When are the Effects of Fiscal Policy Uncertainty Large?

Benjamin K. Johannsen*

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Abstract

I argue that fiscal policy uncertainty can have large and adverse effects when the monetary authority is constrained by the zero lower bound on nominal interest rates. Using a new-Keynesian model with endogenous capital accumulation, I show that uncertainty about short-run and long-run fiscal policy can cause large falls in consumption, investment, and output when the zero lower bound binds, but has modest effects when it does not. I study uncertainty about the level of government spending and uncertainty about tax rates on consumption, dividends, wages, profits, capital, and investment. In my model, uncertainty about government spending and the wage tax rate has particularly large effects. I present empirical evidence indicating that shocks to policy uncertainty had larger effects on the U.S. economy during the Great Recession, a period in which the Federal Reserve's policy rate has been at its effective lower bound, than in the preceding years.

*Department of Economics, Northwestern University, Evanston, IL 60208 (E-mail: bkj@u.northwestern.edu). I am deeply grateful to Marty Eichenbaum for his encouragement, guidance, and support. I also thank Larry Christiano, Sergio Rebelo, and Giorgio Primiceri for their advice and support. All errors and shortcomings are of course my own.

1 Introduction

Since the start of the Great Recession, pundits and policy makers have argued that fiscal policy uncertainty has hampered the recovery.[1] In stark contrast, a growing literature finds that an increase in fiscal policy uncertainty has relatively small effects in workhorse macroeconomic models. For example, in the model studied by Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2012b), consumption falls by about 0.1 percent and investment falls by about 1 percent in response to a two standard deviation increase in fiscal policy uncertainty. Born and Pfeifer (2011) report even smaller changes. Given these findings, it has been difficult to rationalize claims that policy uncertainty has hampered the fragile recovery.

In this paper, I argue that fiscal policy uncertainty can have large and adverse effects when the monetary authority is unable to lower the nominal interest rate because of the zero lower bound (ZLB). Allowing the ZLB to bind distinguishes my work from previous studies on the effects of fiscal policy uncertainty. I carry out the analysis in a new-Keynesian model with endogenous capital accumulation and a monetary authority that follows a Taylor rule when it is not constrained by the ZLB. In my model, the fiscal authority purchases government consumption and sets an array of tax rates, including a tax on consumption, labor, profits, dividends, capital, and investment.

I use the model to conduct two main experiments. In the first, as in Eggertsson and Woodford (2003), the economy is put into a recession by a transitory and unexpected shock that causes the household discount factor to rise. This increase in the discount factor leads to a rise in desired saving, which makes the household more willing to work, causing inflation to fall and the monetary authority to lower the nominal interest rate until the ZLB binds. I

[1]See, for example, the International Monetary Fund's World Economic Outlook for October 2012 at `http://www.imf.org/external/pubs/ft/weo/2012/02/pdf/text.pdf`. Also see Chairman Bernanke's press conference on Septermber 13, 2012. `http://www.federalreserve.gov/mediacenter/files/FOMCpresconf20120913.pdf`

define short-run fiscal policy to be the government spending levels and the tax rates that are effective while the household discount factor is elevated. I model an increase in uncertainty about short-run fiscal policy as a mean-preserving spread in the distribution of the fiscal instruments. In this context, I ask the question: what are the effects of an increase in uncertainty about short-run fiscal policy?

I show that an increase in short-run fiscal policy uncertainty causes large and adverse effects on the economy. The driving force behind this result is that the response of the economy to a change in fiscal policy is not symmetric if the ZLB binds. Consider uncertainty about government spending. In my model, as in Eggertsson (2009) and King, Plosser, and Rebelo (1988), a rise in government spending has large effects while the ZLB binds. The reason is that the rise in government spending increases output and reduces the household's desire to save, which leads to higher inflation. Since the nominal interest rate is at the ZLB, the rise in inflation causes the real interest rate to fall, which encourages consumption and investment and, in turn, causes a further increase in inflation. In equilibrium, the initial increase in government spending causes a large increase in output. However, if the expansion of the economy is large enough so that the ZLB no longer binds (or is binding for a shorter period of time), the effects of any further policy changes are small. In contrast, a decrease in government spending reduces demand, putting downward pressure on wages, marginal cost, and inflation. As inflation falls, the real interest rate rises, and households want to invest and consume less. In equilibrium, there is a large contraction in the economy. Unlike the increase in government spending, there is no decline in the marginal effect of a decrease in government spending because the ZLB continues to bind. When faced with a spread in the distribution of short-run fiscal policy instruments, risk-averse household want to insure against the possibility that the economy will contract by a large amount. The desire to work and save rises, which causes inflation to fall. When the ZLB binds, the associated rise in the real interest rate discourages investment and consumption, and the economy contracts.

Naturally, the exact value of the effects of uncertainty about short-run fiscal policy depends on the details and parameterization of the model. However, I show that if the effects of a change in fiscal policy are larger when the ZLB binds than when it does not, then the effects of uncertainty about short-run fiscal policy are also magnified when the ZLB binds. The reason is that the asymmetric response of the economy to a change in fiscal policy when the ZLB binds arises exactly because of the relatively large effects fiscal policy.

I show that the effects of short-run fiscal policy uncertainty are most pronounced when the nominal interest rate is on the cusp of the ZLB. The reason is that any change in fiscal policy that increases the rate of inflation can be offset by the monetary authority raising the nominal interest rate. However, any change in fiscal policy that causes inflation to fall will not be met with a decline in the nominal interest rate because the ZLB will bind. As a result, the effects of uncertainty are greatest when the nominal interest rate is on the cusp of the ZLB. Using my benchmark calibration, the adverse effects of uncertainty on the economy are at least an order of magnitude larger when the ZLB binds than when it does not. When the nominal interest rate is on the cusp of the ZLB, the effects of fiscal policy uncertainty are nearly 50 percent larger than when the ZLB strictly binds. These results give one way to rationalize claims that policy uncertainty is particularly harmful in a fragile recovery.

My second experiment is designed to shed light on the effects of uncertainty about long-run fiscal policy. As in the first experiment, the economy is put into a recession by a preference shock that increases the household discount factor and causes the ZLB to bind. I define long-run fiscal policy to be the levels of government spending and tax rates that are operative after the household discount factor returns to its long-run level. I show that uncertainty about long-run fiscal policy also has large and adverse effects on the economy. The reason is that households are unsure if consumption will be relatively high or low after the ZLB ceases to bind. Risk-averse households desire to insure against the low-consumption outcome by working more and saving more, which causes inflation to fall, increasing the real interest rate and causing the economy to contract. When the ZLB does not bind, the monetary authority is able to offset the precautionary savings motive by adjusting the nominal interest rate, and the effects of uncertainty about long-run fiscal policy are relatively small.

After analyzing the effect of short-run and long-run fiscal policy uncertainty, I extend the analysis by studying implications for fiscal multipliers. I explore the impact of an increase in long-run fiscal policy uncertainty on the efficacy of expansionary short-run fiscal policy. When the ZLB binds, my results imply that an increase, for whatever reason, in the level of uncertainty about long-run fiscal policy has adverse effects. I show that a simultaneous increase in long-run uncertainty diminishes, and can drown out, the effects of expansionary short-run fiscal policy.

Finally, I present empirical evidence that shocks to policy uncertainty have had a relatively large impact on the U.S. economy since the start of the Great Recession. I estimate a vector autoregression (VAR) that includes the policy uncertainty index created by Baker, Bloom, and Davis (2012). In a similar VAR analysis, they argue that policy uncertainty has been an important contributor to the sluggish recovery of the U.S. economy after the Great Recession. I estimate the VAR parameters on a sample of data that ends in 2007 and a sample that runs through 2012. Using the identifying restrictions of Baker et al. (2012), I find that the estimated response of the economy to a shock to policy uncertainty is much larger when the last 4 years of data are included in the dataset. These results are consistent with the predictions of my model since the last 4 years of data are from a period in which the nominal interest rate was at its effective lower bound.

My paper adds to the rapidly growing literature on the effects of fiscal policy uncertainty by explicitly modeling the ZLB. My results give one way to interpret the empirical evidence from Baker et al. (2012) that suggests that fiscal policy uncertainty has been an important force behind the fall in consumption, investment, and output that we have seen during the

Great Recession. In addition, my model is consistent with the relatively small effects reported by Fernández-Villaverde et al. (2012b) and Born and Pfeifer (2011) since both studies do not consider the impact of the ZLB.

A complementary strand of literature examines the effects of expected fiscal consolidation. Work by Denes, Eggertsson, and Gilbukh (2012) shows that the form of a fiscal consolidation can determine the effectiveness of changes in fiscal policy when the ZLB binds. Bi, Leeper, and Leith (2012), show that uncertainty about the timing and form of a fiscal consolidation can have important effects on the economy. My work abstracts away from the mean change in policy that is associated with a fiscal consolidation and address the effects of uncertainty per se. This disentangles the expected change in fiscal policy from the uncertainty about the change.

My analysis is also related to the large literature on fiscal policy when the ZLB binds that builds on the work of Eggertsson and Woodford (2003). Several papers, including Eggertsson (2009), Erceg and Lindé (2010), Mertens and Ravn (2010), Woodford (2011), Correia, Farhi, Nicolini, and Teles (2011), Werning (2011), and Christiano, Eichenbaum, and Rebelo (2011), consider the effects of changes in government spending and changes in tax rates when the ZLB binds. My paper adds to this literature by considering the effects of increases in uncertainty about fiscal policy rather than changes in fiscal policy. This also distinguishes my work from Mendes (2011) and Fernández-Villaverde, Gordon, Guerrón-Quintana, and Rubio-Ramíerez (2012a) who have emphasized the nonlinearities associated with the ZLB in a stochastic environment.

My results are broadly consistent with Nakova (2008) and Nakata (2011), who show that household and firm decision rules are influenced by the calibrated variance of shocks to a greater degree when the ZLB binds than when it does not. I focus on fiscal policy uncertainty, study the effects of a temporary increase in uncertainty at different horizons, and include capital in my model so that investment is possible for households that have a precautionary saving motive. My results are also consistent with contemporaneous work by Basu and Bundick (2012), who find that an increase in uncertainty about the household discount factor has larger effects when the ZLB binds than when it does not. My work instead focuses on fiscal policy uncertainty. This distinction is important because an increase in uncertainty about the household discount factor in the model of Basu and Bundick (2012) has different implications for inflation than an increase in uncertainty about fiscal policy in my model, and changes in the rate of inflation have large effects on the economy when the ZLB binds.

There is now a large literature that models uncertainty by increasing the heterogeneity among firms. Bloom (2009) and Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2012) study increasing the spread of the distribution of idiosyncratic shocks to firm productivity. Christiano, Motto, and Rostagno (2012) also include financial frictions. Bachmann, Elstner, and Sims (Forthcoming) empirically study uncertainty by identifying uncertainty as disagreement among firms. My work does not introduce idiosyncratic risk as fiscal policy uncertainty effects all firms in the same way in my model.

I structure the rest of the paper as follows. I present the model in section 2. In section 3, I discuss the benchmark parameters and my solution method. I study the effects of uncertainty about short-run fiscal policy in section 4. In section 5, I consider the effects of uncertainty about long-run fiscal policy. I analyze the implications of my results on fiscal multipliers in section 6. I provide supporting vector autoregression evidence in section 7 and concluding remarks in section 8.

2 Model Economy

In this section I describe the model that I use to analyze the effects of fiscal policy uncertainty. The model consists of a representative household, competitive final good producers, monopolistically competitive intermediate goods producers, a monetary authority, and a fiscal authority.

2.1 Households

A representative household maximizes lifetime utility, which is given by

$$E_0 \sum_{t=0}^{\infty} \left(\prod_{i=0}^{t} \beta_{i-1} \right) \left\{ \frac{[C_t^{\gamma}(1-H_t)^{1-\gamma}]^{1-\sigma} - 1}{1-\sigma} + v(G_t) \right\}.$$

Where C_t, H_t, and G_t denote time t household consumption, hours worked, and government consumption, and β_i represents the rate at which the household discounts utility over time. I assume that $\beta_{-1} = 1$, $\sigma > 0$, $\gamma \in (0,1)$, and that $v(\cdot)$ is increasing and concave.

The flow budget constraint of the household is given by

$$\begin{aligned} P_t C_t (1+\tau_{C,t}) + B_t + P_t \int_0^1 Q_{j,t} x_{j,t} dj \leq & P_t W_t H_t (1-\tau_{H,t}) \\ & + R_{t-1} B_{t-1} + P_t \int_0^1 [Q_{j,t} + D_{j,t}(1-\tau_{D,t})] x_{j,t-1} dj + P_t T_t \end{aligned}$$

where P_t is the price level, B_t are nominal bonds, W_t is the real wage, and R_t is the gross nominal interest rate. In the economy, there is a continuum of monopolistically competitive intermediate goods producers, indexed by $j \in [0,1]$. The real price of a share of firm j is given by $Q_{j,t}$ and $x_{j,t}$ denotes the number of shares owned by the household. Dividends paid by firm j are denoted by $D_{j,t}$. Finally, $\tau_{C,t}$, $\tau_{H,t}$, $\tau_{D,t}$, and T_t represent the consumption tax rate, the wage tax rate, the dividend tax rate, and real lump sum taxes net transfers, respectively.

2.2 Final Good Firms

Final output, denoted by Y_t, is produced by competitive firms that aggregate intermediate goods, denoted by $Y_{j,t}$. The final goods firms have technology defined by

$$Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$$

where $\epsilon > 1$. The assumptions of perfect competition in final good production and profit maximization yield a demand curve for intermediate goods given by

$$Y_{j,t} = Y_t \left(\frac{P_{j,t}}{P_t} \right)^{-\epsilon}$$

for every j, where $P_{j,t}$ is the price of intermediate good j, and P_t is the price of the final good.

2.3 Intermediate Goods Firms

Intermediate good j, denoted by $Y_{j,t}$ is produced by a monopolist using technology given by

$$Y_{j,t} = A_t K_{j,t}^{\theta} L_{j,t}^{1-\theta}$$

where A_t is the level of aggregate technology, $\theta \in (0, 1)$, $L_{j,t}$ denotes the amount of labor, denominated in of hours, hired by firm j, and $K_{j,t}$ is capital owned by firm j.[2] Capital evolves according to

$$K_{j,t+1} = I_{j,t} + (1 - \delta) K_{j,t}$$

[2] I maintain the assumption that firms own the capital stock so that firms make the investment decisions. The model could be specified in a way so that households own the capital and firms pay a rental rate. However, the taxes paid by the firm would then multiply rental income in ways that are less transparent than the setup in the text of the paper.

where $\delta \in (0,1)$.

Firms face price adjustment costs and capital adjustment costs. In the vein of Rotemberg (1982), the real costs of price adjustment are given by

$$AC_{j,\pi,t} \equiv \frac{\phi_P}{2}\left(\frac{P_{j,t}}{P_{j,t-1}\pi^*}-1\right)^2 Y_t$$

where $\phi_P \geq 0$ and π^* is the level of target price inflation determined by the monetary authority. Capital adjustment costs are given by

$$AC_{j,K,t} \equiv \frac{\phi_K}{2}\left(\frac{K_{j,t+1}}{K_{j,t}}-1\right)^2 K_t$$

where $\phi_K \geq 0$ and K_t is the aggregate level of capital. This adjustment cost specification is similar to the adjustment costs studied by Lucas (1967) and Hayashi (1982).

Intermediate goods firms take W_t and P_t as given and maximize the expected discount value of after-tax dividends to the household, which is given by

$$\begin{aligned} E_t \sum_{\ell=0}^{\infty}\left(\prod_{i=0}^{\ell}\beta_{t+i-1}\right)\lambda_{t+\ell}\Big\{(1-\tau_{P,t+\ell})\Big[&P_{j,t+\ell}Y_{j,t+\ell} - P_{t+\ell}W_{t+\ell}L_{j,t+\ell} - \tau_{K,t+\ell}P_{t+\ell}K_{j,t+\ell} \\ &- P_{t+\ell}AC_{j,\pi,t+\ell} - P_{t+\ell}AC_{j,K,t+\ell}\Big] \\ &+ \tau_{P,t+\ell}\delta P_{t+\ell}K_{j,t+\ell} - (1+\tau_{I,t+\ell})P_{t+\ell}I_{j,t+\ell}\Big\}(1-\tau_{D,t+\ell}). \end{aligned}$$

Here $\tau_{P,t}$, $\tau_{K,t}$, and $\tau_{I,t}$ are profits, capital, and investment tax rates, respectively.[3] Also, λ_t is the value of the Lagrange multiplier on the household budget constraint. Notice that, for tax purposes, capital and price adjustment costs are treated as input costs, like wages. Also, firms are able to write-off capital depreciation as well as the taxes paid on capital when

[3] The tax structure studied here is similar to that of McGrattan (2012). Capital is taxed at the price at which the firm could purchase the capital. Since the purchase of new capital has the same price as the consumption good, the capital stock of the firm is multiplied by the aggregate price level.

determining taxable income for the tax on profits.

2.4 The Monetary Authority

The monetary authority sets the nominal interest rate according to a truncated version of the policy rule studied by Taylor (1993) given by

$$R_t - 1 = \max\left\{0, \frac{\pi^*}{\beta}\left(\frac{\pi_t}{\pi^*}\right)^{\alpha} - 1\right\}$$

where $\pi_t \equiv \frac{P_t}{P_{t-1}}$ is gross inflation, $\pi^* > 0$ is target gross inflation, $\beta < 1$ is the long-run value of the household's rate of discounting over time, and $\alpha > 1$ in order to satisfy the Taylor principle. Notice that this monetary policy rule allows the ZLB to bind.

2.5 The Fiscal Authority

The government consumes G_t, sets lump-sum taxes (transfers) T_t, and sets tax rates

$$\tau_t = \{\tau_{C,t}, \tau_{D,t}, \tau_{H,t}, \tau_{I,t}, \tau_{K,t}, \tau_{P,t}\}.$$

I assume that the government budget constraint is cleared by lump-sum taxes and I specify the stochastic process for the other fiscal instruments in the experiments that follow.

2.6 Equilibrium

The symmetry among firms implies that I can drop the subscript j from equilibrium conditions and specify the equilibrium in terms of aggregate quantities. The economy's resource constraint is given by

$$Y_t = C_t + G_t + I_t + AC_{\pi,t} + AC_{K,t}.$$

An equilibrium is a collection of stochastic processes

$$\{C_t, D_t, G_t, H_t, I_t, K_t, L_t, Q_t, R_t, T_t, W_t, Y_t, \beta_t, \pi_t, \tau_t\}$$

such that given the processes for G_t, T_t, τ_t, and β_t, the household and firm problems are solved, the resource constraint is satisfied, markets clear, and the interest rate is set according to the monetary policy rule.

3 Parameterization and Solution Method

I assume the model is a quarterly model and set $\beta = 0.99$ so that the steady state annual real interest rate is 4 percent. I set $\sigma = 3$ so that households have a precautionary saving motive and I set $\gamma = 0.35$ so that they spend 25 percent of their time endowment working in steady state. I set $\epsilon = 11$, which implies a 10 percent steady state markup. The value of θ is set to 1/3 and δ is set to 0.02.

The price adjustment cost parameter is set to $\phi_\pi = 116$. I chose this value in the following way. The linearized version of my model has a one-to-one mapping with a model that includes Calvo-style sticky prices where only a fraction of firms are allowed to adjust their prices in any given period.[4] I set the parameter ϕ_π to imply that a firm adjusts its price on average once per year in the equivalent linear model with Calvo price stickiness. The capital adjustment cost parameter is set to $\phi_K = 17$ so as to be consistent with Christiano et al. (2011).

I assume that the monetary authority targets a 2 percent steady state rate of annual inflation, so I set $\pi^* = 1.005$, and I set the value of α to 1.5 so as to satisfy the Taylor principle. I calibrate the baseline level of government spending so that it is 20 percent of steady state output, which corresponds to levels observed in later part of the twentieth

[4] See Keen and Wang (2005) for further discussion.

century. Baseline tax rates are chosen to be near their 2007 levels in the United States. Specifically, I set

$$\tau_C = 0.05,\ \tau_D = 0.21,\ \tau_H = 0.30,\ \tau_I = 0.00,\ \tau_K = 0.005,\ \tau_P = 0.39$$

I arrive at these numbers in the following way. To compute the consumption tax rate, I use NIPA data provided by the Bureau of Economic Analysis.[5] I divide sales taxes collected by consumption expenditures to calculate the tax rate. Dividend tax rates and profits tax rates were obtained from the OECD Tax Database.[6] The wage tax is set according to the Barro-Redlick TAXSIM rate.[7] To calculate the capital tax rate, I again use NIPA data. I divide taxes on production and imports (less sales tax) by private fixed assets. I set the investment tax rate to zero as a benchmark.

The ZLB complicates the model solution. I cannot use perturbation methods, which are standard in the new-Keynesian business cycle literature, because they are unable to deal with inequality constraints. Furthermore, my model includes capital so that the precautionary saving motive can potentially be satisfied by an increase in investment. With this endogenous state variable, the model cannot be solved exactly, as in Braun, Korber, and Waki (2012).

The solution method I use follows Coleman (1991). Given policy functions for consumption, investment, and inflation, the equilibrium conditions determine all of the other variables in the model. Three Euler equations are not used when determining the other variables, and those equations define a nonlinear system, Ψ, that must equal zero in expectation. A set of functions for consumption, investment, and inflation that satisfy

$$E\Psi(C, I, \pi) = 0,$$

[5] http://www.bea.gov/

[6] http://www.oecd.org/tax/taxpolicyanalysis/

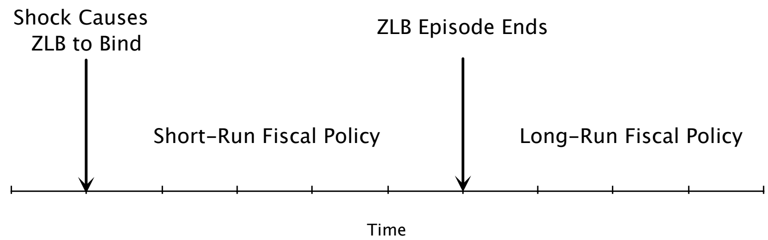
[7] http://users.nber.org/~taxsim/barro-redlick/

constitute an equilibrium. In my model, the household discount factor and the fiscal policy instruments are random, and expectations are taken with respect to their distribution. I solve for unknown policy functions by conjecturing a set of decision rules that will be operative in the next period and then solve for the current values of consumption, investment, and inflation that satisfy Ψ. If these new policy functions are the same as the conjectured policy functions, I have an equilibrium. If not, I continue iterating on the system Ψ by updating the next period's policy functions with the current period policy functions. When the policy functions have converged, I have found an equilibrium. I present the details of my solution method in appendix C.

4 Uncertainty about Short-Run Fiscal Policy

In this section I use the model to study the effects of increasing uncertainty about short-run fiscal policy. At time zero, the economy is in its non-stochastic steady state and $\beta_0 = \beta$. At time 1, an unexpected shock causes $\beta_1 \geq \beta$. After period 1, with probability p, β_t will remain at the value β_1 and with complementary probability β_t will return to its long-run value, β, forever. This shock to β_t is similar to the shock considered in Eggertsson and Woodford (2003). I assume that the government can change the value of its fiscal policy instruments in period 2 if β_t has not returned to its long-run value. If a change in policy takes place, the short-run values of the fiscal instruments persist until β_t returns to its long-run level. Figure 1 shows the timeline of events.

Figure 1: Timeline



I abstract away from the effects of a mean change in fiscal policy in period 2 in order to isolate the effects of uncertainty per se. Thus, I consider distribution over the fiscal instruments in period 2 that is a mean preserving around the period 1 levels. To simplify the analysis and make clear the effects of the spread in the distribution, I allow the support of the distribution to have three points that are equally spaced. That is, for an uncertain tax rate τ_i, I assume that

$$\tau_{i,2} = \begin{cases} \tau_{i,1} + \Delta & \text{with probability } \frac{1}{3} \\ \tau_{i,1} & \text{with probability } \frac{1}{3} \\ \tau_{i,1} - \Delta & \text{with probability } \frac{1}{3} \end{cases}$$

Similarly, when government spending is allowed to be stochastic, its distribution is given by

$$G_2 = \begin{cases} G_1 + \Delta & \text{with probability } \frac{1}{3} \\ G_1 & \text{with probability } \frac{1}{3} \\ G_1 - \Delta & \text{with probability } \frac{1}{3} \end{cases}$$

Any change to fiscal policy in period 2 persists until β_t has returned to its long-run value, at which point fiscal policy returns to its period-one form. I study the effects on the economy as Δ increases. In order to isolate the effects of uncertainty about each fiscal instrument, I allow only one to be uncertain at a time.

I focus on uncertainty about short-run fiscal policy by abstracting away from the way that tax rates or spending might change in the future as a result. If I were to specify a fiscal rule that determines what happens to spending and tax rates as debt and deficits change, the effects of uncertainty about a short-run change in fiscal policy would be influenced by that rule. Though a change in fiscal policy will alter government revenue or expenditure, I assume that lump-sum taxes clear the government budget constraint in order to best isolate the effects of uncertainty per se.

It is worth reviewing the effect of the shock to β_t without any fiscal policy uncertainty. When β_1 is larger than β, households experience an increased desire to save, which makes them more willing to work and causes inflation to fall. In response, the monetary authority lowers the nominal interest rate. Once the ZLB binds, a further decline in inflation leads to an increase in the real interest rate, meaning investment falls and the household's desire to save rises even more. Relatively large declines in output and consumption are required in order to make desired saving equal to investment. When β_t returns to its long-run value, households want to consume more in the present and are less willing to work, which increases marginal cost, causes inflation to rise, and prompts the monetary authority to set the nominal interest rate above zero.

I set the probability that β_t returns to its long-run value to $p = 0.75$ in order to reflect the idea that the shock to β_t is somewhat long-lasting. In this case, it has an expected duration of 4 quarters. I consider two elevated values of β_1 that I denote $\bar{\beta}$ and $\bar{\bar{\beta}}$. I set the value of $\bar{\beta}$ so that the nominal interest rate is on the cusp of the ZLB. That is, without any fiscal policy uncertainty the monetary authority would like to set the interest rate exactly to zero, even if it were not constrained by the ZLB. I calibrate $\bar{\bar{\beta}}$ so that the ZLB strictly binds and consumption falls by 5 percent in the period of the shock, which represents a relatively deep recession. I also study the case in which $\beta_1 = \beta$ but fiscal policy might change as in the other experiments. This scenario is used for comparison as the case when the monetary authority is free to change the nominal interest rate. Note that $\beta < \bar{\beta} < \bar{\bar{\beta}}$.

4.1 Uncertain Government Spending

Consider first uncertainty about government spending. Figure 2 shows the percentage difference in consumption, investment, prices, and hours worked for different values of Δ as compared with the case that $\Delta = 0$. I consider values of Δ between 0 and 5 percent of steady state GDP. The solid line displays the case when $\beta_1 = \beta$ and the monetary authority is unconstrained by the ZLB. As in Fernández-Villaverde et al. (2012b) and Born and Pfeifer (2011), macroeconomic aggregates move by relatively small amounts. The results are strikingly different when $\beta_1 = \bar{\bar{\beta}}$ and the ZLB binds. As shown by the dashed lines in figure 2, as Δ increases, the economy contracts by a relatively large amount. For example, when Δ is equal to 5 percent of GDP, consumption is 4 percent lower than in the case when $\Delta = 0$.

The driving force behind these large and adverse effects when the ZLB binds is that the response of the economy to a change in government spending is not symmetric. In my model, as in Eggertsson (2009), when the ZLB binds an increase in government spending is initially very expansionary. The reason is that it encourages households to spend today rather than save for the next period, which makes prices rise and causes the real interest rate fall since the nominal interest rate is stuck at zero. As the real interest rate falls, investment, consumption, and output rise. After the ZLB no longer binds, the effects of a further increase in government spending are relatively small because the monetary authority is able to offset the fall in the real interest rate. This decline in the marginal effect of government spending has been documented Erceg and Lindé (2010). For a decrease in government spending, there is no similar decline in the marginal effect of the policy change. Thus, for a large enough spread in the distribution of G_2, there is the potential for a dramatically larger contraction of the economy than the possible expansion due to the change in fiscal policy. In period 1, households want to work more and save more in order to insure against low government spending in period 2. However, the precautionary saving and increased willingness to work causes inflation to fall in period 1, which raises the real interest rate since the ZLB binds. The rise in the real interest rate causes consumption and investment to fall. Thus, the potentially large contraction in the economy in period 2 has adverse effects in period 1. The asymmetry in the response of the economy grows larger as the spread in government spending grows, which means the the effects on macroeconomic aggregates in period 1 also grow and Δ increases. This can be seen in figure 2 by the larger declines in consumption, investment, prices, and hours worked associated with larger values of Δ.

The dashed-dotted line in figure 2 shows the effects of uncertainty when $\beta_1 = \bar{\beta}$, which is the case in which the nominal interest rate is on the cusp of the ZLB. Notice that the economy contracts by even more than in the case when $\beta_1 = \bar{\bar{\beta}}$ as Δ increases. The reason is that the monetary authority can raise the nominal interest in response to an increase in government spending, just as it would when $\beta_1 = \beta$, meaning that any increase in government spending has small effects. However, the inability of the monetary authority to decrease the nominal interest rate means that even a small decrease in government spending causes the ZLB to strictly bind. When the ZLB binds, the fall in inflation causes the real interest rate to rise, which causes large declines in investment, consumption, and hours worked. Thus, when the nominal interest rate is on the cusp of the ZLB, households face a situation where the asymmetry in the response of the economy to a change in government spending is largest. As before, households want to insure against the low-spending state by working more and saving more in period 1. The exaggerated asymmetry causes even larger declines in consumption, investment, prices, and hours worked.

4.2 Uncertain Tax Rates

When considering uncertainty about short-run tax rates instead of uncertainty about government spending, the asymmetric response of the economy when the ZLB binds has a similar counterpart. A change in any tax rate will cause inflation to rise in one direction and fall in the other. If inflation rises enough in response to the change in the tax rate, the ZLB will cease to bind and the monetary authority will raise the nominal interest rate, which will offset some of the effects of the change in the tax rate. In the other direction, there is no similar decrease in the marginal effect. Thus, for a large enough spread in the distribution of a short-run tax rate, the economy will have an asymmetric response. This asymmetry is most pronounced exactly when the nominal interest rate is at the cusp of the ZLB, meaning the effects on macroeconomic aggregates are largest in this situation.

Consider uncertainty about the short-run investment tax rate. Figure 6 shows the percentage change in consumption, investment, prices, and hours worked as a function of Δ for each value of β_1 as compared to the case when $\Delta = 0$. A decrease in the investment tax rate, which here amounts to a subsidy, increases the expected return on investment and causes the economy to expand by increasing demand for investment. This expansion requires more labor input, which drives up wages and prices. Conversely, an increase in the investment tax rate depresses demand by decreasing investment. The low demand requires fewer hours, wages decline, and inflation falls. When $\beta_1 = \beta$, the monetary authority is able to offset these changes by adjusting the nominal interest rate. As shown by the black solid line, the effect of an increase in Δ are small in this case. However, when the ZLB binds ($\beta_1 = \bar{\bar{\beta}}$), the monetary authority is unable to adjust the nominal interest rate. For a large enough value of Δ, the previously discussed asymmetry in the response of the economy to a change in the tax rate causes households to insure against the relatively large contraction in the economy associated with an increase in the investment tax rate in period 2. This makes them to want to work more and save more in period 1, which puts downward pressure on inflation and causes the economy to contract.

The dashed line in figure 6 shows the effects of increasing Δ when the ZLB binds. For large values of Δ, the economy contracts noticeably. For small values of Δ, the economy experiences a relatively small expansion. There are two reasons that the economy expands in response to small amounts of uncertainty. First, the firm's pricing decision leads to an upward pricing bias, as has been discussed by Fernández-Villaverde et al. (2012b). The rise in inflation lowers the real interest rate, which causes the economy to expand. Second, in my model price adjustment costs are not linear. When inflation is below the monetary authority's target rate, a given increase in inflation changes price adjustment costs by a smaller amount than a similarly sized decrease in inflation. Thus, the upward pressure on prices from an investment tax decrease is able to initially cause a larger rise in inflation than the fall in inflation caused downward pressure on prices associated with a rise in the investment tax rate. For large enough values of Δ, this effect is dominated by the asymmetry arising from the ZLB. While the nonlinearity in price adjustment costs was present when considering uncertainty about government spending, the large asymmetry caused by the ZLB quickly masked its effects. A similarly small expansion is observed with small amounts of uncertainty about the other short-run tax rates. The reasons for the expansion are the same. Notice in figure 6 that when the nominal interest rate is at the cusp of the ZLB ($\beta_1 = \bar{\beta}$) the effects of increasing Δ are largest and most detrimental, because, as previously discussed, the asymmetric response of the economy is largest in this case.

The effects of uncertainty about short-run capital and profits tax rates are shown in figures 7 and 8. Changes in short-run tax rates on profits and capital have effects similar to changes in the short-run investment tax rate. In each case, a decrease in the short-run tax rate increases the return on investment, which increases demand, marginal cost, and inflation. An increase in the short-run tax rate has the opposite effect. Notice in figures 7 and 8 that the effects of uncertainty about short-run capital and profits tax rates are smaller than the effects of uncertainty about the investment tax rate. The reason is that the majority of the life of installed capital from investment while the ZLB binds will be after tax rates return to their long-run levels. This means that the average profits and capital tax rates over the lifetime of the capital is not much effected by a short-run change. The rate of return on newly installed capital is more directly influenced by a change in the cost of investment meaning that the firm's investment decision is more heavily influenced by a change in the short-run investment tax rate. Since the potential effects on the economy due to a change in the short-run capital and profits tax rates are smaller than the effects due to a change in the short-run investment tax rate, the adverse effects of uncertainty are also smaller.

The effects of uncertainty about the short-run dividend tax rate are show in figure 4. Temporarily raising the short-run dividend tax rate encourages firms to invest after-tax profits rather than return them to the household, which increases demand for investment. At the same time, the households recognize that they will have relatively more income in the future and their desire to save falls, which reduces their desire to work and increases inflation. When the ZLB binds, the rise in inflation causes the real interest rate to fall, which expands the economy. If the ZLB does not bind, the monetary authority raises the nominal interest rate in response to the rise in inflation, which reduces the effects of the change in the tax rate. A decrease in the dividend tax rate encourages firms to disperse profits to the household rather than invest. The household's desire to work and save increases since current income is relatively high, causing inflation to fall. If the ZLB does not bind, the monetary authority lowers the nominal interest rate to encourage consumption. If the ZLB binds, the fall in inflation increases the real interest rate and the economy contracts. Uncertainty about the short-run dividend tax rate causes a contraction in the economy in period 1 because of the previously discussed asymmetric response of the economy to a large enough potential increase or decrease in the tax rate.

The effects of uncertainty about the consumption and wage tax rates are shown in figures 3 and 5. In both cases, an increase in the tax rate causes households to shift hours from labor to leisure. The decreased desire to work increases marginal costs and inflation rises. A decrease in the short-run tax rates has the opposite effect. The previously discussed asymmetric response of the economy to large enough increases or decrease in the tax rates causes uncertainty to have adverse effects in period 1. Uncertainty about the short-run wage tax rate has larger effects than uncertainty about the short-run consumption tax rate because in the intra-temporal Euler equation of the household, the ratio $(1-\tau_{H,t})/(1+\tau_{C,t})$ appears. In the benchmark calibration of the tax rates, a 1 percentage point change in the wage tax rate has a larger effect on this ratio than a 1 percentage point change in the consumption tax rate.

4.3 Sensitivity Analysis

Though the exact value of the effects of fiscal policy uncertainty depends on the details and parameterization of the model, my main results are robust to a number of perturbations. I have studied versions of the model with different values of the adjustment cost parameters, ϕ_π and ϕ_K. For each adjustment cost parameter, changing the value in such a way that the effects of fiscal policy are larger when the zero bound binds also increases the relative effects of fiscal policy uncertainty.

When I increase price adjustment costs, inflation becomes less responsive to changes in fiscal policy. Since inflation is less responsive, the asymmetric response of the economy to a change in short-run fiscal policy is also smaller. This reduces the magnitude of the effects of short-run fiscal policy uncertainty. Thus, increasing price adjustment costs reduces the magnitude of the effects of short-run fiscal policy when the ZLB binds. However, it remains true that the effects are much larger when the ZLB binds since increasing price adjustment costs also decreases the effects of short-run fiscal policy uncertainty when the ZLB does not bind. If I lower price adjustment costs, the response of the economy to a change in fiscal policy is larger. This increases the asymmetric response of the economy to a change in short-run fiscal policy when the ZLB binds, which magnifies the effects of uncertainty about short-run fiscal policy. Hence, decreasing price adjustment costs increases the relative magnitude of the effects of short-run fiscal policy when the ZLB binds as compared to when it does not.

When I increase capital adjustment costs, investment demand becomes less sensitive to changes in fiscal policy, which reduces the magnitude of the effects of short-run fiscal policy uncertainty. However, even with very large costs to capital adjustment, the effects of short-run fiscal policy uncertainty are an order of magnitude larger when the ZLB binds than when it does not. The reason is that the increased desire to save on the part of the household causes inflation to fall, which increase the real interest rate, and discourages consumption. If I decrease capital adjustment costs, investment demand becomes more sensitive to changes in the real interest rate. When investment demand is relatively more responsive, changes in short-run fiscal policy cause larger changes in output. Thus, decreasing capital adjustment costs increases the asymmetric response of the economy to a change in short-run fiscal policy when the ZLB binds, making uncertainty about short-run fiscal policy have larger effects. This magnifies the relative effects of short-run fiscal policy uncertainty when the ZLB binds as compared to when it does not.

I have also experimented with different levels of household risk aversion.[8] Raising σ increases the household's precautionary saving motive and fiscal policy uncertainty causes a larger fall in inflation due to curvature of the utility function. Decreasing σ reduces the precautionary saving motive of the household. However, my results about short-run fiscal policy uncertainty are driven by the asymmetric response of the economy to a change in fiscal policy when the ZLB binds, not curvature of the utility function. Thus, the adverse effects of short-run fiscal policy remain large when the ZLB binds as compared to when it does not.

[8] In my benchmark parameterization, $\sigma = 3$. I have experimented with values of $\sigma = 1$ and $\sigma = 5$.

5 Uncertainty About Long-Run Fiscal Policy

In this section I study the effects of uncertainty about long-run fiscal policy. As in the previous section, at time 0 the economy is in steady state and at time 1 an unexpected shock causes $\beta_1 \geq \beta$. In each period β_t will remain at this value with probability 0.75. Once β_t returns to its long-run level, it remains at that value permanently. I consider the same values of β_1 that were studied in the previous section. At time 1, households and firms learn that once β_t returns to its long-run value the fiscal authority might make a permanent change to either government spending or tax rates. As in the previous section, I consider uncertainty about each of the fiscal instruments separately. In order to study the effects of uncertainty per se, I again use a three-point distribution for the values of the fiscal instruments when a change might happen that takes the form of a mean-preserving spread around the time 1 values. I again denote the spread in the distribution by Δ and allow one fiscal instrument to be uncertain at a time. The timeline of events can be seen in figure 1. Notice that no policy change can occurs until β_t returns to its long-run value.

5.1 Uncertain Government Spending

When government spending is uncertain, the level of private consumption after β_t returns to its long-run value is also uncertain. Households want to insure against the low-consumption outcome and are more willing to work and save, which drives down wages, marginal cost, and inflation. As Δ increases, the desire to save grows larger due to the curvature of the utility function, and inflation falls even more.[9] When $\beta_1 = \beta$ and the ZLB is not binding, the monetary authority responds by lowering the nominal interest rate to encourage consumption and investment. The solid black lines in figure 9 plot the percentage change in consumption, investment, prices, and hours worked at time 1 as a function of the spread in the distribution

[9] Any upward pricing bias is dominated by the desire to of households to save when considering a permanent change to long-run government spending in my model.

of long run government spending, Δ, when compared to the case when $\Delta = 0$. Notice that consumption and prices fall slightly and investment rises modestly as Δ increases.

When $\beta_1 = \bar{\bar{\beta}}$, the monetary authority is not able to lower the nominal interest rate in response to the fall in prices because the ZLB binds. Thus, the real interest rate rises as inflation falls. This rise in the real interest rate encourages households to forego consumption in the current period and discourages investment, leading to a decline in output. Since the uncertainty facing households persists for the entire time during which $\beta_t = \beta_1$, the contraction in the economy is compounded as forward looking agents expect consumption to be low and the real interest rate to be high for as long as the ZLB binds. The resulting contraction in the economy in period 1 can be seen in the dashed lines in figure 9. Notice that the movements in macroeconomic aggregates are an order of magnitude larger than in the case when the monetary authority is free to lower the nominal interest rate.

The dashed-dotted line in figure 9 represents the case when the interest rate is on the cusp of the ZLB. That is, when $\beta_1 = \bar{\beta}$. Here, too, uncertainty about the long-run level of government spending causes a contraction in the economy. However, in this case, the decline is even larger. The difference is due to the nonlinear (quadratic) costs of price adjustment. When inflation is near the monetary authority's target rate, a decline in inflation has relatively low costs compared to the case when inflation is relatively far away from the target rate. Thus, because inflation is higher when the interest rate is on the cusp of the ZLB than when the ZLB strictly binds, when $\beta_1 = \bar{\beta}$ the downward pressure on prices causes a larger increase in the real interest rate than when $\beta_1 = \bar{\bar{\beta}}$.[10] This larger increase in the real interest rate exacerbates the contraction in the economy.

[10]This result is similar to the finding in Erceg and Lindé (2010) that more price flexibility magnifies the effects of an increase in government spending. The intuition is similar: for any given increase in government spending, the real interest rate falls by are larger amount when the economy has greater price flexibility, thus encouraging consumption and investment in the current period. It is related to the point made by De Long and Summers (1986).

5.2 Uncertain Tax Rates

Uncertainty about long-run consumption tax rates, wage tax rates, investment tax rates, and capital tax rates has a similar effect on the economy as uncertainty about the long-run level of government spending, as can be seen in figures 10, 12, 13, and 14. For each of these taxes, the reasons for the contraction in the economy as Δ increase are the same as for the case of uncertainty about government spending. That is, the uncertainty causes agents to want to work and save more, which drives down prices. When the ZLB binds, this increases the real interest rate and leads to a contraction in the economy. When the ZLB does not bind, the monetary authority is able to offset the fall in prices and the effects on the economy are small. The contraction in the economy is largest when the nominal interest rate is on the cusp of the ZLB, and again the reason is that the costs of price adjustment are lower at this point than if the zero bound is strictly binding. Thus, when the nominal interest rate is at the cusp of the ZLB, the downward pressure on prices from the uncertainty about long-run tax rates causes a relatively large rise in the real interest rate. The larger change in the real interest rate causes the larger contraction of the economy.

Figure 11 shows that uncertainty about long-run dividend tax rates has no effect on the economy while $\beta_t = \beta_1$. The reason is that the entire firm problem is multiplied by the dividend tax rate, meaning that only the ratio of the dividend tax rate from one period to the next is important for determining decision rules. After a permanent change in the dividend tax rate, this ratio is one, which renders the decision rules of households and firms identical for any dividend tax rate. Since the decision rules of households and firms are identical for each possible realization of the long-run dividend tax rate, and since the expected change in the dividend tax is zero, there is no effect on the economy while $\beta_t = \beta_1$. A model in which heterogenous agents trade shares in the firm may well draw different conclusions since there could be interplay between the dividend tax and the capital gains tax.

Figure 15 shows the effects of increasing Δ when the long-run profits tax is uncertain.

Unlike the other fiscal instruments studied in this paper, uncertainty about the long-run profits tax is slightly expansionary. If the long-run profits tax turns out to be high, firms are relatively willing to pay price and capital adjustment costs after the change in tax policy. If the long-run profits tax turns out to be low, firms would prefer to have a high capital stock and return profits to the households in the form of dividends. Hence, when faced with uncertainty about long-run profits taxes, firms raise prices and increase investment. As can be seen by the black solid line in figure 15, when $\beta_1 = \beta$, the effects are relatively small because the monetary authority can offset the uptick in inflation by raising the nominal interest rate. The dashed line shows that the increase in the price level is expansionary when the ZLB binds because the real interest rate falls as inflation picks up, which encourages households to invest and consume. The expansion in the economy is muted when the nominal interest rate is at the cusp of the ZLB because the monetary authority can increase the nominal interest rate in order to offset the increase in inflation. In this case, the effects of increasing Δ are larger than if $\beta_1 = \beta$ because the monetary authority is accommodating inflation returning to its target value.

5.3 Sensitivity Analysis

As was the case for uncertainty about short-run fiscal policy, the exact magnitude of the effects of uncertainty about long-run fiscal policy is determined by the parameters of the model. Here I discuss the robustness of my main finding that the effects of uncertainty about long-run fiscal policy are magnified when the ZLB binds.

When I increase price adjustment costs, inflation becomes less responsive to changes in fiscal policy. This reduces the magnitude of the effects of long-run fiscal policy uncertainty when the ZLB binds because the real interest rate rises by less in response to the same amount of uncertainty. However, it remains true that the effects are much larger when the ZLB binds than when it does not. The reason is that effects of uncertainty have a smaller magnitude in both cases. When I decrease price adjustment costs, the same amount of long-run fiscal policy uncertainty causes a larger fall in inflation. When the ZLB does not bind, the monetary authority lowers the nominal interest rate and the effects of long-run fiscal policy uncertainty remain small. Since the monetary authority cannot lower the nominal interest rate when the ZLB binds, the effects of long-run fiscal policy uncertainty are larger when price adjustment costs are lower. This increases the magnitude of the difference between the effects of fiscal policy uncertainty when the ZLB binds and when it does not.

When I decrease capital adjustment costs, investment demand becomes more sensitive to changes in the real interest rate. When the ZLB binds, the fall in inflation due to long-run fiscal policy uncertainty causes investment to fall by more. When the ZLB does not bind, the monetary authority offsets the fall in inflation caused by long-run fiscal policy uncertainty, meaning that investment does not change by much. In this way, decreasing capital adjustment costs increases the relative effect of long-run fiscal policy uncertainty. If I increasing capital adjustment costs, investment demand becomes less sensitive to changes in the real interest rate, which reduces the effects of long-run fiscal policy uncertainty when the ZLB binds. However, the effects of fiscal policy uncertainty remain much larger when the ZLB binds than when it does not. The reason is that the relatively high real interest rate continues to encourage households to forego consumption in order to save, which decreases demand and causes the economy to contract.

My results about long-run uncertainty are driven by the precautionary saving motive from curvature in the utility function. This means that the exact value of σ matters more in determining the magnitude of the effects of long-run fiscal policy uncertainty than it did for short-run fiscal policy uncertainty. In my benchmark parameterization I set $\sigma = 3$. As I decrease σ, the adverse effects of long-run fiscal policy uncertainty also decrease because the household has less of a precautionary saving motive. However, it remains true that the effects of fiscal policy uncertainty are much larger when the ZLB binds than when it does not.

The reason is that the real interest rate rises for any fall in inflation due to the precautionary saving motive when the ZLB binds, however the real interest rate falls when inflation falls and the monetary authority is able to lower the real interest rate.[11] Increasing σ increases the precautionary saving motive and magnifies the effects of fiscal policy uncertainty when the ZLB binds. The reason is that the uncertainty causes an increased desire to save, which causes inflation to fall by more. When the ZLB binds, the monetary authority cannot offset the fall in inflation, meaning the economy contracts by a relatively large amount. This increases the magnitude of the effects of long-run fiscal policy uncertainty when the ZLB binds as compared to when it does not.

6 Implications for Fiscal Multipliers

A large literature that studies the effectiveness of fiscal policy at stabilizing the economy finds that the effects of government spending are large when the ZLB binds. My model shares this feature. In light of my results about the large effects of fiscal policy uncertainty, a natural question is: what is the effect of long-run uncertainty on the government spending multiplier when the ZLB binds?

In particular, it is plausible that, for whatever reason, a decision to change government policy while the ZLB binds causes long-run uncertainty to rise. This may be due to budgetary or political reasons that are not captured by my model. However, I am able to investigate the effect that the simultaneous increase in long-run uncertainty will have on the multiplier. To do this, I consider an economy that experiences a shock that that causes $\beta_1 = \bar{\bar{\beta}}$. I compute the change in output due to a 1 percent increase in government spending when the ZLB binds and there is no long-run fiscal policy uncertainty. I assume that the change in government spending persists until β_t returns to its long-run value. I compare the change in

[11] Of course, in the case of uncertainty about long-run profits taxes, the results are not much changed since uncertainty causes inflation.

output in this scenario to the change in output due to a 1 percent increase in government spending when the ZLB binds that also induces uncertainty about long-run wage tax rates. Again, I assume that the wage tax rate might stay the same or go up or down by Δ, all with equal probability. Figure 17 shows that small amounts of uncertainty about long-run wage tax rates have small effects. However, if larger amounts of uncertainty arise because of the increase in government spending, the multiplier can be significantly reduced or even negative. This result could be anticipated from figure 12 since larger amounts of uncertainty are associated with larger contractions in the economy.

7 VAR Evidence

Since 2008, the Federal Reserve's policy rate has been at its effective lower bound. My model implies that the effects of uncertainty would have been particularly large during this time period. In order to explore this implication empirically, I analyze the estimated effects of policy uncertainty in a VAR. The statistical model takes the form

$$y_t = Cx_t + B(L)y_{t-1} + \Sigma\epsilon_t$$

where y_t is a realization vector of the time-series of interest at time t, x_t is an exogenous but known process, B is a polynomial in the lag operator, Σ is a square matrix, and ϵ_t is a vector of independent standard-normal random variables.

For my analysis, the vector y_t contains the policy uncertainty index from Baker et al. (2012), the federal funds rate, total employment, industrial production, the consumer price index, and real consumption.[12] The federal funds rate and the consumer price index are included to allow the real interest rate to be a determining factor in the evolution of other

[12] I use data from FRED, `http://research.stlouisfed.org/fred2`. The federal funds rate is FEDFUNDS. Employment is PAYEMS. Industrial production is INDPRO. The consumer price index is CPIAUCSL. Real consumption is PCE divided by CPIAUCSL.

macroeconomic time series. I include employment, industrial production, and consumption in order to study the response of time series in my economic model. The data are of a monthly frequency and I take the natural logarithm of every variable except the federal funds rate. Following Baker et al. (2012), I include a constant and a linear time trend in x_t. Using a flat prior over the parameters, I calculate the posterior distribution of the coefficients over two sample periods. The first sample period is from January of 1985 through December of 2007. The starting period is picked as the beginning of the data from Baker et al. (2012). The ending period is picked to exclude the time period during which the ZLB has been binding. The second sample period includes data up through July of 2012, which is the date of the most recent update of the policy uncertainty index.

Following Baker et al. (2012), I include 6 lags in the VAR and I identify a policy uncertainty shock by ordering the policy uncertainty index first in y_t and using a Cholesky decomposition of the estimated covariance matrix. Figure 16 shows the median impulse response and one standard-error bands to an uncertainty shock of size 1 for posteriors that consider the two sample periods of data. I normalize the size of the shock to the uncertainty index to be 1 in order to study the relative response of the economy to a similar increase in policy uncertainty. Since the impulse response functions are linear in $\Sigma\epsilon_t$, the magnitude of the shock is unimportant and I focus on the relative impulse response functions.

While draws from the posterior distribution using data through 2007 imply that policy uncertainty shocks cause a contraction in the economy, when the data from 2008 through 2012 are included the contraction is larger. Notably, the median impulse responses of consumption, industrial production, and employment from the posterior distribution using data through 2012 are below the one standard error bands from the 2007 posterior. Moreover, there are periods in which the one standard error bands of the 2007 and 2012 posterior distributions do not overlap for the responses of consumption and industrial production. Taken together, these results imply that the data from 2008 through 2012 are particularly informative for the shape of the impulse response functions and that the response of the economy to an increase in policy uncertainty has been heightened during this period. This amplification of the response of the economy to a policy uncertainty shock is consistent with the conclusions drawn from the economic model studied in this paper.

8 Conclusion

In this paper, I argued that fiscal policy uncertainty can have large and adverse effects when the ZLB binds. Using a new-Keynesian model with endogenous capital accumulation, I confirm the findings of past studies and show that the effects of fiscal policy uncertainty are small when the monetary authority is not constrained by the ZLB. In addition, I showed that uncertainty about both short-run and long-run fiscal policy can cause a large contraction in the economy. Finally, I offered VAR evidence that implies that shocks to policy uncertainty have had a particularly large effect on the U.S. economy over the past four years, which is consistent with the implications of my model.

These findings have important implications for government policy when the ZLB binds. Studies like Eggertsson (2009) and Christiano et al. (2011) advocate raising government spending in response to an episode in which the ZLB binds. My results imply that the effects of such a policy action will in part be determined by the level of fiscal policy uncertainty. Moreover, my findings suggest that clarity in the future path of fiscal policy is at a premium when the ZLB binds. Correia et al. (2011) have argued that with a flexible enough tax policy, the detrimental effects on the economy associated with the ZLB can be avoided. However, my results imply that uncertainty about the willingness or ability of the fiscal authority to implement the correct path of policy may mean that prices and allocations differ drastically from their desired levels.

It seems clear that the fiscal policy response to the Great Recession in the U.S. and abroad has been far from optimal and at times erratic. The subsequent uncertainty about both short-run and long-run fiscal policy could have further depressed economies across the globe. Quantifying the effects of fiscal policy uncertainty during the Great Recession remains an important topic for future research.

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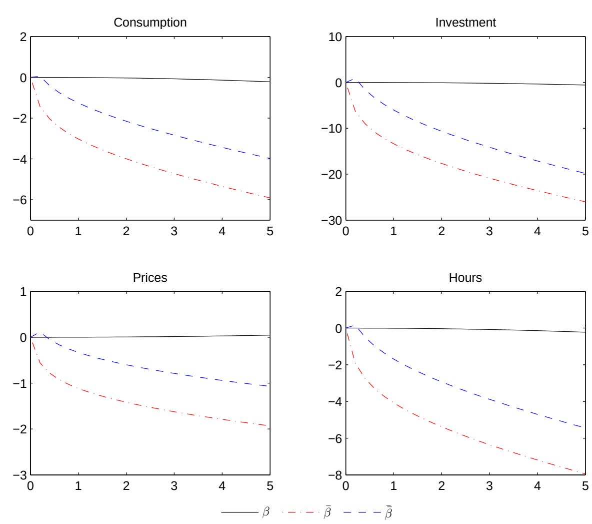
A Figures

A.1 Uncertain Short-Run Fiscal Policy

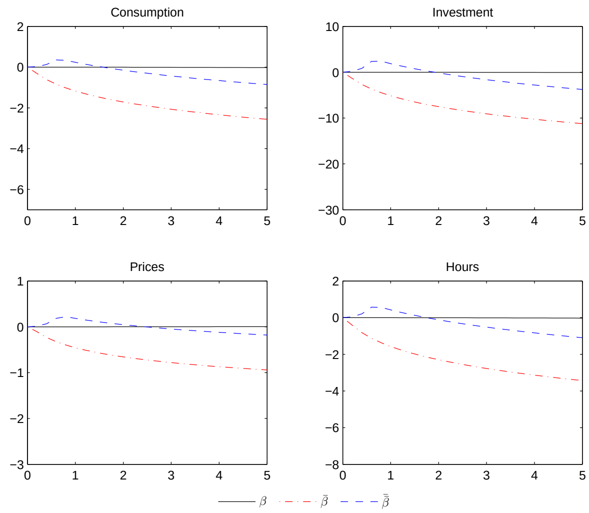
Here I present the figures associated with the uncertainty about a transitory policy response to a change in β_t. The solid line represents no change in the time discounting of the household, $\beta_1 = \beta$. The dashed line represent a shock so that $\beta_1 = \bar{\bar{\beta}}$. With no further uncertainty, consumption initially falls by 5 percent in response to the shock and the ZLB binds. The dashed-dotted line represent a shock so that $\beta_1 = \bar{\beta}$. With no further uncertainty, the economy is put on the cusp of the ZLB.

Figure 2: Uncertain Government Spending



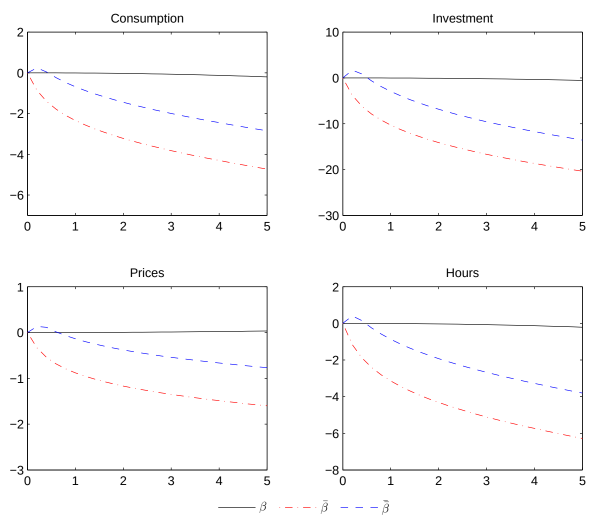
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage of steady state GDP. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 3: Uncertain Consumption Tax Rate



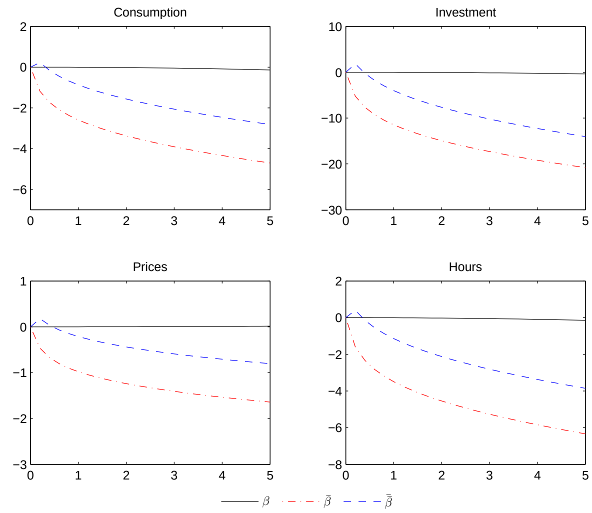
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 4: Uncertain Dividend Tax Rate



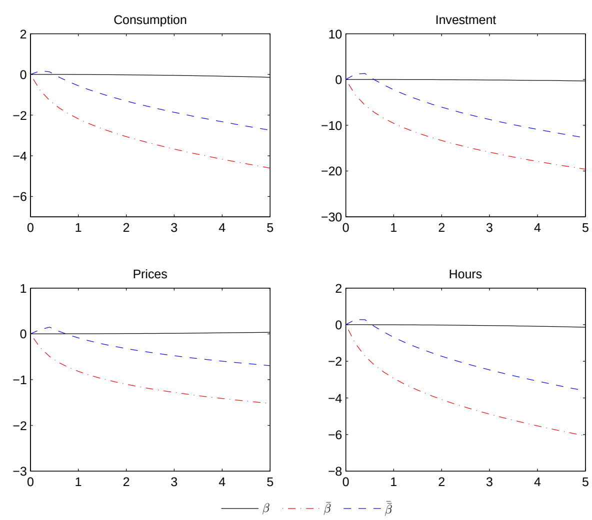
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 5: Uncertain Wage Tax Rate



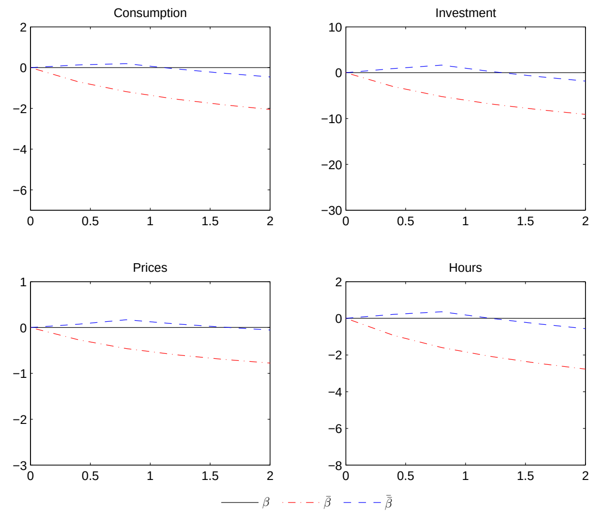
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 6: Uncertain Investment Tax Rate



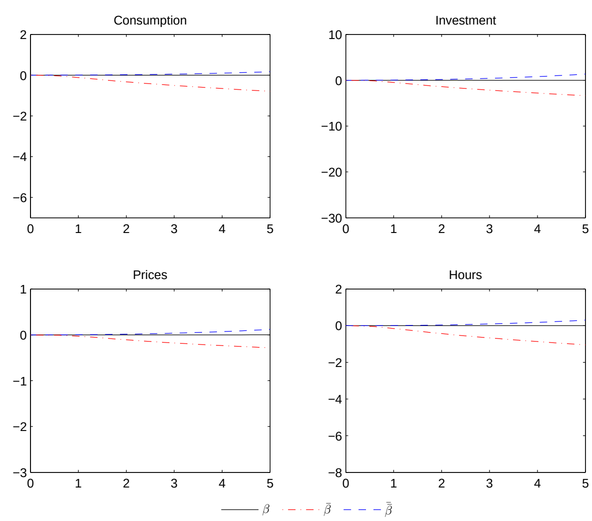
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 7: Uncertain Capital Tax Rate



The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 8: Uncertain Profits Tax Rate

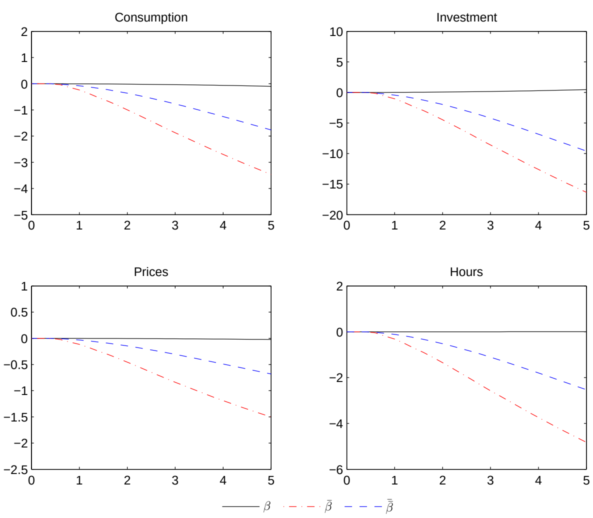


The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

A.2 Uncertain Long-Run Fiscal Policy

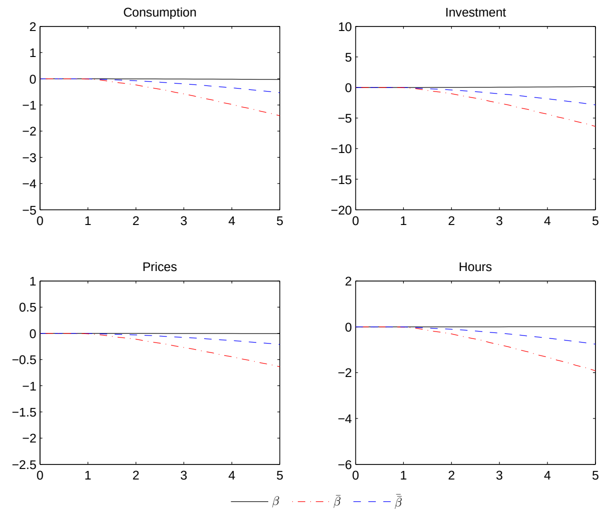
Here I present the figures associated with the uncertainty about policy after β_t returns to its long-run value. The lines in the figures represent different values of $\tilde{\beta}$. The solid line represents no change in the time discounting of the household, $\beta_1 = \beta$. The dashed line represent a shock so that $\beta_1 = \bar{\bar{\beta}}$. With no further uncertainty, consumption initially falls by 5 percent in response to the shock and the ZLB binds. The dashed-dotted line represent a shock so that $\beta_1 = \bar{\beta}$. With no further uncertainty, the economy is put on the cusp of the ZLB.

Figure 9: Uncertain Government Spending



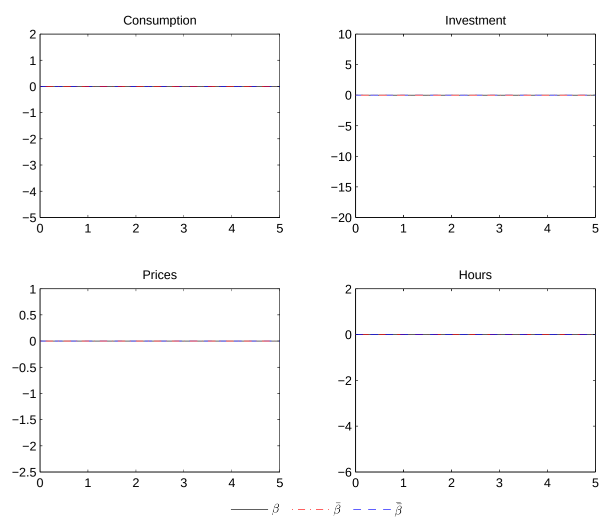
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage of steady state GDP. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 10: Uncertain Consumption Tax Rate



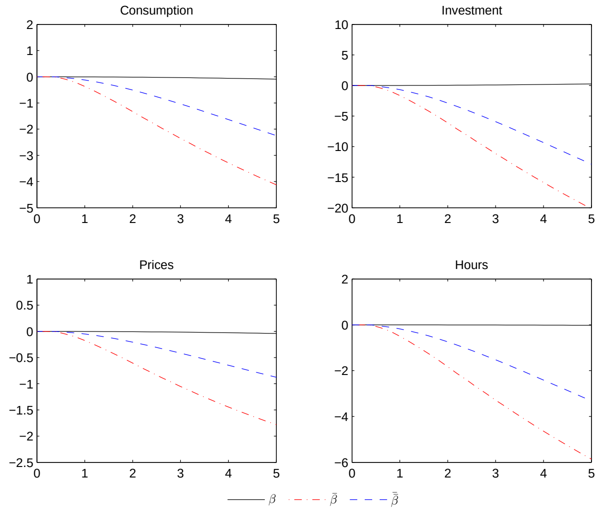
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 11: Uncertain Dividend Tax Rate



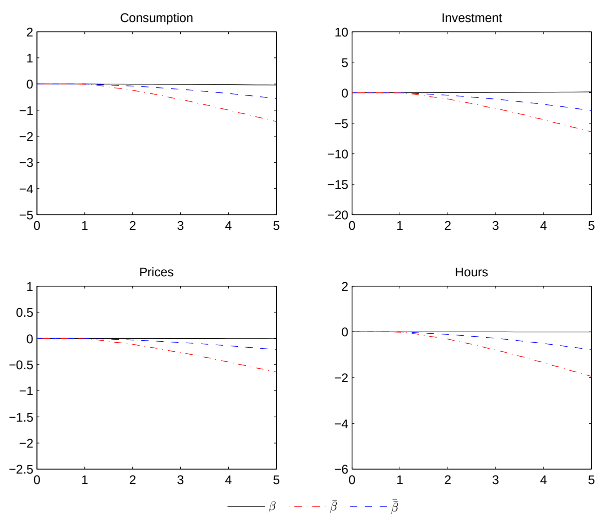
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 12: Uncertain Wage Tax Rate



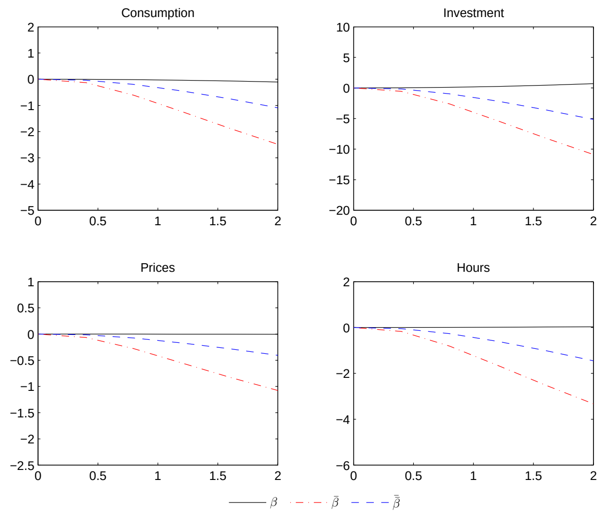
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 13: Uncertain Investment Tax Rate



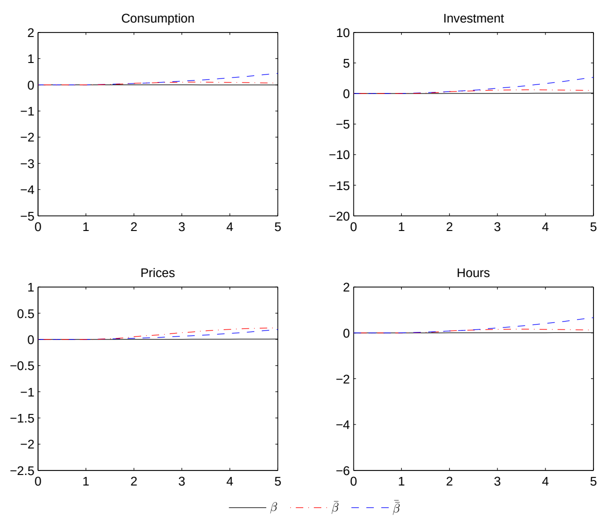
The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

Figure 14: Uncertain Capital Tax Rate



The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

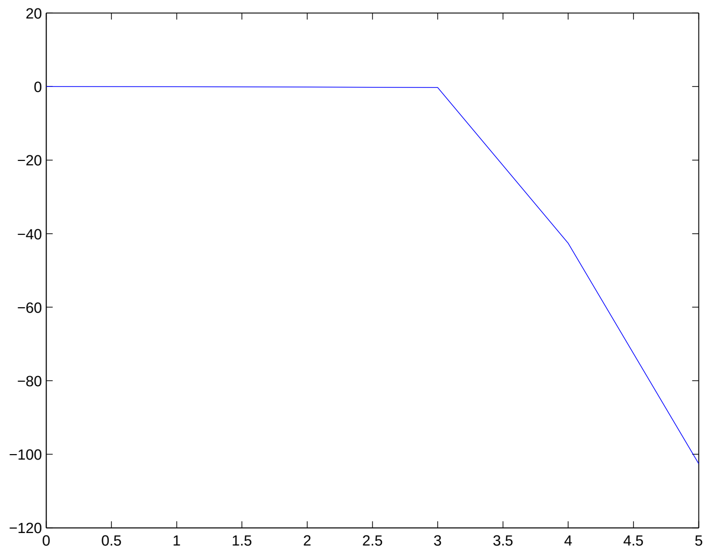
Figure 15: Uncertain Profits Tax Rate



The horizontal axis is the spread in the distribution, Δ, expressed as a percentage point. The vertical axis is the percent change due to the spread in the distribution as compared to the case when $\Delta = 0$.

A.3 Implications for the Multiplier

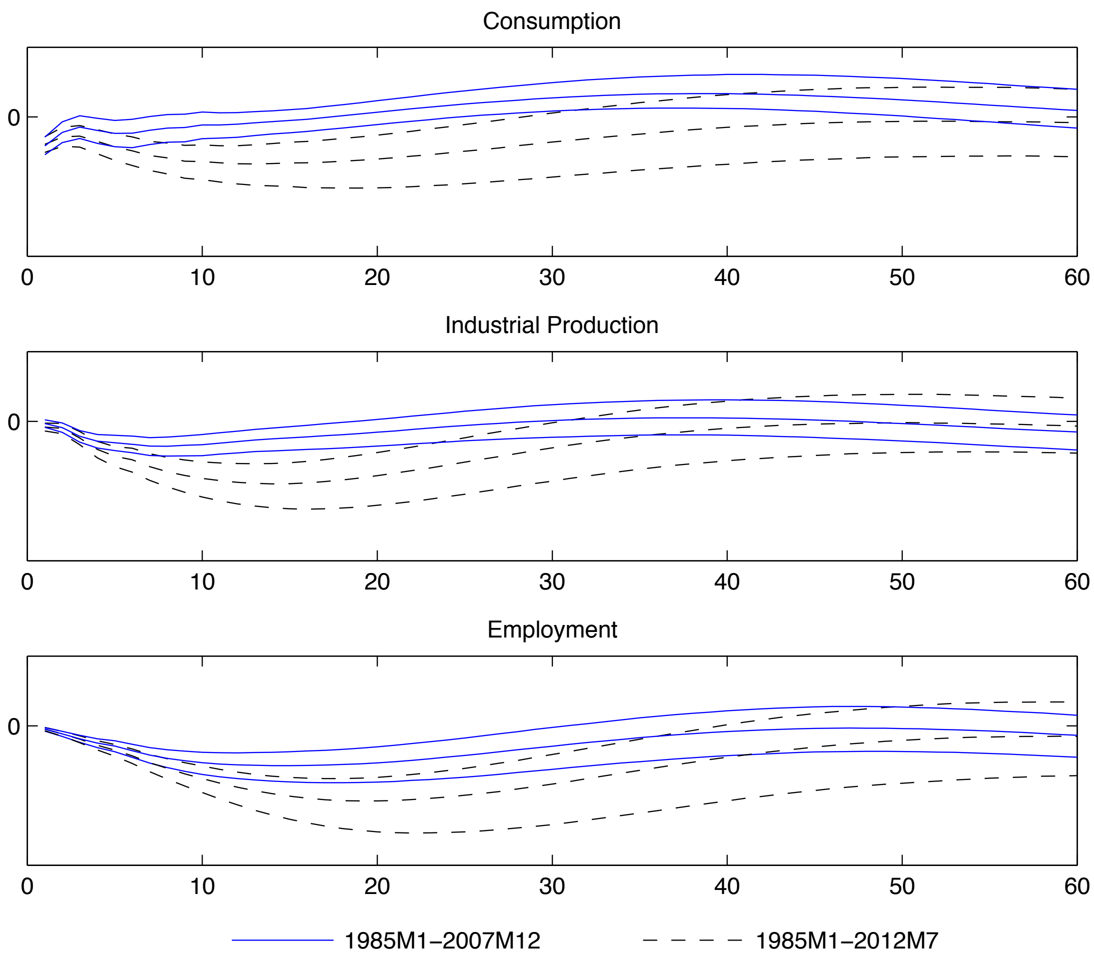
Figure 16: Percent Change in the Government Spending Multiplier



Note: The horizontal axis is the spread in the distribution of the long-run value of τ_H, Δ. The vertical axis is the percentage change in the government spending multiplier when compared to the case when $\Delta = 0$.

A.4 VAR Results

Figure 17: Impulse Response Functions to a Policy Uncertainty Shock



Note: The horizontal axis is in months. The three lines of each line type represent the median and one-standard-error bands of the posterior distribution of the impulse response function under a flat prior on the VAR coefficients. The posterior distribution of the impulse response function is formed using 10,000 draws from the posterior distribution of the VAR parameters.

B Equilibrium Conditions

Household optimality requires that

$$\begin{aligned}
\frac{1}{R_t} =& \beta_t E_t \left\{ \frac{C_{t+1}^{\gamma(1-\sigma)-1}(1-H_{t+1})^{(1-\gamma)(1-\sigma)}(1+\tau_{C,t})}{C_t^{\gamma(1-\sigma)-1}(1-H_t)^{(1-\gamma)(1-\sigma)}\pi_{t+1}(1+\tau_{C,t+1})} \right\} \\
C_t =& \frac{W_t(1-\tau_{H,t})}{1+\tau_{C,t}} \frac{\gamma}{1-\gamma}(1-H_t)
\end{aligned}$$

Final good firm optimality implies that

$$Y_{j,t} = Y_t \left(\frac{P_{j,t}}{P_t} \right)^{-\epsilon}$$

and that $P_t = P_{j,t}$ when $P_{j,t} = P_{i,t}$ for all j and i. Intermediate goods firms take wages, the aggregate price level, and the demand curve for their product as given. I assume that $K_0 = K_{j,0}$ for all j. Furthermore, $P_0 = P_{j,0}$ for all j. The symmetric nature of the intermediate firm problem implies that $P_t = P_{j,t}$ and $K_t = K_{j,t}$ for all t and all j. This means that I can drop the j subscripts in the first-order conditions. The optimality condition for the pricing decision is given by

$$\begin{aligned}
\lambda_t \left\{ (1-\tau_{P,t})Y_t \left[(1-\epsilon) + \frac{\epsilon}{1-\theta} W_t \left(\frac{Y_t}{K_t} \right)^{\frac{\theta}{1-\theta}} - \phi \left(\frac{\pi_t}{\pi^*} - 1 \right) \frac{\pi_t}{\pi^*} \right] \right\} (1-\tau_{D,t}) \\
+ E_t \beta_t \lambda_{t+1} \pi_{t+1} (1-\tau_{P,t+1}) \phi \left(\frac{\pi_{t+1}}{\pi^*} - 1 \right) \frac{\pi_{t+1}}{\pi^*} Y_{t+1} (1-\tau_{D,t+1}) = 0.
\end{aligned}$$

The optimality condition for investment is given by

$$
\begin{aligned}
0 = & -\lambda_t(1-\tau_{D,t})\left[(1+\tau_{I,t}) + \phi_K\left(\frac{K_{t+1}}{K_t}-1\right)(1-\tau_{P,t})\right] \\
& + E_t\beta_t\lambda_{t+1}\pi_{t+1}\Bigg\{(1-\tau_{P,t+1})\Big[\frac{\theta}{1-\theta}W_{t+1}\left(\frac{Y_{t+1}}{K_{t+1}}\right)^{\frac{1}{1-\theta}} - \tau_{K,t+1} + \phi_K\left(\frac{K_{t+2}}{K_{t+1}}-1\right)\frac{K_{t+2}}{K_{t+1}}\Big] \\
& + \tau_{P,t+1}\delta + (1+\tau_{I,t+1})(1-\delta)\Bigg\}(1-\tau_{D,t+1}).
\end{aligned}
$$

Capital evolves according to

$$K_{t+1} = I_t + (1-\delta)K_t$$

The resource constraint and market clearing require that

$$
\begin{aligned}
Y_t &= C_t + G_t + I_t + AC_{\pi,t} + AC_{K,t} \\
Y_t &= Y_{j,t} = K_{j,t}^{\theta}L_{j,t}^{1-\theta} \\
H_t &= L_t = L_{j,t}
\end{aligned}
$$

Finally, the interest rate satisfies the monetary policy rule

$$R_t - 1 = \max\left\{0, \frac{\pi^*}{\beta}\left(\frac{\pi_t}{\pi^*}\right)^{\alpha} - 1\right\}$$

C Solution Method

The solution method I use involves time iteration on the Euler equations that define the equilibrium. The method is outlined in chapter 17 of Judd (1998). It has been implemented in Coleman (1991) as well as in Bi et al. (2012), among others.

Consider a constant set of tax rates, τ, and government spending, G, and set $\beta_t = \beta$

forever. Nothing is random in the model and the only state variable is capital. Assume that we have equilibrium, consumption, investment, and inflation as a function of the capital stock. From the resource constraint we can recover output, which also gives us hours worked. The nominal interest rate can be computed from the monetary policy equation and the wage rate can be computed from the intra-temporal Euler equation of the household. Profits and dividends can then be computed from their definitions and asset prices are set to clear asset markets. Three equilibrium conditions remain unused: the two first-order optimality conditions of the intermediate goods firms and the inter-temporal Euler equation from the household. These three equations define a set of nonlinear equations, Ψ, so that

$$\Psi(K, C(K), I(K), \pi(K)) = 0.$$

A set of function $C(\cdot)$, $I(\cdot)$, and $\pi(\cdot)$ that satisfy these conditions constitute an equilibrium. If we conjecture a set of such function for the following period and call them $\{C^+(\cdot), I^+(\cdot), \pi^+(\cdot)\}$ we can read the equilibrium conditions instead as a set of restrictions on on functions for the current period, denoted $\{C(\cdot), I(\cdot), \pi(\cdot)\}$. That is, equilibrium requires that

$$\Psi(K, C(K), I(K), \pi(K), C^+(K), I^+(K), \pi^+(K)) = 0.$$

Conditional on the capital stock, the above restrictions require simply the solution to a system of nonlinear equations to determine the values $\{C(K), I(K), \pi(K)\}$. We can then set $\{C^+(\cdot), I^+(\cdot), \pi^+(\cdot)\} = \{C(\cdot), I(\cdot), \pi(\cdot)\}$ and check to see if the functions have changed. If they are unchanged, we have an equilibrium. If they have changed, we can continue to iterate in this fashion.

To make the procedure operational, I define an equally spaced grid of 311 points over the interval $[\log(0.75K_{ss}), \log(1.25K_{ss})]$, where K_{ss} is the non-stochastic steady state level of capital of the baseline parameterization of the model. I specify the function C, I, and π to be piece-wise linear functions, where the value of the function at a grid point is a parameter and the value of the function between two grid points is a linear interpolation between them. The number of grid points was chosen as what seemed like a reasonable trade-off between accuracy and computational time. I have experimented with 1000 grid points and the extra grid-points do not effect the conclusions of the paper in a noticeable way. To determine if the functions have converged, I check to see if the values of the functions at any each grid point have changed by more than 1×10^{-6}.

Given the above method for solving the model with constant fiscal instruments, a same methodology can be adapted the experiments I consider in the body of the paper. I first compute the decision rules for each possible value of the fiscal instruments after β_t has returned to its long-run value. I then set $\beta_1 \geq \beta$, fix a set of values for the fiscal instruments for the period in which $\beta_t = \beta_1$, and conjecture decision rules for the remainder of the time that $\beta_t = \beta_1$. If β_t returns to its long run value, I have the decision rules in hand as well as the probability distribution over the fiscal instruments that define each decision rule. With some probability β_t remains at β_1, and the conjectured decision rule will be operative. In the case that β_t does not return to its long-run level, the situation facing agents is the same as it was the period before, so I can use the Euler equations to iterate on the decision rules as before. In this way, I am able to solve for the functions $\{C(\cdot), I(\cdot), \pi(\cdot)\}$ while $\beta_t = \beta_1$, conditional on a set of values for the fiscal instruments, the probability that β_t will remain at this level, and a distribution over fiscal instruments after β_t returns to its long-run value. When I consider uncertainty about policy during the period in which $\beta_t = \beta_1$, I compute the decision rules for each possible set of values for the fiscal instruments and then solve the set of nonlinear equations that define the equilibrium conditions in the period before the potential change in policy.