

$$0 = \left[(1-\varepsilon) + \varepsilon mc_t - \phi_p \Pi_t \left(\Pi_t - \Pi \right) + \frac{\varepsilon \phi_p}{2} \left(\Pi_t - \Pi \right)^2 \right] + \phi_p \, \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \Pi_{t+1} \left(\Pi_{t+1} - \Pi \right) \frac{y_{t+1}}{y_t} \quad (6)$$

2.3 Government

The model is closed by a description of the monetary and fiscal authorities. The monetary authority sets the nominal interest rate according to a Taylor rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{1-\phi_R} \left(\frac{\Pi_t}{\Pi} \right)^{(1-\phi_R)\gamma_\Pi} \left(\frac{y_t}{y} \right)^{(1-\phi_R)\gamma_y} e^{\sigma_m \xi_t}.$$

The parameter $\phi_R \in [0, 1)$ generates interest-rate smoothing. The parameters $\gamma_\Pi > 0$ and $\gamma_y \geq 0$ control the responses to deviations of inflation from target Π and of output from its steady-state value y. R marks the steady-state nominal interest rate. The monetary policy shock, ξ_t, follows a $\mathcal{N}(0, 1)$ process. As regards the fiscal authority, its budget constraint is given by:

$$b_t = \quad b_{t-1} \frac{R_{t-1}}{\Pi_t} + g_t - \left(c_t \tau_{c,t} + w_t l_t \tau_{l,t} + r_{k,t} u_t k_{t-1} \tau_{k,t} - \delta k^b_{t-1} \tau_{k,t} + \Omega_t \right).$$

where g_t is government spending. Keeping with the majority of the literature, g_t is pure waste.

To finance spending, the fiscal authority levies taxes on consumption and on labor and capital income, according to the fiscal rules described in equations (1) and (2). Lump-sum taxes stabilize

the debt-to-output ratio. More precisely, we impose a passive fiscal/active monetary regime as defined by Leeper (1991): $\Omega_t = \Omega + \phi_{\Omega,b}\left(b_{t-1} - b\right)$, where $\phi_{\Omega,b} > 0$ and just large enough to ensure a stationary debt. Note that, while we do not have explicit time-varying volatility for lump-sum taxes, those inherent an implicit time-varying volatility from the other fiscal instruments through the budget constraint and the evolution of debt.

In appendix C, we show the first-order conditions of the household, firms, and the aggregate market clearing conditions of the model. Also, since the definition of equilibrium for this economy is standard, we skip it.

3 Solution and Estimation

We solve the model by a third-order perturbation around its steady state. Perturbation is, in practice, the only method that can compute a model with as many state variables as ours in any reasonable amount of time. A third-order perturbation is important because, as shown in Fernández-Villaverde, Guerrón-Quintana and Rubio-Ramírez (2010), innovations to volatility shocks only appear by themselves in the third-order terms. Our non-linear solution implies moments of the ergodic distribution of endogenous variables that are different from the ones implied by linearization. To compute these moments, we rely on pruning as described in Andreasen et al. (2013) and use them to estimate some of the parameters of our model using simulated method of moments (SMM).[6] We then compute IRFs of several endogenous variables.

Before proceeding, given that we are dealing with a large model, we need to fix several parameters to conventional values. With respect to preferences, we set the risk aversion parameter to $\omega = 2$.[7] We set $\vartheta = 2$, implying a Frisch elasticity of labor supply of 0.5. This number, in line with the recommendation of Chetty et al. (2011), is appropriate given that our model does not distinguish between an intensive and extensive margin of employment (in fact, a lower elastic labor supply would increase the effect that fiscal volatility shocks have on economic activity). Habit formation

[6] Ideally, we would like to jointly estimate the parameters in the model and the fiscal rules using a likelihood-based approach. Because of the size of our model, this is computationally unfeasible at this point.

[7] This value is within the range entertained in the literature. The literatures on volatility shocks, for example, Fernández-Villaverde et al. (2011), choose values around 4. Quantitatively, the transmission of fiscal volatility shocks is hardly affected by the value for ω. Corresponding IRFs are available upon request.

Table 4: Parameters

Preferences		*Rigidities*		*Policy*		*Technology*		*Shocks*	
β^*	0.9945	ϕ_w^*	2501	Π^*	1.0045	α	0.36	ρ_A	0.95
ω	2	ϵ_w	21	ϕ_R^*	0.7	δ^*	0.010	σ_A^*	0.001
ϑ	1	ϕ_p^*	236.10	γ_Π	1.25	Φ_1	0.0155	ρ_d	0.18
ψ^*	23.86	ϵ	21	γ_y	0.25	Φ_2^*	0.01	σ_d^*	0.08
b_h^*	0.75			Ω	$-5.1e-2$	κ^*	3	σ_m^*	0.0025
				$\phi_{\Omega,b}$	0.0005				
				b^*	2.64				

Note: Parameters with (*) indicate those set using SMM.

is fixed to the value estimated in Christiano, Eichenbaum and Evans (2005).

With respect to nominal rigidities, we set the wage stickiness parameter, ϕ_w, to a value that would replicate, in a linearized setup, the slope of the wage Phillips curve derived using Calvo stickiness with an average duration of wages of one year. The parameter ϕ_p renders the slope of the Phillips curve in our model consistent with the slope of a Calvo-type Phillips curve without strategic complementarities when prices last for a year on average (see Galí and Gertler (1999)).

For technology, we fix the elasticity of demand to $\epsilon = 21$ as in Altig et al. (2011).[8] By symmetry, we also set $\epsilon_w = 21$. The cost of utilization and adjusting investment, $\Phi_1 = 0.0165$, comes from the first-order condition for capacity utilization. We set α to the standard value of 0.36.

For policy, the values for $\gamma_\Pi = 1.25$ and $\gamma_y = 0.25$ follow Fernández-Villaverde, Guerrón-Quintana and Rubio-Ramírez (2010). Our choice of size of the response of lump-sum taxes to the debt level $\phi_{\Omega,b}$ has negligible quantitative effects. We set the steady-state value of lump-sum taxes Ω to satisfy the government's budget constraint. Finally, we chose 0.95 and 0.18 for the persistence of the productivity and the intertemporal shocks, both standard choices.

The rest of the parameters are estimated using the SMM to match moments of quarterly data for the U.S. economy. In particular, $\{\beta, \psi, \Pi, \Phi_2, \kappa, \delta, \phi_R, \sigma_A, \sigma_d, \sigma_m, b\}$ are selected to match the annualized average real rate of interest of 2 percent, the average share of hours worked of 1/3, the average annualized inflation rate of 2 percent, the standard deviations of output, consumption,

[8] The literature entertains a wide range of values for ϵ, which is often not precisely identified; see the discussion in Altig et al. (2011). Our value of $\epsilon = 21$ is also roughly what Kuester (2010) has estimated ($\epsilon = 22.7$). We report robustness checks in appendix F. Also, with a reasonable price adjustment costs, as the one we use, it is nearly a zero probability event that firms price below marginal cost even with low average mark-ups. We have corroborated this in simulations of our model.

Table 5: Second Moments in the Model and the Data

	Model			Data		
	std	AR(1)	Cor(x,y)	std	AR(1)	Cor(x,y)
Output, consumption and investment						
y_t	1.59	0.62	1	1.57	0.87	1
c_t	1.27	0.68	0.54	1.28	0.89	0.87
i_t	6.42	0.95	0.25	7.69	0.83	0.91
Wages, labor and capacity utilization						
w_t	0.17	0.95	0.53	0.88	0.76	0.10
h_t	1.74	0.55	0.96	1.93	0.92	0.87
u_t	1.61	0.69	0.84	3.24	0.87	0.86
Nominal variables						
R_t	2.92	0.83	0.05	3.67	0.93	0.18
Π_t	3.26	0.63	0.37	2.47	0.98	-0.004

Note: Data for the period 1970.Q1 - 2010.Q3 are taken from the St. Louis Fed's FRED database (mnemonics GDPC1 for output, GDPIC96 for investment, PCECC96 for consumption, FEDFUNDS for nominal interest rates, GDPDEF for inflation, HCOMPBS for nominal wages, HOABS for hours worked, and TCU for capacity utilization). All data are in logs, HP-filtered, and multiplied by 100 to express them in percentage terms. Inflation and interest rate are annualized.

investment, capacity utilization, inflation, and interest rates, the average ratio of investment to output, and the average government debt-to-output ratio (40 percent of annual GDP) found in the data (table 5 provides details on data sources). Table 4 summarizes our parameter values except for those governing the processes for the fiscal instruments, which we set equal to the posterior median values reported in table 1. As a preliminary diagnosis of the model, table 5 presents summary information for first and second moments of selected endogenous variables and compares them with the data. The model does a fairly good job at matching those moments we do not use in the SMM.

4 Results

We look now at how our model reacts when we increase the volatility of the innovation to the capital income tax. More concretely, we study a positive innovation to $u_{\tau_k,t}$. Such exercise parsimoniously captures the idea of heightened fiscal policy uncertainty that motivated our paper. We could also increase the volatility of any of the other three instruments or of some combination of them. It turns out, however, that only volatility increases in the capital income tax instrument have sizable effects. Thus, we defer the other cases to the appendix.

At this point, we confront an important choice: the magnitude of the increase in volatility. We define a fiscal volatility shock as an increase of two-standard-deviations in the innovations to the volatility of the capital income tax. This choice is motivated by our interest in analyzing the effects of roughly once-in-a-decade event. In our sample, and given the posterior probability of smoothed innovations, a two-standard-deviations innovation to the volatility of capital income taxes is inside the 90 percent posterior probability set 5 percent of the quarters. Thus, the event is large but, by no means, extreme. The observation also validates why, after Bloom (2009), the size of volatility shocks that we look at has become customary.

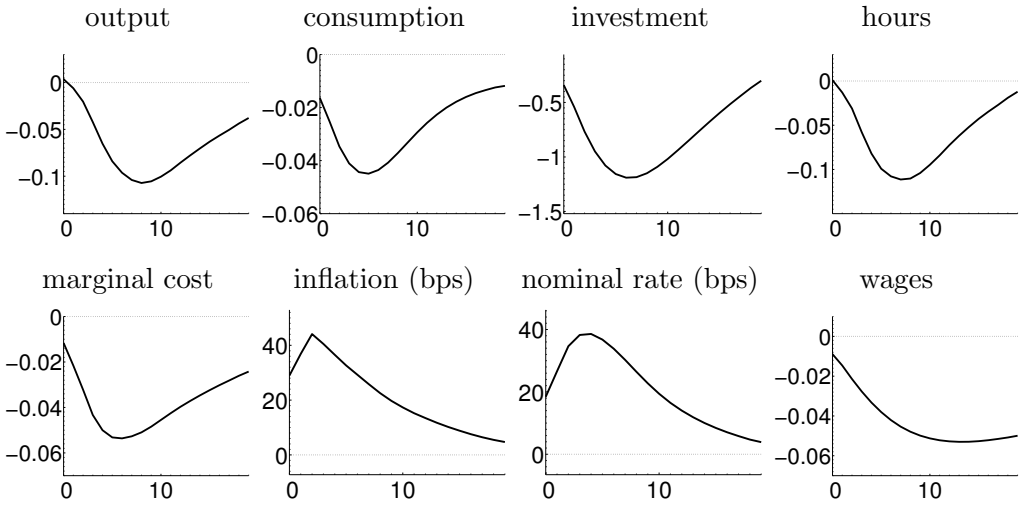


Figure 2: IRFs to a fiscal volatility shock

Note: The solid black lines are the IRFs to a fiscal volatility shock. The figures are expressed as percentage changes from the mean of the ergodic distribution of each variable. Interest rates and inflation rates are in annualized basis points.

We plot the IRFs to our fiscal volatility shock in figure 2. The fiscal volatility shock causes a moderate but prolonged contraction in economic activity: output, consumption, investment, hours, and real wages fall, while inflation rises. Output reaches its lowest point about six quarters after the shock. Most of the decline comes from a drop in investment, which falls around ten times more in percentage terms. The modest decline in consumption illustrates households' desire for smoothing. Remarkably (a point we will revisit shortly), higher fiscal volatility is "stagflationary": it causes lower output amid higher inflation.

In appendix F, we show that the effects in output of a fiscal volatility shock in our model are roughly equivalent to the effects of a 30-basis-point (annualized) increase in the nominal interest

rate implied by Altig et al. (2011)'s VAR of the U.S. economy. We picked a 30-basis-point increase in the federal funds rate because it corresponds to a one-standard-deviation contractionary monetary innovation as typically identified in empirical studies.

The responses in figure 2 happen in the absence of either an increase in taxes or increase of government spending at the time of the fiscal volatility shock. To the contrary, the endogenous feedback of the fiscal rules with respect to the state of the economy will, in expectation, reduce the tax rates and increase government spending currently and in future periods, which stabilizes output. Similarly, the real interest rate falls -the nominal rate increases less than inflation-, ameliorating the contraction. We will revisit these two points when we discuss the interaction of fiscal volatility shocks with the ZLB and in the appendix.

The transmission mechanism for fiscal volatility shocks is an increase in markups. This rise in markups is best illustrated by the first two panels of the bottom row in figure 2. The first panel shows that real marginal costs fall after a fiscal volatility shock. With Rotemberg pricing, the gross markup equals the inverse of real marginal costs. A fall in marginal costs thus means that markups are endogenously rising. In the model, markups work like a distortionary wedge that reduce labor supply because they resemble a higher tax on consumption. This generates positive co-movement between the consumption and output that was difficult to deliver in Bloom (2009). The second panel on the bottom row illustrates that, despite lower marginal costs, firms raise their prices, so that inflation increases and markups increase even more.

The sign of the IRFs and the transmission mechanism are the same when we increase the volatility of any other fiscal instrument. As mentioned above, the results for the capital income tax are the most important quantitatively.

4.1 Accounting for the Rise in Markups

Markups rise in the model because of two channels: an aggregate demand channel and an upward pricing bias channel, both related to nominal rigidities in price setting.

The first channel starts with a fall in aggregate demand. Faced with higher uncertainty, households want to consume less and save more. At the same time, saving in capital comes with riskier returns. In the absence of nominal rigidities, the effect of the scramble to save would be small. With rigidities,

however, a desire to increase saving reduces demand. Prices do not fully accommodate the lower demand, so that markups rise and aggregate output falls. However, while this channel is important, by itself it would induce a drop in inflation, whereas inflation increases in figure 2.

The increase in inflation in the IRFs (and a further fall in output) comes from a second channel: the upward pricing bias channel. The best way to understand this channel is to look at the period profits of intermediate goods firms (to simplify the exposition, we abstract for a moment from price adjustment costs and we focus on the steady state):

$$\left(\frac{P_j}{P}\right)^{1-\epsilon} y - mc \left(\frac{P_j}{P}\right)^{-\epsilon} y,$$

where $mc = (\epsilon - 1)/\epsilon$. Marginal profits, thus, are strictly convex in the relative price of the firm's product. Figure 3 illustrates this for three different levels of the demand elasticity (implying a 10 percent, 5 percent, and 2.5 percent markup, respectively). Figure 3 also shows that, given the Dixit-Stiglitz demand function, it is more costly for the firm to set too low a price relative to its competitors, rather than setting it too high. This effect is the stronger the more elastic the demand.

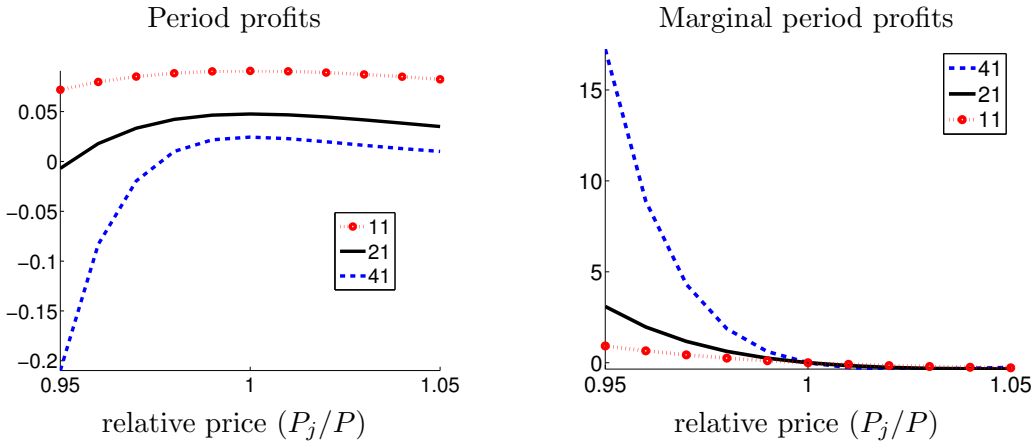


Figure 3: Properties of the profit function

Note: Profit function and marginal profits (relative to output) for different demand elasticities as functions of the relative price. Dotted red line: $\epsilon = 11$ (implying a markup of 10 percent), solid black: $\epsilon = 21$ (implying a markup of 5 percent), dashed blue: $\epsilon = 41$ (implying a markup of 2.5 percent).

The constraint for the firm is that the price that it sets today determines how costly it will be to change to a new price tomorrow. When uncertainty increases, firms will bias their current price toward higher relative prices. If, tomorrow, a large shock pushes the firm to raise its price, it will be less costly in terms of adjustment costs to get closer to that price if today's price was already

high. If a large shock pushes the firm to lower its price, it will not be very costly in terms of profit loss to keep a high relative price because of the shape of the profit function. A similar mechanism would also work under Calvo pricing. Appendix D elaborates on these arguments.

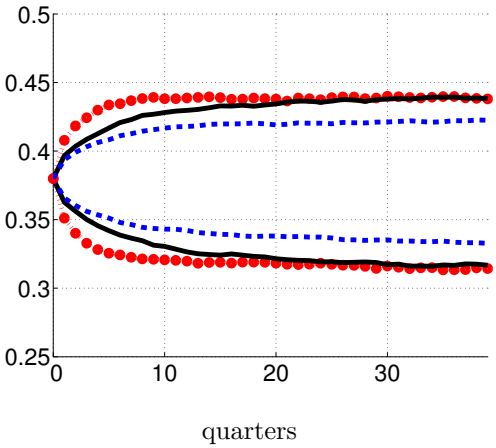


Figure 4: Dispersion of capital tax rate

Note: 95 percent confidence intervals for forecasts made at period 0 for fiscal instruments up to 40 quarters ahead. Solid black line: fiscal volatility shock innovations are set to zero in period 1. Red dots: a two-standard-deviation fiscal volatility shock innovation to all instruments in period 1. Dashed blue line: fiscal volatility shocks when $\eta_x = 0$ for all instruments.

A fiscal volatility shock increases the dispersion of likely future aggregate demand and marginal costs and, hence, the probable range for the optimal price tomorrow. This can be seen in the future path of capital income tax displayed in figure 4, where we show forecast confidence intervals (see also appendix B for additional confidence bands). The larger dispersion of the capital income tax will raise the dispersion of marginal costs through its effects on the rental rate of capital (both directly, through the utilization decision, and indirectly, through investment). Firms respond to the fiscal volatility shock by biasing their pricing decision upward even more than when fiscal volatility is at its average value. Realized marginal costs fall because, at a higher price and lower production, firms rent less capital and this lowers the rental rates. Wages, subject to rigidities, barely move and the labor market clears through a reduction in hours worked. This same line of reasoning will help us to understand, below, why the tax on capital income is the main driving force of the effects of fiscal volatility shocks.

4.2 How Important Is the Upward Pricing Bias?

We have described two channels behind the fall in output: an aggregate demand channel and an upward pricing bias channel. Figure 5 seeks to disentangle the importance of each of them by comparing the IRFs to a fiscal volatility shock in the baseline economy in section 2 (solid black line) and in a counterfactual one (dashed blue line). All the equilibrium conditions of the counterfactual economy are the same as in the baseline case except that now inflation evolves according to the linearized version of equation (6). That is, the Phillips curve is in this exercise given by:

$$\Pi_t - \Pi = \beta \mathbb{E}_t \left(\Pi_{t+1} - \Pi \right) + \frac{\epsilon}{\phi_p \Pi} \left(mc_t - mc \right), \tag{7}$$

where $mc = (\epsilon - 1)/\epsilon$. Equation (7) imposes that inflation is governed only by a linear function of marginal costs. We interpret this system as one where the upward pricing bias is absent because we suppress the nonlinearities that are at the core of the bias.[9]

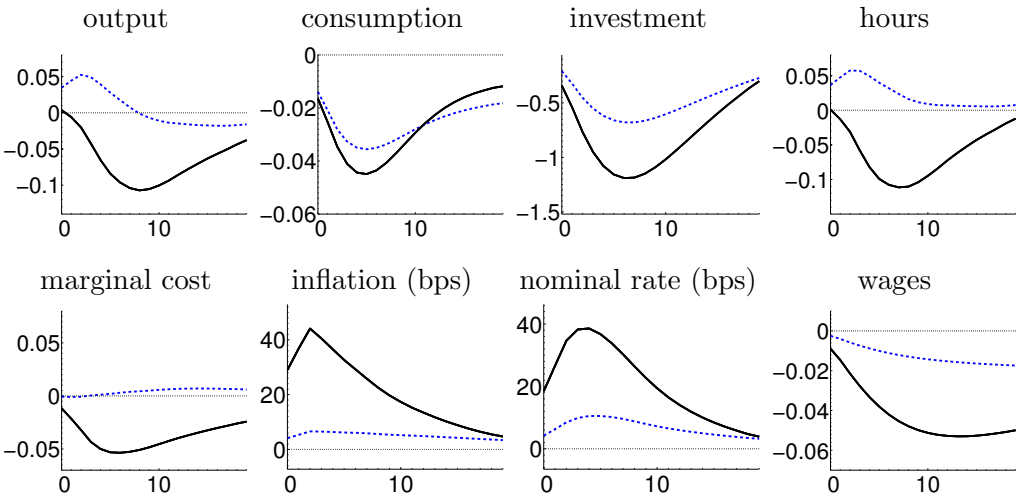


Figure 5: The role of precautionary price setting

Note: The solid black lines are the IRFs to a fiscal volatility shock in the baseline economy. The blue dashed lines are the IRFs in the counterfactual economy. The figures are expressed as percentage changes from the mean of the ergodic distribution of each variable. Interest rates and inflation rates are in annualized basis points.

Comparing the blue dashed line and the black solid line indicates that the upward-pricing bias is fundamental for explaining the impact of fiscal volatility shocks on aggregate activity. When the upward-pricing bias is not present, the effects are delayed and reduced. In particular, we see a

[9] We still solve the model through a third-order expansion. This means that the demand channel of fiscal volatility shocks is still present since (7) implies that firms set prices in response to current and expected marginal cost.

short-run small bump in output. This is due to an increase in labor supply and, thus, in hours. When fiscal volatility is high, precautionary behavior leads households to supply more hours for any given wage. To clear markets, wages fall and more output is produced. Only a few quarters later, as the marginal productivity of labor decreases as a consequence of lower investment (also triggered by precautionary behavior), output goes down. In comparison, when the upward pricing bias is present, the wedge caused by higher markups that we discussed a few paragraphs before overcomes this precautionary behavior and hours worked start falling at impact.

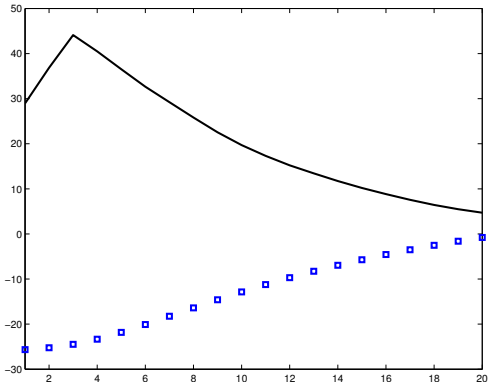


Figure 6: The inflation gap

Note: The solid black line shows the IRF of inflation to a fiscal volatility shock in the baseline economy. The blue squared line is the IRF of inflation in the counterfactual economy Inflation rates are in annualized basis points.

An alternative way of communicating the importance of the upward pricing bias is to define and quantify an "inflation gap." We ask: how would inflation have evolved absent the upward pricing bias? To do so, we compute first the evolution of the economy according to the baseline case and we plot, in figure 6 and with a black line, the IRF of inflation to a fiscal volatility shock. Then, we take the evolution of marginal costs period by period from the baseline economy and we feed it into equation (7) to generate a counterfactual path for inflation.[10] The result is shown by the blue squares in figure 6. The measured inflation gap is the difference between the black line and the blue squares. The gap is large, around 60 basis points at the maximum, and it closes only slowly over time. Absent the upward pricing bias, inflation would fall after a fiscal volatility shock. But since firms bias their pricing decision toward higher prices, actual inflation rises.

[10] Note the difference with the exercise underlying figure 5: now we use equation (7) only to back out a measure of inflation given the path of mc_t in the baseline economy. This counterfactual inflation rate here does not feed back into the economy; that is, we abstract from the general equilibrium effects of altering the price setting. In figure 5, instead, equation (7) is part of the equilibrium conditions of the counterfactual economy and hence it feeds back into the dynamics of the economy.

4.3 Some Empirical Implications

Our discussion has shown that fiscal volatility shocks have different effects on the dynamics of key variables than supply and demand shocks. Furthermore, fiscal volatility shocks can generate correlations among variables that would otherwise be puzzling. In particular, the combination of falling output, falling real marginal cost, and increasing inflation after a fiscal volatility shock would be hard to interpret as a negative demand shock (which would deliver falling output and real marginal cost but also less inflation) or a negative supply shock (which would mean falling output and higher inflation but an increasing real marginal cost). Fiscal volatility shocks are, thus, potentially important forces while interpreting stagflationary episodes.

At the same time, fiscal volatility shocks affect the economy in a way that, at first glance, would look similar to the effect of an exogenous positive shock to price markups: there is a fall in output and hours worked and an increase in inflation. However, there is a key difference: the response of capital utilization. While after a fiscal volatility shock capital utilization drops at impact, it increases after a positive shock to the price markup. This difference is relevant because Smets and Wouters (2007), without using capital utilization data, found markup shocks to be important drivers of inflation and business cycles dynamics. The policy implications of this distinction are also relevant. Contrary to markups shocks, section 7.1 will show that in our model fiscal volatility shocks do not create a trade-off between stabilizing output and inflation. The reason is that the response of markups to fiscal volatility shocks strongly depends on monetary policy.

5 VAR Evidence

Is there empirical evidence that fiscal volatility shocks lead to lower output and higher markups? Can we document in the data the mechanism that our model highlights? We answer these questions by estimating a VAR of the type used by Christiano, Eichenbaum and Evans (2005) augmented with a measure of fiscal policy volatility (either one of the fiscal volatility series we estimate in section 1 or the BBD index) and markups (from Nekarda and Ramey (2013)). The CEE-type specification is a natural framework for this exercise because it has proven popular in the literature and effective at accounting for the time-series properties of U.S. aggregate variables.

More concretely, we estimate a quarterly VAR(4) with a constant and a linear time trend and

identify the shocks recursively. The observables are a measure of fiscal volatility, output per capita, consumption per capita, investment per capita, real wages, hours per capita, markups, the GDP deflator, and the quarterly average of the effective federal funds rate (see Fernández-Villaverde et al. (2013) for details about the data construction). This ordering is motivated by our view that the fiscal volatility shocks we estimate are exogenous. We documented in sensitivity analysis that our findings would be robust with respect to the ordering of the volatility shock.

Our model does not completely satisfy the recursive ordering of the VAR with respect to the monetary policy shock. However, fiscal volatility is ordered at the top of the VAR. Hence, the IRFs of output and markups to a fiscal volatility shock, our objects of interest, are mostly unaffected by this slight inconsistency. But even for the monetary policy shock this is a small issue, as other papers, such as Kuester (2010) find that the IRFs to a monetary shock in a New Keynesian model with a timing restriction look very similar to those without.

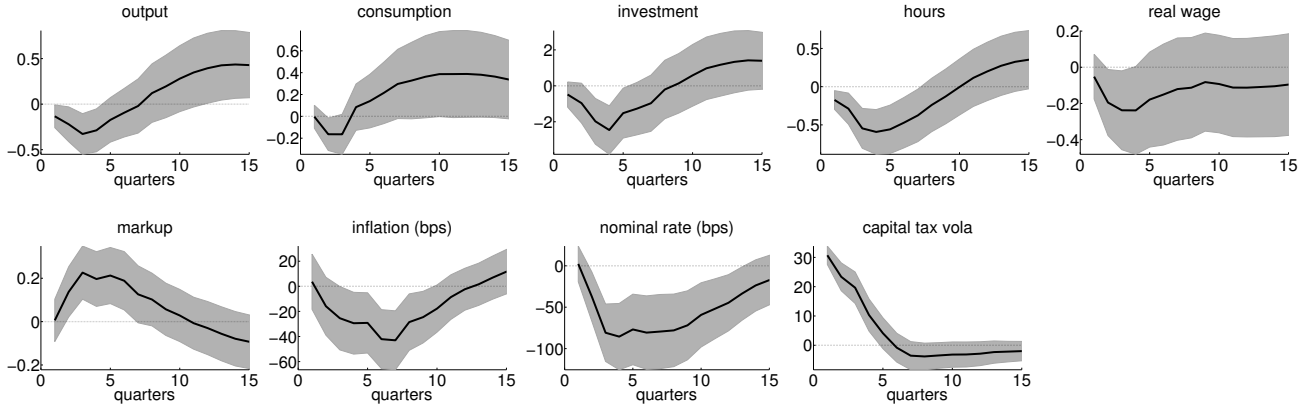
Our sample is 1970Q2:2008Q3. The first observation is dictated by the start of our smoothed volatility estimates in section 1. We trim the end of the sample from 2010Q2 to 2008Q3 to reserve the observations of the recent ZLB episode for an exercise below where we re-estimate the VAR with those observations.[11] Since the ZLB is a highly non-linear event, one should be concerned about its effects in a linear representation of the time series such as a VAR. It is advisable, thus, to first estimate the VAR without those observations and, next, to repeat the estimation including 2008Q4:20010Q2. In that way, we will learn that, with data up to 2010Q2, the effects of a fiscal volatility shock become stronger: output goes down and markups go up more after a fiscal volatility shock than in the shorter sample.

Figure 7 shows the IRFs to a two-standard-deviation shock to the volatility of the capital income tax in the extended VAR. Output, consumption, investment, hours, inflation, and the real wage fall while markups increase; and significantly away from zero. In fact, the size of the response is somewhat bigger than in the theoretical model. These IRFs are evidence that supports the main predictions of our model: 1) an increase in capital income tax volatility is recessionary (first panel, top row) and 2) fiscal volatility shocks raise markups (first panel, second row).[12]

[11] Our VARs are designed to bring independent evidence about the behavior of markups after fiscal volatility shocks (we are not, for instance, using the IRFs to estimate parameter values). Therefore, there is no a priori reason why the sample sizes should be the same (even if, heuristically, it may be desirable in many exercises).

[12] As a preliminary validation test, we ascertained that the estimated VAR generate IRFs to a monetary policy

Figure 7: IRFs to a 2-std. deviation capital income tax volatility shock



Notes: All entries in percent, with the following exceptions: the Fed Funds rate and the inflation rate are in basis points, annualized.

Figure 7 also tells us that inflation and the nominal rate fall in response to a fiscal volatility shock. This is in contrast to the IRFs in the model, where both variables increase. We can easily rationalize both the sign and much of the size of the IRFs to inflation and the nominal interest rate in the model if we allow the monetary authority to respond to fiscal volatility shocks. This can be seen in Figure 8, which reports the IRFS generated by the model when the Taylor rule is:

$$R_t = R_s \left(\frac{R_{t-1}}{R_s}\right)^{\rho_r} \left[\left(\frac{\pi_t}{\pi_s}\right)^{\phi_\pi} \left(\frac{y_t}{y_s}\right)^{\phi_y} \left(\frac{\sigma_{k,t}}{\sigma_k}\right)^{\phi_\sigma}\right]^{1-\rho_r}.$$

Since fiscal volatility shocks destabilizes the economy, the monetary authority reacts to those via changes in interest rates, i.e. $\phi_\sigma < -0$. We use the same parametrization for the parameters in the Taylor rule as in the benchmark model and $\phi_\sigma = -0.025$. We pick this small value because it is comparable to ϕ_y and to show that we only need a small response of the Fed to fiscal policy shocks to rationalize the IRFs from the VAR.

In conclusion, we read our results as compelling case that the model and the VAR-evidence are aligned and that the main mechanisms highlighted by our model are present in the data. We complete this section by summarizing some sensitivity analysis we performed with our VAR. The interested reader should consult Fernández-Villaverde et al. (2013) for more details and graphs, in

shock that are in line with previous findings in the literature.

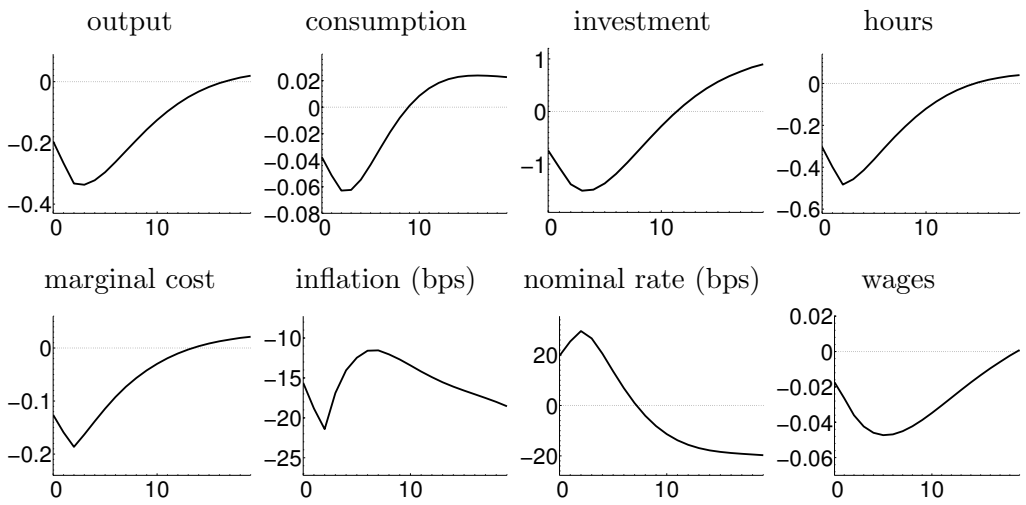


Figure 8: IRFs to a fiscal volatility shock

Note: IRFs in the model when the Taylor rule responds to the capital volatility shock (with a coefficient of -0.025). The solid black lines are the IRFs to a fiscal volatility shock. The figures are expressed as percentage changes from the mean of the ergodic distribution of each variable. Interest rates and inflation rates are in annualized basis points.

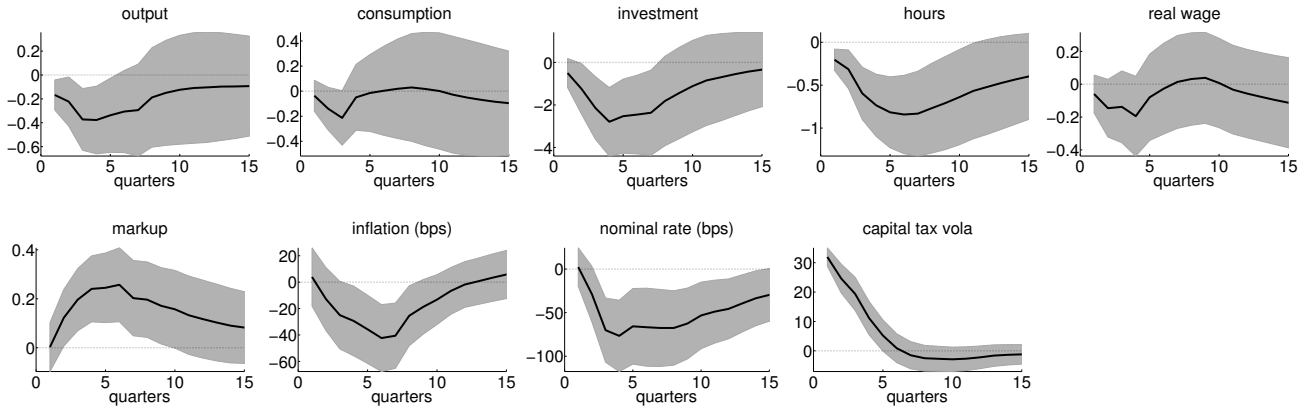
special for the estimation of an alternative VAR specification that follows Altig et al. (2011).

First, we extended the sample through 2010Q2, the last period in the estimation of our fiscal policy volatility series. Since, according to the NBER, the recession ended in 2009Q2, we include now the financial crisis, the first few quarters of the recovery, and the observations of the Federal Funds rate close to zero. Figure 9 tells us that, in the new estimation, output falls more after a fiscal volatility shock and markups increase more. Qualitatively, the results match well the finding of the ZLB exercise that we will report in the section 5. In particular, the effect of capital income tax volatility shock on output is greatly amplified. While this exercise does not fully capture the nonlinearities imposed by the ZLB, it is suggestive of the effects that the bound has.

Second, we trim the start of the sample (1970Q2 to 1979Q4) to keep only the data after Paul Volcker became Chairman of the Fed on August 6, 1979. This follows the practice of many papers that prefer a smaller sample to avoid structural instabilities in parameter estimates, such as Christiano, Eichenbaum and Evans (1999). Reassuringly, we find that our results are mainly robust to including data from the 1970s. Figure 10 shows that also on this sample, a capital income tax volatility shock decreases output and it increases the markup.

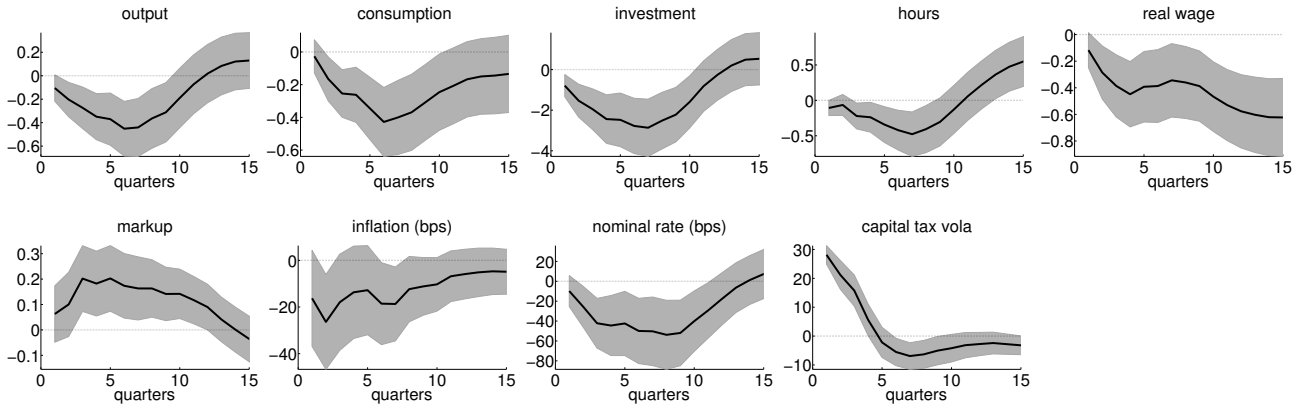
Third, we checked whether the VAR supports the finding that increases in fiscal policy volatility in the other three fiscal instruments (labor income tax, consumption tax, and government con-

Figure 9: Extending the Sample through 2010Q2: IRFs to a 2-std. deviation capital income tax volatility shock (90% confidence bands)



Notes: All entries in percent, with the following exceptions: the Fed Funds rate and the inflation rate are in basis points, annualized.

Figure 10: Starting the sample in 1979Q4: IRFs to a 2-std. deviation capital income tax volatility shock (90% confidence bands)



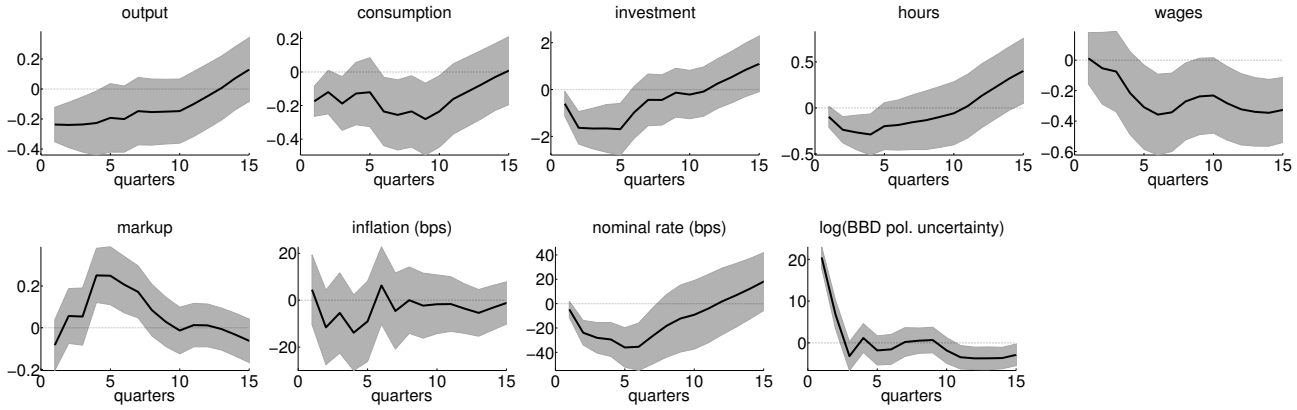
Notes: All entries in percent, with the following exceptions: the Fed Funds rate and the inflation rate are in basis points, annualized. The confidence areas are bootstrapped, symmetric 90% bands. The sample is 1979Q4:2008Q3.

sumption) do not have significant recessionary effects. To do so, Fernández-Villaverde et al. (2013) plots the IRFs of the economy when replacing capital income tax volatility by one of the other fiscal instrument volatility series. The findings support the results from the model, with the partial exception of increases in the volatility of labor income taxes. While the response in the model

to that increase is very small, the VAR suggested a more vigorous contractionary reaction of the economy. Possible generalizations of the model (labor adjustment costs, search, or complementarity of consumption and labor) could help in mitigating this discordance between theory and data.

Fourth, we looked at the consequences of different orderings of the variables in the VAR. In our benchmark we have shown the result from ordering it in position 1. Fernández-Villaverde et al. (2013) plot the other 8 cases, as we move the volatility series from position 2 through 9 (that is, last just before the monetary policy shock). The additional IRFs are unanimous; regardless of the ordering of the fiscal volatility shock, output goes down and markups increase.

Figure 11: IRFs to a shock that moves Baker, Bloom and Davis (2011) policy index by 2-std. deviation — starts 1985Q1



Notes: All entries in percent, with the following exceptions: the Fed Funds rate and the inflation rate are in basis points, annualized. Baseline VAR is not stationary (even after detrending).

Fifth, we substituted our measures of fiscal policy volatility by the BBD index of economic policy uncertainty (Figure 11). Since their sample starts in 1985, we re-estimate our VAR accordingly (their data start in January of 1985; we take quarterly averages of their monthly data.) Remarkably the shape and size of the IRFs (and, in particular, of output and markups), are quite similar to the ones of the benchmark estimation. That such different indexes deliver results that are so close is a most interesting piece of evidence behind our belief that our theoretical model captures an important feature of the data.

6 Fiscal Volatility Shocks at the ZLB

In section 4, we documented how the real interest rate falls after a fiscal volatility shock. Following an increase in the volatility of the capital income tax, households want to invest less because of the increased probability of a high tax rate on capital income and because higher markups imply that the firms will produce less output and require less capital. Similarly, because of precautionary motives against the risk of higher taxes, households want to save more. Therefore, the real interest rate that clears the saving-investment market is smaller. Operationally, the monetary authority raises the nominal interest rate less than the increase in inflation since the Taylor rule also responds to the fall in output triggered by higher fiscal policy volatility. The lower real interest rate ameliorates the contractionary effect of fiscal volatility shocks.

However, changes in real interest rates are complicated when the economy is at the ZLB, when all changes to real interest rates must come through changes in inflation. Recall that fiscal volatility shocks affect inflation in two ways (figure 6). On the one hand, the contractionary impact of these shocks reduces marginal costs and inflation. Since lower inflation leads to a deeper recession by the usual ZLB logic, this channel exacerbates the recessionary impact of fiscal volatility shocks. On the other hand, higher fiscal policy volatility by itself rises markups and inflation. This upward pricing bias channel undoes some of the negative effects of the ZLB by lowering real interest rates. Given these two opposite channels, what are the total effects of combining fiscal volatility shocks and the ZLB? Since during the last few years, the US economy has been characterized by precisely such combination of high fiscal volatility and a spell at the ZLB, we explore this case.

Implementing the ZLB in our model is challenging. To address this difficulty, we extend the computational strategy in Bodenstein, Erceg and Guerrieri (2009) and Coibion, Gorodnichenko and Wieland (2012). The appendix presents the algorithm in detail. However, we can outline its main structure. We divide the solution of the model into two blocks. The first block deals with the periods when the economy is at the ZLB and the second block with the periods when it is outside the ZLB. We find the policy functions corresponding to this second block by using the perturbation method described in Section 3. Hence, if the economy is outside the ZLB, the endogenous variables evolve as if the ZLB would never bind. When, instead, we are at the ZLB from period t_1 to period t_2 (where t_1 and t_2 are endogenously determined within the algorithm), we find the path of the

variables backwards using the set of nonlinear equilibrium conditions and the value of the variables at $t = t_2 + 1$ from the second block.

We compute the IRFs associated with a fiscal volatility shock while being at the ZLB as follows. Starting at the mean of the ergodic distribution, we use a combination of innovations to preference and productivity shocks to force the economy to the ZLB for $t_1 \leq t \leq t_2$ (preference shocks increase households' desire to save and productivity shocks lower the nominal interest rate). The mix of innovations is such that the economy is at ZLB for 2 years (8 quarters).[13] Next, we compare the path of the variables of this economy with the path of the same variables associated with another economy that, not only faces the same preference and productivity shocks that force the spell at the ZLB, but that is also buffeted by a fiscal volatility shock at $t = t_1$.[14] Thus, the IRFs do not measure the fall in output caused by the negative preference and productivity shocks, but the *additional* fall in output triggered by the fiscal volatility shock when we are already at the ZLB. Comparing these IRFs with the IRFs in section 4 quantifies by how much fiscal volatility shocks get amplified because the ZLB is binding. As before, we define a fiscal volatility shock as an increase of two standard deviations in the innovations to the volatility of the capital income tax rate.

Figure 12 displays such IRFs starting at $t = t_1$. For each variable, we plot the percentage change deviation with respect to the case without a fiscal volatility shock except for 1) inflation, where this change is expressed in basis points and 2) the nominal interest rate, for which we plot the actual expected path conditional on the ZLB and the fiscal volatility shock (since in our simulation, t_2 is the same with and without the fiscal volatility shock, the IRF of the nominal interest rate is trivially equal to zero for the first 8 quarters.)

In Figure 12 , we observe that the ZLB amplifies the drop of the real variables after a fiscal volatility shock. Indeed, the effects are one order of magnitude larger for most variables. For example, output drops 1.7 percent (compared with 0.14 percent when the ZLB does not bind) and investment around

[13] The length of the spell at the ZLB matters: the longer the economy is at the ZLB, the bigger the effects of fiscal volatility shocks. Thus, we must decide what is a sensible duration of the spell at the ZLB. Until the time that the Fed put an explicit date for the ZLB into its communication (that is, through fall 2011), the professional forecasters expected the ZLB to bind for 4 quarters -see Swanson and Williams (2012), Figure 5.- However, the current ZLB event has turned out to be, ex-post, much longer (almost 5 years by now) . Our choice of 8 quarters is a sensible compromise between the ex-ante views of professional forecasters and the actual realization of events.

[14] While t_1 is the same for the cases with and without fiscal volatility shocks, our algorithm lets t_2 to be different (for example, a fiscal volatility shock may keep the economy for longer time at the ZLB). However, we found that in our simulations t_2 did not change.

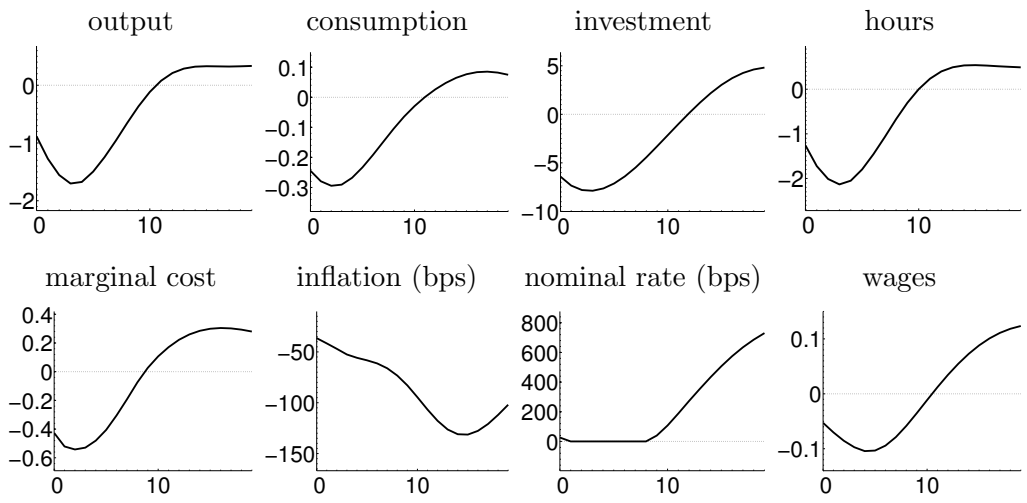


Figure 12: IRFs to a fiscal volatility shock conditional on 8 quartes ZLB

Note: The solid black lines are the IRFs to a fiscal volatility shock. The figures are expressed as percentage changes from the mean of the ergodic distribution of each variable. Interest rates and inflation rates are in annualized basis points.

7.9 percentage percent (compared with 1.3 percent when the ZLB does not bind).

There are two mechanisms behind this result. First, as documented by Christiano, Eichenbaum and Rebelo (2011), the effects of fiscal policy changes at the ZLB are much larger than outside it. Consequently, and because of the same arguments than in Section 4, households and firms respond more decisively to the probability of a large change in capital income tax that fiscal volatility brings. Second, the ZLB changes the direction of the response of inflation: instead of an increase in inflation as we documented when we are out of the ZLB, we observe a drop. When the nominal interest rate cannot adjust, the upward bias in markups induced by a fiscal volatility shock is offsetted by the larger deflationary pressures coming from the fall in aggregate demand caused by precautionary behavior. This additional fall in inflation -and the subsequent increase in the real interest rate- deepens the recession.

7 Additional Analysis

In this section, we discuss two additional points. First, we explore how monetary policy interacts with fiscal volatility shocks. Second, we assess the role of the price and wage rigidities. The appendices include several additional exercises.

7.1 The Role of Monetary Policy

The "stagflation" induced by a fiscal volatility shock hints at a difficult choice for monetary policymakers. The monetary authority could try to accommodate fiscal volatility shocks. However, this would increase inflation in a situation where it is already higher than usual. It is interesting, then, to explore how the economy responds to fiscal volatility shocks under different values of the parameters on the Taylor rule.

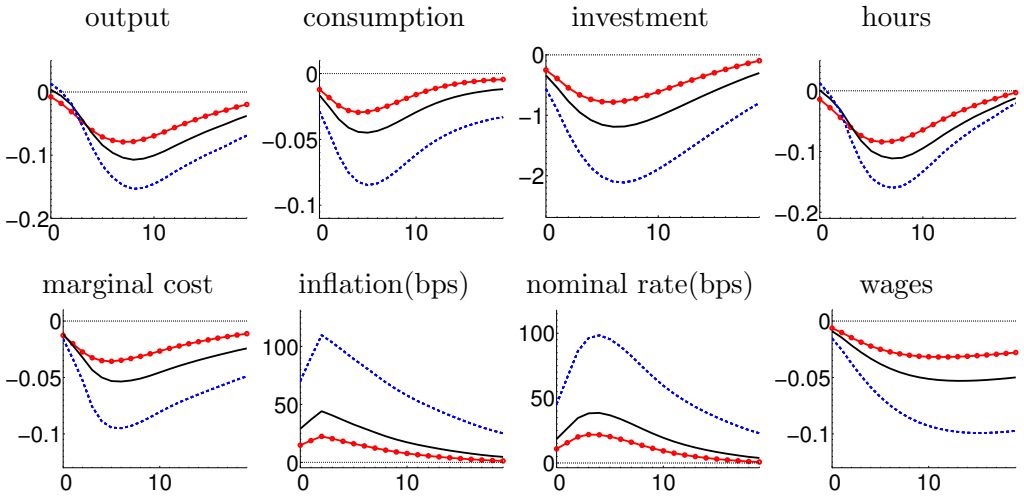


Figure 13: Fiscal volatility shocks – effect of Taylor rule

Note: The solid black lines are the IRFs to a fiscal volatility shock in the benchmark calibration. The dashed blue lines are the IRFs when $\gamma_y = 0.5$. The dotted red lines are the IRFs when $\gamma_\Pi = 1.5$. The figures are expressed as percentage changes from the mean of the ergodic distribution of each variable. Interest rates and inflation rates are in annualized basis points.

The IRFs in figure 13 show the response under our benchmark calibration as a solid line and two alternative scenarios. In the first one, the monetary authority reacts more strongly to output (a value of $\gamma_y = 0.5$ instead of $\gamma_y = 0.25$, dashed blue lines). In the second one, the monetary authority reacts more aggressively to inflation (a value of $\gamma_\Pi = 1.5$ instead of $\gamma_\Pi = 1.25$, dotted red lines). The economics behind the new IRFs is the following. When the response to output in the Taylor rule (γ_y) is high, firms anticipate that inflation will be tolerated. To counterbalance declining profits, firms aggressively increase prices with a view toward higher markups. Firms' anticipation of a loose stance of monetary policy would, therefore, result in still higher inflation and lower output (the dashed blue lines). An accommodative monetary policy then exacerbates the effects of fiscal volatility. In contrast, if the central bank assigns less weight to stabilizing output, firms consider

future inflation less likely, which reduces the upward pricing bias. Thus, in equilibrium, the smaller the monetary response to output, the more moderate is the inflation response and the contraction in output to a fiscal volatility shock. An analogous argument explains why a stronger focus of monetary policy on inflation alleviates the negative outcomes of fiscal volatility shocks on output and stabilizes inflation at the same time (the dotted red lines). If the central bank becomes more responsive to inflation (higher γ_{Π}), the stagflationary effects of fiscal volatility shocks are much less pronounced. Thus, fiscal volatility shocks do not create a trade-off between stabilizing output and inflation, as we would have, for instance, with markup shocks.

7.2 The Role of Price and Wage Rigidities

In our last exercise, figure 14 shows how the degree of price and wage rigidity affects the impact of fiscal volatility shocks. The dashed blue line plots the IRFs when we reduce price stickiness to the one equivalent to a Calvo model with an average price duration of about one quarter. The response is less pronounced and shorter-lived. The dotted red line in turn plots the IRFs when we reduce wage stickiness to an equivalent Calvo model with an average wage duration of about one quarter. As with more flexible prices, the response to a volatility shock is less pronounced. Finally, the squared magenta line reduces price and wage stickiness to the one equivalent to a Calvo model with an average price and wage duration of one quarter. In the absence of nominal rigidities, fiscal volatility shocks have only a negligible impact on economic activity. This finding resembles the results in Bloom (2009) that require irreversibilities at the individual firm level for generating a propagation of volatility shocks. At the same time, Bloom's findings suggest that irreversibilities could make the effects of fiscal volatility shocks still bigger.

8 Conclusions

Most economic decision-making is subject to pervasive uncertainty, some of it introduced by the political process. This applies, in particular, to uncertainty about future fiscal policy. Several observers have argued that the increase in fiscal policy uncertainty has weighed negatively on the U.S. economy's recovery from the recent financial crisis. To assess this concern, we have analyzed the effect that fiscal volatility shocks can have on economic activity and have discussed the mechanisms

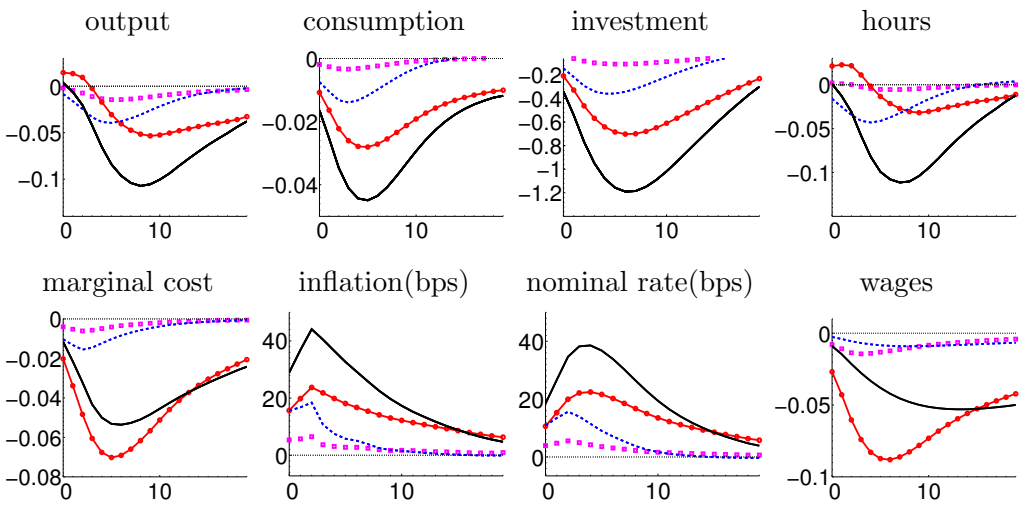


Figure 14: Fiscal volatility shocks – effect of price/wage rigidities

Note: The solid black lines are the IRFs to a fiscal volatility shock in the benchmark calibration. The dashed blue lines are the IRFs if price stickiness is equivalent to a Calvo parameter $\phi_p = 0.1$. The dotted red lines are the IRFs if wage stickiness is equivalent to a Calvo parameter $\phi_w = 0.1$. The squared magenta lines are the IRFs if price stickiness is equivalent to a Calvo parameter $\phi_p = 0.1$ and wage stickiness to a Calvo parameter $\phi_w = 0.1$. The figures are expressed as percentage changes from the mean of the ergodic distribution of each variable. Interest rates and inflation rates are in annualized basis points.

behind our results, in particular the endogeneity of markups. We have found that fiscal volatility shocks can shave up to about 1.7 percentage points from output when the economy at the ZLB. Our results may well be, however, a lower bound. We have ignored, longer-term budgetary issues –such as the impact of entitlement programs–, financial frictions, and non-convexities on investment. All of these channels might further increase the effects of fiscal volatility shocks. Also, our experiments considered a spread in tax and spending risk, so the risk was two-sided. To the extent that observers have in mind one-sided risks (for example, a lack of clarity about the size of future increases alone in taxes), the effects of fiscal volatility shocks, if they are defined to include those mean effects, could also be larger. In current work, Fernández-Villaverde, Guerrón-Quintana and Rubio-Ramírez (2014) are exploring how to perform one-sided analysis of risk shocks.

Finally, we have abstracted from modeling explicitly the political process that generates the fiscal volatility shocks. Thus, we do not have clear policy recommendations about how to eliminate or reduce the "noise" from fiscal policy. This modeling of the political economic determinants of fiscal volatility shocks is a key issue for future research.

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