Online Appendices to

Fiscal Volatility Shocks and Economic Activity

(Not for Publication)

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A Comparison with Alternative Fiscal Rules

Our estimated fiscal rule follows the structure of Bohn (1998) (although that paper does not have stochastic volatility, our main empirical innovation). In this appendix, we compare our estimated fiscal rules with previous work in the literature. Our paper is closest to Leeper, Plante and Traum (2010). Building on contributions by Braun (1994), McGrattan (1994), and Jones (2002), Leeper, Plante and Traum (2010) estimate a linearized RBC model with fiscal rules for several instruments without stochastic volatility. Besides the absence of stochastic volatility, the main difference between that paper and ours is that Leeper, Plante and Traum (2010) jointly estimate the model and the fiscal rules. While there may be efficiency gains, Leeper, Plante and Traum (2010) can do that because they linearize their model and, hence, can evaluate the likelihood function with the Kalman filter. However, in our paper, stochastic volatility is inherently a non-linear process that cannot be linearized. A joint estimation using likelihood-based methods of a non-linear business cycle model of this dimensionality and the fiscal rules is a challenging task given current computational power. Most of the remaining literature focuses on more aggregated fiscal reaction functions, such as those centered on the (primary) deficit (that nets out the various spending and revenue components) rather than on specific fiscal instruments. See, for instance, Bohn (1998). Thus, it is hard to compare most of the estimated rules in that stream of the literature with our specification.[1] Nevertheless, and because of its influence in the literature, it is of interest to compare our fiscal rules with Galí and Perotti (2003), who study the cyclically adjusted primary deficit, $deficit_t$, for OECD countries. Using annual data, they estimate a rule for the $deficit_t$ using the output gap x_t and debt b_t. The rule takes the form:

$$deficit_t = const + \alpha_1 \mathbb{E}_{t-1} x_t + \alpha_2 b_{t-1} + \alpha_3 deficit_{t-1} + u_t,$$

instrumenting for the output gap using the lagged output gap and the output gap of another economic area (in their case, they instrument for the output gap in the euro area using the output gap in the U.S. and vice versa). Their rule is close to our specification given that the regressor $\mathbb{E}_{t-1} x_t$ and our measure of the business cycle component with a lag are similar.

[1] An exception is Lane (2003), who focuses on the cyclical responses of subcomponents of government spending for OECD countries to measures of economic activity.

Finally, a large literature has concentrated on the identification of the fiscal transmission mechanism with vector autoregressions (VARs), either through the use of timing conventions (Blanchard and Perotti (2002)), of sign restrictions (Mountford and Uhlig (2009)), or of a narrative approach (Ramey and Shapiro (1998), Ramey (2011), and Romer and Romer (2010)).

B Tax Data

In this appendix, we describe how we build our data. We follow (most of) the methodology of Leeper, Plante and Traum (2010), who construct aggregate effective tax rates using national account information. Their work in turn is based on Mendoza, Razin and Tesar (1994) and Jones (2002).

We aggregate all levels of the government (state, local, and federal) into one general government sector. While state, local, and federal governments are legally different entities that could merit a separate treatment, in practice, the different levels of government are closely interconnected. For instance, there are joint programs such as Medicaid or federal matching funds for unemployment insurance and education. Also, changes in federal fiscal policy, such as the American Recovery and Reinvestment Act of 2009, have a direct impact on the fiscal situation of state and local governments.

There are two alternatives to our choice. One would be to explicitly model three levels of government (or perhaps just two, federal and non-federal). However, this would considerably increase the state space and would come at the expense of reduced transparency. For example, state and local governments are largely subject to balanced-budget requirements, while the federal government can engage in tax-smoothing by issuing debt. Besides, the different levels of government use different bases for their taxation. All these aspects would need to be (at least partially) included in a model with several levels of government. A second possibility would be to disregard local and state tax revenue altogether and focus entirely on the federal side, as in Leeper, Plante and Traum (2010). However, state and local finances were hit hard by the last recession. As a result, at least some of the uncertainty about the fiscal mix originated at the state and local levels (and what the federal government might do about it). We now explain how we derive measures of tax rates.

B.1 Consumption taxes

The average tax rate on consumption is defined as:

$$\tau_c = \frac{\text{TPI} - \text{PRT}}{\text{PCE} - (\text{TPI} - \text{PRT})}. \tag{1}$$

The numerator is taxes on production and imports (TPI, NIPA Table 3.1, line 4) less state and local property taxes (PRT, NIPA Table 3.3, line 8). The denominator is personal consumption expenditures (PCE, NIPA Table 1.1.5, line 2). Property taxes make up a large share of the cost of housing. In the national accounts, homeowners are treated as businesses that rent out their properties to themselves. Property taxes are therefore accounted for as taxes on capital.

B.2 Labor income taxes

Following Jones (2002), the average personal income tax is computed as:

$$\tau_p = \frac{\text{PIT}}{\text{WSA} + \text{PRI}/2 + \text{CI}}. \tag{2}$$

The numerator is federal, state, and local taxes on personal income (PIT, NIPA Table 3.2, line 3 plus NIPA Table 3.3, line 4). The denominator is given by wage and salary accruals (WSA, NIPA Table 1.12, line 3), proprietor's income (PRI, NIPA Table 1.12, line 9), and capital income (CI). We define CI = PRI/2 + RI + CP + NI, where the first term is half of the proprietor's income, and the latter three terms are, respectively, rental income (RI, NIPA Table 1.12, line 12), corporate profits (CP, NIPA Table 1.12, line 13), and interest income (NI, NIPA Table 1.12, line 18).
The average tax on labor income is computed as:

$$\tau_l = \frac{\tau_p \left[\text{WSA} + \text{PRI}/2\right] + \text{CSI}}{\text{CEM} + \text{PRI}/2}. \tag{3}$$

In the numerator are taxes paid on personal income plus contributions to Social Security (CSI, NIPA Table 3.1, line 7). The denominator features compensation of employees (CEM, NIPA Table 1.12, line 2) and proprietor's income.

B.3 Capital taxes

The average capital tax rate is calculated as:

$$\tau_k = \frac{\tau_p \text{CI} + \text{CT} + \text{PRT}}{\text{CI} + \text{PRT}}. \tag{4}$$

The denominator features taxes on capital income, taxes on corporate income (CT, NIPA Table 3.1, line 5), and property taxes (PRT, NIPA Table 3.3, line 8).

B.4 Other variables

Real domestic product is obtained by dividing seasonally adjusted nominal domestic product (NIPA Table 1.1.5) by the output deflator (NIPA Table 1.1.4). Real output is detrended using the Christiano-Fitzgerald band pass filter (Christiano and Fitzgerald (2003)).

B.5 Plots of the data and summary statistics

Figure 1 plots the resulting data series for the tax rates and government spending. Table 1 reports summary statistics of our sample and the values of the variables at the end of our sample for comparison. The data cover 1970.Q1 to 2014.Q2.

Table 1: Average and Current Tax Rates, Expenditure and Debt Level

	Tax on (percent)			Ratio to GDP (percent)	
	Labor	Consumption	Capital	Gov. spending	Debt
Average	22.44	7.66	36.74	20.23	37.59
2014.Q2	23.33	6.73	36.09	18.25	72.96

Notes: Average and current tax rates, and ratios of spending and debt to output in the sample.

C Estimation

In the estimation, we entertain uniform priors over the support of each of the parameters for two reasons. First, we want to show how our results arise from the shape of the likelihood and not from pre-sample information. Second, Fernández-Villaverde et al. (2011) illustrate that eliciting priors for the parameters controlling stochastic volatility processes is difficult: We deal with units that

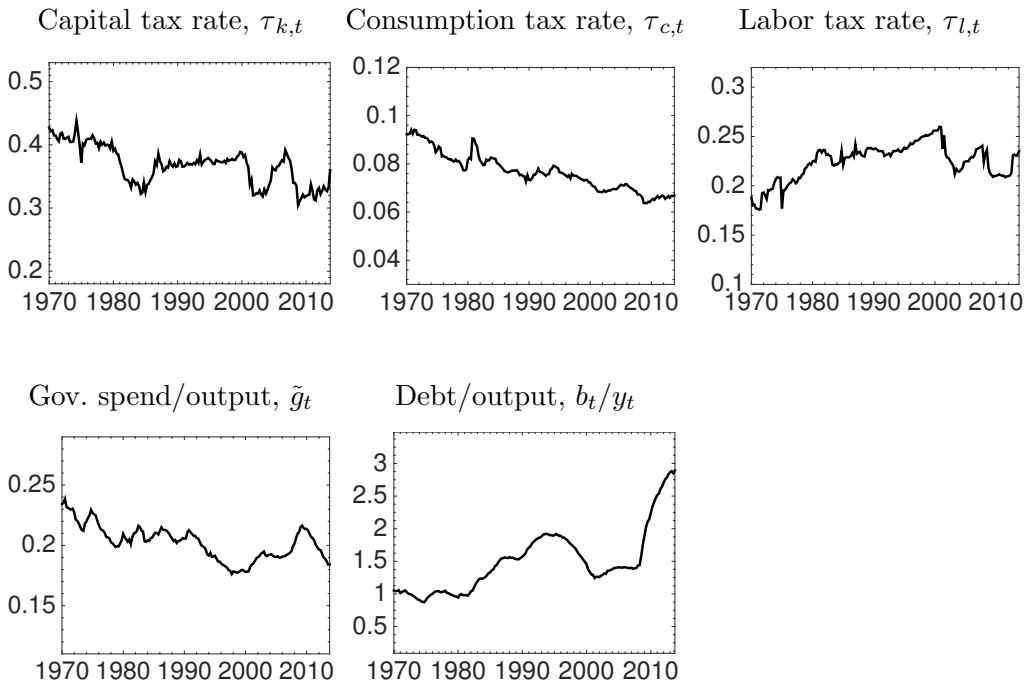

Figure 1: Data

Note: The figure shows the time series for the three tax rates and the government spending series entertained in this paper. Also shown is the debt-to-output series used in the estimation.

are unfamiliar to most economists. We draw 1,000,000 times from the posterior. These draws are obtained after an extensive search for appropriate initial conditions. We discarded an additional 100,000 burn-in draws at the beginning of our simulation. We selected the scaling matrix of the proposal density to induce the appropriate acceptance ratio of proposals as described in Roberts, Gelman and Gilks (1997). Each evaluation of the likelihood was performed using 40,000 particles. Conditional on a set of parameters, the initial values of the particles necessary to compute the likelihood are drawn from their unconditional distribution. The smoothed draws are computed using 1,000 draws from the posterior and 1,000 particles.

D Narrative Evidence

This appendix compiles narrative evidence that supports our econometric findings regarding the evolution of fiscal policy volatility. As we do in the quantitative exercises with our business cycle model, we will focus on the volatility of the tax rate on capital income.

According to our smoothed estimate of the volatility of the tax on capital income, there were four periods where the 97.5th percentile of the smooth distribution of $100 \exp(\sigma_{\tau_k,t})$ is within the 2.5 percent right tail of the unconditional distribution of $100 \exp(\sigma_{\tau_k,t})$ evaluated at the median of the posterior. We pick this threshold to maintain the discussion succinct to very large events.
Those four periods were:

1. 1974-1975, the last months of the Nixon administration and the early months of the Ford administration.

2. 1985-1987, during the tax reform of the second Reagan administration.

3. 2001-2002, right around the terrorist attacks of 9/11.

4. In three spells between 2008-2014, during the financial crisis and its aftermath. In particular, from 2008.Q2 to 2009.Q1, 2011.Q3, and 2014.Q1.

We will have a thorough subsection describing the first peak (1974-1975), since it is probably the one less familiar to macroeconomists today and the one where uncertainty was at its highest level in our sample, and three shorter subsections for the other peaks.

D.1 Fiscal policy uncertainty in 1974-1975

> This is an age of ambiguity...And the result is that people are experiencing a great sense of unease and uncertainty.
>
> *Leaders and Followers in an Age of Uncertainty*, George P. Shultz, pp. 26-27.

Our smoothed estimate of the volatility of the tax on capital income starts climbing quickly in 1974.Q1 and peaks in 1975.Q2. Were those times of unusual fiscal policy uncertainty? Most definitely yes.
We will momentarily present detailed historical evidence, but fewer proofs could be more revealing than the quote with which we start this section. *Leaders and Followers in an Age of Uncertainty* was the title of a talk given by George P. Shultz at Stanford University on May 13, 1975 (see Shultz (1975) for the published version of the same lecture as given at New York University). Shultz, who as director of the Office of Management and Budget from July 1, 1970 to June 11, 1972 and

Secretary of the Treasury from June 12, 1972 to May 8, 1974, had been at the very core of fiscal policy decision making in the U.S. over the previous years,[2] explained in his talk why he thought the U.S. was living in an unprecedented "age of uncertainty."

We will present some of the reasons that led George Shultz to reach this conclusion in three parts, one for the Nixon administration, one for the Ford administration, and one for Congress, the principal decision-makers regarding fiscal policy in the U.S. We will not discuss the Federal Reserve, as its influence on fiscal issues is only indirect. That means, for example, that we avoid the issues related to the collapse of the Bretton Woods system after 1971 and the high level of policy volatility associated with the transition to a flexible exchange-rate system. Also, we avoid a discussion of the tax-rate drift triggered by inflation and that was not fixed until 1981. Since inflation was quite volatile at the time, the tax-rate drift was, by itself, an important cause of fiscal policy volatility. Similarly, we will not discuss the large volatility of oil prices and energy supplies at the time. Suffice it to say that all these factors probably made fiscal policy even more volatile. We conclude this subsection with a summary of our main findings.

D.1.1 The Nixon administration

> "Indecision on Taxes and Inflation"
>
> Is the Nixon administration inclined to favor a tax increase? The authoritative answer last week was: (1) Yes; (2) No; (3) Maybe; (4) It is under consideration.
>
> *The Washington Post*, September 16, 1973.

The first months of 1974 witnessed how the Watergate scandal gathered critical momentum and engulfed the attention of the President and his Cabinet. On May 9, 1974, the House Judiciary Committee started impeachment hearings against Richard Nixon. A few weeks later, on July 24, the Supreme Court unanimously ruled in *United States v. Nixon* that the full tapes of his recorded conversations at the White House, not just the selected transcripts offered by the President, should be made available to the special prosecutor, Leon Jaworski. After this ruling, Nixon lost hope of surviving an impeachment trial in the Senate and resigned from office on August 9, 1974.

[2] Previously, he had also been Secretary of Labor from January 22, 1969 to July 1, 1970.

But the Watergate scandal was not only about abuse of power and a constitutional dispute about the extent of executive privilege. The Watergate scandal meant that the last months of the Nixon presidency were a period of disconcerting neglect of domestic issues and, as the *Washington Post*'s correspondent so wittingly captured, high uncertainty regarding fiscal policy. Arthur Burns, chairman of the Board of Governors of the Federal Reserve at the time and a privileged observer of the White House, wrote in his diary that as early as April 1973:[3]

> "the individuals involved in the Watergate scandal were now conferring with the attorneys, etc., instead of attending to the business of government." (Ferrell (2010), pp. 99.)

Perceptive observers soon appreciated the economic consequences of this uncertainty. A few months later, on December 3, 1973, Otto Eckstein, a former member of the Council of Economic Advisers and a well-respected macroeconometric modeler, explained to the *New York Times* how the uncertainty about the Watergate scandal was likely to have a negative effect on the economy:

> "The instability at the center of national power poses a major risk to the economy in 1974. The United States is not accustomed to doubts about the durability and continuity of national authority, but other countries such as Italy have demonstrated over and over again that the economy is adversely affected."[4]

To make things worse, Richard Nixon had neither a strong belief about economics nor a taste for the subject.[5] For the President, economic policy was nothing but an instrument in his political calculations. As the Watergate scandal progressed, Nixon jumped from one fiscal idea to another to use the federal budget as a tool to shore up his ever-weakening position. Arthur Burns summarized Nixon's attitude after a meeting with the President on April 24, 1974 as indicating that the President lacked clear fiscal policy plans and that:

[3] Burns's diary, recently published by Robert H. Ferrell, is a fascinating source of insight about economic policy at the time and we will quote from it repeatedly.

[4] The same article also talks about "increasing confusion among businessmen" regarding the administration's policy.

[5] As George Shultz mentions in his memoirs, "Nixon didn't like budget work or economics much" (Shultz (2010), loc. 305.) This observation was confirmed by many other senior officials of the Nixon economic group, such as Herbert Stein.

> "RN (*Richard Nixon; our clarification notes appear in italics*) shows little respect for the budget." (Ferrell (2010), pp. 126-127.)

And, after a later meeting on May 27 (Ferrell (2010), p. 128), Burns wondered:

> "And what, if anything, does he really believe?"

The delicate position of Richard Nixon and his cavalier attitude toward economic principles was a fundamental source of large fiscal policy volatility.

Things were not better at the Treasury. George Shultz, the Secretary of the Treasury since July 1, 1970 and the coordinator of economic policy within the administration, had completely lost his confidence in Richard Nixon at some moment in the fall of 1973. The reasons for this change of heart were the reintroduction of price controls in June 1973 as a tool to control inflation and the growing evidence of Nixon's moral turpitude. As related again by Burns (Ferrell (2010), p. 121), Shultz repeatedly tried to resign:

> "Shultz told me on plane, returning from Rome on Jan. [?] that he had resigned twice, the last time having sent a handwritten letter to the President... that he (*George Shultz*) is fully determined nevertheless to resign, for RN (*Richard Nixon*) now is and will remain a president without power, that all RN is interested is in his personal problem, that he (*George Shultz*) doesn't trust him..."[6]

Shultz's emotional disengagement from the Treasury job meant that, for several months, fiscal policy lacked any clear medium-term objectives. Also, Washington was full of rumors about his possible replacement. Among the names discussed at the White House (and, one suspects, leaked to the press), there was a wide range of ideological leanings, with John Connally (who had just switched his registration from Democrat to Republican), Wilbur Mills (a Democrat who will reappear in a few paragraphs), and Nelson Rockefeller (a liberal Republican)[7] sharing chances with much more conservative candidates.

[6] In July 1974, after resigning, Shultz stated in a White House meeting: "The country is in a terrible shape, and I wish you guys in government would do something about it." July 1974, cited by Patterson (2005), p. 8.

[7] At the time, the Republican party encompassed a much larger spectrum of ideological positions than nowadays. During his 16-year tenure as Governor of New York, Rockefeller somehow found enough time away from his projects to rebuild Albany in the Brutalist architectural style to raise New York taxes to the highest level in the country (Connery and Benjamin (1979), p. 428).

When Shultz finally resigned on May 8, 1974, his successor was William E. Simon, the Deputy Secretary. While one could think that Simon's choice indicated some continuity in fiscal policy, the reality was more nuanced. Simon got the job despite some serious shortcomings because, at the moment, it would have been too difficult for the White House to explain any other choice. He was a publicity-seeker and without a sense of direction. Even his memoirs, *A Time for Truth*, Simon (1978), are a dull exercise in boastfulness. Furthermore, he had combined his position as a Deputy Secretary of the Treasury with the position of "Energy Czar." In that role, Simon had shown a remarkable inclination toward price and quantity controls and floated ambitious plans for energy generation in the U.S., including possible massive depreciation allowances, such as those seen during the Korean War. However, given the situation of Richard Nixon, there was widespread uncertainty about whether these depreciation allowances, a key factor behind effective tax rates on capital income, would ever be approved.

D.1.2 The Ford administration

> President Ford has not turned the economy around with his new energy and economic proposals, but at least he has turned himself around.
>
> *The New York Times*, January 15, 1975.

After Nixon's resignation, Gerald Ford became the only President of the U.S. not elected by the electoral college. The full and unconditional pardon of Nixon one month later was a mortal blow to his popularity. These two facts dominated Ford's presidency and limited his ability to steer policy in a predictable path.[8]

Ford's vice-president, Nelson Rockefeller, did not help. Rockefeller, who was much more liberal than nearly any other Republican of importance, added an extra degree of volatility to policy because of his desire to participate in policymaking to a much larger extent than other vice-presidents. Ford's two White House Chiefs of Staff, Donald Rumsfeld and Dick Cheney,[9] fought constantly

[8] Ominously for Ford, in the special election to fill his old seat in the House -Michigan's 5th congressional district- after he became vice-president, Vander Veen, a Democrat without experience carried the day. It was the first time a Democrat had won the district since 1910. In the previous 1972 election, Ford had won the district with 61 percent of the vote.

[9] Donald Rumsfeld and Dick Cheney are, of course, of later fame during George W. Bush's presidency. Another senior player in the Ford administration economic team was Paul O'Neill, at the time deputy director of Office of

with Rockefeller about domestic policy, as they had extremely divergent views about where the administration should go.[10]

Nevertheless, Gerald Ford brought with him to the presidency a strong belief in the market as an economic system and respect for the old rules of balancing budgets and sound money. He believed that corporate profit taxes were too high and he wanted to reduce consumption and public spending in order to increase investment and long-run growth (Mieczkowski (2005), p. 75). Ford purposely appointed Alan Greenspan, previously nominated by Nixon, as chairman of his Council of Economic Advisers and made controlling the budget deficit and inflation the top economic priorities of his administration. In Ford's view, a tight fiscal policy of lower government expenditure and higher tax revenue was fundamental to taming inflation.

This led the new president to announce to a joint session of Congress, on October 8, 1974, a tax increase, in particular, a 5 percent surcharge on families making more than $15,000 a year, which at the time received the majority of capital income. Part of the increase was compensated by raising the investment tax credit from 7 to 10 percent. The address, however, was a "patchwork of proposals without a unifying theme" (Crain (2009), p. 78) and left many observers puzzled.[11]

But this change with respect to Nixon's budgetary shenanigans was itself rather short-lived. As the economic situation quickly deteriorated in the second half of 1975, Gerald Ford called his economic advisers to a meeting at his vacation home over the holidays (Crain (2009), p. 103). Ford's advisers were seriously divided about fiscal policy. Rumsfeld, Cheney, and Greenspan proposed tax cuts, while Simon (who had kept his position at the Treasury after Nixon's resignation) opposed them. Tax-cutters won the battle and, in the State of the Union address on January 16, 1975, Ford flip-flopped his past proposal of tax increases and asked, instead, for a tax cut quite favorable to capital income. As Ford admitted in his autobiography, this was to:

> "reverse completely the economic strategy developed from the economic summit meeting

Management and Budget and later Secretary of the Treasury from January 20, 2001 to December 31, 2002.

[10] See Crain (2009), pp. 78 and 79, for how Rockefeller tried, but failed, to outmaneuver Rumsfeld by appointing some of his aides at the Domestic Council. Rumsfeld proved to be, however, a most resourceful bureaucratic infighter who knew how to successfully navigate the White House administrative jungle to defeat Rockefeller's encroachment attempts one obscure memo at a time.

[11] The address also plays a small role in the history of economics. At a dinner with Donald Rumsfeld and Dick Cheney after the surcharge announcement, Arthur Laffer famously drew his revenue curve on a napkin to explain why he thought Ford's surcharge was unlikely to generate much revenue.

and adopted during the first three months of my presidency." (Ford (1979), p. 204).

The tax cut proposal included rebates from income tax as the 1975 *Economic Report of the President* stated (p. 4):

> "I have also proposed a $4-billion investment tax credit which would encourage businessmen to make new commitments and expenditures now on projects that can be put in place this year or by the end of next year."

As explained in more detail in the report (p. 20):[12]

> "For business the President proposed a 1-year increase in the investment tax credit to 12 percent. Except for utilities, which now have a 4 percent credit, the present credit is equal to 7 percent of investment in equipment. For electric utility investment in generating capacity that does not use oil or gas, the higher tax credit would remain in force through 1977. The increase in the tax credit is expected to reduce tax liabilities of businesses by approximately $4 billion during 1975. The credit will apply to machinery and equipment put into service during 1975, as well as to orders placed during 1975 and put into service by the end of 1976."

When the 1976 budget was presented on February 4, the reaction was extremely critical, both from Republicans and from Democrats. Among the Republicans, Simon was widely rumored to be on his way out as Secretary of the Treasury because of his opposition to the tax cuts. Among the Democrats' leaders in Congress, Hubert Humphrey labelled the budget proposal "completely unacceptable" and Al Ullman (whom we will introduce below) considered it "a disaster for the economy" (both quotes from Crain (2009), p. 109). This strong opposition from what we will see

[12] One is surprised, while reading the 1975 *Economic Report of the President*, at how many times one can find expressions such as "sharp rise in uncertainty" (p. 19), "important source of uncertainty regarding the stimulus program" (p. 21), "uncertainties that underlie the outlook for 1975" (p. 26), "The uncertainties are so great at the present time" (p. 27), "the official estimates themselves are subject to more than the usual uncertainties" (p. 40), "More than a usual amount of uncertainty surrounds the behavior of real output in the first 3 quarters of 1974" (p. 45), "Profits data are currently subject to a good deal of uncertainty" (p. 54), "due to the greater uncertainty among both the employed and the unemployed" (p. 116), "because the uncertainties surrounding the decision-making processes in markets would reduce economic activity" (p. 137), "the increased uncertainty of earnings, which is itself a deterrent to additional investment and production" (p. 161). While many of these uncertainties are not directly linked with the fiscal volatility shocks we study in the main text of the paper, the repeated emphasis on increased uncertainty is, at the very least, suggestive.

below was a powerful Congress increased the uncertainty about the shape of the tax on capital income.

The Democratic leadership in Congress reacted by proposing their own, much more generous tax cut. Ford asked for a $16 billion tax cut, the House voted a $21.3 billion reduction, and the Senate a $29.2 billion reduction. The final conference committee cut was $22.8 billion and the *Tax Reduction Act* of 1975 was sent to Ford in March. An important difference of the Congress' act with respect to Ford's proposal was that the investment tax credit was temporarily increased to 10 percent through 1976 (chapter 10 in Mieczkowski (2005) recounts the legislative history of the tax cut).

Ford agonized about what to do with the bill. Simon advised him to veto it (as the President had warned during the last round of the legislative process), and Burns and Greenspan advised him to sign it. Reluctantly, Ford sided with Burns and Greenspan and signed the *Tax Reduction Act* on March 29, 1975, but not without warning:

> "This is as far as we dare to go. I will resist every attempt by the Congress to add another dollar to the deficit. I will make no exceptions." (Crain (2009), p. 109.)

Not surprisingly, Congress was of a different mind and the next few months witnessed constant fights between the President and Congress about taxes, spending, and the general direction of fiscal policy.[13] By the late fall, the struggle started to abate, although as late as December 17, 1975, Ford vetoed an extension of the tax cuts that he considered was too far away from his own proposal on October 7 and forced the Congress to pass a much smaller tax cut. Coincidently, our index of volatility peaks in the spring of 1975 and starts to quickly fall after that. This seems, therefore, a good moment to start dealing with the Congress that had proven to be so difficult to deal with for the administration.

D.1.3 Congress

> The new mood on Capitol Hill made any kind of a coalition virtually impossible even for such an experienced legislative hand as Gerald Ford. More so than any other time since 1945, American government was truly divided...

[13] Also, somewhat quietly but importantly for the taxation of capital, Congress extended the preferential tax treatment of pension and retirement plans.

> ...the administration quickly learned that the economic policies they believe were best for the nation, the measures Congress would approve in that area, and the policies most efficacious in the political arena were irreconcilable.
>
> *The Presidency of Gerald Ford*, John Robert Greene, p. 54 and pp. 68-69 (Greene (1994).

Nixon's troubles had several unexpected consequences for Congress. First, for the first time in several decades, the leaders of Congress found the strength to impose meaningful limits on executive power. While less known than the *War Powers Act* of 1973, the *Congressional Budget and Impoundment Control Act* (signed by Richard Nixon on July 12, 1974) thoroughly restructured the budgetary process in the U.S. As observers at the time emphasized, the consequences of that restructuring were hard to forecast at the time. In fact, the peculiarities of this bill regarding appropriations and taxes have been behind many of the budgetary stand-offs of the last several years (such as the federal government shutdown of 2013) that have contributed so much to increasing fiscal volatility.

Second, the midterm election of November 4, 1974, held in the aftermath of the Watergate scandal and Ford's extremely unpopular pardon of Nixon, had returned a Congress heavily dominated by the Democratic Party. In the House, the Democrats' 291 seats more than doubled the Republicans' 144 seats and were supported by a difference in the popular vote of 16.8 percentage points. This was the biggest difference in the popular vote since 1926. The difference was even bigger than in 1936, when the Democrats held the largest seat majority that any party has had since Reconstruction. Of those 291 Democrats, 75 were freshmen.

The large contingency of freshmen Democrats had two important effects. First, it moved the party caucus to the left, opening a constant struggle with the President (as pointed out by Greene's quote above) and increasing uncertainty about policy in general, particularly in economic issues.[14] As a reflection of this struggle, Gerald Ford vetoed 66 bills during his just 29 months in office, including two in his very first week.[15]

[14] See Perlstein (2014), loc. 866, for an engaging description of some of the more unconventional Democratic candidates in that election.

[15] Twelve of Ford's 66 vetoes were overridden by Congress, a relatively high percentage by historical standards; see Mieczkowski (2005), p. 87, for statistics about presidential vetoes. Ford, perhaps because he had been in the

Second, since many of the new Democratic representatives had been elected from traditionally Republican districts, they sought to assert their independence by ignoring the committee chairman (many of them old white Southerners who had been in Congress for decades; see Patterson (2005), p. 85) and making the House particularly unpredictable.

The dismissal of the old political bosses in Congress and the associated uncertainty created by it is perfectly illustrated by the resignation of Wilbur Mills. Mills was the chairman of the House Ways and Means Committee, the chief tax-writing committee of the United States House of Representatives, from 1957 to 1974 and, therefore, a key player in fiscal policy. Mills' tenure -the longest in history at Ways and Means- made him an extremely powerful politician. Newspapers called him "the most powerful man in Washington" (Perlstein (2014), loc. 848.). George Shultz and Kenneth W. Dam wrote of him (Shultz and Dam (1977), p. 62):

> Another circumstance that long shaped the tax legislative process was the dominance of Wilbur Mills, the Ways and Means chairman until 1975. By dint of hard work and attention to detail, as well as long years in the chairmanship, Mills had an influence on the shape of the tax code and on the administration of the tax system that would be difficult to exaggerate. ....His role over the years shows that an individual can have an important, even a decisive, impact on public policy if he has talent, energy, and a long government career.

On the night of October 9, 1974, Wilbur Mills' car was stopped by the police. Mills was intoxicated and accompanied by Fanne Foxe, a colorful Argentinean stripper, with whom he had just had a fight that had left both of them bruised. After the police stopped the car, Fanne, drunk and panicked, ran away from the car and jumped into the cold waters of the Tidal Basin. If this was not enough for popular entertainment, a few weeks later, on November 30, 1974, Mills gave a press conference in Fanne Foxe's changing room while visibly drunk. After this second incident, Mills admitted to being an alcoholic, left his chairmanship, and checked into a rehabilitation clinic.

His successor, Al Ullman, a Democrat from Oregon, was a very different type of congressman: more "modern," less powerful (and less ruthless), and in charge of a deeply restructured committee. This

House for many years, understood that vetoes were his most powerful tool against a Congress where he did not have anything even remotely close to a working majority.

change of guard left many in Washington wondering about the shape that fiscal policy would take over the next years. Even as late as 1977, Shultz and Dam still expressed uncertainty about the impact on future fiscal policy of the new leadership (Shultz and Dam (1977), p. 63):

> It is still too early to tell whether the restructured Ways and Means Committee, even with the talented leadership of Al Ullman and Barber Conable, as chairman and ranking Republican member, will be able to avoid centrifugal tendencies associated with varied interests.

In the Senate, the Democrats won four additional seats, getting to a majority of 60. Under the parliamentarian rules of the time, cloture required two-thirds of the Senate and that, therefore, the Democratic majority was not filibuster-proof.[16] Furthermore, the 39 seats held by the Republicans (there was a vacant seat until September 16, 1975, because of an election dispute) meant that the Democratic senators could not override, by themselves, a possible presidential veto, opening the door to stalemate and uncertainty.

While the Senate -due to its electoral rules, a lagging indicator of the state of the country- experienced fewer changes than the House, the Upper House was also a source of uncertainty, with policy proposals that could surprise nowadays.

On May 5, 1975, Hubert Humphrey introduced the *Balanced Growth and Economic Planning Act*,[17] which soon was known as the *Humphrey-Javits Act* for its co-sponsor, Jacob Javits. The act proposed the establishment of an Economic Planning Board and the move toward an "indicative planning system" in the U.S., which would determine the rate of capital accumulation and, therefore, could have acted as a tax on capital income by dramatically changing the return on capital. As the *New York Times* put it (June 18, 1975):

> The Humphrey-Javits bill, it is acknowledged here, would be, if enacted, a major step toward central economic planning, albeit on a voluntary basis.

The bill was not a fringe proposal. Humphrey was, of course, a heavy weight: a former Vice-President under Johnson, Democratic candidate for President in 1968, former Senate Majority

[16] The rules governing filibuster were changed in March 1975, when cloture was reduced to 60 votes.

[17] See `https://www.congress.gov/bill/94th-congress/senate-bill/1795/all-info`

Whip, etc. Moreover, he spent considerable political capital in pushing the bill, calling it his "single most important piece of legislation." Javits, a Republican from New York, was also himself a heavy hitter in the Senate and the bill had another 9 co-sponsors.

At the same time, the bill evoked strong opposition from the Administration. As the *New York Times* added in the same article as above:

> But the Ford administration is not likely to go along with a central economic planning agency. President Ford is probably the least receptive chief executive toward Government intervention in the marketplace since Calvin Coolidge....
>
> "In the months ahead," he (*Ford*) said, "we face a critical choice. Shall business and Government work together in a free economy for the betterment of all? Or shall we slide head-long into an economy whose vital decisions are made by politicians while the private sector dries up and shrivels away?"

This is a transparent example of policy uncertainty: two very different views of how to decide capital accumulation, both with very strong supporters. Even if the Humphrey-Javits bill faced an uphill battle, the open discussion of central planning in the U.S. was quite unprecedented. Again, quoting the *New York Times*:

> The issue has been debated before, but never in a world quite like today's.

The probability of a move to central planning was not idle speculation. Robert L. Heilbroner, in a four-page op-ed in the *New York Times* on January 25, 1976, wrote:

> Thus, for better or worse, whether we welcome it or not, under the Humphrey-Javits bill or another, I expect that within five years, perhaps much sooner, we will be officially embarked on something called National Economic Planning.

In the end, the Humphrey-Javits bill was too radical, but a drastically watered-down version, the *Humphrey-Hawkins Full Employment Act* was passed in 1978. This suggests that a scenario in which the unprecedentedly open Democratic primary of 1976 was won by a more left-leaning candidate (perhaps Jerry Brown?) and in which the Humphrey-Javits bill was approved by Congress had a non-trivial probability in 1975.

D.1.4 Summary

The historical evidence we just reviewed suggests that:

1. The Nixon administration did not have clear plans about fiscal policy in 1974.Q1 to 1974.Q3. Nixon was ready to accept whatever plan would have been expedient for him.

2. Ford arrived, in 1974.Q4, with the idea of raising taxes to balance the budget. Only a few months later, in 1975.Q1, he was forced to ask Congress for a tax cut.

3. Congress changed Ford's proposal into a much larger tax cut (and with a different composition). Ford threatened to veto the congressional bill and he was in doubt until the very end about whether or not to carry out the veto.

4. Ford and the Congress fought bitterly about fiscal policy for the remainer of 1975.

5. The Congress elected in the aftermath of 1974 was more left-leaning than its predecessors, but also more unpredictable than previous Congresses, with the power of the Ways and Means Committee severely damaged by the resignation of Wilbur Mills and procedural changes.

6. There was some serious discussion about the introduction of "indicative central planning."

Our reading of all this evidence is that 1974.Q2 to 1975.Q3 was a time of unusual fiscal policy volatility. While we accept that some of the different elements of our narrative can be interpreted in different ways, taking the evidence as a whole, we find compelling support of our econometric estimates reported in Figure 1 and Table 1 in the main text.

D.2 Fiscal policy uncertainty in 1986-1987

According to our estimates, President Reagan's victories in 1980 and 1984 did not substantially increase the smoothed fiscal volatility shocks. Reagan was elected on a platform of tax reductions which was partially implemented by the *Economic Recovery Tax Act* of 1981 (the famous "Kemp-Roth Tax Cut"). While the tax reduction was fiercely debated (and, therefore, it might have contributed to increased fiscal policy uncertainty), two of the provisions of the *Economic Recovery Tax Act* of 1981 may have reduced fiscal volatility. First, the tax reductions were phased-in over a

number of years. Second, the act indexed the tax system to inflation, eliminating the bracket creep that had created so much uncertainty during the 1970s, a decade of volatile inflation.[18]

Indeed, it is only later in Reagan's presidency -from 1985.Q1 to 1987.Q2- that we observe for the second time in our sample that the 97.5th percentile of the smoothed distribution of $100 \exp(\sigma_{\tau_k,t})$ is with the 2.5 percent right tail of the unconditional distribution of $100 \exp(\sigma_{\tau_k,t})$ evaluated at the median of the posterior. The years 1985 and 1986 were difficult ones for fiscal policy. The combination of tax reductions, the defense build up, and the lack of reduction in social programs had generated unprecedented fiscal deficits by 1984. This situation led to numerous proposals about how to tackle the situation that widely diverged in emphasis. For example, the 1985 *Economic Report of the President* made the deficit reduction through expenditure control one of the President's priorities. On the other hand, a Democratic-dominated House of Representatives favored an increase in tax revenue. The *Tax Reform Act* of 1986 split the difference in the middle, with a revenue-neutral reorganization of the tax brackets and deductions and radical simplification of the code. Indeed, the *Tax Reform Act* of 1986 is still the most recent deep change in the U.S. tax code.

Although the final version of the *Tax Reform Act* of 1986 received widespread bipartisan support, it was only due to the extraordinary legislative skills of Bob Packwood, the chairman of the Senate Finance Committee, that the act went from a rather indifferent initial reception in 1984 to its final enactment. We read the improbable passing of the *Tax Reform Act* of 1986 as an example of a fiscal policy innovation (see, for example, the description in Weiss (1989)).

D.3 Fiscal policy uncertainty in 2001-2002

The third volatility spike in the sample is from 2001.Q2 to 2002.Q1. These quarters coincided with the 9/11 terrorist attacks (with their potentially vast fiscal implications) and with the 2001-2002 recession. A few months before, the U.S. had witnessed the acrimonious partisan debates surrounding President George W. Bush's tax cuts. Since these events are well-known and identified by other indices such as Bloom (2009) as uncertainty peaks, we skip a more detailed discussion.

[18] Also note that our fiscal policy rules control for the systematic change in taxes induced by the business cycle. As long as part of the "Kemp-Roth Tax Cut" was part of the systematic response of Congress over our sample to the weak economy of the early 1980s, our estimates rightly do not classify this as generating fiscal uncertainty.

D.4 Fiscal policy uncertainty in 2008-2014

Our sample ends with a high level of the fiscal volatility shock, with three events clustered around each other (2008.Q2 to 2009.Q1, 2011.Q3, and 2014.Q1) where the 97.5th percentile of the smoothed distribution of $100 \exp(\sigma_{\tau_k,t})$ is within the 2.5 percent right tail of the unconditional distribution of $100 \exp(\sigma_{\tau_k,t})$ evaluated at the median of the posterior.

There have been two main reasons behind this high level of uncertainty. First is the financial crisis and its aftermath. Not only did the financial crisis highlight the very different approaches between the two main political parties with respect to the use of fiscal policy as a stabilization instrument, it also created many unknowns about the possible costs for the government of rescuing banks and about the extent to which the social transfers (from the spending side) and tax revenue (from the income side) would be affected by the recession and the recovery.

Second, the last decade has been a period of extreme electoral instability. There are three centers of power in the federal government: the Presidency, the Senate, and the House. Given the U.S. two-party system, there are 8 patterns of control of these three centers of power. The 6 elections between 2004 and 2014 have produced 5 out of the 8 possible patterns of party control:

1. 2004: Republican president, Republican majority in the Senate, Republican majority in the House.

2. 2006: Republican president, Democratic majority in the Senate, Democratic majority in the House.

3. 2008: Democratic president, Democratic majority in the Senate, Democratic majority in the House.

4. 2010 and 2012: Democratic president, Democratic majority in the Senate, Republican majority in the House.

5. 2014: Democratic president, Republican majority in the Senate, Republican majority in the House.

This instability ties with 1878-1896 and 1910-1920 for the highest level of electoral instability in U.S. history (and if there is an additional change in 2016, it will become the highest peak of instability).

Furthermore, ideological indexes, such as those elaborated by Keith T. Poole and Howard Rosenthal, suggest that the electoral instability of 1878-1896 and 1910-1920 had less severe consequences than the current electoral instability because there was a bigger overlap between the parties in ideological terms.[19] Back in 1878-1896 and 1910-1920, the Democratic and Republican parties stood as much for regional politics (Democrats in the South, Republicans in the North) as for political ideologies. Many Southern Democrats were deeply conservative and most of the "progressive" movement of the early 20th century found a home in the Republican party (most famously Theodore Roosevelt and Robert M. La Follette).[20] In comparison, Republicans are nowadays solidly aligned on the right and Democrats on the left. Therefore, any change in party control (which, as we have seen, is constantly occurring and which might depend to a significant degree on unforeseeable events) is likely to bring considerable variation in fiscal policy. Furthermore, back in 1878-1920, the size of the federal government budget and, hence, the potential impact of fiscal policy volatility on economic activity, was considerably smaller.

As we mentioned in the main text, concrete examples of events associated with large fiscal policy uncertainty around this time include TARP being signed into law in 2008.Q4 after having been discussed in 2008.Q3 (the true cost of TARP being highly unknown at the time) and the changes in the sequestration caps for 2014 approved in December 2013.

D.5 Figures 1 and 2

We include now, for completeness, the formulae behind figures 1 and 2 in the main text. Let $F_t\left(\cdot;\{\tau_{k,1},\cdots,\tau_{k,T}\}\{\tilde{y}_0,\cdots,\tilde{y}_{T-1}\},\{b_0,\cdots,b_{T-1}\},\{y_0,\cdots,y_{T-1}\}\right)$ be the cumulative distribution function (CDF) of $100\exp\left(\sigma_{\tau_{k,t}}\right)$ at time t given the data.

If we define, $F_{t,T}\left(\cdot\right)\equiv F_t\left(\cdot;\{\tau_{k,1},\cdots,\tau_{k,T}\}\{\tilde{y}_0,\cdots,\tilde{y}_{T-1}\},\{b_0,\cdots,b_{T-1}\},\{y_0,\cdots,y_{T-1}\}\right)$, for $t\in\{1,\cdots,T\}$, figure 1 plots the series of the set

$$\mathscr{X}_t\equiv\{X\in\mathbb{R}_+|F_{t,T}^{-1}\left(0.025\right)\leq X\leq F_{t,T}^{-1}\left(0.975\right)\}\text{ for t }\in\{1,\cdots,T\}.$$

Let $\mathbb{G}_t\left(\cdot;\{\tau_{k,1},\cdots,\tau_{k,T}\}\{\tilde{y}_0,\cdots,\tilde{y}_{T-1}\},\{b_0,\cdots,b_{T-1}\},\{y_0,\cdots,y_{T-1}\}\right)$ be the CDF of the $Prob\left(u_{\tau_{k,t}}\geq 2\right)$

[19] See `www.voteview.com` for the data and for extensive references.

[20] Even William Howard Taft called himself a "believer in progressive conservatism"; see Lurie (2012).

at time t given the data.

If we define, $\mathbb{G}_{t,T}(\cdot) \equiv \mathbb{G}_t(\cdot; \{\tau_{k,1}, \cdots, \tau_{k,T}\}\{\tilde{y}_0, \cdots, \tilde{y}_{T-1}\}, \{b_0, \cdots, b_{T-1}\}, \{y_0, \cdots, y_{T-1}\})$, for $t \in \{1, \cdots, T\}$, the left panel of figure 2 plots the series of the set

$$\mathscr{Y}_t \equiv \{Y \in [0,1] \,|\mathbb{G}_{t,T}^{-1}(0.025) \leq Y \leq \mathbb{G}_{t,T}^{-1}(0.975)\} \text{ for t } \in \{1, \cdots, T\}.$$

Define the counting function $\Pi(y) : \mathbb{R}_+ \to \mathbb{N}$. This function counts the number of times that any value of the sequence of innovations $\{u_{\tau_{k,1}}, \cdots, u_{\tau_{k,T}}\}$ is larger than some positive real number y. Let $\mathbb{H}_x(\cdot; \{\tau_{k,1}, \cdots, \tau_{k,T}\}\{\tilde{y}_0, \cdots, \tilde{y}_{T-1}\}, \{b_0, \cdots, b_{T-1}\}, \{y_0, \cdots, y_{T-1}\})$ be the CDF of the $Prob(\Pi(2) \geq x)$ for $x \in \mathbb{N}$.

If we define, $\mathbb{H}_{x,T}(\cdot) \equiv \mathbb{H}_x(\cdot; \{\tau_{k,1}, \cdots, \tau_{k,T}\}\{\tilde{y}_0, \cdots, \tilde{y}_{T-1}\}, \{b_0, \cdots, b_{T-1}\}, \{y_0, \cdots, y_{T-1}\})$, for $t \in \{1, \cdots, T\}$, the right panel of figure 2 plots the series of the set

$$\mathscr{J}_x \equiv \{J \in [0,1] \,|\mathbb{H}_{x,T}^{-1}(0.025) \leq J \leq \mathbb{H}_{x,T}^{-1}(0.975)\} \text{ for x } \in \{1, \cdots, 6\}.$$

Similar sets could be easily plotted for other percentiles.

E Model

We offer now some additional details about the model. Remember that there is a representative household that works, consumes, and invests in capital and government bonds. The government taxes labor and capital income, as well as consumption, and engages in spending following the laws of motion estimated in section 1 of the main text. The household sets wages for differentiated types of labor input subject to wage rigidities. There is a continuum of monopolistically competitive firms. They produce intermediate goods by renting capital services from the household and homogeneous labor from a packer that aggregates the different types of labor. Intermediate goods firms set their prices subject to price rigidities. The final good used for investment and consumption is competitively produced by a firm that aggregates all intermediate goods. The monetary authority steers the short-term nominal interest rate following the prescriptions of a Taylor rule.

E.1 Households

First, note that the preferences of the households are subject to shocks to allow the model to capture fluctuations in interest rates not accounted for by variations in consumption.

Second, the optimal behavior of the labor packer implies a demand for each type of labor: $l_{j,t} = \left(\frac{w_{j,t}}{w_t}\right)^{-\epsilon_w} l_t$. Then, by a zero-profit condition $w_t = \left(\int_0^1 w_{j,t}^{1-\epsilon_w}\right)^{\frac{1}{1-\epsilon_w}}$.

Focusing on a symmetric equilibrium, the first-order conditions of the household problem of maximizing expected utility with respect to $w_{j,t}$, $j \in (0,1)$, c_t, b_t, u_t, k_t, k_t^b, and i_t are:

$$\frac{d_t}{(c_t - b_h c_{t-1})^\omega} - \mathbb{E}_t \frac{b_h \beta d_{t+1}}{(c_{t+1} - b_h c_t)^\omega} = \lambda_t (1 + \tau_{c,t}),$$

$$\phi_w y_t \left(\frac{w_t}{w_{t-1}} - g_A\right) \frac{w_t}{w_{t-1}} =$$

$$\mathbb{E}_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \phi_w y_{t+1} \left(\frac{w_{t+1}}{w_t} - g_A\right) \frac{w_{t+1}}{w_t} \right\} + \left[A_t^{(1-\omega)} \frac{d_t}{\lambda_t} \psi \epsilon_w (l_t^d)^{1+\vartheta} - (\epsilon_w - 1)(1 - \tau_{l,t}) w_t l_t^d \right],$$

$$\lambda_t = \beta \mathbb{E}_t \left\{ \lambda_{t+1} \frac{R_t}{\Pi_{t+1}} \right\},$$

$$r_{k,t}(1 - \tau_{k,t}) = q_t \delta' \left[u_t\right],$$

$$q_t = \mathbb{E}_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \left[(1 - \delta[u_{t+1}]) q_{t+1} + (1 - \tau_{k,t+1}) r_{k,t+1} u_{t+1} \right] \right\},$$

$$q_t^b = \mathbb{E}_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \left[(1 - \delta) q_{t+1}^b + \delta \tau_{k,t+1} \right] \right\},$$

and

$$1 = q_t \left(1 - S\left[\frac{i_t}{i_{t-1}}\right] - S'\left[\frac{i_t}{i_{t-1}}\right] \frac{i_t}{i_{t-1}}\right) + \beta \mathbb{E}_t \left\{ q_{t+1} \frac{\lambda_{t+1}}{\lambda_t} S'\left[\frac{i_{t+1}}{i_t}\right] \left(\frac{i_{t+1}}{i_t}\right)^2 \right\} + q_t^b.$$

Above, λ_t is the Lagrange multiplier associated with the budget constraint and q_t is the marginal Tobin's Q, that is, the multiplier associated with the investment adjustment constraint normalized by λ_t. Similarly, q_t^b is the normalized multiplier on the book value of capital.

E.2 Firms

Taking prices as given, the final good producer minimizes its costs subject to equation (5) in section 2 of the main text. This results in a demand function for each intermediate good: $y_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\varepsilon} y_t$ where y_t is the aggregate demand and the price index for the final good is $P_t = \left(\int_0^1 P_{it}^{1-\varepsilon} di\right)^{\frac{1}{1-\varepsilon}}$.

E.3 Aggregation

Aggregate demand is given by: $y_t = c_t + i_t + g_t + \frac{\phi_p}{2}\left(\Pi_t - \Pi\right)^2 y_t + \frac{\phi_w}{2}\left(\frac{w_t}{w_{t-1}} - g_A\right)^2 y_t$.
By relying on the observation that the capital-labor ratio is the same for all firms and that the capital market must clear, we derive that aggregate supply is $y_t = \left(u_t k_{t-1}\right)^{\alpha}\left(A_t l_t\right)^{1-\alpha}$. Market clearing requires that

$$y_t = c_t + i_t + g_t + \frac{\phi_p}{2}\left(\Pi_t - \Pi\right)^2 y_t + \frac{\phi_w}{2}\left(\frac{w_t}{w_{t-1}} - g_A\right)^2 y_t = \left(u_t k_{t-1}\right)^{\alpha}\left(A_t l_t\right)^{1-\alpha}.$$

Aggregate profits of firms in the economy are given by $\digamma_t = y_t - w_t l_t - r_t^k u_t k_{t-1} - \frac{\phi_p}{2}\left[\Pi_t - \Pi\right]^2 y_t$.

F Fiscal Volatility Shocks Versus a Monetary Policy Shock

How big are the effects of fiscal volatility shocks in comparison with other shocks that the literature has emphasized? A simple comparison is to plot the IRFs in our model to a fiscal volatility shock together with the IRFs from other shocks as computed by standard VARs. We are just using that second set of IRFs as a yardstick, and hence, whether or not the model satisfies the identifying restrictions behind them is somewhat irrelevant. Similarly, we could compare the IRFs to a fiscal volatility shock with the IRFs to a monetary shock, both delivered by the model. However, this approach suffers from the problem that we are comparing two objects created by the model and not bringing any new independent information, as we do by employing the IRFs from a VAR.[21]
Figure 2 compares the effects of a fiscal volatility shock in our model (for both the baseline and extended versions) and the IRFs to a 30-basis-point (annualized) increase in the nominal interest

[21] 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. 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.

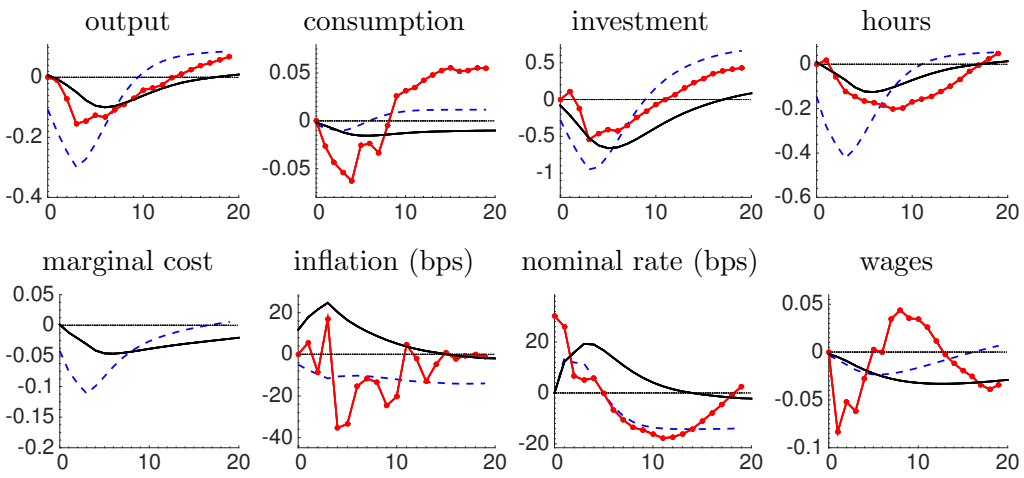

Figure 2: Fiscal volatility shock vs. 30 bps monetary shock

Note: Solid black (dashed blue) for IRFs to a fiscal volatility shock in the (extended) baseline economy. The dotted red lines are the IRFs to a 30-basis-point shock to the annualized nominal interest rate from Altig et al. (2011). Variables in percentage change from trend except for interest and inflation, which are are in annualized basis points.

rate implied by Altig et al. (2011)'s VAR of the U.S. economy.[22] We pick 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. From this comparison, we obtain the information that fiscal volatility shocks induce contractions that are of the same size as those that the empirical literature associates with a typical contractionary monetary shock.[23]

G Uncertainty and Markups: A Simple Example

In this appendix, we use a standard Dixit-Stiglitz monopolistic competition setup to show the relation between the uncertainty level and the pricing decision of firms. To simplify, we will assume a volatility shock that the firm takes as given and abstract from general equilibrium feedbacks. Also, and only in this section of the appendix, we will assume risk-neutral investors and forget about economic growth. This further clarifies our argument in section 5 of the main text.

[22] We thank Jesper Linde for kindly providing the code to replicate their results. Using the VAR in the main text to identify a monetary shock recursively leads to responses of a magnitude similar to those shown by Altig et al. (2011)' VAR in figure 2.

[23] An alternative comparison is as follows. Hamilton (2008) and Hamilton and Wu (2012) estimate that the purchase of $300 billion in long-term securities such as the one undertaken by the Fed between March and October 2009 translates into a drop of roughly 25 basis points in the fed funds rate. Against these numbers, the effects of a fiscal volatility shock appear to be about the same size (but of opposite sign) as the effects achieved through the 2009 exercise in quantitative easing.

Monopolistic producers set their price $P_{i,t}$ subject to adjustment costs and given the demand function $y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon} y_t$, where P_t is the aggregate price level, y_t is aggregate demand, and ϵ is the demand elasticity. Each firm's production function is given by $y_{i,t} = l_{i,t}$. Firms hire labor $l_{i,t}$ at the real wage w_t.

G.1 Aggregate demand and costs

Aggregate demand is exogenously determined according to

$$y_t = y + \exp\{\sigma^0_{y,t}\}\varepsilon_{y,t},\ \varepsilon_{y,t} \sim (0, \sigma_{e_y}). \tag{5}$$

Without loss of generality, let the steady-state level of demand be $y = 1$. We look at the effect of volatility shocks for period t, $\sigma^0_{y,t} > 0$, that are realized at the start of period 0. This volatility shock causes a mean-preserving spread of the distribution of future demand. Throughout, we will assume that the support of y_t is the positive real line.

In any period j, the real wage is linked "endogenously" to aggregate demand

$$w_t = w + \chi(y_t^{\phi} - \mathbb{E}_0 y_t^{\phi}),\ \chi > 0,\ \phi \geq 0,\ \text{with } w = \frac{\epsilon - 1}{\epsilon}. \tag{6}$$

We subtract $\mathbb{E}_0 y_t^{\phi}$, since we are interested in a shock in period 0 that induces a mean-preserving spread of future y_t's and possibly w_t's but does not affect the mean of w_t. Without this term, a volatility shock to y_t would lead to a higher average marginal cost, so inflation would rise still more. The w_t process is meant to capture the idea that uncertainty about aggregate demand will translate into uncertainty about costs.

G.2 Price-setting

Given risk-neutral investors and the quadratic adjustment cost in prices, the problem of the firm is to maximize:

$$\mathbb{E}_0 \sum_{j=0}^{\infty} \beta^j \left[\left(\frac{P_{i,t+j}}{P_{t+j}}\right)^{1-\epsilon} y_{t+j} - w_{t+j} \left(\frac{P_{i,t+j}}{P_{t+j}}\right)^{-\epsilon} y_{t+j} - \frac{\phi_p}{2} \left(\frac{P_{i,t+j}}{P_{i,t+j-1}} - 1\right)^2 \right],$$

where $\phi_p > 0$ is the price adjustment-cost parameter.

Denote by P_t^* the optimal price in t. The firm's first-order condition is:

$$(1-\epsilon)\left(\frac{P_t^*}{P_t}\right)^{1-\epsilon} y_t + \epsilon w_t \left(\frac{P_t^*}{P_t}\right)^{-\epsilon} y_t - \phi_p \left(\frac{P_t^*}{P_{t-1}^*} - 1\right)\frac{P_t^*}{P_{t-1}^*} + \beta\phi_p \mathbb{E}_t \left(\frac{P_{t+1}^*}{P_t^*} - 1\right)\frac{P_{t+1}^*}{P_t^*} = 0.$$

In a symmetric equilibrium, $P_t = P_t^*$ in all periods, so

$$(1-\epsilon)y_t + \epsilon w_t y_t - \phi_p(\pi_t - 1)\pi_t + \beta\phi_p \mathbb{E}_t(\pi_{t+1} - 1)\pi_{t+1} = 0,$$

where $\pi_t = P_t/P_{t-1}$ is the gross inflation rate, with steady state $\pi = 1$. Iterating forward, evaluating in period 0, and using $\mathbb{E}_0 y_j = y$ and $\mathbb{E}_0 w_j = w$, we get:

$$\begin{aligned}
\phi_p(\pi_0 - 1)\pi_0 &= \mathbb{E}_0 \textstyle\sum_{j=0}^{\infty} \beta^j [(1-\epsilon)y_j + \epsilon w_j y_j] \\
&= \textstyle\sum_{j=0}^{\infty} \beta^j [(1-\epsilon)\mathbb{E}_0 y_j + \epsilon \mathbb{E}_0 w_j y_j] \\
&= \textstyle\sum_{j=0}^{\infty} \beta^j [(1-\epsilon)y + \epsilon \mathbb{E}_0 w_j y_j] \\
&= \textstyle\sum_{j=0}^{\infty} \beta^j [(1-\epsilon)y + \epsilon w y + \epsilon Cov\,(w_j, y_j)],
\end{aligned}$$

In the following, we will focus on solutions with a positive price level, that is, on $\pi_0 > 0$. Then, we take advantage of the fact that $w = \frac{\epsilon - 1}{\epsilon}$ and that, given (6), $Cov\,(w_j, y_j) = \chi Cov\left(y_j^{\phi}, y_j\right)$ to get

$$\phi_p(\pi_0 - 1)\pi_0 = \chi\epsilon \sum_{j=0}^{\infty} \beta^j Cov\left(y_j^{\phi}, y_j\right). \tag{7}$$

Note that $Cov(y_j^{\phi}, y_j) \geq 0$ as long as y_t is restricted to the positive real line, a maintained assumption, with the equality being strict if $\phi > 0$. Thus, an increase in uncertainty in future periods leads to a precautionary increase in prices in the period of the shock as long as marginal costs are positively correlated with demand ($\phi > 0$). In the main text, the general equilibrium effects generate that positive covariance: a fiscal volatility shock pushes down both aggregate demand and marginal costs. Equation (7) also shows that the effect will be the bigger, the more elastic demand is (the larger ϵ).

G.3 The effect of an uncertainty shock on inflation

We are ready now to state the following proposition.

PROPOSITION:

Consider the model above and two realizations A and B of the spread shock such that $\sigma_{y,t}^{0,A} > \sigma_{y,t}^{0,B}$ for all t. In other words, for every date t, the distribution of y_t under A is a mean-preserving spread of the distribution under B. Then,

1. For $\phi = 0$ (marginal costs are not correlated with demand), inflation π_0 is invariant to the spread shock: $\pi_0^A = \pi_0^B = 1$.

2. For $\phi > 0$ (marginal costs are positively correlated with demand), up to a second-order approximation $\pi_0^A > \pi_0^B > 1$. In other words, inflation is larger, the larger the uncertainty.

3. For $\phi \in (0, 1]$, the statement in item 2 can be shown without taking an approximation.

Proof. The proof goes through each case one by one.

1. For $\phi = 0$, $Cov(y_j^\phi, y_j) = 0$, so by equation (7), $\pi_0 = 1$.

2. For $\phi > 0$, $Cov(y_j^\phi, y_j) > 0$, so $\pi_0^A > 1$ and $\pi_0^B > 1$.

   Note that:

$$\begin{aligned} Cov_A(y_j^\phi, y_j) &= \int_0^\infty y_j^{1+\phi} dF_A(y_j) - y \int_0^\infty y_j^\phi dF_A(y_j) \\ &\approx \int_0^\infty \left[y^{1+\phi} + (1+\phi) y^\phi (y_j - y) + \tfrac{1}{2}(1+\phi)\phi y^{\phi-1}(y_j - y)^2 \right] dF_A(y_j) \\ &\quad - y \int_0^\infty \left[y^\phi + \phi y^{\phi-1}(y_j - y) + \tfrac{1}{2}\phi(\phi-1) y^{\phi-2}(y_j - y)^2 \right] dF_A(y_j) \\ &= \phi \int_0^\infty (y_j - y)^2 dF_A(y_j) \quad \text{where } y = 1. \\ &= \phi V_A(y_j) \quad \text{where } V() \text{ marks the variance.} \end{aligned}$$

   Now, a mean-preserving spread means $V_A(y_j) > V_B(y_j)$, which establishes the claim.

3. Last, some exact results.

   For $\phi = 1$, we have exactly that $Cov(y_j^\phi, y_j) = V(y_j)$, so π_0 will be larger, the bigger the variance of y_j, which will be the case with a mean-preserving spread.

   For $\phi \in (0, 1)$ the proof proceeds by contradiction. Suppose that $\pi_0^A \leq \pi_0^B$. By (7), this requires $Cov_A(y_j^\phi, y_j) \leq Cov_B(y_j^\phi, y_j)$. This is the same as

$$\int_0^\infty y^{1+\phi} dF_A(y) - y \int_0^\infty y^\phi dF_A(y) \leq \int_0^\infty y^{1+\phi} dF_B(y) - y \int_0^\infty y^\phi dF_B(y),$$

or

$$\underbrace{\int_0^\infty y^{1+\phi} dF_A(y) - \int_0^\infty y^{1+\phi} dF_B(y)}_{(a)} < y \underbrace{\left[\int_0^\infty y^{\phi} dF_A(y) - \int_0^\infty y^{\phi} dF_B(y) \right]}_{(b)}.$$

If A is a mean-preserving spread of B, and $y \sim F_A(y)$, $x \sim F_B(x)$, then one can find some mean-zero distribution $H(z|x)$, such that $y = x + z$, with $z \sim H(z|x)$.

Note that if $\phi \in (0,1)$, $y^{1+\phi}$ is convex on the support of y so

$$\begin{aligned} \int_0^\infty y^{1+\phi} dF_A(y) &= \int_0^\infty \int (x+z)^{1+\phi} dH(z) dF_A(B) \\ &> \int_0^\infty (x + \int z dH(z))^{1+\phi} dF_B(x) = \int_0^\infty x^{1+\phi} dF_B(x), \end{aligned}$$

where the inequality follows from Jensen's inequality. So $(a) > 0$. Also, for $\phi \in (0,1)$ y^ϕ is concave on the support of y, so $(b) < 0$ by Jensen's inequality. This contradicts the assumption $\pi_0^A \leq \pi_0^B$. So, $\pi_0^A > \pi_0^B (> 1)$.

∎

The previous proposition also indicates that the increase in inflation will be bigger, the more steeply marginal costs rise with output (the bigger χ and/or ϕ).

We close this section by noting that our argument is close to that in Kimball (1989). While Kimball emphasizes a precommitment in prices and the effect of the uncertainty level, we focus on the presence of adjustment costs to prices and the effect of changes in uncertainty. Thus, while his mechanism works through convex marginal cost, ours works through the shape of the demand function (in our model, we have constant returns to scale at the firm level and, hence, marginal costs are constant given input prices). Our result also resembles equation (10) in Ball and Romer (1990), although our mechanism is different, since the term W_{211} in their equation is zero in our model. A different take appears in Bachmann and Moscarini (2011), where firms can learn about their demand curves by price experimentation.

H Algorithm for Solving the Model with the ZLB

We now describe the algorithm to implement the ZLB in more detail. First, let us define t_1 and t_2 as the periods when the economy goes into and out of the ZLB, respectively. Further, let X_t denote

the vector containing the states and controls in our model at time t. Let ϵ_t denote the innovations to the shocks in our model at time t. Let

$$\boldsymbol{X}_t = f^{3rd}(\boldsymbol{X}_{t-1}, \boldsymbol{\epsilon}_t) \tag{8}$$

be the law of motion implied by the third-order perturbation described in section 3 of the paper. This law of motion assumes that the ZLB binds neither today nor in the future. We exploit the law of motion (9) to compute $\mathbb{E}[\boldsymbol{X}_t]$, the mean of the ergodic distribution.

Let us assume we want to simulate the economy for T periods. Then, we use the following algorithm:

1. Let the state variables be equal to the mean of the ergodic distribution at $t = 0$, i.e. $\boldsymbol{X}_0 = \mathbb{E}[\boldsymbol{X}_t]$.

2. Choose a sequence of innovations to preference and productivity shocks $\{\boldsymbol{\epsilon}_1, ..., \boldsymbol{\epsilon}_{t_3}\}$ to force the economy to the ZLB at some time $t > 0$. Note that t_3 is the period after which the innovations to preferences and productivity are zero. This period is not necesarily t_2, the period when the economy leaves the ZLB.

3. Use the law of motion (9) to obtain $\boldsymbol{X}_{t+1}$.

4. If the implied nominal interest rates obtained are above zero, let $t = t + 1$ and move to step 10.

5. If the implied nominal interest rates obtained are below zero, set $t_1 = t + 1$ and discard $\boldsymbol{X}_{t+1}$ obtained in step 3.

6. Guess the number of periods at the ZLB (this automatically gives a guess for t_2).

7. Let $\boldsymbol{X}_{t_2+1}$ be as defined by the law of motion (9) and the path of innovations to preference and productivity shocks $\{\boldsymbol{\epsilon}_1, ..., \boldsymbol{\epsilon}_{t_3}\}$.

8. Find $\{\boldsymbol{X}_{t_1}, ..., \boldsymbol{X}_{t_2}\}$ backwards using the non-linear equilibrium conditions and $\boldsymbol{X}_{t_2+1}$ as defined in step 7.

9. If $\{\boldsymbol{X}_{t_1}, ..., \boldsymbol{X}_{t_2+1}\}$ is such that the nominal interest rate is zero for $t_1 \leq t \leq t_2$ and positive for $t = t_2 + 1$; let $t = t_2 + 1$ and move to step 3. Otherwise, go back to step 6.

10. If $t \geq T$, stop. Otherwise, go back to step 3.

11. Repeat steps 1 to 10, adding a fiscal volatility shock of a 2-standard-deviation positive innovation to the volatility of the capital income tax.

12. Compute the non-linear IRFs of the effect of a fiscal volatility shock using the results from steps 1 to 10 and step 11.

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