Redistribution and Fiscal Uncertainty Shocks

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Abstract

This paper revisits the macroeconomic impact of an uncertainty shock about fiscal policy in a New Keynesian framework. Motivated by the observation that many fiscal policies are redistributive and that many U.S. households do not own capital, I introduce household heterogeneity in the form of limited capital market participation. I show that household heterogeneity significantly magnifies the aggregate effect and restores co-movement of macroeconomic variables in a contraction that is generated by a fiscal uncertainty shock. This is because the heterogeneous household model captures individual uncertainty about redistribution that cancels out in representative agent models. Importantly, the impact of fiscal uncertainty shocks becomes larger as wealth becomes more concentrated.

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1 Introduction

A popular view among policymakers and business economists is that changes in uncertainty about fiscal policy are important factors in explaining postwar macroeconomic fluctuations, including the slow recovery from the Great Recession since 2009. A recent work by Baker et al. (2016) confirms this view. They construct new indexes of policy uncertainty using newspaper coverage and find that uncertainty about fiscal policy and economic policy in general have increased substantially over the post-Great Recession period. Using vector autoregressive (VAR) models, they show that innovations to policy uncertainty are associated with a sizable decline in industrial production and employment.

A structural investigation of the above hypothesis, in contrast, has been relatively mixed. For example, using a representative-agent New Keynesian framework, Fernández-Villaverde et al. (2015) find sizable adverse effects of fiscal uncertainty shocks on economic activity while Born and Pfeifer (2014) find relatively small impact. In this paper, I revisit their findings and show that, once household heterogeneities are introduced, fiscal uncertainty shocks have much larger contractionary effects that are consistent with co-movement.

This paper is motivated by the observation that many fiscal policies are redistributive. I call a fiscal policy redistributive when there are winners and losers in a sense that the policy makes some agents strictly worse off while other agents are strictly better off. For example, raising capital income tax might harm those who have capital income but households who do not hold capital may be better off because they may receive more transfers due to the increased government revenue. To investigate the aggregate implications of this redistributive nature of fiscal policies, I introduce household heterogeneities in a parsimonious manner by considering limited capital market participation in the spirit of Galí et al. (2007). In contrast to standard models where the representative household hold capital stocks, I assume that a subset of population does not participate in the capital market. This is a natural assumption, since we know from studies such as Mankiw and Zeldes (1991) and Vissing-Jørgensen (2002) that only a subset of U.S. households hold stocks and their behavior is considerably different from that of households who do not hold stocks. I call those who participate in the capital market “capital holders” and those who do not “non-capital holders”. The standard representative agent assumption can be obtained as a special case when the share of non-capital holders is zero.

I assume that agents have recursive multiple prior preferences and perceive uncertainty as not only as risk but also as ambiguity (Knightian uncertainty). Under this preference representation, agents lack confidence in assigning probabilities to relevant events and act as if they evaluate plans according to the worst-case scenario drawn from a set of multiple beliefs. An increase in the set of beliefs implies a loss of confidence. In this paper, I focus on confidence about future fiscal policies: government spending, capital and labor income taxes, and consumption taxes. Here the loss of confidence could be triggered, for example, due to political disputes or lingering possibility of a war. The belief sets are parameterized by intervals of conditional means about their innovations. A fiscal

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1The multiple prior utility was axiomatized by Gilboa and Schmeidler (1989). Epstein and Schneider (2003) introduce a recursive version that is consistent with dynamic optimization.
uncertainty shock means an increase in the width of the intervals.

The two features — household heterogeneity in the form of limited capital market participation and (Knightian) uncertainty shocks about fiscal policy — are embedded into the standard New Keynesian business cycle framework of Christiano et al. (2005). Government spending, capital and labor income taxes, and consumption tax follow exogenous AR(1) processes and government bonds and lump-sum transfers adjust to satisfy the government budget constraint. Using the quantitative model, I study the impulse responses to fiscal uncertainty shocks and compare them to those from the representative agent model. I find that the model magnifies the impact and generates co-movement of macroeconomic variables in response to fiscal uncertainty shocks compared to the representative agent model.

I illustrate the mechanism by using a capital income tax example. First, consider the representative-agent model. An increase in uncertainty about the capital tax rate increases the width of the set of the conditional mean for the one-period-ahead capital tax and thus the representative household act as if future capital tax rates are higher. Due to lower after-tax return on capital, households reduce their investment. In contrast, consumption increases because it becomes cheap relative to investment. Low investment reduces the household’s incentive to supply labor. The increase in consumption, however, counteracts this by mitigating the decline in overall aggregate demand and thus equilibrium employment and output decline mildly.

Next, consider a model with limited capital market participation. The key feature of the limited capital market participation model is that the worst-case scenario is heterogeneous. Capital holders fear higher future capital tax rate. Non-capital holders, in contrast, act as if future capital tax is lower. Lower capital tax makes non-capital holders worse off since, assuming transfers are equally distributed across households, lump-sum transfers are lower (lump-sum taxes are higher) because of lower government revenue. As a result of this (perceived) negative income effect, non-capital holders reduce their consumption. Capital holders also reduce their consumption because they also perceive a negative income effect; their disposable income is lower because of higher capital income tax and the loss of income due to the higher tax is not offset because some of the transfer goes to non-capital holders. Because both capital holders and non-capital holders reduce consumption, aggregate demand declines and hence markups increase due to sticky prices. The increase in markups leads to lower wages and labor and as a result output falls significantly. To sum up, in the heterogeneous household model, both capital holders and non-capital holders perceive negative income effect; in other words, they both act as if they are losers. In other words, the heterogeneous household model captures individual uncertainty about redistribution that is canceled out in the representative agent model. This is why an uncertainty about capital income tax that is redistributive generates a sizable fall in output, investment, consumption, and hours.

Similar results hold for other redistributional fiscal policies such as consumption tax. In my model, capital holders tend to be more wealthy and hence consume more. An increase in uncertainty about consumption tax causes capital holders to act as if future consumption tax is higher. Non-capital
holders, in contrast, act as if consumption tax is lower because on net, lower tax makes them worse off due to lower lump-sum transfer. As in the case of an uncertainty shock of the capital income tax, the perceived negative income effect on both capital holders and non-capital holders magnifies the negative effect of an uncertainty shock on economic activity.

This amplification due to heterogeneity is minor for fiscal uncertainty shocks that are not redistributive. This is in sharp contrast to the implication of zero-lower-bound, where both first-moment fiscal shocks and fiscal uncertainty shocks have larger effects, irrespective of whether they are redistributive or not.\textsuperscript{2} Consider, for example, an increase in uncertainty about labor income tax. In my model, labor income tax is not redistributive because both types of households earn relatively similar wages and work similar amount of hours. Thus, in response to an increase in uncertainty, both capital holders and non-capital holders act as if future labor income tax is higher. As a result, in (worst-case) expectation, the general equilibrium effect of a redistribution, i.e., the government budget constraint, kicks in: the increased tax is rebated back to households as a lump-sum transfer. Because of this general equilibrium effect, uncertainty shocks about fiscal policy that is not redistributive have similar contractionary effects in both representative-agent and heterogeneous-agent models.

1.1 Relation to the Literature

This paper is related to three strands of literature. As mentioned above, this paper is most closely related to Fernández-Villaverde et al. (2015) and Born and Pfeifer (2014). Both papers study the effects of fiscal uncertainty shocks using a representative-agent New Keynesian model. I introduce limited capital market participation and show that household heterogeneity has important implications for aggregate outcomes. To the best of my knowledge, Bachmann et al. (2015) is the only paper that studies the interaction of household heterogeneity and fiscal uncertainty. Their focus is different from that in this paper. They use an incomplete-market real business cycle model a lá Krusell and Smith (1998) to study the welfare and distributional consequences of permanently eliminating fiscal uncertainty. My goal is to investigate the short-run impact of changes in fiscal uncertainty on macroeconomic variables. More broadly, this paper is part of a rapidly-growing literature that are interested in how other types of uncertainty shocks affect macroeconomic fluctuations. Examples in this literature include Bloom (2009), Fernández-Villaverde et al. (2011), Basu and Bundick (2017), Arellano et al. (2012), Bachmann and Bayer (2013), and Christiano et al. (2014).

I also relate to the emerging literature on Knightian uncertainty and business cycles. For example, Ilut and Schneider (2014) show that Knightian uncertainty shocks to aggregate TFP can explain a substantial fraction of aggregate fluctuations. For other applications, see Bianchi et al. (2017) and Ilut and Saijo (2016). Methodologically, I build on the work by Ilut et al. (2016), who develop an algorithm to solve linear, dynamic, heterogeneous agent models with Knightian uncertainty and study

\textsuperscript{2}See Fernández-Villaverde et al. (2015) and Johannsen (2014) for analyses of fiscal uncertainty shocks under the zero lower bound.
the properties of a borrower-lender model. I apply their method to a New Keynesian environment with heterogeneous households who are ambiguity averse.

In this paper, I introduce household heterogeneity to a New Keynesian environment by considering limited asset market participation in the tradition of Galí et al. (2007). Bilbiie (2008), Broer et al. (2016), Saijo (2016), Walsh (2016) and others use the framework to study the transmission mechanism of various aggregate shocks. This paper characterizes the impact of fiscal uncertainty shocks in a setting with limited capital market participation.

2 Model

To evaluate the impact of fiscal uncertainty shocks, I study a New Keynesian business cycle model in the tradition of Christiano et al. (2005) and Smets and Wouters (2007). The framework is a natural environment for my quantitative analysis since it has now become the foundation of applied research in both academic and government institutions. I introduce two additional features. First, households are ambiguity averse as in Ilut and Schneider (2014) and face Knightian uncertainty about fiscal policies. Second, I assume limited capital market participation in the spirit of Galí et al. (2007). This allows me to consider meaningful heterogeneity on the household side in a parsimonious way. In the following, letters without a time subscript refer to steady-state values and letters with hats to log-deviations from the steady states.

2.1 Households

There are a unit mass of ambiguity-averse households. A fraction $1 - \chi$ of households have access to capital markets. I call them capital holders (and hence the superscript “c”). The rest of the $\chi$ fraction of households do not hold capital. I call them non-capital holders (and hence the superscript “n”). The standard representative agent model obtains when $\chi = 0$.

Capital holders have recursive multiple priors utility (Epstein and Schneider 2003). Collect the exogenous state variables in a vector $s_t \in S$. A household consumption plan $C^c_t$ gives, for every history $s^t$, the consumption of the final good $C^c_t(s^t)$ and the amount of hours worked $H^c_t(s^t)$. For a given consumption plan $C^c_t$, utility is defined recursively by

$$U^c_t(C^c_t; s^t) = \ln(C^c_t - bC^c_{t-1}) - \frac{(H^c_t)^{1+\phi}}{1+\phi} + \beta \min_{p \in \mathcal{P}_t(s^t)} E_p[U^c_{t+1}(C^c_t; s^t, s_{t+1})],$$

where $b$ is the consumption habit, $\phi$ is the inverse of Frisch labor supply elasticity and $\beta$ is the subjective discount factor. $\mathcal{P}_t(s^t)$ is a set of conditional probabilities about next period’s state $s_{t+1} \in S_{t+1}$. Agents evaluate plans under the conditional probability $p$ that minimizes continuation utility, subject to the constraint that $p$ is contained in the set $\mathcal{P}_t(s^t)$.

$^3$The model reduces to the standard rational expectations model when $\mathcal{P}_t(s^t)$ is a singleton.
that agents are less confident in probability assessments, perhaps because she has poor information about future states.

Capital holders maximize their utility subject to the budget constraint:

\[(1 + \tau_{c,t}) P_t C_t^c + P_t I_t^c + B_t^c \leq (1 - \tau_{h,t}) P_t W_{i,t} H_{i,t}^c + (1 - \tau_{k,t}) P_t R_t^k K_{i,t-1}^c + P_t \tau_{k,t} \delta K_{i,t-1}^c + R_{i,t-1} B_{i,t-1}^c + Q_{i,t}^c + D_t^c + P_t T_t^c, \tag{2}\]

and the capital accumulation equation:

\[K_t^c = (1 - \delta) K_{t-1}^c + \left\{ 1 - \frac{\kappa}{2} \left( \frac{I_t^c}{I_{t-1}^c} - \gamma \right)^2 \right\} I_t^c, \tag{3}\]

where \(P_t\) is the price level, \(I_t^c\) is investment, \(B_t^c\) is the nominal bond holding, \(W_t\) is the real wage, \(R_t^k\) is the real rental rate of capital, \(R_t\) is the nominal interest rate, \(D_t\) are dividends from intermediate firms, and \(T_t^c\) is a lump-sum transfer (or tax if it takes a negative value). I assume that households buy securities, whose payoff \(Q_t^c\) is contingent on whether they can re-optimize their wage.\(^4\) \(\tau_{c,t}, \tau_{h,t},\) and \(\tau_{k,t}\) are the consumption, labor, and capital income tax rates, respectively. I incorporate depreciation allowances, where \(\delta\) is the depreciation rate. I assume an investment adjustment cost where \(\kappa > 0\) is a parameter that controls the size of the adjustment cost and \(\gamma\) is the rate of deterministic labor-augmenting technology growth.

Non-capital holders also have recursive multiple priors utility:

\[U^n_t(C^n; s^t) = \ln(C^n_t - b C^n_{t-1}) - \frac{(H^n_{i,t})^{1+\phi}}{1+\phi} + \beta \min_{p \in P_t(s^t)} E^p[U^{n+1}_t(C^n; s^t, s_{t+1})], \tag{4}\]

and their budget constraint is

\[(1 + \tau_{c,t}) P_t C_t^n + B_t^n \leq (1 - \tau_{h,t}) P_t W_{i,t} H_{i,t}^n + R_{i,t-1} B_{i,t-1}^n + Q_{i,t}^n + P_t T_t^n - \frac{v}{2} \left( \frac{B_t^n}{P_t Y_t} \right)^2 P_t Y_t. \tag{5}\]

Non-capital holders do not participate in the capital market but have access to risk-less bonds. The last term in the budget constraint is the quadratic bond-holding cost, whose size is controlled by the parameter \(v > 0\). This bond-holding cost induces stationarity in equilibrium bond holding and is frequently used in small open economy models (Schmitt-Grohe and Uribe 2003).

\(^4\)The existence of state-contingent securities ensures that capital holders are homogeneous with respect to consumption and asset holdings, even though they are heterogeneous with respect to the wage rate and hours because of the idiosyncratic nature of the timing of wage re-optimization. I assume that both capital holders and non-capital holders trade the securities among themselves. This implies that consumption and asset holdings could be different between the two groups.
2.2 Firms

In each period $t$, the final goods, $Y_t$, are produced by a perfectly competitive representative firm that combines a continuum of intermediate goods, indexed by $j \in [0, 1]$, with technology

$$Y_t = \int_0^1 Y_{j,t}^{\theta_p - 1} dj. \quad Y_{j,t}$$

denotes the time $t$ input of intermediate good $j$ and $\theta_p$ controls the price elasticity of demand for each intermediate good. The demand function for good $j$ is

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

where $P_t$ and $P_{j,t}$ denote the price of the final good and intermediate good $j$, respectively. $P_t$ is related to $P_{j,t}$ via the relationship

$$P_t = \int_0^1 P_{j,t}^{1-\theta_p} dj. \quad P_{j,t}$$

The intermediate-goods sector is monopolistically competitive. In period $t$, each firm $j$ rents $K_{j,t}$ units of capital stock from the household sector and buys $H_{j,t}$ units of aggregate labor input from the employment sector to produce intermediate good $j$ using technology

$$Y_{j,t} = K_{j,t}^\alpha (\gamma^t H_{j,t})^{1-\alpha}. \quad K_{j,t}$$

Intermediate firms face a Calvo-type price-setting friction: in each period $t$, a firm can re-optimize its intermediate-goods price with probability $(1 - \xi_p)$. Firms that cannot re-optimize index their price according to the steady-state inflation rate, $\pi$.

2.3 Employment

In each period $t$, a perfectly competitive representative employment agency hires labor from households to produce an aggregate labor service, $H_t$, using technology

$$H_t = \int_0^1 H_{i,t}^{\theta_w - 1} di. \quad H_{i,t}$$

where $H_{i,t}$ denotes the time $t$ input of labor service from household $i$ and $\theta_w$ controls the price elasticity of demand for each household’s labor service. The agency sells the aggregated labor input to the intermediate firms for a nominal price of $W_t$ per unit. Households (both capital holders and non-capital holders) face a Calvo-type wage-setting friction: In each period $t$, a household can re-optimize its nominal wage with probability $(1 - \xi_w)$. Households that cannot re-optimize index their
wage according to the steady-state wage growth rate, $\gamma \pi$.

2.4 Aggregation, Government, and Resource Constraint

Aggregate consumption, hours, investment, and capital are defined as:

\begin{align*}
C_t &\equiv \chi C^n_t + (1 - \chi) C^c_t, \\
H_t &\equiv \chi H^n_t + (1 - \chi) H^c_t, \\
I_t &\equiv (1 - \chi) I^c_t, \\
K_t &\equiv (1 - \chi) K^c_t.
\end{align*}

The resource constraint is

$$C_t + I_t + G_t + \frac{\nu}{2} \left( \frac{B^n_t}{P_t Y_t} \right)^2 Y_t = Y_t,$$

where $G_t$ is government spending.

The central bank follows a Taylor rule with interest-rate smoothing:

$$R_t = \left( \frac{R_{t-1}}{R_t} \right)^{\rho_R} \left\{ \left( \frac{\pi_t}{\pi} \right)^{\phi_\pi} \left( \frac{Y_t}{\gamma Y} \right)^{\phi_Y} \right\}^{1-\rho_R},$$

where $R$ is the steady-state level of the nominal interest rate, $\rho_R$ is the persistence of the rule, and $\phi_\pi$ and $\phi_Y$ are the size of the policy response to the deviation of inflation and output from their steady states, respectively.

The government budget constraint is

$$T_t = \chi T^n_t + (1 - \chi) T^c_t$$

where $T_t \equiv \chi T^n_t + (1 - \chi) T^c_t$ and $B^\theta_t$ is the government bond. The transfers are equally distributed across households: $T_t = T^n_t = T^c_t$. I assume that the government bond is related to the previous period transfer according to

$$\hat{B}^\theta_t = \rho_B \hat{B}^\theta_{t-1} + (1 - \rho_B) \phi_{B,T} \hat{T}_{t-1},$$

where $\phi_{B,T}$ is restricted to a value that makes the government bond non-explosive. The lump-sum transfers adjust so that the government budget constraint is satisfied period by period. Finally, the bond market clearing condition is

$$\chi B^n_t + (1 - \chi) B^c_t = B^\theta_t.$$
2.5 Shocks

I specify the fiscal rules that describe the law of motion of four policy instruments: the ratio of government spending to output, $g_t$, consumption tax rate, $\tau_{c,t}$, labor income tax rate, $\tau_{h,t}$, and capital income tax rate, $\tau_{k,t}$. Each instrument follows the process described below:

\[
\hat{x}_t = (1 - \rho_x)x + \rho_x \hat{x}_{t-1} + \phi_{x,Y}\hat{Y}_{t-1} + \phi_{x,B}\hat{B}_{t-1} + \mu^*_x + u_{x,t+1}, \quad u_{x,t+1} \sim i.i.d.N(0, \sigma^2_x),
\]

for $x \in \{g, \tau_c, \tau_h, \tau_k\}$. The fiscal rule (6) embeds two feedbacks. First, there is an “automatic stabilizer” component that allows an instrument to respond to the log-deviation of output from the steady state ($\phi_{g,Y} < 0$ and $\phi_{\tau_x,Y} > 0$). Second, an instrument may also respond to the level of government debt ($\phi_{g,B} < 0$ and $\phi_{\tau_x,B} > 0$).

$\mu^*_x$ is a deterministic sequence that agents perceive as ambiguous. Agents’ ambiguity changes over time due to, for example, worrisome news about the political development. In some periods, agents may be able to form relatively precise forecast about future fiscal policy while in other periods various experts and news reports conflict each other and agents may not be confident about the forecasts. As in Ilut and Schneider (2014), I parameterize agents’ belief set by an interval of means centered around zero:

\[
\hat{x}_t = (1 - \rho_x)x + \rho_x \hat{x}_{t-1} + \phi_{x,Y}\hat{Y}_{t-1} + \phi_{x,B}\hat{B}_{t-1} + \mu_x + u_{x,t+1}, \quad \mu_x \in [-a_x, a_x].
\]

Higher $a_x$ means a wider set of beliefs and that there is more uncertainty. I assume that $a_x$ follows an exogenous AR(1) process

\[
a_{x,t+1} = (1 - \rho_{a_x})a_x + \rho_{a_x}a_{x,t} + \epsilon^a_{x,t}, \quad \epsilon^a_{x,t} \sim i.i.d.N(0, \sigma^2_{a_x}).
\]

3 Quantitative Investigation

I now quantify the effects of fiscal uncertainty shocks using the model. After I describe the parameterization and the solution method, I conduct impulse response analysis and show that, compared to the standard representative agent model with full market participation, uncertainty shocks to fiscal policies that are redistributive have much bigger impacts in the heterogeneous agent model featuring limited capital market participation.

3.1 Calibration

Preference, production, and pricing. The period is a quarter. The rate of the deterministic labor-augmenting technological change is $\gamma = 1.004$, which implies 1.6% growth per year. The discount factor $\beta$ is set to $0.99$. The consumption habit parameter is $b = 0.65$ and the parameter $\kappa$ that determines the size of the investment adjustment cost is set to $4$. These values are in line with the
estimates found in Christiano et al. (2005) and Smets and Wouters (2007). I set $\delta = 0.02$, which implies an annual depreciation rate of 8%. $\phi$ is set to 1, which gives a Frisch elasticity of labor supply of 1. The capital share in production $\alpha$ is set to 0.35. I set the elasticity of substitution across intermediate goods $\theta_p$ to 6 and the elasticity of substitution across differentiated labor $\theta_w$ to 6. These values imply steady-state price and wage markups of 20%. The Calvo parameter for not adjusting prices $\xi_p$ and the Calvo parameter for not adjusting wages $\xi_w$ are both set to 0.75. These values give average frequencies of price and wage adjustments of 4 quarters.

Capital market participation. There are several sources that could be used to determine the share of capital holders in the economy. According to the household survey conducted in Investment Company Institute (2008), around 50 percent of U.S. households held stocks in recent years. In contrast, according to the Consumer Expenditure Survey (CEX) conducted by the Bureau of Labor Statistics, around 20 percent of households hold stocks (Vissing-Jørgensen 2002). Finally, the Survey of Consumer Finances (SCF) by the Federal Reserve Board finds that 13.8 percent of U.S. households held stocks in 2013 but that figure rises to 22 percent if we include indirect holdings through investment funds (Bricker et al. 2014). These disparities possibly reflect differences in samples or whether the definition of a stock holding includes indirect holdings through, for example, pension plans. I set $1 - \chi = 0.4$, which implies a capital market participation rate of 0.4. For a parameter that governs the non-capital holders’ bond-holding cost, I set $v = 2$.

Monetary policy. The interest rate smoothing parameter is set to $\rho_R = 0.8$. The policy responses to inflation and output gap are set to $\phi_\pi = 1.35$ and $\phi_Y = 0.1$, respectively.

Fiscal policy, fiscal policy shocks, and fiscal uncertainty shocks. The steady-state government spending to output and government bond to output ratios are set to 0.2 and 0.6, respectively. The debt smoothing parameter is set to $\rho_B = 0.95$ and the elasticity that relates government bond to transfers is set to $\phi_{B,T} = 0.05$. The steady-state consumption tax, labor income tax, and capital income tax rates are set to the average values in the data: $\tau_c = 0.08$, $\tau_h = 0.22$, and $\tau_k = 0.37$. The parameters of the fiscal policy shock processes are estimated from the data: $\rho_g = 0.98, \rho_{\tau_c} = 0.98, \rho_{\tau_h} = 0.94, \rho_{\tau_k} = 0.94, 100\sigma_g = 1.4, 100\sigma_{\tau_c} = 6.6, 100\sigma_{\tau_h} = 2.5, 100\sigma_{\tau_k} = 3.6$. For simplicity, all the feedback parameters for fiscal instruments are set to zero. The steady-state levels of ambiguity about each fiscal instrument are set to $a_x = 0.5\sigma_x$, where $x \in \{g, \tau_c, \tau_h, \tau_k\}$. This ensures that the level of ambiguity should not be “too large” in a statistical sense compared to the variability of the data (Ilut and Schneider 2014). Finally, for the parameters that govern the fiscal ambiguity shocks processes I set $\rho_{a_x} = 0.95$ and $100\sigma_{a_x} = 1$. In line with the policy uncertainty indexes in Baker et al. (2016), I assume that fiscal uncertainty is fairly persistent.
3.2 Solution

To solve the model, I follow the methodology developed in Ilut et al. (2016). They analyze a class of dynamic models with ambiguity averse agents where agents differ in their worst-case beliefs and apply their method to a borrower-lender model. Because there is heterogeneity in the worst-case beliefs in the steady state, one needs to jointly solve for the steady state and the equilibrium decision rules. The brief outline of the solution method is as follows. First, we log-linearize the equilibrium conditions of the model. Second, we guess the elasticities that map from state variables to endogenous variables. Third, we jointly solve for the steady state and the dynamics taking into account the heterogeneity in worst-case beliefs. We iterate the second and the third steps until the guessed elasticities and the solution coincide. Finally, we verify that the guessed beliefs are indeed the worst-case beliefs by plugging in the decision rules into the linearized value functions. In the context of my model, this can be done simply by checking that both capital holders and non-capital holders become worse off when fiscal uncertainty increases. For more details, see Ilut et al. (2016).

3.3 Impulse Response Analysis

I conduct impulse response analysis to study the impact of fiscal uncertainty shocks and the implications of household heterogeneity. Figure 1 plots the responses of aggregate variables to a 1% increase in ambiguity about capital income tax. Black dashed lines are the responses in the representative agent model with full capital market participation and blue solid lines are the responses in the heterogeneous household model with limited capital market participation. First, consider the representative agent model. In response to an increase in uncertainty about capital income tax, the representative household acts as if future tax is high. Facing lower after-tax return on capital, they substitute away from investment and increase consumption. Low investment reduces household’s incentive to supply labor. The increase in consumption, however, counteracts this by mitigating the decline in overall aggregate demand and thus equilibrium employment and output decline mildly.

Next, consider the heterogeneous agent model. In contrast to the representative agent model, output, consumption, and hours all drop substantially. To understand this further, in Figure 2 I report the capital holders’ and non-capital holders’ consumption, hours, total tax paid (including lump-sum transfers), and capital income tax rate in response to the capital income tax ambiguity shock (blue solid lines). I also report impulse responses under the worst-case beliefs: they describe the worst-case expected path that agents worry about when uncertainty increases. The responses under the worst-case beliefs are in green lines with stars. In this version of the model, the worst-case capital income tax rate is heterogeneous: capital holders’ worst case is high capital income tax while non-capital holders’ worst case is low capital income tax. The worst-case tax is heterogeneous because the capital income tax heavily shifts the tax burden on one agent to the other. Indeed, the capital holders’ total tax paid increases substantially under the worst-case belief because they fear that they will be taxed more on capital income and that the increased revenue will be distributed
Figure 1: Impulse responses to a capital income tax uncertainty shock: aggregate variables

Notes: The figure reports the impulse responses to a 1% increase in $a_{\tau_k}$ (capital income tax ambiguity). The units are in percents (percentage points for inflation and nominal rate). The black dashed lines are the responses from the representative agent model with full capital market participation and the blue solid lines are the responses from the heterogeneous agent model with limited capital market participation.
Figure 2: Impulse responses to a capital income tax uncertainty shock: individual variables under the true and worst-case DGPs

Notes: The figure reports the impulse responses to a 1% increase in $\alpha_{\tau_k}$ (capital income tax ambiguity). The units are in percents (percentage points for inflation and nominal rate). The blue solid lines and the green lines with stars are the responses under the true and the worst-case DGPs, respectively, from the heterogeneous agent model with limited capital market participation. The black line with circles is the total tax paid under the worst-case DGP from the representative agent model with full capital market participation.
across capital holders and non-capital holders. This is in sharp contrast to the total tax paid in the representative agent model (black line with circles). There the representative agent also fears high capital income tax. However, under the worst-case DGP, the total tax paid actually decreases because of lower aggregate activity and the fact that the tax raised will be distributed back to the representative household through lump-sum transfers. In the heterogeneous agent model, faced with concerns about lower after tax income, capital holders cut their consumption. They also have less incentive to supply labor because, as in the representative agent case, they invest less due to higher future capital tax. Consider now the responses of non-capital holders. The non-capital holders fear lower capital income tax because lower government revenue reduces their transfers. Hence their total tax paid rises sharply under the worst-case belief, in contrast to the representative agent model (again shown in a black line with circles to ease comparison). Thus, under the worst-case scenario, non-capital holders reduce their consumption and increase hours due to the negative income effect. Under the true DGP, however, the reduction in transfer is not realized and hence the drop in consumption is milder and hours actually decline. In the aggregate, the decline of consumption by both types of households reduce aggregate demand and, through nominal rigidities, raises markups. This, in turn, depresses labor demand and lowers real wages. As a result, equilibrium employment and hence output drops substantially.

Similar effects take place in the transmission of an uncertainty shock about consumption tax (Figure 3). In the representative agent model, the household fears high future consumption tax. Since future consumption is more expensive due to the tax and the future return to capital is lower because of low aggregate demand, current consumption rises and investment declines. As in the case of a capital income tax uncertainty shock, because of lower investment, employment declines but the decline in output is limited because of the counteracting effect coming from consumption.

With limited capital market participation, output, consumption, and hours all drop sharply. The intuition is similar to the capital income tax uncertainty shock case. Since capital holders are wealthier than non-capital holders, they consume more than non-capital holders. Thus, as shown in Figure 4, capital holders’ worst case is high consumption tax because they will be paying more taxes and the non-capital holders’ worst case is low consumption tax because they will receive lower transfers. Since the total tax paid by both types of households increases dramatically under the worst-case beliefs, the negative income effect reduces consumption substantially. As a result, aggregate demand declines and hence raises markups. The increase in markups lowers labor demand and hence hours worked and output falls substantially.

Interestingly, household heterogeneity has small impact and does not necessarily lead to amplification when uncertainty about fiscal policy is not redistributive. For example, in my model an increase in government spending makes both types of households worse off because it is financed by a lump-sum tax. Similarly, an increase in labor income tax makes both types of households worse off because they earn relatively similar wages and work similar amount of hours. Figures 7 and 8 in the Appendix show that impulse responses of aggregate variables for the government spending un-
Figure 3: Impulse responses to a consumption tax uncertainty shock: aggregate variables

Notes: The figure reports the output responses to a 1% increase in $\tau_c$ (capital income tax ambiguity). The units are in percents (percentage points for inflation and nominal rate). The black dashed lines are the responses from the representative agent model with full capital market participation and the blue solid lines are the responses from the heterogeneous agent model with limited capital market participation.
Figure 4: Impulse responses to a consumption tax uncertainty shock: individual variables under the true and worst-case DGPs

Notes: The figure reports the impulse responses to a 1% increase in $\alpha_{\tau_c}$ (consumption tax ambiguity). The units are in percents (percentage points for inflation and nominal rate). The blue solid lines and the green lines with stars are the responses under the true and the worst-case DGPs, respectively, from the heterogeneous agent model with limited capital market participation. The black line with circles is the total tax paid under the worst-case DGP from the representative agent model with full capital market participation.
certainty shock and the labor income tax uncertainty shock are similar for both representative agent and heterogeneous agent models. The key reason is that, because these fiscal policies are not redistributive, the worst-case is the same for both capital holders and non-capital holders. Consider, for example, an increase in uncertainty about labor income tax. In response to an increase in uncertainty, both capital holders and non-capital holders act as if future labor income tax is higher. As a result, in (worst-case) expectation, the general equilibrium effect of a redistribution, i.e., the government budget constraint, kicks in: the increased tax is rebated back to households as a lump-sum transfer. Because of this general equilibrium effect, uncertainty shocks about fiscal policy that is not redistributive have similar contractionary effects in both representative-agent and heterogeneous-agent models.

3.4 Additional Analysis

In this section, I investigate how some perturbations in parameter values change the baseline results reported above. To keep the exercise focused, I concentrate on the impulse responses to the capital income tax uncertainty shock.

*The role of price and wage rigidities.* To examine the role of sticky prices and wages, in Figure 5, I plot the impulse responses of the representative agent economy and the heterogeneous agent economy with flexible prices and wages, where I set Calvo parameters to $\xi_p = 0.01$ and $\xi_w = 0.01$. In the representative agent model, the flexible prices and wages specification (red lines with stars) produces very similar impulse response compared to the baseline specification (black dashed lines). In the heterogeneous agent model, the amplification of the impulse response compared to the baseline specification (black dashed lines) is considerably smaller in the flexible prices and wages case (green lines with circles). The nominal rigidities are crucial because they magnify the negative income effects perceived by capital holders and non-capital holders through countercyclical markups. This finding echoes conclusions from Fernández-Villaverde et al. (2015) and Basu and Bundick (2017) which emphasize countercyclical markups due to nominal rigidities in the transmission of uncertainty shocks.

*The role of capital market participation rate.* As mentioned above, the estimates of the capital market participation rate differ across several data sources. To examine how the share of non-capital holders affect the results, in Figure 6, I plot impulse responses with high capital market participation ($1 - \chi = 0.7$, green dotted lines) and low capital market participation ($1 - \chi = 0.2$, red lines with squares). Note that the participation rate in the latter is in line with the CEX and SCF data. Figure 6 shows that effect of a capital income tax uncertainty shock becomes larger as the capital market participation rate becomes lower. When $1 - \chi = 0.7$, the impulse responses are very similar to the representative agent model. When $1 - \chi = 0.2$, the impact of uncertainty shocks are substantially larger than those in the representative agent model and the baseline limited capital market participation model where the participation rate is $1 - \chi = 0.4$. In particular, the maximum
Notes: The figure reports the output responses to a 1% increase in $a_{\tau_k}$ (capital income tax ambiguity). The units are in percents (percentage points for inflation and nominal rate). The black dashed lines are the responses from the representative agent model with full capital market participation and sticky prices and wages ($\xi_p = 0.75$ and $\xi_w = 0.75$) and the blue solid lines are the responses from the heterogeneous agent model with limited capital market participation and sticky prices and wages ($\xi_p = 0.75$ and $\xi_w = 0.75$). The red lines with stars are the responses from the representative agent model with full capital market participation and flexible prices and wages ($\xi_p = 0.01$ and $\xi_w = 0.01$) and the green lines with circles are the responses from the heterogeneous agent model with limited capital market participation and flexible prices and wages ($\xi_p = 0.01$ and $\xi_w = 0.01$).
Figure 6: Capital income tax uncertainty shock: the role of capital market participation rate

Notes: The figure reports the output responses to a 1% increase in $a_{\tau_k}$ (capital income tax ambiguity). The units are in percents (percentage points for inflation and nominal rate). The black dashed lines are the responses from the representative agent model with full capital market participation and the blue solid lines are the responses from the heterogeneous agent model with limited capital market participation where the capital market participation rate is the baseline value of $1 - \chi = 0.4$. The green dotted lines are the responses when the participation rate is $1 - \chi = 0.7$ and the red lines with squares are the responses when the participation rate is $1 - \chi = 0.2$. 

0 5 10 15 20
−0.25
−0.2
−0.15
−0.1
−0.05
0
Output
0 5 10 15 20
−0.025
−0.02
−0.015
−0.01
−0.005
0
Real wage
0 5 10 15 20
−0.08
−0.06
−0.04
−0.02
0
Consumption
0 5 10 15 20
−0.25
−0.2
−0.15
−0.1
−0.05
0
Investment
0 5 10 15 20
−0.025
−0.02
−0.015
−0.01
−0.005
0
Hours
0 5 10 15 20
−0.35
−0.3
−0.25
−0.2
−0.15
−0.1
−0.05
0
Nominal rate
0 5 10 15 20
−0.025
−0.02
−0.015
−0.01
−0.005
0
Nominal rate
0 5 10 15 20
−1
−0.5
0
0.5
1
$\tau_k$
output drop is more than 6 times deeper than that of the representative agent model (0.2 percent vs. 0.03 percent). Intuitively, as the participation rate becomes lower, wealth (capital per agent) becomes more concentrated and the redistributitional effect of capital income tax becomes larger. This, in turn, magnifies the perceived negative income effect by agents and amplifies the drop in aggregate demand in response to fiscal uncertainty shocks.

4 Bayesian Estimation on U.S. Data (in progress)

I plan to conduct a Bayesian estimation of the quantitative model on U.S. data. Because the model is solved under a first-order approximation, standard tools such as the Kalman filter can be used. In addition to standard macroeconomic variables, I plan to use consumption data of stock holders and non-stock holders from the CEX and policy uncertainty indexes about fiscal policy from Baker et al. (2016) as observables. The former allows me to identify the differences in consumption fluctuations of capital and non-capital holders in the model and the latter allows me to identify the fiscal uncertainty shock processes. I use the estimated model and ask several interesting questions. First, what is the contribution of fiscal uncertainty shocks in postwar U.S. fluctuations as well as the recent Great Recession and its slow recovery? Second, how do the results compare to those from the representative agent model?

5 Conclusion

This paper revisited the macroeconomic impact of an uncertainty shock about fiscal policy in a New Keynesian framework featuring household heterogeneity in the form of limited capital market participation. Impulse response analysis shows that household heterogeneity significantly magnifies the aggregate effect and restores co-movement of macroeconomic variables in a contraction that is generated by a fiscal uncertainty shock. This is because the heterogeneous household model captures individual uncertainty about redistribution that cancels out in representative agent models. Additionally, the impact of fiscal uncertainty shocks becomes larger as wealth becomes more concentrated.
References


Appendix

I report additional impulse responses. As mentioned in the main text, for the shocks reported below (uncertainty shocks for fiscal policies that are not redistributive), household heterogeneity has small impacts.

Figure 7: Impulse responses to a government spending uncertainty shock: aggregate variables

Notes: The figure reports the output responses to a 1% increase in $a_g$ (government spending ambiguity). The units are in percents (percentage points for inflation and nominal rate). The black dashed lines are the responses from the representative agent model with full capital market participation and the blue solid lines are the responses from the heterogeneous agent model with limited capital market participation.
Figure 8: Impulse responses to a labor income uncertainty shock: aggregate variables

Notes: The figure reports the output responses to a 1% increase in $\alpha_{\tau_h}$ (labor income tax ambiguity). The units are in percents (percentage points for inflation and nominal rate). The black dashed lines are the responses from the representative agent model with full capital market participation and the blue solid lines are the responses from the heterogeneous agent model with limited capital market participation.