# Household Debt and the Effects of Fiscal Policy

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## Abstract

This paper examines how the effects of government spending shocks depend on the balance-sheet position of households. Employing U.S. household survey data, we find that in response to a positive government spending shock, households with mortgage debt have a large, positive consumption response, while renters have a smaller rise in consumption. Homeowners without mortgage debt, in contrast, have an insignificant expenditure response. We consider a dynamic stochastic general equilibrium (DSGE) model with three types of households: savers who own their housing, borrowers with mortgage debt, and rule-of-thumb consumers who rent housing, and show that it can successfully account for these findings. The model suggests that liquidity constraints and wealth effects, tied to the persistence of public spending, play a crucial role in the propagation of government spending shocks. Our findings provide both empirical and theoretical support for the notion that household mortgage debt position plays an important role in the transmission mechanism of fiscal policy.

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# 1 Introduction

In the aftermath of the Great Recession, there has been growing interest in the role of household debt in the transmission of macroeconomic shocks, as policymakers have increasingly relied on fiscal policy to stabilize and stimulate the economy. This paper examines how the transmission of government spending shocks depend on the balance-sheet position or debt level of households in the economy.

Since mortgage debt constitutes the vast majority of household debt, we employ data on mortgagors, outright owners and renters to proxy for the financial position of households. This is in the spirit of Cloyne and Surico (2017) and Cloyne, Ferreira and Surico (2020), who have shown that housing tenure status can be a useful proxy for debt and asset position, and exploiting information in the U.S. Consumer Expenditure Survey by tenure status allows us to circumvent the issue that few datasets have detailed information about household income, expenditures and liabilities over a long period of time. There might be concerns about selection bias and endogenous choice into tenure status, and we show in our particular case, that the share of households in each group does not respond significantly to aggregate public spending shocks.

Our first contribution is to establish heterogeneity of government spending effects based on housing tenure status. Notably, we find that in response to a positive government spending shock, mortgagor households experience a large rise in their consumption. Renters also experience a rise in their consumption, but it is smaller than mortgagors. Outright homeowners without mortgage debt, in contrast, have an insignificant consumption expenditure response to a public spending shock. This heterogeneity cannot be explained by differences in the income responses, which have a similar response across the three types of households. We further show how consumption patterns differ across durable and non-durable consumption. Our results show that it is not the housing tenure status, per say, that matters but the level of household indebtedness or liquid wealth that differentiates the household response to a government spending shock.

Our second contribution is to provide a theoretical framework to rationalize these empirical findings and dig deeper into the transmission mechanism. We construct a dynamic stochastic general equilibrium (DSGE) model with housing, borrowing and lending across heterogeneous households, and financial frictions in the form of collateral constraints similar to Iacoviello (2005). In departure from most literature, the model features three types of households: savers who own their housing, borrowers with mortgage debt, and rule-of-thumb consumers who rent housing. Thus, we introduce a rental housing market alongside owner-occupied housing. Since our focus is on mortgage debt, we model fixed-rate mortgage loans which are amortized over the long term, similar to Kydland, Rupert and Šustek (2016) and Alpanda and Zubairy (2017). We calibrate the parameters of the model in order to match micro-evidence and various data moments like housing shares of various types of households in the U.S. economy.

We show that this model can successfully match aggregate responses and also account for the different responses across households to a public spending shock. Government spending shocks propagate through the economy primarily through wealth and liquidity effects. We show that labor income responds positively and similarly across all types of households. However, the negative wealth effect based on expectation of higher taxes affects the households differently. Saver households are hit hardest by this negative wealth effect given their portfolio of taxable assets. The renters living hand-to-mouth are least affected, with the borrower households affected intermediately. We show that the persistence of the spending shock generates different degrees of wealth effects and plays an important role in the propagation of the shock. For the borrower households, government spending shocks help relax their borrowing constraint and thus their ability to borrow and consume. Therefore, particularly for those households with a mortgage, liquidity constraints play a crucial role in the propagation of government spending shocks.

We also extend the model to account for durable and non-durable consumption, and overall match the responses seen in our empirical analysis. Notably, durable consumption responses are distinct from housing responses, particularly for the renters. We also consider robustness of the heterogeneous consumption responses to variations in the parameters of the model, introduction of additional lines of credit such as home-equity lines of credit or refinancing, and the stance of monetary policy. Our findings provide both empirical and theoretical support for the notion that household mortgage debt position plays an important role in the transmission mechanism of fiscal policy.

## 1.1 Literature Review

Our paper contributes to the growing literature that has shown that we need a departure from a representative agent model to understand the aggregate consumption dynamics in response to a government spending shock. Galí, López-Salido and Vallés (2007) show in a New-Keynesian model with two types of agents that the presence of liquidity constrained households matters for the aggregate consumption response. These non-Ricardian agents who can not borrow and save raise their consumption in response to a positive shock to public spending and if their share is large enough, lead to a rise in aggregate consumption. Similarly, other have considered the heterogeneous effects of government spending based on various features including, income (Ma (2019) and references within) and age/ demographics (Basso and Rachedi (2021)).

The pre-existing literature also establishes that balance sheets matter and wealthy hand-to-mouth households play an important role in the propagation of aggregate shocks including fiscal innovations. Notably, Kaplan and Violante (2014) show that wealthy hand-to-mouth or liquidity constrained households are important to explain the response to transfers in the form of tax rebate checks. Cloyne and Surico (2017) consider the role of tax shocks, and show empirically that mortgagor households have the largest response to tax shocks, focusing on survey data from the UK. Brinca et al. (2016) develop a life-cycle model with heterogeneous agents and incomplete markets, and find that the fiscal multiplier is highly sensitive to the fraction of the population facing binding credit constraints and to the average wealth level in the economy. In a similar spirit, we consider the role of household debt for the propagation of a different aspect of fiscal policy in the form of government spending shocks.

While our focus is on the different types of households, our paper is also related to studies that focus on the time and space variation in household indebtedness. For instance, Demyanyk, Loutskina and Murphy (2016) exploit U.S. regional data to document that relative fiscal multipliers are higher in areas with higher consumer indebtedness. Bernardini and Peersman (2018) employ historical data for the U.S. and show that the aggregate government spending multiplier is higher during periods of private debt overhang.

In a related study, Andres et al. (2021) show how changes in the wealth distribution of households in recent decades affect the transmission of fiscal shocks. They employ PSID data and construct a new-Keynesian model with multiple types of agents featuring search and matching frictions, and are interested in employment dynamics as well. They find that the effects of fiscal shocks are sensitive to the fraction of households in the left tail of the wealth distribution. Unlike our analysis, they are more focused on the household financial position, and do not consider housing tenure status.

The remainder of this paper proceeds as follows. Section 2 and 3 describe our empirical estimation and discusses the dynamic effects of government spending shock. In Section 4, we present our model and its calibration. Section 5 discusses the results of the model with transmission mechanisms. Section 6 provides some extensions and robustness checks. Section 7 concludes.

# 2 Empirical approach

## 2.1 Identification and estimation methodology

In order to examine the effects of government spending shocks, we first need to specify our identification scheme. We employ the Survey of Professional Forecasters (SPF) forecast errors for federal spending to identify government spending shocks, as introduced in Ramey (2011). We consider the difference between actual government spending growth and the one-quarter ahead forecast of its growth rate by professionals. The key identifying assumption of this approach is that the shocks are orthogonal to professional forecasts of future government purchases, i.e. the forecasters are incorporating all available information about the state of the economy and other aspects in their forecasts.

Unlike existing identification strategies including SVARs (Structural Vector Autoregressions) with short-run timing restrictions a la Blanchard and Perotti (2002), these shocks are not subject to anticipation effects. The other alternative based on military news from narrative accounts, Ramey (2011) have low predictive power in the post-Korean war sample, which is the sample under consideration here. In contrast, SPF forecast errors have been shown not to suffer from these anticipation effects and have large first-stage F-statistics for predicting total government and military spending in samples excluding these large military events (see Ramey (2011)).

In order to study the empirical effects of government spending shocks on both aggregate and disaggregate variables across various types of households, we employ the following VAR,

$$\mathbf{y}_t = \alpha_0 + \alpha_{1t} + A(L)\mathbf{y}_{t-1} + \mathbf{u}_t \tag{1}$$

where $\mathbf{y}_t$ is $n \times 1$ vector with variables of interest, $\mathbf{A}(L)$ is a polynomial in the lag operator, and $\mathbf{u}_t$ is an error term. In the baseline estimation with aggregate macroeconomic variables, we consider the following ordering: with SPF forecast errors first followed by log of real government spending, log real per capita GDP and consumption, household debt (both flow and stock), house price index, and the Federal Funds rate.[1] We use shocks to the first equation with SPF forecast errors (identified with a Choleski decomposition) as the government spending shock of interest.[2]

In addition to considering the responses of macroeconomic aggregate variables, we investigate the existence of heterogeneity across households with different financial positions in response to a positive government spending shock. Since mortgage debt constitutes the vast majority of household debt, we employ household survey data on consumption and income across housing tenure status to proxy for the households' balance sheet position following Cloyne, Ferreira and Surico (2020).[3] Equation (2) indicates the order of a VAR analysis for three housing tenure groups: mortgagors, outright homeowners, and renters.[4] Specifically, we consider SPF forecast errors first followed by log of real government spending, log real per capita GDP, and housing tenure group-specific consumption (i.e. aggregate consumption, $rCON_t^i$, non-durable and durable consumption, $rNDC_t^i$ and $rDC_t^i$, respectively) or income (i.e. gross and net income, $rGI_t^i$ and $rNI_t^i$, respectively) as the last variable.

$$\mathbf{y}_t \equiv \begin{pmatrix} SPF\ FE_t \\ \log\ rGOV_t \\ \log\ rGDP_t \\ \log\ X_t^i \end{pmatrix} \tag{2}$$

where $i \in \{$mortgagors, outright homeowners, renters$\}$ and $X_t^i \in \{rCON_t^i, rNDC_t^i, rDC_t^i, rGI_t^i, rNI_t^i\}$.

## 2.2 Data

In this subsection, we describe the data used in the empirical estimation. The key aggregate variables used in the baseline empirical analysis such as real per capita GDP, government spending, and consumption are from national income and product accounts (NIPA). The SPF forecast errors are constructed using the SPF

[1] Data sources are available in Appendix A.

[2] We choose a lag length of four based on the Akaike information criterion (AIC). We apply a linear time trend and the impulse responses are calculated based on the three-period moving average. Moving average is based on three periods: $(t-1, t, t+1)$ to smooth the responses over time. In our robustness analysis, we remove the moving average approach to smooth the IRFs and show that the results are unaffected.

[3] We employ the consumption and income series constructed by Cloyne, Ferreira and Surico (2020) in our empirical analysis. The next section provides further details on these data.

[4] The lag operator is equal to two with housing tenure group specific variables. Standard errors are bootstrapped with 68 percent confidence bands generated by Monte Carlo simulations.

forecasts for federal spending which are available from the Federal Reserve Bank of Philadelphia. Since the SPF forecasts for federal spending are available starting 1981, it limits the start of our sample. We end our sample in 2007 in order to ensure we exclude the zero lower bound (ZLB) period. We also consider data from the U.S. Consumer Expenditure Survey (CEX) to investigate the heterogeneous responses across households. Survey of Consumer Finances (SCF) data is used to provide additional information about asset and wealth position across households in the baseline sample period.[5]

Table 1: Consumption, income, and share by housing tenure group

| Housing tenure group | Non-durable cons. | Durable cons. | Gross inc. | Net inc. | Share (%) |
|---|---|---|---|---|---|
| Mortgagors | 2,860 | 480 | 3,412 | 3,052 | 46% |
| Outright owners | 2,799 | 394 | 2,617 | 2,454 | 20% |
| Renters | 2,324 | 301 | 2,394 | 2,149 | 34% |

Note: Table 1 reports the mean value of real per capita values of non-durable and durable expenditure and gross and net income for one quarter (deflated by consumer price index) for the CEX, 1981:Q1-2007:Q1.

The CEX data contains the demographic characteristics (household size, birth year of household head, and educational attainment), housing related variables (tenure status, outstanding mortgage debt, rental payments), consumption expenditure (weekly expenditure on non-durable and durable goods excluding housing), and income coverage (labor and non-labor income) for many decades.[6] Labor income includes wages and salaries and non-labor income includes income from investments and social payments, net of taxes. Since mortgage debt accounts for the vast majority of household debt, we classify households by three housing tenure group - mortgagors, outright owners, and renters - to proxy for the financial positions of households following Cloyne, Ferreira and Surico (2020).[7] Table 1 describes the mean value of real per capita consumption (in non-durable and durable goods), income (gross and net income), and the share of each housing tenure group out of total population (%) across three housing tenure groups in the sample period for the 1981:Q4 to 2007:Q1. Mortgagors constitute the majority of households, with a share of about 47% of all households on average, followed by renters and then outright owners.

SCF data includes basic demographic features similar to the CEX, liquid wealth such as checking and savings account, and illiquid wealth including home equity. Following Kaplan, Violante and Weidner (2014), we use the SCF data to define the wealthy hand-to-mouth (HtM) households who hold little or no liquid wealth despite owning sizable illiquid assets. Table 2 shows the share of each housing tenure group and

[5]In our baseline empirical analysis with a VAR approach, the sample period covers from 1981:Q4 to 2007:Q1. We use SCF data from 1995 to 2007 at 3-year frequency. The SCF data includes net liquid and illiquid asset position across housing tenure groups following Kaplan, Violante and Weidner (2014) definition.

[6]Household size is used to determine the real per capita term and the birth year of household head gives information about life-cycle positions across households, considered in a robustness check.

[7]For each housing tenure group, the data includes group specific consumption (i.e. non-durable and durable expenditures) and income (i.e. gross and net income) based on the CEX. The final series of data is aggregated and converted into a quarterly frequency, deflated by the Consumer Price Index (CPI).

wealthy hand to mouth based on SCF data.[8] Both the CEX and SCF data help us establish that mortgagors own sizable wealth based on housing (which is an illiquid asset) with a sizable debt mostly in the form of mortgages. Outright homeowners own both liquid and illiquid assets while renters tend to have low wealth. Housing tenure status can thus provide a useful proxy to represent the balance sheet positions of households. The share of each group varies over time but by a relatively insignificant amount.

Table 2: Share of each housing tenure group and wealthy HtM

PANEL A: Share of each housing tenure group

| | 1995 | 1998 | 2001 | 2004 | 2007 |
|---|---|---|---|---|---|
| *Number of observation* | | | | | |
| Mortgagors | 9,359 | 9,112 | 9,535 | 10,026 | 10,278 |
| Outright homeowners | 5,600 | 5,146 | 5,583 | 5,589 | 5,197 |
| Renters | 5,355 | 5,795 | 5,797 | 5,770 | 5,130 |
| Total | 20,314 | 20,053 | 20,915 | 21,385 | 20,605 |
| *Share of each group* | | | | | |
| Mortgagors | 0.46 | 0.45 | 0.46 | 0.47 | 0.50 |
| Outright homeowners | 0.28 | 0.26 | 0.27 | 0.26 | 0.25 |
| Renters | 0.26 | 0.29 | 0.28 | 0.27 | 0.25 |

PANEL B: Wealthy Hand-to-Mouth households

| | 1995 | 1998 | 2001 | 2004 | 2007 |
|---|---|---|---|---|---|
| *Wealthy HtM (Total)* | | | | | |
| Mortgagors | 0.16 | 0.12 | 0.11 | 0.13 | 0.15 |
| Outright homeowners | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 |
| Renters | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 |
| Total | 0.26 | 0.21 | 0.20 | 0.21 | 0.23 |

Note: Table 2 reports the share of each housing tenure group and the share of wealthy Hand-to-Mouth for the SCF 1995-2007.

# 3 Aggregate and disaggregate effects of government spending shocks

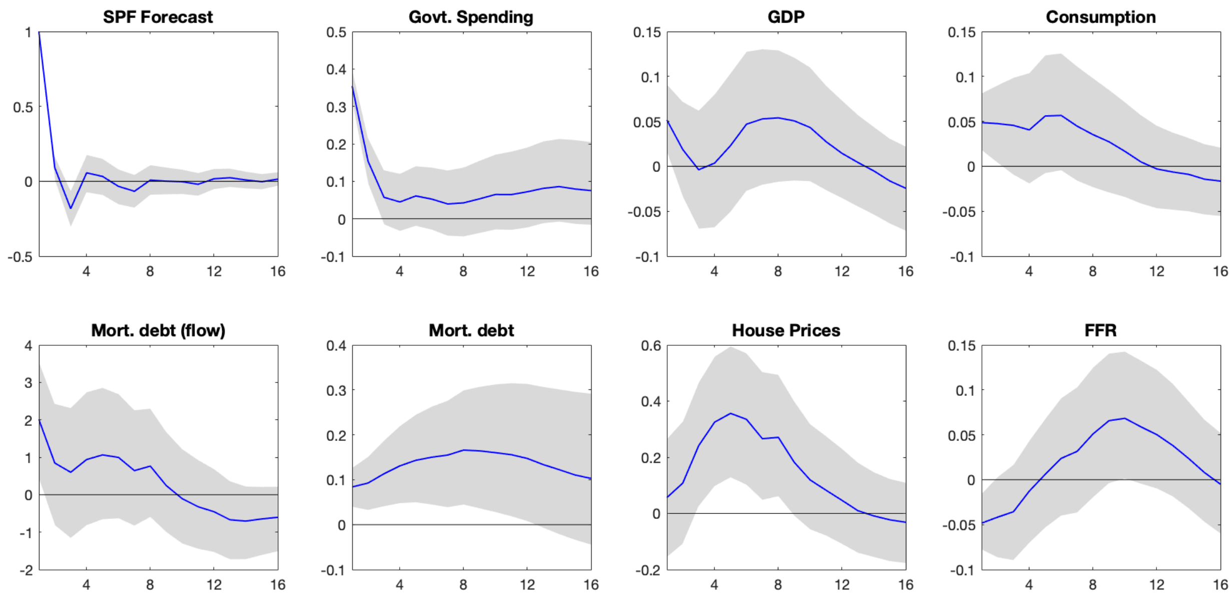
## 3.1 Aggregate estimation results

Figure 1 shows the impulse responses of key macroeconomics variables to a positive government spending shock. Government spending increases significantly in response to a shock to SPF forecast errors. Output and consumption rise for a few quarters and then fall. Consumption response peaks between four and five quarters. The rise in GDP, hours, consumption and real wages is consistent with previous literature (Rotemberg and Woodford, 1992; Blanchard and Perotti, 2002; Galí, López-Salido and Vallés, 2007; Ramey, 2011). We also

[8] Both the CEX and SCF show that mortgagors accounts for the majority share on average, followed by renters and outright owners. In Appendix B, Table B.1 shows the share of asset and debt to income ratio of each housing tenure group.

find that both the stock and the flow of mortgage debt increase on impact while the persistence of flow response is relatively small. Lastly, real house prices increase in response to a positive government spending shock.

Figure 1: Baseline impulse response functions of aggregate variables in response to a positive SPF shock



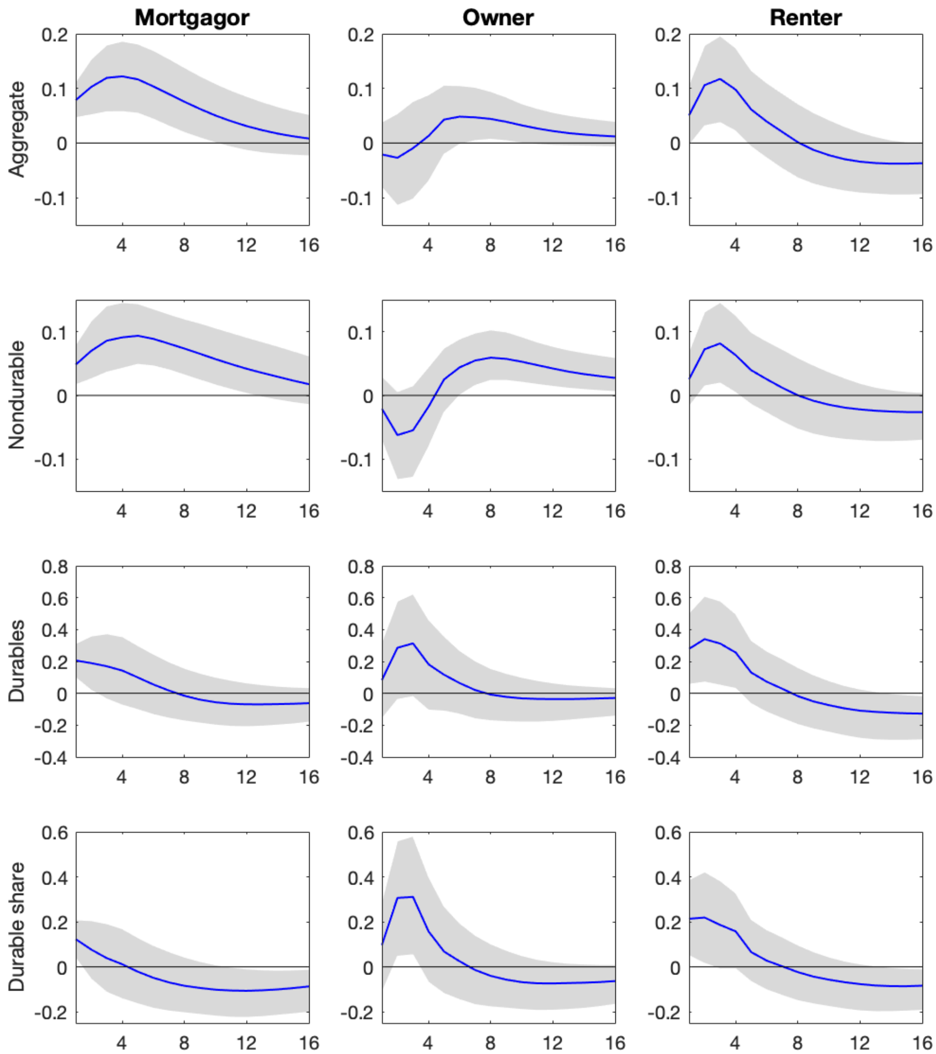

Note: Figure 1 shows the impulse responses functions of government spending, GDP, consumption, Mortgage debt (stock and flow), house price index, and FFR in response to a positive SPF shock with 68 % confidence interval bands based on bootstrapped standard errors (shaded area).

## 3.2 Disaggregate estimation results by housing tenure group

We now consider the response of housing tenure group-specific consumption and income. Consumption data accounts for non-durable and services consumption and durable expenditure, and income data includes net and gross income across households. In Figure 2, we show the dynamic effects of aggregate government spending shocks on consumption including aggregate, durable, non-durable consumption, and the share of durable goods across the three housing tenure groups. The first column of Figure 2 illustrates the responses for mortgagors and the second and third columns show the responses of outright homeowners and renters, respectively.

For aggregate consumption responses, we find sizeable differences across households: i) aggregate consumption of mortgagors rises significantly, ii) renters households also raise their consumption expenditures but to a smaller extent than mortgagors, and iii) outright homeowners have an insignificant consumption response. When we decompose consumption into non-durable and durable expenditure, we find that mortgagors and renters increase both categories while outright homeowners have statistically insignificant responses for both. The response of the share of durable captures the relative changes in the share of durable expenditure

Figure 2: Consumption responses by housing tenure groups

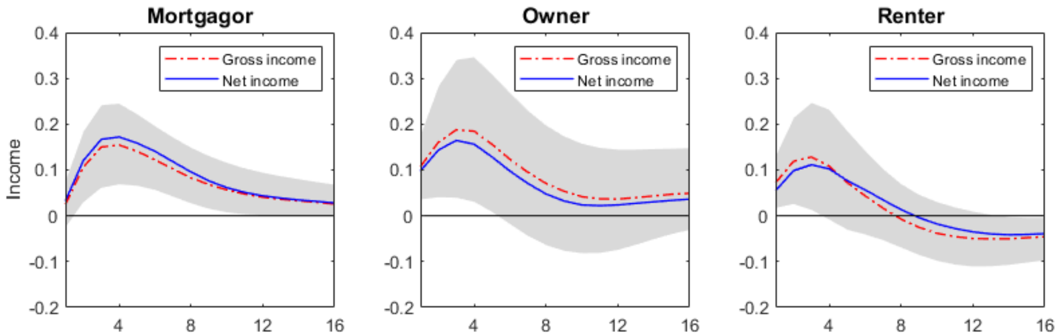



Note: Figure 2 shows the impulse responses functions of aggregate consumption, durable, nondurable & services consumption, and durable share by housing tenure groups in response to a positive SPF shock with 68 % confidence interval bands based on bootstrapped standard errors (shaded area).

in total consumption. The outright owners have a larger tendency to increase their durable share than the other two types of households. For mortgagors and renters, the peak aggregate and non-durable consumption responses occur after four to six quarters while durable consumption rises on impact and then falls gradually over time.

Next, we consider the income response across the various types of households. When income of a certain group is more sensitive to changes in economic conditions, it potentially drives the heterogeneity in the consumption response (Gornemann, Kuester and Nakajima, 2012). Figure 3 shows the dynamic effects on

Figure 3: Income responses by housing tenure groups




Note: Figure 3 shows the impulse responses functions of gross income (red dashed-dot) and net income (blue solid) by housing tenure groups in response to a positive SPF shock with 68 % confidence interval bands based on bootstrapped standard errors (shaded area).

gross and net income across the different housing tenure groups.[9] Both gross and net income of all types of households significantly rise in response to a positive government spending shock, which is consistent with the general equilibrium of aggregate demand shocks. However, there are no significant differences in the gross and net income responses across the different types of households. This suggests that with almost no heterogeneity in income responses across households, the heterogeneous responses in consumption cannot be explained by income changes across households. In addition, the net income responses are similar across households, as are gross income responses, which suggest that differing tax burdens also do not seem to play a big role across the different households.

### 3.2.1 Role of wealthy hand-to-mouth households

Our VAR analysis with group-specific data provides clear evidence of heterogeneity in consumption responses across the housing tenure groups. To test what is behind this consumption heterogeneity, we consider the role of wealthy hand-to-mouth households following Kaplan, Violante and Weidner (2014). First of all, the key distinction across the three housing tenure groups is related to the households' balance sheet status. By definition, mortgagors own a sizable illiquid asset such as housing with sizable debt. Outright homeowners own sizable wealth in both liquid and illiquid assets. Renters do not own sizable wealth nor have mortgage debt. In Table B.1, we show that these characteristics are also consistent in micro-data based on the SCF for the 1995-2007.[10]

Second, we show the distribution of wealthy hand-to-mouth in total population and within group variation. As in Kaplan, Violante and Weidner (2014), we define the wealthy hand-to-mouth if households hold a

[9]Net income is sum of labor and non-labor household income after tax payment.

[10]Following Kaplan, Violante and Weidner (2014), we define net liquid assets as liquid assets minus liquid debt. This includes checking, saving, money market and call accounts minus total credit card balances. Net illiquid asset contains the residential and non-residential real estate net of mortgages and related loans, retirement accounts, retirement accounts including future pensions, and saving bonds.

positive net illiquid wealth and the net liquid wealth is less than half of their labor income.[11] In Table 2, we show the share of each housing tenure group and the share of wealthy HtM households. On average, mortgagor households account almost half of total population which is similar to that in CEX data. The total share of wealthy HtM households is around 25% where mortgagors have the largest share among the three groups. Mortgagors tend to have liquidity concerns and consume most of their disposable income despite owning a sizable illiquid asset. Renter households have little to no wealth, and therefore, are consistent with the notion of poor HtM.

In summary, we find a significant increase in aggregate consumption responses following a positive government spending shock. This finding is mostly driven by mortgagors and there is clear evidence of heterogeneity of responses across households with different financial positions. Notably, this heterogeneity is not explained by changes in income or taxes. Based on household survey data, mortgagors exhibit behavior consistent with wealthy hand-to-mouth households while renters are more likely poor hand-to-mouth households. Our empirical findings suggest that the household balance sheet position may play an important role in the transmission mechanism of fiscal policy.

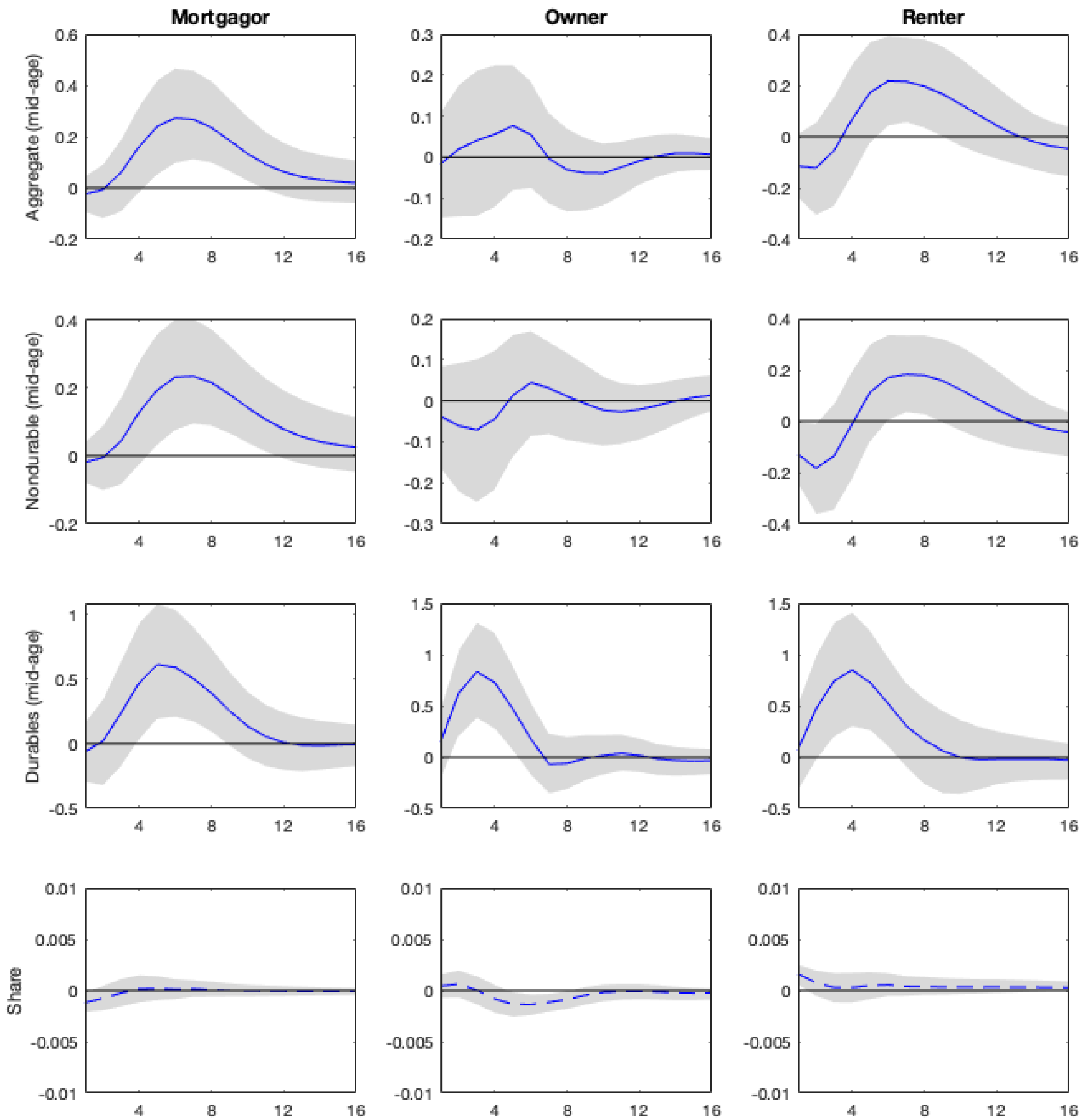
### 3.3 Robustness checks

There are two potential concerns with our empirical analysis. First, there could be a selection issue in grouping. Each housing tenure group has its own demographic characteristics and each household is not randomly assigned to a specific group. Over the life-cycle positions, mortgagors are mostly in their mid-age (around 35 to 45), outright owners are in their late 60s, and renters tend to be young (mostly in their 20s). To address whether there are any life-cycle effects on household heterogeneity, we use sub-groups by controlling the effects of age to avoid any possibility of selection issue following Cloyne, Ferreira and Surico (2020). We consider the middle-aged sub-group in each housing tenure group, using the demographic characteristics of the household head. We show in Figure 4, top three panels, that household heterogeneity does not come from demographic characteristics, and the life-cycle position does not change our main results. Notably, mid-aged mortgagor consumption is much more responsive than renters and outright owners in the same age group.

Second, there is a possibility of compositional changes in response to a positive government spending shock. First, note that the share of each housing tenure group is fairly stable over the sample period using the SCF data (see Table 2). Second, we also estimate the responses of housing tenure shares following a fiscal shock to test the existence of compositional changes. The share of each housing tenure group has an insignificant response to a positive government spending shock, shown in Figure 4, bottom panel, which suggests that there is only limited endogenous compositional change.

[11] Net illiquid wealth includes not only home equity but also savings in bonds, future pensions, and life insurance; therefore, we also have some renters households who are wealthy HtM.

Figure 4: Robustness checks




Note: Figure 4 plots the dynamic effects of a positive SPF shock on consumption responses for middle-aged subgroups and tenure share responses for each housing tenure group: mortgagors, homeowners, and renters. The shaded area indicates 68 % confidence interval bands.

# 4 Theoretical model featuring three types of households

In this section, we consider a closed-economy dynamic stochastic general equilibrium (DSGE) model to account for the empirical findings described in the previous section and determine the effects of government spending shocks on key macroeconomic variables. We extend the DSGE model with housing and household debt and features such as adjustment costs in capital and housing investment, costs of capital utilization, and price and wage rigidities. There are three types of households in the economy: patient households (savers), impatient households (borrowers), and renters, as in Alpanda and Zubairy (2016). Patient households own capital and housing, lend long-term debt to borrowers, and rent some housing to renters. Impatient households own housing and are subject to a LTV constraint on their borrowing, similar to Kiyotaki and Moore (1997) and Iacoviello (2005). Renter households are hand-to-mouth. Our model also features a production side with non-housing goods producers, rental service producers, and residential and non-residential investment producers. We differentiate between the flow and stock of household debt with consideration of long-term fixed rate mortgages as in Kydland, Rupert and Šustek (2016), and Alpanda and Zubairy (2017). The model also includes housing related taxes as in Alpanda and Zubairy (2016). In our sensitivity analysis, we introduce habit formation in consumption, durable goods, and housing market related features such as refinancing and home equity.

## 4.1 Households

### 4.1.1 Patient households (savers)

The economy is populated by a continuum of measure one of infinitely-lived patient households indexed by $i$, whose intertemporal preferences over consumption, $x_{P,t}$, housing, $h_{P,t}$, and labor supply, $n_{P,t}$ are described by the following expected utility function:[12]

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \upsilon_t \left[ \log x_{P,t}(i) + \xi_h \log h_{P,t}(i) - \xi_n \frac{n_{P,t}(i)^{1+\vartheta}}{1+\vartheta} \right], \tag{3}$$

where $E_t$ is the expectations operator conditional on information available at time $t$, $0 < \beta_P < 1$ is the time-discount parameter, $\xi_h$ and $\xi_n$ determine the relative importance of housing and labor in the utility function, and $\vartheta$ denotes the inverse of the Frisch-elasticity of labor supply. The preference shock, $\upsilon_t$, follows an AR(1) process:

$$\log \upsilon_t = \rho_\upsilon \log \upsilon_{t-1} + \varepsilon_{\upsilon,t}. \tag{4}$$

Patient households face heterogeneous labor services which are aggregated into a homogeneous labor service by perfectly-competitive labor intermediaries that use a standard Dixit-Stiglitz aggregator. These labor intermediaries rent labor services to goods producers, with the labor demand curve facing each patient

[12] As in Iacoviello (2005), the size of household is normalized to a unit measure for households.

household given by,

$$n_{P,t}(i) = \left(\frac{W_{P,t}(i)}{W_{P,t}}\right)^{-\eta_w} n_{P,t}, \tag{5}$$

where $W_{P,t}$ is the aggregate nominal wage rate and $n_{P,t}$ is labor services for patient households. $\eta_w$ is the elasticity of substitution between the differentiated labor services.

The patient households' period budget constraint is given by

$$\begin{aligned} x_{P,t}(i) + q_{h,t}\left[\tilde{i}_{hP,t}(i) + \tilde{i}_{hR,t}(i)\right] + q_{k,t}\tilde{i}_{k,t}(i) + \frac{B_t(i)}{P_t} + \frac{L_t(i)}{P_t} \leq \frac{W_{P,t}(i)}{P_t} n_{P,t}(i) + r_{h,t} h_{R,t}(i) \\ + r_{k,t} k_{t-1}(i) + (1 + R_{t-1}) \frac{B_{t-1}(i)}{P_t} + \left[R^M_{t-1}(i) + \kappa\right] \frac{D_{t-1}(i)}{P_t} + \frac{\Pi_t}{P_t} + tr_{P,t} - tax_{P,t} - adj.\ costs, \end{aligned} \tag{6}$$

where $\tilde{i}_{hP,t}$, $\tilde{i}_{hR,t}$, and $\tilde{i}_{k,t}$ denote the patient households' new investment in owner-occupied housing, rental housing, and capital, respectively, while $q_{h,t}$ and $q_{k,t}$ are the relative prices of stock of housing and capital. $r_{h,t}$ and $r_{k,t}$ are the rental income that patient households earn from owning and renting out housing and capital.

The laws of motion of owner-occupied, rental housing, $h_{P,t}$ and $h_{R,t}$, and capital stock holdings, $k_t$, for patient households are given by,

$$h_{P,t}(i) = (1 - \delta_h) h_{P,t-1}(i) + \tilde{i}_{hP,t}(i), \tag{7}$$

$$h_{R,t}(i) = (1 - \delta_h) h_{R,t-1}(i) + \tilde{i}_{hR,t}(i), \tag{8}$$

$$k_t(i) = (1 - \delta_k) k_{t-1}(i) + \tilde{i}_{k,t}(i), \tag{9}$$

where $\delta_h$ and $\delta_k$ are the depreciation rates for housing and capital.

Patient households receive government transfers, $tr_{P,t}$, and lump-sum profits from goods producer, $\Pi_t$. Households also pay taxes on their consumption, income, capital and interest income, and their owned property. Note that the property tax on housing, $\tau_p$, is deductible when paying income taxes. The total tax burden of a patient households is given by,

$$\begin{aligned} tax_{P,t} = \tau_c x_{P,t}(i) + \tau_{yP}\left[\frac{W_{P,t}(i)}{P_t} n_{P,t}(i) + r_{h,t} h_{R,t}(i) - \delta_h h_{R,t-1}(i) - \tau_p q_{h,t}\left[h_{P,t}(i) + h_{R,t}(i)\right]\right] \\ + \tau_k (r_{k,t} - \delta_k) k_{t-1}(i) + \tau_b \left(R_{t-1}\frac{B_{t-1}(i)}{P_t} + R^M_{t-1}(i)\frac{D_{t-1}(i)}{P_t}\right) + \tau_p q_{h,t}\left[h_{P,t}(i) + h_{R,t}(i)\right], \end{aligned}$$

where $\tau_c$ is the consumption tax rate, $\tau_{yP}$ denotes the income tax rate on patient households, and $\tau_k$ and $\tau_b$ are the tax rates on capital and interest income, respectively.

Patient households purchase one-period nominal government bonds, $B_t$, and lend to impatient households, $L_t$, and receive a predetermined nominal interest rate of $R_t$ on the bonds and collect mortgage payments as the sum of interest and principal payments. The law of motion for the stock of household debt, $D_t$, is as follows,

$$\frac{D_t(i)}{P_t} = (1-\kappa)\frac{D_{t-1}(i)}{P_t} + \frac{L_t(i)}{P_t}, \tag{10}$$

where $\kappa$ is the constant amortization rate which determines the principal payment amount paid out of the stock of mortgage debt.

Each period, new lending, $L_t$, is subject to a fixed mortgage interest rate; hence, the effective interest rate on the mortgage stock, $R_t^M$, is determined as follows,

$$R_t^M(i)\frac{D_t(i)}{P_t} = (1-\kappa)\frac{D_{t-1}(i)}{P_t}R_{t-1}^M(i) + \frac{L_t(i)}{P_t}R_t^F, \tag{11}$$

which can be rewritten as,

$$R_t^M(i) = \left(1-\frac{L_t(i)}{D_t(i)}\right)R_{t-1}^M(i) + \frac{L_t(i)}{D_t(i)}R_t^F, \tag{12}$$

where $R_t^F$ denotes a fixed mortgage interest rate on new mortgage loans.

Note that when $\kappa = 1$, our model features the full amortization rate (i.e. one-period debt) and Eq.(10) implies that the stock and the flow of mortgage debt are equal to each other (i.e. $D_t = L_t$). Then, the effective interest rate of mortgages (coupled with $R_t^M(i) = R_t^F$ and the Euler condition for government debt) is equal to the interest rate on government debt (i.e. $R_t^M = R_t^F = R_t$ for all t).

Wage rigidities is introduced via Rotemberg (1982) type of quadratic cost of wage adjustments, given by,

$$\frac{\kappa_w}{2}\left(\pi^{-1}\frac{W_{P,t}(i)}{W_{P,t-1}(i)} - 1\right)^2 \frac{W_{P,t}}{P_t}n_{P,t}, \tag{13}$$

where $\kappa_w$ denotes a scale parameter and $\pi$ is the steady state inflation rate. Our model also features quadratic adjustment costs in housing and capital stocks with $\kappa_h$ and $\kappa_k$ as their corresponding level parameter values.[13] Housing adjustment costs ensure that housing stocks are not sold rapidly across patient and impatient households, and the amount of substitution between housing and non-housing sectors is limited.

The patient households' objective is to maximize utility subject to their budget constraints with the No-Ponzi conditions. The first-order condition of owner-occupied housing sets the marginal cost of obtaining one more unit of housing equal to the marginal utility gains from housing services and expected present discounted value of capital gains net of taxes, which is as follows (ignoring housing stock adjustment costs):

$$q_{h,t} = \frac{\upsilon_t \xi_h}{\lambda_{P,t}h_{P,t}} + E_t\left[\left(\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\right)\left[1-\delta_h - \tau_{p,t+1}(1-\tau_{yP})\right]q_{h,t+1}\right], \tag{14}$$

where $\lambda_{P,t}$ is the Lagrange multiplier on the budget constraint. Similarly, the first-order conditions for rental housing and capital imply that their marginal costs are equal to the expected marginal gain in net tax rental income and capital gains. The rest of the optimality conditions are included in the Appendix.[14]

[13] Capital adjustment costs are defined as $(\kappa_k/2)[(k_t(i)/k_{t-1}(i)) - 1]^2 q_{k,t}k_t$, Owner-occupied and rental housing adjustment costs are specified as $(\kappa_h/2)[(h_{P,t}(i)/h_{P,t-1}(i)) - 1]^2 q_{h,t}h_{P,t}$ and $(\kappa_h/2)[(h_{R,t}(i)/h_{R,t-1}(i)) - 1]^2 q_{h,t}h_{R,t}$, respectively.

[14] See Appendix E for more details.

### 4.1.2 Impatient households

The economy is also populated by a continuum of unit measure of infinitely-lived impatient households. The utility function of impatient households is identical to patient households, except for their time-discount factor. Similar to Iacoviello (2005), the discount factor of impatient households is smaller than patient households which facilitates borrowing and lending across agents (i.e. $\beta_I < \beta_P$). Labor services are also heterogeneous across impatient households, and are aggregated into a homogeneous labor service using a standard Dixit-Stiglitz aggregator by perfectly-competitive labor intermediaries. The labor demand function of each impatient household is then given by,

$$n_{I,t}(i) = \left(\frac{W_{I,t}(i)}{W_{I,t}}\right)^{-\eta_w} n_{I,t}, \tag{15}$$

where $W_{I,t}$ is the aggregate nominal wage rate and $n_{I,t}$ denotes the labor services of impatient households.[15]

The impatient households' budget constraint is as follows:

$$\begin{aligned}(1+\tau_c)x_{I,t}(i) + q_{h,t}\tilde{i}_{hI,t}(i) + \left[R^M_{t-1}(i)+\kappa\right]\frac{D_{t-1}(i)}{P_t} &\leq \frac{W_{I,t}(i)}{P_t}n_{I,t}(i) + \frac{L_t(i)}{P_t} + tr_{I,t} \\ -\tau_{yI}\left[\frac{W_{I,t}(i)}{P_t}n_{I,t}(i) - \tau_p q_{h,t}h_{I,t}(i) - R^M_{t-1}(i)\frac{D_{t-1}(i)}{P_t}\right] &- \tau_p q_{h,t}h_{I,t}(i) - adj.\ costs,\end{aligned} \tag{16}$$

where $x_{I,t}$ and $\tilde{i}_{hI,t}$ denote consumption and residential housing investment, respectively.

Impatient households also receive lump-sum transfers from the government, $tr_{I,t}$, and pay taxes on their consumption and income. Similar to patient households, the property tax on housing, $\tau_p$, is deductible when paying income taxes, $\tau_{yI}$. There also exists quadratic adjustment costs on their wages (to capture wage stickiness) and housing stocks. In our model, only patient households are assumed to own rental housing and capital. These assumptions, particularly the latter one, captures the fact that the impatient households have liquidity constraints and thus are the wealthy hand-to-mouth households.

The law of motion for the stock of debt held by the impatient households, $D_t$, and the evolution of the effective mortgage rate, $R^M_t$, follow Eq.(10) and (11), as shown previously. The law of motion of housing for the impatient households is similar to patient households: $h_{I,t}(i) = (1-\delta_h)h_{I,t-1}(i) + i_{hI,t}(i)$.

Impatient households face a borrowing constraint which is given by,

$$\frac{L_t(i)}{P_t} = \phi q_{h,t}\tilde{i}_{hI,t}(i), \tag{17}$$

where $\phi$ is the LTV ratio on new housing investment. As our model features a borrowing constraint with the flow instead of the stock of housing, the purchase of housing in the current period increases the level of housing in next period, and therefore, households face a lower need of investing. This dampens the marginal

[15] $\eta_w$ is the elasticity of substitution between the differentiated labor services as shown in the patient households' problem. Also, $\theta_w = \eta_w/(\eta_w - 1)$, where $\theta_w$ is the real wage markup over the marginal rate of substitution at the steady state.

gain in the next period of the borrowing constraint in that corresponding period.[16]

The impatient households' first-order condition with respect to housing (ignoring adjustment costs) is given as,

$$(1-\phi\mu_t)q_{h,t} = \frac{\upsilon_t \xi_h}{\lambda_{I,t} h_{I,t}} + E_t\left[\left(\beta_I \frac{\lambda_{I,t+1}}{\lambda_{I,t}}\right)\{(1-\delta_h)(1-\phi\mu_{t+1}) - \tau_p(1-\tau_{yI})\}\, q_{h,t+1}\right], \tag{18}$$

where $\mu_t$ is the Lagrange multiplier for impatient households' borrowing constraint. Eqn.(18) implies that the marginal cost of obtaining a unit of housing is equal to the marginal utility gain from housing and expected present discounted value of net-of-tax capital gains.

The optimality condition with respect to new borrowing is given by,

$$1 - \mu_t = \Omega_{dI,t} + \Omega_{rI,t} R_t^F, \tag{19}$$

where $\Omega_{dI,t}$ and $\Omega_{rI,t}$ denote the Lagrange multiplier on the laws of motion for mortgage debt and the effective mortgage interest rate, respectively. The rest of the optimality conditions are discussed in Appendix E.

#### 4.1.3 Renter households

There is a continuum of unit measure of infinitely-lived renter households indexed by $i$ with utility function identical to impatient households. Note that renter households have an identical discount factor to impatient households (i.e. $\beta_R = \beta_I < \beta_P$), and solve a problem that is not intertemporal, as they live hand-to-mouth, consuming their disposable income in each period. The budget constraint of the renter households is given by,

$$(1+\tau_c)x_{R,t}(i) + \frac{P_{h,t}}{P_t} h_{R,t}(i) \le (1-\tau_{yR})\frac{W_{R,t}(i)}{P_t} n_{R,t}(i) + tr_{R,t} - adj.costs, \tag{20}$$

where $x_{R,t}$, $\tau_c$, and $\tau_{yR}$ denote consumption and proportional taxes on consumption and income for renter households, respectively. Renter households earn wage income and get transfers from the government, $tr_{R,t}$, and rent housing, $h_{R,t}$, from patient households.[17] Note that there are adjustment costs for wage stickiness similar to patient and impatient households.

The first-order condition with respect to rental housing is given by,

$$p_{h,t} = \frac{\upsilon_t \xi_h}{\lambda_{R,t} h_{R,t}}, \tag{21}$$

where $\lambda_{R,t}$ is the Lagrange multiplier on the renters' budget constraint. Eqn.(21) implies that the marginal cost of acquiring a unit of rental housing is equal to the marginal utility gain. The rest of the first-order conditions for renter households are discussed in the Appendix.

[16] In our sensitivity analysis, we also examine the role of refinancing and home equity withdrawal by adding features related to these. Typically, mortgage equity withdrawals constitute less than two percent on existing equity per quarter in data.

[17] We also normalize for the amount of government transfers across three types of households with allowance of the size related to their labor share in the production.

## 4.2 Production

### 4.2.1 Non-housing goods producers

There is a continuum of monopolistically competitive non-housing goods producers indexed by $j$, whose production technology is given by,

$$y_{n,t}(j) = z_t \left[u_t(j) k_{t-1}(j)\right]^{\alpha} \left[n_{P,t}(j)^{\psi_P} n_{I,t}(j)^{\psi_I} n_{R,t}(j)^{\psi_R}\right]^{1-\alpha} - f_n, \tag{22}$$

where $y_n$ is non-housing output, $\alpha$ is the capital share in production function, and $\psi_i$ (for $i = P, I, R$ where $\psi_P + \psi_I + \psi_R = 1$) denotes the labor share of each household: patient, impatient, and renters households. $u_t$ and $z_t$ denote the capital utilization rate and exogenous aggregate productivity shock which follows an AR(1) process. $f_n$ is a fixed cost of production.

The final goods producers follow a standard Dixit-Stiglitz model to aggregate heterogeneous goods into a homogeneous good and the demand curve for the final goods producer is given by:

$$y_{n,t}(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\eta_n} y_{n,t}, \tag{23}$$

where $y_{n,t}$ and $\eta_n$ are aggregate non-housing output and the elasticity of substitution between goods, respectively. Firm $j$'s objective is to maximize its profit, subject to a utilization cost and a price adjustment cost. For more details on non-housing goods' producers problem, see Appendix E.

### 4.2.2 Investment goods and rental services producers

There is a unit measure of perfectly-competitive investment goods producers following Bernanke, Gertler and Gilchrist (1999). Non-residential investment goods producers purchase new capital investment goods from final-goods producers at a relative price of 1 and turn their $i_{k,t}$ units of goods into $\tilde{i}_{k,t} = z_{k,t} i_{k,t}$ units of effective investment goods. These goods are sold to end-users later at the relative price of $q_{k,t}$. Our model's production function also captures adjustment costs in the change in investment that are similar to those in Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2007).

Non-residential investment goods producers maximize their expected discounted value of future profits, given by,

$$\max E_0 \sum_{t=0}^{\infty} \beta_P^t \frac{\lambda_{P,t}}{\lambda_{P,0}} \left[q_{k,t}\tilde{i}_{k,t} - q_{k,t}\frac{\kappa_{ik}}{2}\left(\frac{i_{k,t}}{i_{k,t-1}} - 1\right)^2 \tilde{i}_{k,t} - i_{k,t}\right], \tag{24}$$

where $\kappa_{ik}$ is the adjustment cost parameter in capital investment. $\tilde{i}_{k,t}$ is effective investment goods where $\tilde{i}_{k,t} = z_{k,t} i_{k,t}$ and $z_{k,t}$ denotes the investment-specific technological change in new capital which follows an AR (1) process.

Residential investment goods producers solve an analogous problem to the capital investment goods producers and maximize their profit subject to the law of motion of housing. The total housing investment (i.e.

$i_{h,t} = i_{hP,t} + i_{hI,t} + i_{hR,t}$) is purchased from final-goods producers at relative price of 1 and turned into $\tilde{i}_{h,t}$ units of effective housing investment goods that can be purchased by end users at the relative price $q_{h,t}$.

Rental services producers maximize their expected discounted value of future profits, given by,

$$\max E_0 \sum_{t=0}^{\infty} \beta_P^t \frac{\lambda_{P,t}}{\lambda_{P,0}} \left[ \frac{P_{h,t}(i)}{P_t} h_{R,t}(i) - r_{h,t} h_{R,t}(i) - \frac{\kappa_{ph}}{2} \left( \frac{P_{h,t}(i)}{P_{h,t-1}(i)\pi} - 1 \right)^2 \frac{P_{h,t}}{P_t} h_{R,t} \right], \tag{25}$$

where $\kappa_{ph}$ is the price adjustment cost parameter in rental services.

The demand curve faced by rental services is given by

$$h_{R,t}(i) = \left( \frac{P_{h,t}(i)}{P_{h,t}} \right)^{-\eta_h} h_{R,t}, \tag{26}$$

where $\eta_h$ is the elasticity of substitution between rental services.

The optimality condition with respect to housing rental rate is given by,

$$\left( \frac{\pi_{h,t}}{\pi} - 1 \right) \frac{\pi_{h,t}}{\pi} = E_t \left[ \beta_P \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \left( \frac{\pi_{h,t+1}}{\pi} - 1 \right) \frac{\pi_{h,t+1}}{\pi} \frac{\pi_{h,t+1}}{\pi_{t+1}} \frac{h_{R,t+1}}{h_{R,t}} \right] - \frac{\eta_h - 1}{\kappa_{ph}} \left( 1 - \theta_h \frac{r_{h,t}}{p_{h,t}} \right), \tag{27}$$

where $\theta_h$ is the real housing services markup over the marginal rate of substitution at the steady state.

The relative price of rental housing services and rental inflation is given by

$$\frac{\pi_{h,t}}{\pi_t} = \frac{p_{h,t}}{p_{h,t-1}}. \tag{28}$$

### 4.3 Government and monetary policy

The government issues bonds, collects taxes, and pays transfers to households (patient, impatient, and renters households). Note that the aggregate tax revenue is generated from consumption, income, property, capital and interest rate income taxes from various types of households, as detailed earlier in their respective budget constraints.

The aggregate level of transfer payments to households is given by,

$$tr_t = \Xi y_n - \varrho_b b_{t-1}, \tag{29}$$

where $\Xi$ denotes a level parameter and $\varrho_b$ determine the response of transfers to government debt.[18] government debt cannot follow a Ponzi scheme. We ensure this considion by Aggregate transfers, $tr_t$, are distributed to each type of households based on their respective labor shares (i.e. $tr_{i,t} = \psi_i tr_t$ for $i = \{P, I, R\}$).

[18]Following Leeper, Walker and Yang (2010), government debt cannot follow a Ponzi scheme. We ensure this condition by the adjusted level of either taxes, government spending, or transfers.

The government faces a budget constraint as follows,

$$tax_t + b_t = \left(\frac{1 + R_{t-1}}{\pi_t}\right) b_{t-1} + g_t + tr_t, \tag{30}$$

where $g_t$ is government expenditure which follows an exogenous AR(1) process:

$$\log g_t = (1 - \rho_g) \log g + \rho_g \log g_{t-1} + \varepsilon_{g,t}, \tag{31}$$

where $\varepsilon_{g,t}$ represents an i.i.d government spending shock with variance $\sigma_g^2$.

The central bank sets monetary policy following a Taylor rule, given by,

$$R_t = R + a_\pi \log\left(\frac{\pi_{c,t}}{\pi}\right) + a_y \log\left(\frac{y_t}{y}\right), \tag{32}$$

where $R$ denotes the steady-state level of nominal interest rate in gross terms. $a_\pi$ and $a_y$ are the coefficients of inflation, output gap, respectively.

## 4.4 Market clearing conditions

The goods market clears

$$x_t + i_t + g_t = y_{n,t} - \text{adj.costs}, \tag{33}$$

where $x_t = x_{P,t} + x_{I,t} + x_{R,t}$ denote total consumption. Total investment is $i_t = i_{k,t} + i_{h,t}$ where $i_{k,t}$ is non-residential investment and $i_{h,t} = i_{hP,t} + i_{hI,t} + i_{hR,t}$ is residential investment.

A competitive equilibrium is defined as the set of prices, allocations, and policies where households maximize the discounted present value of utility, firms maximize their profits, and all markets clear.

## 4.5 Calibration

We calibrate the model parameters so that the model's steady state matches some of the key statistics in the U.S. macroeconomic and financial data and our model is set in a quarterly frequency.[19] Table 3 summarizes our calibration values and Table 4 represents the steady-state ratios of the model and its counterparts in the data.

The time-discount factor of patient households, $\beta_P$, is set to 0.9916, implying a steady-state annualized real interest of near 4 percent. The time-discount factors of impatient and renter households, $\beta_I$ and $\beta_R$, are fixed at 0.9852 to match a Lagrange multiplier on household debt equivalent to a 200 basis point spread

[19]Data target ratios come from the National Income and Product Accounts (NIPA), Flow of Funds Accounts (FOF), the 2001 Residential Financial Survey (RFS), and the 2011 American Housing Survey (AHS). The calibration methodology of using steady-state relationships in the model is similar to Cooley, Hansen and Prescott (1995). Parameters related to durable stock is based closely on the findings in Mertens and Ravn (2011) and other parameters are mostly drawn from Alpanda and Zubairy (2016, 2017).

on the risk-free rate.[20] The labor disutility parameter, $\xi_n$, is normalized to 1 as it affects the scale of the economy. The housing preference parameter, $\xi_h$, is set to 0.16 to match aggregate housing to GDP share, and is close to the estimate in Justiniano, Primiceri and Tambalotti (2015). The inverse of the Frisch labor supply elasticity is set to 1. This value is picked as a compromise between the estimated values in the Real Business Cycle and New Keynesian literatures (Smets and Wouters, 2007).

Table 3: Model Parameters

| Description | Symbol | value |
|---|---|---|
| Discount factor | $\beta_P$, $\beta_I$, $\beta_R$ | 0.9916, 0.9852, 0.9852 |
| Inverse labor supply elasticity | $\vartheta$ | 1 |
| Level for housing and labor in utility | $\xi_h, \xi_n$ | 0.16, 1.00 |
| LTV ratio on new regular mortgages | $\phi$ | 0.85 |
| Amortization rate on household loans | $\kappa$ | 0.0178 |
| Capital share in production | $\alpha$ | 0.24 |
| Depreciation rates | $\delta_h$, $\delta_k$ | 0.0112, 0.0176 |
| Investment adj. cost | $\kappa_{ih}$, $\kappa_{ik}$ | 2.00, 2.00 |
| Stock adj. cost | $\kappa_h$, $\kappa_k$ | 2.00, 2.00 |
| Labor shares in production | $\Psi_P$,$\Psi_I$, $\Psi_R$ | 0.26, 0.47, 0.27 |
| Tax rates | | |
| Consumption tax rate | $\tau_c$ | 0.05 |
| Capital income tax rate | $\tau_\kappa$ | 0.40 |
| Interest income tax rate | $\tau_b$ | 0.15 |
| Property tax rate | $\tau_p$ | 0.0035 |
| Income tax rate | $\tau_{yP}, \tau_{yI}$, $\tau_{yR}$ | 0.30, 0.30, 0.20 |
| Transfers | $\Xi$ | 0.024 |
| Response of transfers to gov. debt | $\varrho_b$ | 5.00 |
| AR(1) Government spending shock | $\rho_g$ | 0.85 |
| Taylor rule for inflation response | $a_\pi$ | 1.50 |
| Taylor rule for output gap | $a_y$ | 0.01 |

The steady-state non-residential investments to GDP ratio is about 13% while capital-to-GDP ratio is 1.85 on annualized basis in the data. Based on these values, we calibrate the quarterly depreciation rate for capital stocks, $\delta_k$, to 1.76%. Capital investment adjustment cost parameters, $\kappa_{ik}$, is calibrated to be 2 which is rounded to be close to estimates as in Eberly, Rebelo and Vincent (2012) and Justiniano, Primiceri and Tambalotti (2015).[21] The capital share in production, $\alpha$, is set to 0.24 using the capital-output ratio and the model-implied after-tax rental rate of capital.

The steady-state LTV ratio, $\phi$, is calibrated to be 0.85 in order to match the first mortgage loan ratio (median value) to the purchase of one unit of mortgaged properties estimated by Duca, Muellbauer and Murphy (2011). In data, the residential investments to GDP ratio is about 4% while housing-to-GDP ratio is about 1.07. In order to match these, we calibrate the depreciation of houses, $\delta_h$, to 0.0112.[22] The amortization

[20]As in Alpanda and Zubairy (2016), this value reflects the spread between 30-year mortgages and 10-year Treasury bonds of around 170 bps on average over 1971-2014.

[21]Housing investment adjustment cost, $\kappa_{ih}$, is treated symmetrically and is set to 2.00.

[22]This value is also consistent with estimates in Hull (2017) and Wilhelmsson (2008).

rate on households loans, $\kappa$, is set to 0.0178 to imply the duration of mortgage loans around 18 years in the model.[23]

We calibrate the wage share of impatient households, $\Psi_I$, to 0.47 and their share of housing, $h_I/h$, to 0.38. The wage share of rental households $\Psi_R$ is set to 0.27 with the rental housing share, $h_R/h$, of 0.17 which is similar to those values from the RFS and AHS surveys. The wage share of patient households, $\Psi_P$, is thus set to 0.26 and the share of patient households' housing, $h_P/h$, to 0.44.[24]

Table 4: Model steady-state ratios

| Description | Symbol | Model | Data target |
|---|---|---|---|
| Total consumption/GDP | $c/y$ | 0.62 | 0.62 |
| Share of patient household | $c_P/c$ | 0.41 | |
| Share of impatient household | $c_I/c$ | 0.36 | |
| Share of renter household | $c_R/c$ | 0.23 | |
| Total investment/GDP | $i/y$ | 0.17 | 0.17 |
| Non-residential investment/GDP | $i_k/y$ | 0.13 | 0.13 |
| Residential investment/GDP | $i_h/y$ | 0.04 | 0.04 |
| Government expenditure/GDP | $g/y$ | 0.20 | 0.20 |
| Tax revenue/GDP | $tax/y$ | 0.31 | |
| Transfers/GDP | $tr/y$ | 0.02 | |
| Wage share in non-housing income | $1-\alpha$ | 0.76 | |
| Share of patient households | $\psi_P$ | 0.26 | 0.26 |
| Share of impatient households | $\psi_I$ | 0.47 | 0.47 |
| Share of renter households | $\psi_R$ | 0.27 | 0.27 |
| Capital stock/GDP (qtr) | $k/y$ | 7.60 | 7.60 |
| Housing stock/GDP (qtr) | $h/y$ | 4.25 | 4.28 |
| Share of patient households | $h_P/h$ | 0.46 | |
| Share of impatient households | $h_I/h$ | 0.38 | |
| Share of renter households | $h_R/h$ | 0.17 | |

The steady state government expenditure to GDP ratio, $g/y$, is set to 20% based on the NIPA data average over the sample period under consideration. The steady state transfers to GDP ratio is calibrated at 0.01 and the level parameter for transfers, $\Xi$, is set to 0.024. The responsiveness of transfers to government debt is assumed to be 5, in order to preserve determinacy within the model. Income tax rates for patient and impatient households, $\tau_{yP}$ and $\tau_{yI}$, are set to 0.3 while the renters households income tax rate, $\tau_{yR}$, is set to 0.2 to imply tax progressivity. The consumption tax rate and property tax rate, $\tau_c$ and $\tau_p$, are set to 0.05 and 0.0035, respectively. We also calibrate the capital and interest rate income tax, $\tau_k$ and $\tau_b$, as 0.40 and 0.15 following Alpanda and Zubairy (2016). The government shock persistence, $\rho_g$, is set to 0.85. In our sensitivity analysis, we alter this persistence parameter to explore the role of the negative wealth effect of the shock. The Taylor rule coefficients of inflation response and output gap, $a_\pi$ and $a_y$, are set to 1.50 and 0.01, respectively.

[23]This mortgage loan duration is close to AHS average duration of outstanding loan data.

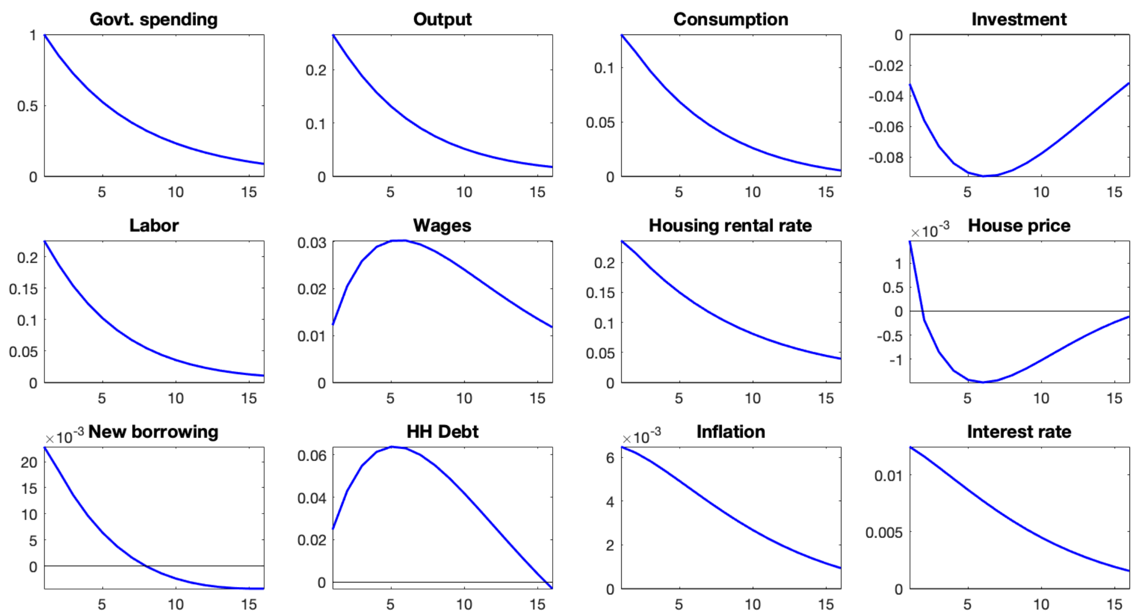
[24]We aim to target the average share of each housing tenure group based on the SCF data (1995 to 2007). Altering this value to match the CEX share (1981 to 2007) also gives consistent simulation results.

# 5 Model Results

In this section, we analyze the effects of government spending shocks based on the benchmark parameters. First, we present the dynamic effects on aggregate variables. We then compare consumption and income responses among different types of households and illustrate some of the possible transmission mechanisms of heterogeneity. As our benchmark model focuses on aggregate consumption responses without habit formation, we further explore the role of durable goods, habit formation, and adjustment costs in our extensions.

## 5.1 Benchmark results

Figure 5: Impulse responses in the benchmark model



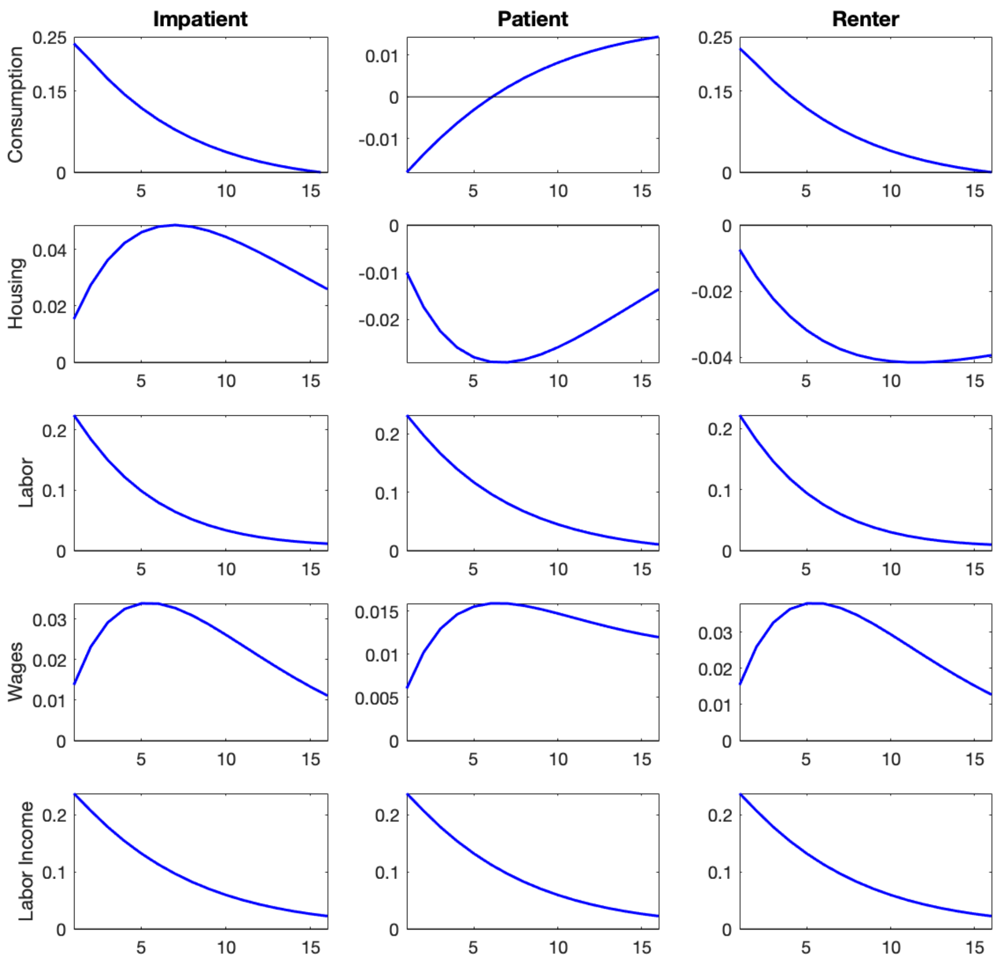

Note: Figure 5 shows the impulse responses functions of key aggregate variables in response to a positive government spending shocks.

Figure 5 illustrates the effects of a positive government spending shock based on the baseline calibration parameter values described in Section 4.5. In response to a positive government spending shock, output and consumption increase, significantly. Investment is crowded out, which is consistent with findings from Galí, López-Salido and Vallés (2007) and Mountford and Uhlig (2009).[25] Labor and real wages both rise. House prices, inflation, and interest rate all also rise on impact. Note that we are able to generate a rise in house prices to a positive government spending shock on impact, though not the hump-shaped positive response seen in Figure 1. However, Khan and Reza (2017) have shown that most standard models face a challenge in generating a positive response of house prices to a government spending shock, and even their proposed fix

[25] A positive government spending shock crowds out both residential and non-residential investment in our model results.

does not generate a hump-shaped response. Lastly, new borrowing increases which leads to a slow rise in the stock of household debt.

Figure 6: Impulse responses in the benchmark model across households




Note: Figure 6 shows the impulse responses functions of key variables across different households (patient, impatient, and renters) in response to a positive government spending shock.

Figure 6 displays the dynamic responses among three types of households - patient, impatient, and renters - to a positive shock to government spending. Our model generates heterogeneous consumption responses across agents: impatient households (borrowers) have a large and persistent increase, patient households' (savers) consumption declines on impact at a relatively small magnitude, renters households have a similar response to impatient households but the increase is slightly smaller. The responses of housing stock and investment rise for impatient households while the stock of housing owned by the patient household falls. Labor, wage, and labor income increase for all households. Overall, we do not find any heterogeneity in the labor market responses. Notably, the rise in labor income is of the same magnitude across all types of households.

Higher government spending generally induces negative wealth effects for all agents and the supply of labor increases, which results in the rise of output. With higher labor income for all types of households, the heterogeneous consumption responses may be explained as following. Impatient households respond the most and this may be explained by the effects on their borrowing power and liquidity constraints. Patient households tend to cut their consumption while supplying more labor, which is more like a representative household behavior. Renters are more like hand-to-mouth consumers as they do not hold any asset, and therefore, spend their disposable labor income on consumption expenditures. The general equilibrium effects of a positive government spending shock with the rise in aggregate demand is consistent, though there exists heterogeneity across households.

## 5.2 Transmission mechanisms

Given the model results, we explore the potential transmission mechanisms of a government spending shock on heterogeneous consumption responses. In the standard RBC model, households face higher taxes following a positive government spending shock, and therefore experience negative wealth effects (Aiyagari, Christiano and Eichenbaum, 1992; Baxter and King, 1993). This negative wealth effect induces the representative household to decrease consumption and increase labor supply, implying output rises as a result.[26] Investment response depends on the persistence of government spending shocks. The presence of nominal rigidities imply a shift in the labor demand in response to increased demand due to public spending. As a result, we see an overall rise in wages.[27]

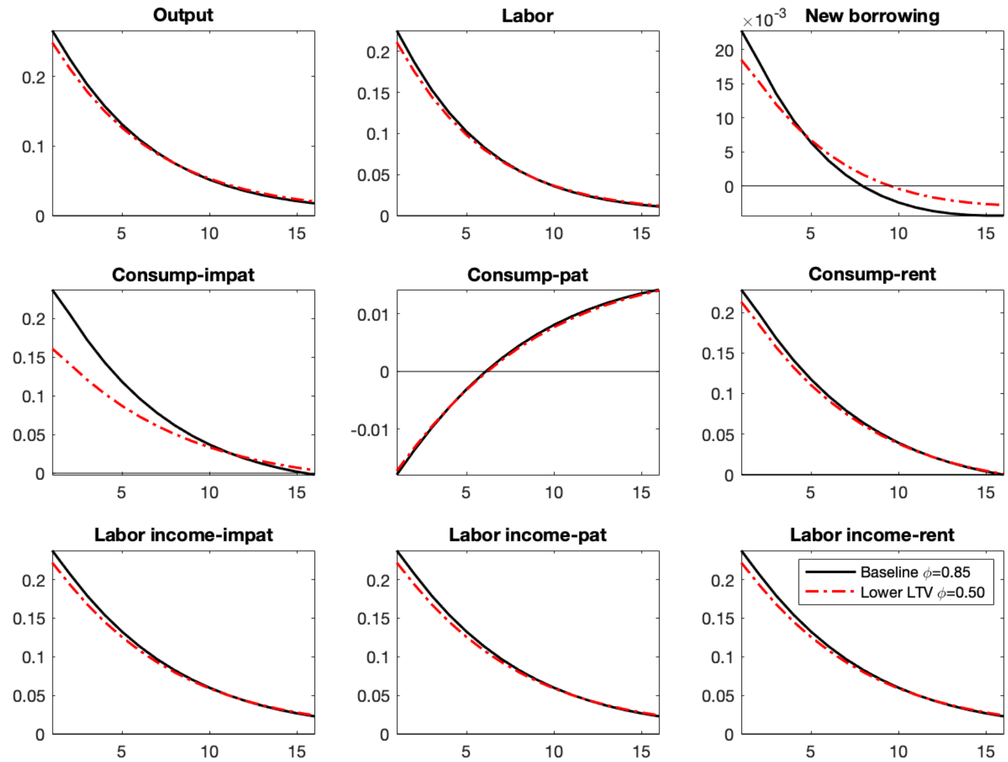
Our paper contributes to the new-Keynesian literature studying the effects of fiscal shocks by extending the model with households in different financial positions. In this case the households' consumption responses following a government spending shock are determined by the income effect, credit effect and the wealth effect. As show above, since wages and labor for all three households rise, the labor income goes up for all of them, and that too to a similar degree and puts upward pressure on their consumption. Thus the differences across the various households are likely driven by the other two channels. In particular, the two potential transmission channels we consider are as follows: (i) liquidity constraints, and (ii) the persistence of shock propagating the negative wealth effect.

In the benchmark model, the impatient household faces a borrowing constraint given by $d_t = \phi q_{h,t} h_{I,t} (i)$. Since house prices rise in response to a government spending shock, this implies that the credit constraint for the impatient household is loosened by the spending shock. The steady-state LTV ratio, $\phi$, plays an important role in dictating the degree of borrowing ability of these households, in response to the house price changes. As shown in Figure 7, the lower level of LTV ratio (i.e. a larger down-payment requirement) clearly affects the consumption responses of impatient households negatively, while the consumption responses of

[26]In a standard RBC model, a higher labor supply lowers the real wage and consumption is crowded-out

[27]The presence of rule-of-thumb consumers generates the positive response of consumption and wages when government spending increases (Devereux, Head and Lapham, 1996; Galí, López-Salido and Vallés, 2007).

Figure 7: Impulse responses to a positive government spending shock for varying values of $\phi$



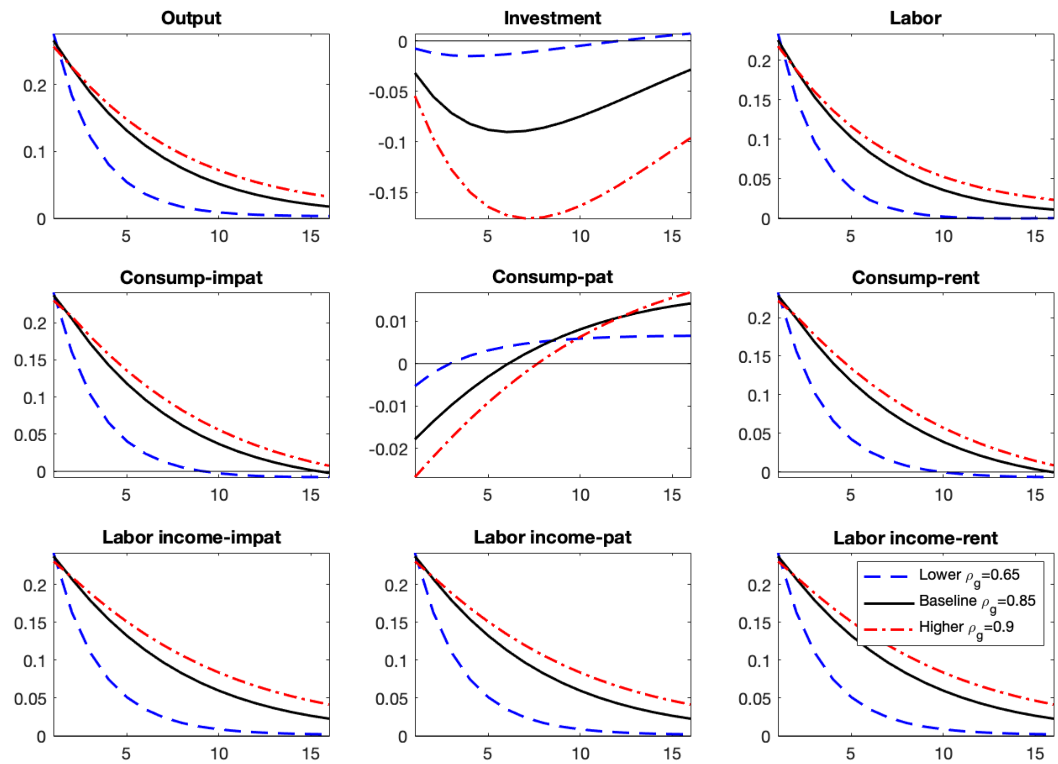

Note: Figure 7 shows the impulse responses functions of key variables across different households (patient, impatient, and renters) in response to a positive government spending shock. The solid line indicates the baseline model results. The red dotted-line represents the lower LTV ratio which lowers the borrowing ability of impatient households.

patient and renters households are almost identical. At $\phi = 0.50$, output, labor, and labor income are almost identical while the new borrowing slightly falls and the lower borrowing power induces impatient households to relatively reduce their consumption. Despite the negative wealth effect following a positive government spending shock, the liquidity and credit effects still boost up impatient households' consumption expenditures overall.

One of the main features that affects consumption and labor responses is through the negative wealth effect channel following a positive government spending shock. High spending generate expectation of higher tax today or in the future. For the renter households, since they consume their disposable income each period, only current taxes matter and if taxes do not rise immediately, they do not face these negative wealth effects on their consumption. These types of consumers are highlighted in Galí, López-Salido and Vallés (2007). On the other hand, the patient households are the Ricardian households in the model and bear the largest brunt of this negative wealth effect.[28] In Figure 8, we show the impulse responses with different degrees of shock persistence, which determines the size of the negative wealth effect. The baseline shock persistent, $\rho_g$,

[28] This is particularly the case since they are taxed on both owner-occupied and rental housing via property taxes and house prices rise in response to a spending shock. They are also subject to taxes on interest income which will rise as borrower household increase borrowing in response to increased spending.

Figure 8: Impulse responses to a positive government spending shock for varying values of $\rho_g$




Note: Figure 8 shows the impulse responses functions of key variables across different households (patient, impatient, and renters) in response to a positive government spending shock. The solid line indicates the baseline model results. The blue dash-dotted line represents the lower $\rho_g$ and red dotted line represents the higher $\rho_g$ indicating high persistence of the shock.

is set to 0.85. When we consider a less persistent shock, and $\rho_g$ equal to 0.65, increase in output, labor, and consumption on impact are almost identical to the baseline result while the effects of the shock is less persistent. Consumption response heterogeneity across households are reduced as patient households no longer endure the significant negative wealth effect, and therefore, cut their consumption by less. Impatient and renters household have larger responses but this only lasts up to four quarters after the shock. Similarly, when we consider a more persistent shock, and $\rho_g$ to be 0.9, then the decline in the consumption response of the patient household is even larger on impact.

In summary, we find that the liquidity constraints and the persistence of the shock play an important role in the propagation of government spending shocks, with the former of particular importance to the mortgagors and the latter of particular importance to the patient households (savers). Notably, our findings provide theoretical support for the notion that household mortgage debt positions play an important role in the transmission mechanism of fiscal policy. In the next section, we consider an extended version of the model with durable goods and further test the robustness of our results to alternative parameterizations.

# 6 Extensions and robustness analysis

In this section, we further distinguish between the effects on durable and non-durable consumption across the different types of households. We then discuss some of robustness analysis for our model results.

## 6.1 Durable goods and habit formation

In the benchmark model, we focus on aggregate consumption responses across different types of households following a positive government spending shock. In our model housing is an investment and depreciates slowly, and can potentially be thought of as a durable asset. However, the borrowing ability of impatient households is determined by the housing value where it is tied up as a collateral. Thus. in this subsection, we further extend our model to distinguish between durable and non-durable expenditure and explore the effects of government spending shocks on durable consumption explicitly.

Note that our habit-adjusted consumption basket with durable goods for households $j = \{P, I, R\}$, $x_{j,t}$, is given by

$$x_{j,t}(i) = c_{j,t}(i)^{\theta} s_{j,t}(i)^{1-\theta} - \mu_c c_{j,t-1}(i)^{\theta} s_{j,t-1}(i)^{1-\theta}, \tag{34}$$

where $\theta$ is a share parameter, $\mu_c$ is a parameter for habit persistence, $c_{j,t}$ denotes the non-durable consumption, and $s_{P,t}$ is the stock of durable consumption.[29]

When $\theta = 1$ and $\mu_c = 0$, the above expression reduces to the benchmark case with no durable goods in the consumption basket. We follow Mertens and Ravn (2011) for key parameter values of durable goods. The share parameter, $\theta$, is calibrated to be 0.88, in order to target the durables accounting for 12 percent of total consumption during the post WWII period in the U.S. The depreciation rate of durable stock, $\delta_s$, is assumed to be shorter than housing and set to 0.025.[30] The adjustment costs for durable stocks, $\kappa_s$, and durable investments, $\kappa_{\tilde{c}}$, are rounded close to the estimates of Mertens and Ravn (2011) with value of 8.00.[31] The rest of the parameters remain the same as the baseline case.

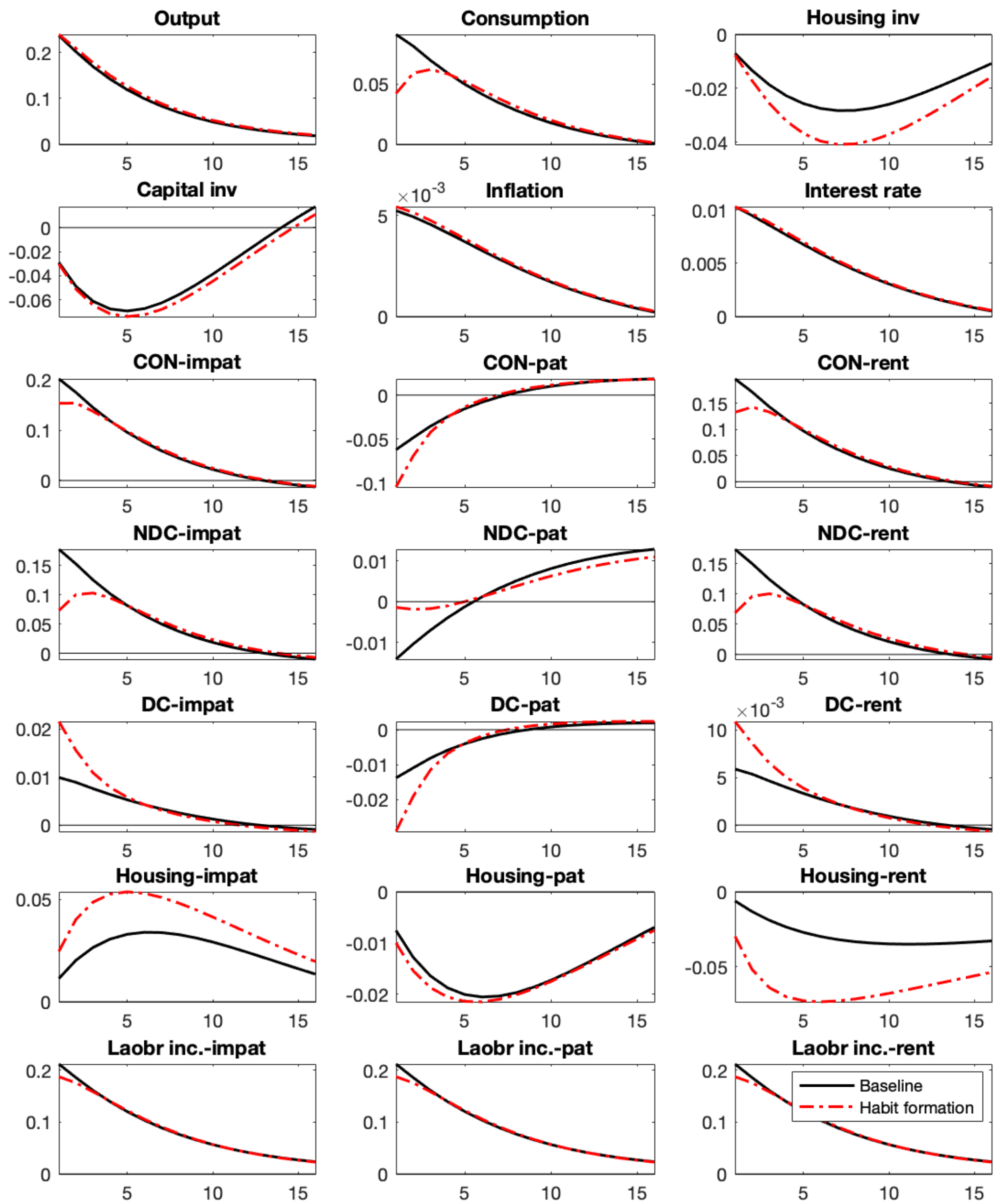
Figure 9 displays the effects of a positive government spending shock for the model with durable goods. Similar to the benchmark results, output and consumption rise significantly. Housing and capital investment are crowded out. The model also features heterogeneous consumption responses across households. Most notably, we can generate a rise in both non-durable and durable consumption for impatient households. Also, renters households behave similar to impatient households which is also replicating evidence from the empirical analysis. On the other hand, the patient households' consumption response is very small in magnitude and we see a decline in both types of consumption. Habit formation generates similar results to the baseline case. With a moderate habit formation (i.e. $\mu_c = 0.70$), impatient households' non-durable expenditure becomes hump-

[29]Durable stock follows the law of motion as $s_t = (1 - \delta_s)s_{t-1} + \tilde{c}_t$ where $\tilde{c}_t$ denotes the purchases of new consumer durables.

[30]The depreciation rate of housing is set to $\delta_h = 0.0112$ implying the longer duration compared to the 10 years of depreciation in durable stock.

[31]Mertens and Ravn (2011) finds that the investment adjustment costs matter slightly less for durable stocks than capital stocks.

Figure 9: Impulse responses in the model with durable goods




Note: Figure 9 shows the impulse responses of key variables for the model with durable goods. The black solid line indicates the baseline results and red dash-dotted line indicates the responses with habit formation in response to a positive government spending shock.

shaped while they increase durable consumption. Renter households behave similar to impatient households but at a smaller magnitude. Patient households tend to cut durable consumption and adjust their non-durable expenditures.

These results further illustrate that housing in the baseline model without durable goods does not represent the (non-housing) durable consumption shown in the empirical analysis.[32] The main evidence are the responses of renters, where durable consumption rises but rental housing falls, as rents rise due to housing market dynamics. In further explorations, we eliminate the role of the collateral channel on housing and set the same depreciation and adjustment costs across durable consumption and housing stocks, and evaluate whether housing and durable goods display identical responses. In this case, expenditure heterogeneity across different types of households is still evident while the magnitude of impatient households' non-durable adjustment is less than the baseline case due to the reduction in borrowing ability.

## 6.2 Robustness to alternative parameterization

In Figure 10, we conduct several robustness analysis by altering the baseline parameterization. In our sensitivity analyses, we consider the case with (i) habit formation in consumption, (ii) refinancing and equity withdrawal on existing loans, and (iii) low adjustment costs in housing stock.

*The role of habit formation.* In the baseline model calibration, we focus on the case without habit formation in consumption. In this subsection, we add habit formation to model specification to explore the effects on expenditure heterogeneity.[33] As shown in the first row of Figure 10, adding a moderate habit formation does not alter heterogeneous consumption responses across different types of households qualitatively. With habit formation, the consumption responses is hump-shaped while the impact response is slightly lower than the baseline case.

*Role of refinancing and equity withdrawal.* In the benchmark model, the new lending is determined by the steady-state LTV ratio associated with new investment in housing. In our sensitivity analysis, we consider the role of refinancing and home equity withdrawal to consider additional effects on mortgage debt. From our model, note that the effective interest rate on mortgage stock is given by,

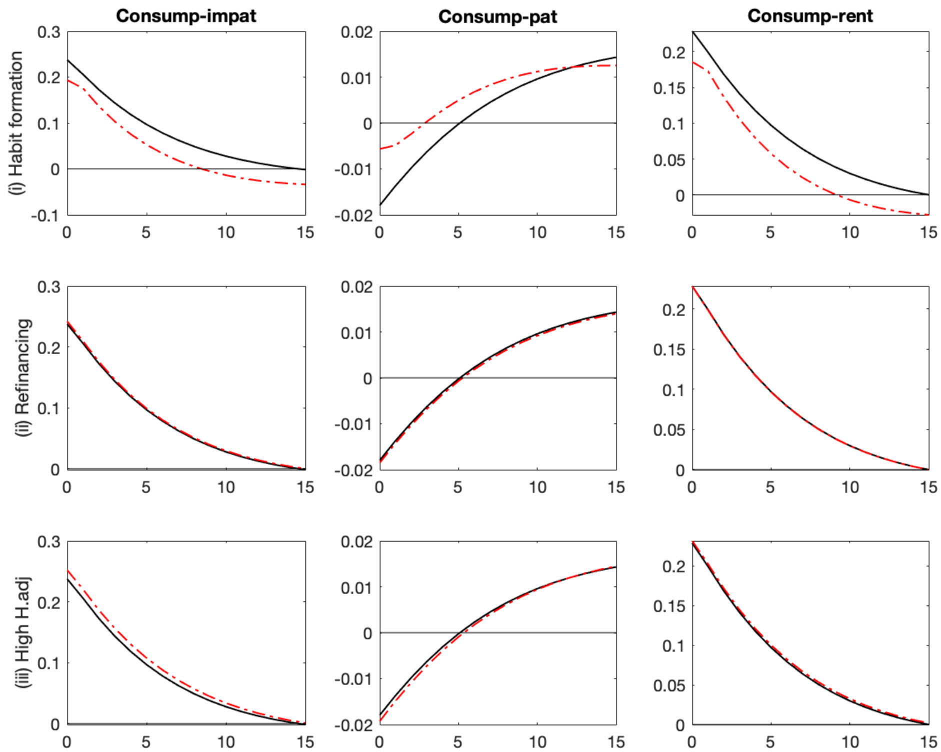
$$R_t^M(i)d_t(i) = (1-\Phi)(1-\kappa)\frac{d_{t-1}(i)}{\pi_t}R_{t-1}^M(i) + \left[l_t(i) + \Phi(1-\kappa)\frac{d_{t-1}(i)}{\pi_t}\right]R_t^F, \tag{35}$$

where $\Phi$ is the refinancing rate.

[32] See Appendix F for more details.

[33] In the figure, we show the moderate level of habit formation with $\mu_c = 0$ and imposing a moderate value of habit formation, $\mu_c = 0.3$ still provides a similar results.

Figure 10: The effects of fiscal policy under alternative parameterizations




Note: Figure 10 shows the dynamics of consumption responses with alternative parameterizations in response to a positive government spending shocks. The solid line indicates the baseline model results and the red dash-dotted line represents corresponding alternative features.

With the home equity withdrawal rate, $\Upsilon$, the new lending is then given by

$$l_t = \phi q_{h,t} \tilde{i}_{hI,t}(i) + \Upsilon \left[ q_{h,t}(1-\delta_h) h_{I,t-1}(i) - (1-\kappa) \frac{d_{t-1}(i)}{\pi_t} \right]. \tag{36}$$

Following Greenspan and Kennedy (2005) and Alpanda and Zubairy (2017), we set the refinancing rate to 0.0475 and the home equity withdrawal rate to 0.0172.[34] Figure 10 second row displays the sensitivity of consumption variations with alternative parameterization. Allowing refinancing and home equity withdrawal enhances the borrowing ability of impatient households, which slightly increases their consumption response but the changes are rather small in magnitude. This suggests that for the propagation of fiscal shocks, the additional channel coming from refinancing does not alter the results considerably.

*Adjustment costs in housing stock.* The third row of Figure 10 shows the consumption responses when the degree of housing stock adjustment costs, $\kappa_h$, change. When we increase adjustment costs in housing

[34] The ratio of repayments from refinancing is averaged around 4.4% (implying 7.8 years of an interest rate duration) quarterly during 1991-2005 based on the data provided by Greenspan and Kennedy (2005). Following Alpanda and Zubairy (2016), we consider the average interest rate duration of 7.1 years with the refinancing rate, $\Phi$, to 0.0475. We also set the home equity withdrawal rate to 0.0172 to match the 1.72% of existing equity of borrowers during 1991-2005.

stock, $\kappa_h$ to be 10.00, the house price rises by more and housing stock accumulates more slowly. Impatient households face a rise in their collateral values which further strengthens their borrowing ability. As a result, consumption of the impatient households rises by more.

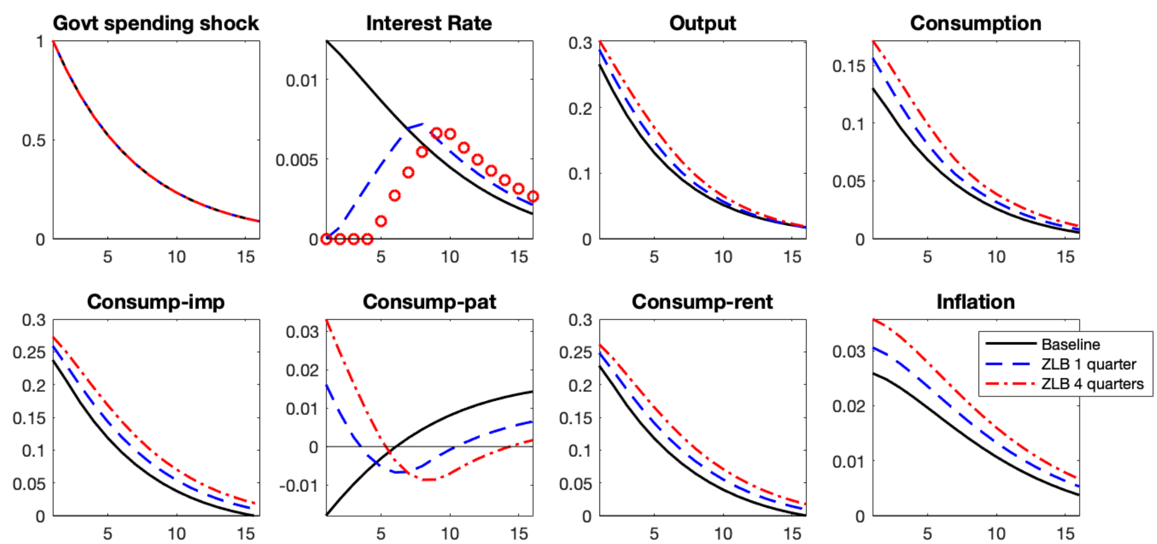
### 6.3 Alternative Monetary Stance: Considering ZLB

In this subsection, we discuss how the effects of government spending shocks are different when monetary policy is constrained by zero lower bound (ZLB). In particular, we consider the following monetary policy rule:

$$R_t = \max\left[R + a_\pi \log\left(\frac{\pi_{c,t}}{\pi}\right) + a_y \log\left(\frac{y_t}{y}\right), 0\right]$$

A vast literature has shown that the aggregate effects of government spending are amplified when short term rates are constrained by the ZLB (Eggertsson (2011); Christiano, Eichenbaum and Rebelo (2011)).

Figure 11: Impulse responses with ZLB periods




Note: Figure 11 shows the impulse responses of key variables for the baseline model and ZLB period (1 quarter and 4 quarters).

In Figure 11, we show the impulse responses of key variables for our baseline case along with two alternative scenarios: i) when the ZLB binds for 1 quarter and ii) when the ZLB binds for four quarters.[35] In response to a positive government spending shock, output and consumption increase significantly and these effects are amplified under ZLB. Even a moderate duration of ZLB generates heterogeneous consumption responses while the differences in the effects compared to the baseline case are largest for patient households. Patient households' consumption response is similar to that of a representative agent setup, and is crowded out in

[35] We generate this scenario by employing the Occbin code of Guerrieri and Iacoviello (2015), by introducing a preference shock driven recession that takes the interest rate to the ZLB.

normal times while it increases during the ZLB period.

Under ZLB, the rise in government spending is inflationary due to a rise in demand, which decreases the real interest rate as nominal rates are bound at zero. A lower real interest rate generates the intertemporal substitution effects, which stimulates current consumption. This effect becomes evident under ZLB for all types of households while the magnitude of consumption response increases the most for impatient households.

Table 5: Output and consumption multipliers

| | Normal times | ZLB (1 quarter) | ZLB (4 quarters) | %Δ (Base, ZLB 1Q) |
|---|---|---|---|---|
| PANEL A: Output multipliers | | | | |
| One-year Integral | 1.31 | 1.45 | 1.58 | 0.11 |
| Two-year Integral | 1.28 | 1.42 | 1.58 | 0.11 |
| PANEL B: Consumption multipliers | | | | |
| One-year Integral | 0.41 | 0.49 | 0.56 | 0.20 |
| Two-year Integral | 0.40 | 0.48 | 0.57 | 0.20 |
| PANEL C: Consumption multipliers for **Impatient** Households | | | | |
| One-year Integral | 0.27 | 0.30 | 0.33 | 0.11 |
| Two-year Integral | 0.26 | 0.30 | 0.34 | 0.15 |
| PANEL D: Consumption multiplier for **Patient** Households | | | | |
| One-year Integral | -0.02 | 0.01 | 0.03 | 1.50 |
| Two-year Integral | -0.02 | 0.00 | 0.02 | 1.00 |
| PANEL E: Consumption multipliers for **Renter** Households | | | | |
| One-year Integral | 0.16 | 0.18 | 0.20 | 0.13 |
| Two-year Integral | 0.16 | 0.18 | 0.21 | 0.13 |

In Table 5, we compute the cumulative output and consumption multipliers.[36] We find that the one-year cumulative output multiplier is 1.45 in the ZLB period which is higher than that of 1.31 in normal times.[37] At longer horizons, output multiplier increases by even more under ZLB.

Similarly, we compute the cumulative consumption multipliers at the aggregate and disaggregate level. We find that the consumption multiplier is around 0.41 during normal times while it is higher during ZLB

[36] All horizons are shown in Figure G.1 in the Appendix G.

[37] Miyamoto, Nguyen and Sergeyev (2018) find the on-impact output multiplier as 1.5 in the zero lower bound and Christiano, Eichenbaum and Rebelo (2011) also find that the multiplier is substantially larger than one. The amplification effect of ZLB on our baseline government spending multiplier is relatively smaller than some of these documented studies, as Abo-Zaid and Kamara (2020) point out that a model with credit constraints potentially dampens the consumption response relative to one in the absence of these constraints.

periods. Impatient and renter households have positive consumption multipliers in both normal times and in the ZLB scenario, while the magnitude is much higher for the latter case. However, patient households have qualitatively different consumption multipliers during and outside of the ZLB periods, with the largest percentage change overall as well, though the size of the magnitude is small. From this exercise, we conclude that the effects of government spending shock on the economy are amplified and output and consumption for all types of agents is crowded-in, under ZLB periods.

# 7 Conclusion

Employing U.S. household survey data, this paper examines how the effects of government spending shocks depend on the balance-sheet position of households. Since mortgage debt constitutes the vast majority of household debt, we use housing tenure status to proxy for the financial positions of the households. In response to a positive government spending shock, we find that mortgagor households experience a large, positive consumption response, while renters have a smaller rise in consumption. Outright homeowners without mortgage debt, in contrast, have an insignificant consumption expenditure response to a public spending shock. We consider a dynamic stochastic general equilibrium (DSGE) model with housing and financial frictions, and provide a theoretical framework to rationalize these empirical findings and transmission mechanism. Our model features three types of households: savers who own their housing, borrowers with mortgage debt, and rule-of-thumb consumers who rent housing. We show that this model can successfully match heterogeneous consumption responses. The model suggests that liquidity constraints and wealth effects tied to the persistence of public spending, play a crucial role in the propagation of government spending shocks. Our findings provide both empirical and theoretical support for the notion that household mortgage debt position plays an important role in the transmission mechanism of fiscal policy.

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# Appendix

# A Data sources

## A.1 Aggregate data

Table A.1: Data description

| Data | Description | Source |
|---|---|---|
| NGDP | Nominal GDP | BEA |
| PGDP | GDP deflator | BEA |
| GOV | Nominal government purchases | BEA |
| NCONS | Nominal personal consumptoin expenditure | BEA |
| NCDUR | Personal consumption expenditures: Durable goods | BEA |
| NCDC | Personal consumption expenditures: Nondurable goods | BEA |
| NCSV | Personal consumption expenditures: Service goods | BEA |
| Population | Population, thousands (POPTHM) | FRED |
| Hours | Total hours worked | BLS |
| PBUS | Nonfarm business Sector: Implicit price deflator | BLS |
| Wages | Nonfarm business sector: Compensation per hour | BLS |
| Tbill3 | 3-month Treasury bill (TB3MS) | FRED |
| HHDEBT | Households and nonprofit organizations; debt securities and loans; liability (CMDEBT) | FRED |
| HPI | House price index; Median sales price for new houses sold (MSPNHSUS) | FRED |
| Recession | NBER recession periods | FRED |
| SPF shock | Survey of Professional Forecasters forecast error shock | Ramey (2011) |
| GB shock | Green Book forecast error shock | Ramey (2011) |

Note: Table A.1 reports the data source for key aggregate variables. Real values are all deflated by GDP deflator for the sample period, 1981:Q1-2007:Q1.

## A.2 Data by housing tenure groups

We use the U.S. Consumer Expenditure Survey (CEX) data which is available from the U.S. Bureau of Labor Statistics for the sample period, 1981-2007. We use the household expenditure and income data constructed by different types of housing tenure groups following Cloyne, Ferreira and Surico (2020). Consumption data covers non-durable goods and services (food, alcohol, tobacco, clothing and footwear, leisure goods, household services) and durable expenditures (motor vehicles, durable leisure goods, durable household goods). In terms of income data, labor income includes wages and salaries and non-labor income includes income from investments and social payments, net of taxes. Households are excluded from the sample if (i) the income data is missing or the net-income is negative, (ii) the expenditure is in either top or the bottom 1% of distribution, (iii) household head is aged either below 25 or above 74 years old.

The U.S. Survey of Counsumer Finance (SCF) data which is available from the Federal Reserve is also used for the sample period, 1995-2007. This household survey data includes a triennial cross-sectional survey of U.S. households. We use information on households' balance sheets, wealth and asset positions, pensions, demographic characteristics, and income to classify households who are wealthy hand-to-mouth following Kaplan, Violante and Weidner (2014).

# B Asset, Wealth, and Debt to Income Ratio

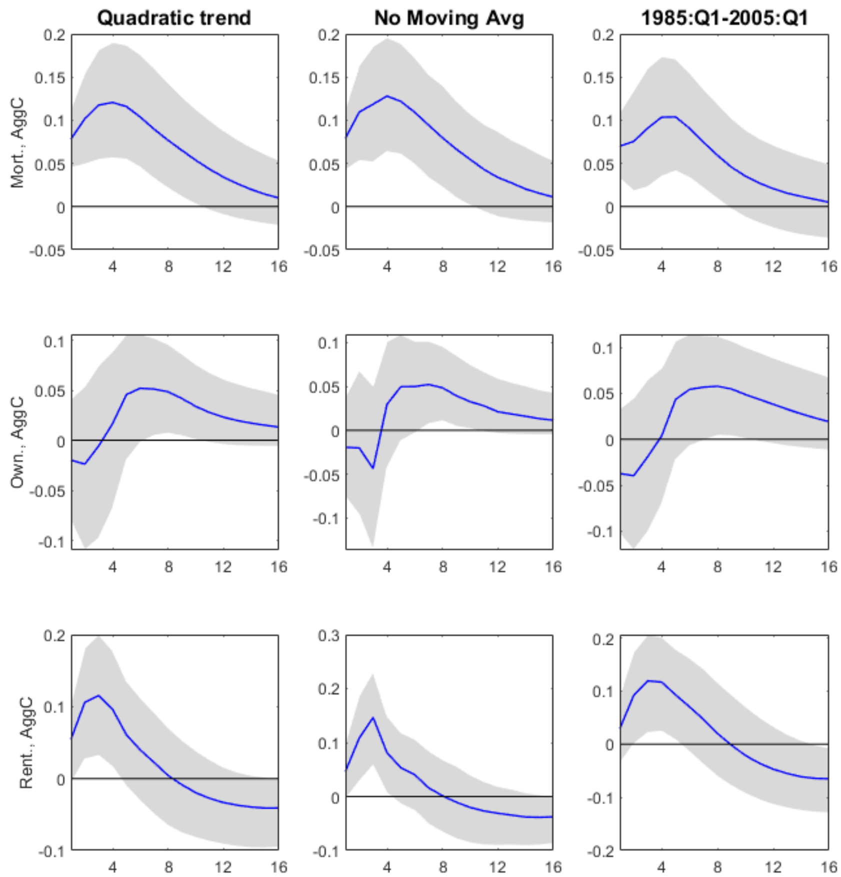
Table B.1: Asset, wealth, and debt to income ratio by housing tenure

| | PANEL A: 1995 SCF | | PANEL B: 1998 SCF | | PANEL C: 2001 SCF | | PANEL D: 2004 SCF | | PANEL E: 2007 SCF | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Asset* | Mean | 95% Conf. interval | Mean | 95% Conf. interval | Mean | 95% Conf. interval | Mean | 95% Conf. interval | Mean | 95% Conf. interval |
| Mortgagors | 540,976 | [525,118, 556,834] | 664,010 | [644,196, 683,824] | 799,320 | [775,740, 822,899] | 850,222 | [826,873, 873,570] | 957,274 | [931,649, 982,900] |
| Outright homeowners | 599,946 | [575,176, 624,715] | 820,483 | [782,035, 858,931] | 1,028,879 | [983,941, 1,073,817] | 1,186,705 | [1,134,975, 1,238,434] | 1,367,399 | [1,304,774, 1,430,025] |
| Renters | 77,098 | [70,687, 83,508] | 75,459 | [69,744, 81,174] | 88,321 | [79,961, 96,681] | 85,913 | [77,562, 94,265] | 97,034 | [87,667, 106,402] |
| *Net liquid asset* | | | | | | | | | | |
| Mortgagors | 46,492 | [42,967, 50,018] | 90,778 | [84,409, 97,147] | 115,131 | [107,793, 122,468] | 90,039 | [84,657, 95,421] | 92,356 | [86,910, 97,803] |
| Outright homeowners | 105,282 | [97,034, 113,530] | 173,283 | [160,420, 186,146] | 203,731 | [187,892, 219,571] | 236,670 | [217,578, 255,762] | 250,772 | [232,421, 269,123] |
| Renters | 12,747 | [9,303, 16,192] | 11,994 | [10,610, 13,379] | 19,304 | [15,210, 23,399] | 14,421 | [10,749, 18,092] | 16,826 | [13,571, 20,082] |
| *Net illiquid asset* | | | | | | | | | | |
| Mortgagors | 178,597 | [173,314, 183,881] | 213,069 | [206,743, 219,396] | 258,878 | [251,567, 266,188] | 283,353 | [275,083, 291,623] | 324,389 | [315,765, 333,013] |
| Outright homeowners | 208,039 | [201,820, 214,258] | 261,544 | [252,092, 270,995] | 348,328 | [334,778, 361,879] | 408,219 | [392,586, 423,852] | 467,158 | [447,044, 487,272] |
| Renters | 18,921 | [17,124, 20,719] | 19,671 | [17,592, 21,750] | 20,040 | [18,003, 22,078] | 14,286 | [12,769, 15,804] | 18,605 | [16,509, 20,700] |
| *Home equity* | | | | | | | | | | |
| Mortgagors | 96,065 | [93,634, 98,495] | 107,436 | [104,563, 110,309] | 136,836 | [132,925, 140,746] | 168,845 | [163,892, 173,798] | 192,533 | [187,676, 197,391] |
| Outright homeowners | 148,703 | [144,692, 152,714] | 170,233 | [164,526, 175,939] | 212,581 | [205,845, 219,318] | 270,776 | [261,220, 280,331] | 303,421 | [289,629, 317,214] |
| Renters | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Debt to income* | | | | | | | | | | |
| Mortgagors | 1.80 | [1.74, 1.87] | 2.76 | [1.97, 3.54] | 1.80 | [1.74, 1.86] | 2.39 | [2.29, 2.50] | 2.47 | [2.41, 2.53] |
| Outright homeowners | 0.51 | [0.30, 0.71] | 0.25 | [0.22, 0.28] | 0.28 | [0.24, 0.33] | 0.32 | [0.28, 0.35] | 0.51 | [0.42, 0.60] |
| Renters | 0.43 | [0.39, 0.47] | 0.56 | [0.47, 0.64] | 0.95 | [0.40, 1.51] | 0.43 | [0.40, 0.46] | 0.49 | [0.45, 0.53] |

Note: Table B.1 reports mean and 95% confidence interval value of an asset, net liquid asset, net illiquid asset (including home equity), and debt to income ratio by housing tenure group. Data are from SCF for the 1995-2007 and each series is in corresponding year's dollar.

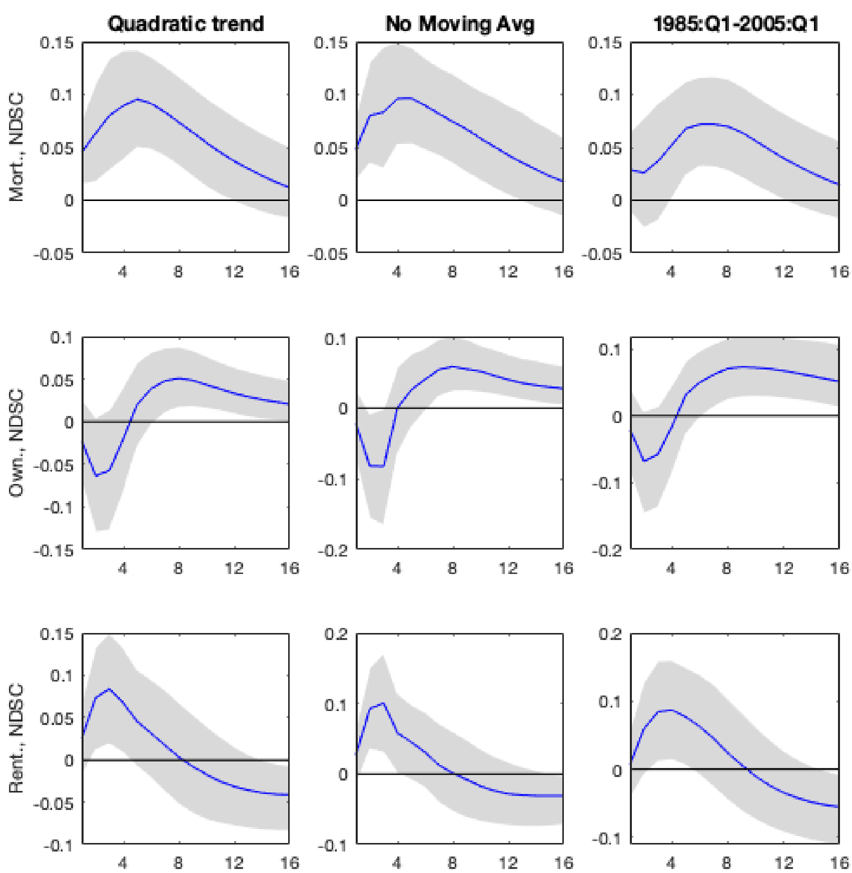
# C Robustness checks for empirical analysis

Figure C.1: Impulse responses of **aggregate** consumption in response to a positive govt spending shock



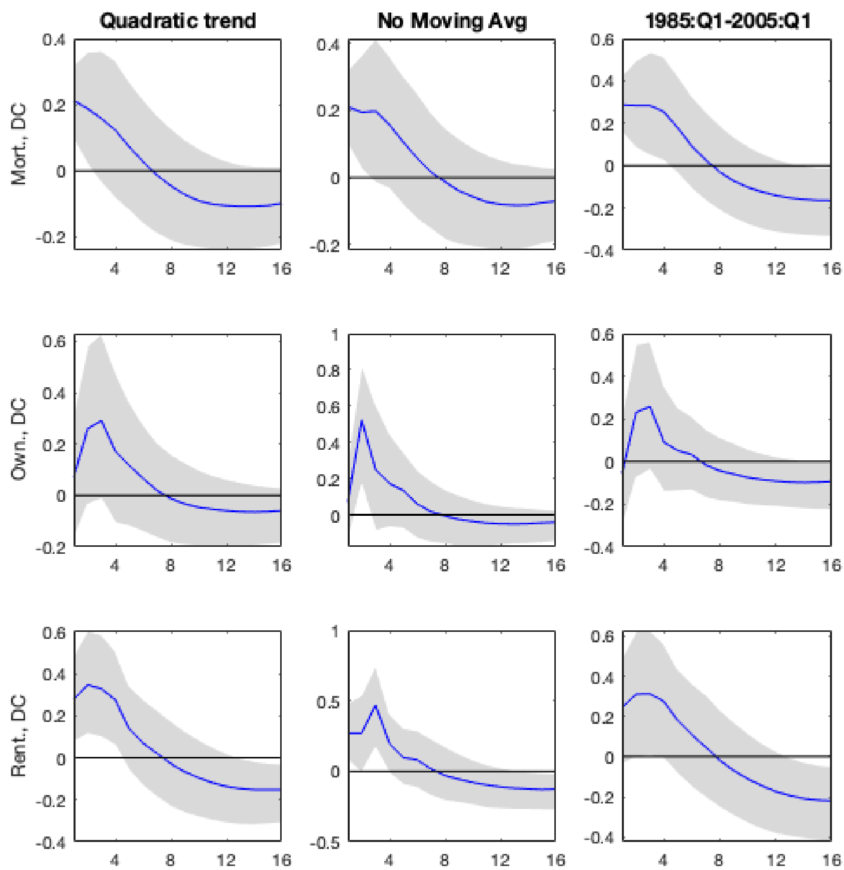

Note: Figure C.1 plots the impulse response functions of aggregate consumption in response to a positive government spending shock with 68 % confidence interval bands based on bootstrapped standard errors (shaded area).

Figure C.2: Impulse responses of **non-durable** consumption in response to a positive govt spending shock




Note: Figure C.2 shows the impulse responses functions of non-durable consumption responses to a positive SPF shock by each housing tenure group. The shaded area indicates 68 % confidence interval bands.

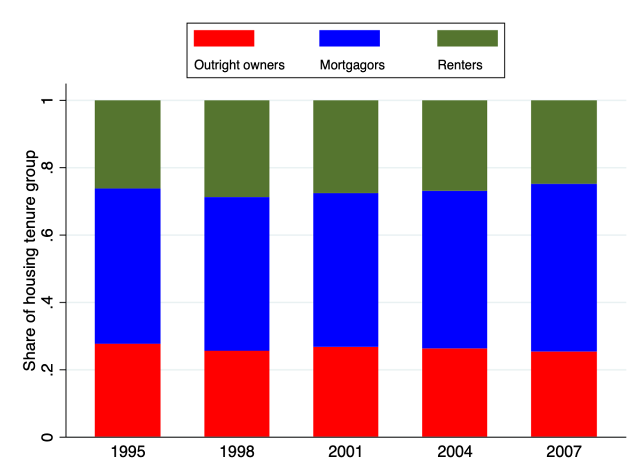
Figure C.3: Impulse responses of **durable** consumption in response to a positive govt spending shock




Note: Figure C.3 shows the impulse responses functions of durable consumption responses to a positive SPF shock by each housing tenure group. The shaded area indicates 68 % confidence interval bands.

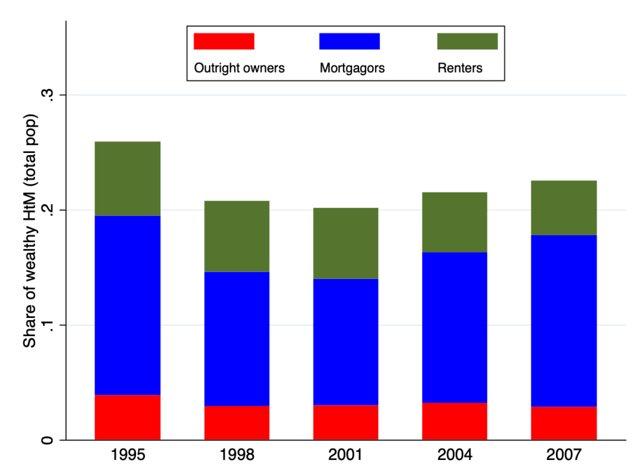
# D Share of housing tenure groups

Figure D.1: Share of housing tenure group (total population, SCF)



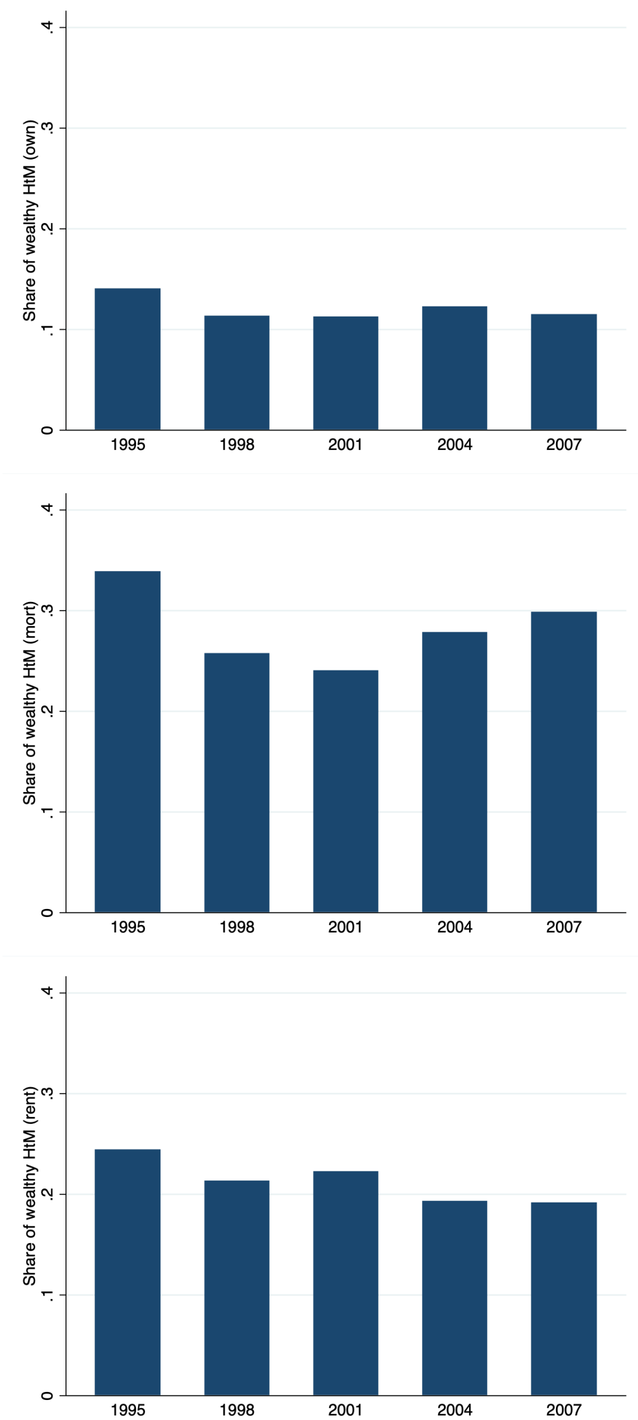

Note: Figure D.1 shows the share of each housing tenure groups in total population.

Figure D.2: Share of wealthy hand to mouth by housing tenure group (total population, SCF)




Note: Figure D.2 shows the share of wealthy Hand-to-Mouth (HtM) by housing tenure groups in total population.

Figure D.3: Share of wealthy hand to mouth by housing tenure group (within group, SCF)




Note: Figure D.3 shows the share of wealthy Hand-to-Mouth (HtM) within each housing tenure group.

# E Model: First order conditions

## E.1 Patient Households (savers)

$$\frac{\upsilon_t}{x_{P,t}} = (1+\tau_c)\,\lambda_{P,t} \tag{E.1}$$

$$\begin{aligned}&\left[1+\tau_p\,(1-\tau_{yP})+\kappa_h\left(\frac{h_{P,t}}{h_{P,t-1}}-1\right)\frac{h_{P,t}}{h_{P,t-1}}\right]q_{h,t}=\frac{\upsilon_t\xi_h}{\lambda_{P,t}h_{P,t}}\\&\quad+E_t\left[\left(\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\right)\left[1-\delta_h+\kappa_h\left(\frac{h_{P,t+1}}{h_{P,t}}-1\right)\left(\frac{h_{P,t+1}}{h_{P,t}}\right)^2\right]q_{h,t+1}\right]\end{aligned} \tag{E.2}$$

$$\begin{aligned}&\left[1+\tau_p\,(1-\tau_{yP})+\kappa_h\left(\frac{h_{R,t}}{h_{R,t-1}}-1\right)\frac{h_{R,t}}{h_{R,t-1}}\right]q_{h,t}=(1-\tau_{yP})\,r_{h,t}\\&\quad+E_t\left[\left(\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\right)\left\{\left[1-\delta_h+\kappa_h\left(\frac{h_{R,t+1}}{h_{R,t}}-1\right)\left(\frac{h_{R,t+1}}{h_{R,t}}\right)^2\right]q_{h,t+1}+\tau_{yP}\delta_h\right\}\right]\end{aligned} \tag{E.3}$$

$$\begin{aligned}&\left[1+\kappa_k\left(\frac{k_t}{k_{t-1}}-1\right)\frac{k_t}{k_{t-1}}\right]q_{k,t}\\&=E_t\left[\left(\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\right)\left\{\left[1-\delta_k+\kappa_k\left(\frac{k_{t+1}}{k_t}-1\right)\left(\frac{k_{t+1}}{k_t}\right)^2\right]q_{k,t+1}+(1-\tau_k)\,r_{k,t+1}+\tau_k\delta_k\right\}\right]\end{aligned} \tag{E.4}$$

$$\upsilon_t\xi_n n_{P,t}^{\vartheta} = \lambda_{P,t}\Omega_{nP,t}\,(1-\tau_{yP})\,w_{P,t} \tag{E.5}$$

$$\begin{aligned}&\left(\frac{\pi_{wP,t}}{\pi}-1\right)\frac{\pi_{wP,t}}{\pi}\\&=E_t\left[\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\left(\frac{\pi_{wP,t+1}}{\pi}-1\right)\frac{\pi_{wP,t+1}}{\pi}\frac{\pi_{wP,t+1}}{\pi_{t+1}}\frac{n_{P,t+1}}{n_{P,t}}\right]-\frac{(\eta_w-1)\,(1-\tau_{yP})}{\kappa_w}\,(1-\theta_w\Omega_{nP,t})\\&\text{where } \theta_w=\frac{\eta_w}{\eta_w-1},\ \ \pi_{wP,t}=\frac{W_{P,t}}{W_{P,t-1}}\end{aligned} \tag{E.6}$$

$$\frac{\pi_{wP,t}}{\pi_t}=\frac{w_{P,t}}{w_{P,t-1}} \tag{E.7}$$

$$1=E_t\left[\left(\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\right)\left(\frac{1+(1-\tau_b)\,R_t}{\pi_{t+1}}\right)\right] \tag{E.8}$$

$$1 = \Omega_{dP,t} + \Omega_{rP,t} R_t^F \tag{E.9}$$

$$\Omega_{dP,t} + \Omega_{rP,t} R_t^M = E_t \left[ \left( \beta_P \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \right) \left( \frac{(1-\tau_b) R_t^M + \kappa + (1-\kappa) \left\{ \Omega_{dP,t+1} + \Omega_{rP,t+1} R_t^M \right\}}{\pi_{t+1}} \right) \right] \tag{E.10}$$

$$\Omega_{rP,t} = E_t \left[ \left( \beta_P \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \right) \left( \frac{1 - \tau_b + (1-\kappa) \Omega_{rP,t+1}}{\pi_{t+1}} \right) \right] \tag{E.11}$$

## E.2 Impatient Households (borrowers)

$$\frac{\upsilon_t}{x_{I,t}} = (1+\tau_c) \lambda_{I,t} \tag{E.12}$$

$$\begin{aligned} &\left[ 1 + \tau_p (1-\tau_{yI}) + \kappa_h \left( \frac{h_{I,t}}{h_{I,t-1}} - 1 \right) \frac{h_{I,t}}{h_{I,t-1}} - \phi \mu_t \right] q_{h,t} = \frac{\upsilon_t \xi_h}{\lambda_{I,t} h_{I,t}} \\ &\quad + E_t \left[ \left( \beta_I \frac{\lambda_{I,t+1}}{\lambda_{I,t}} \right) \left\{ \left[ (1-\delta_h) \left[ 1 - \phi \mu_{t+1} \right] + \kappa_h \left( \frac{h_{I,t+1}}{h_{I,t}} - 1 \right) \left( \frac{h_{I,t+1}}{h_{I,t}} \right)^2 \right] q_{h,t+1} \right\} \right] \end{aligned} \tag{E.13}$$

$$\upsilon_t \xi_n n_{I,t}^{\vartheta} = \lambda_{I,t} \Omega_{nI,t} (1-\tau_{yI}) w_{I,t} \tag{E.14}$$

$$\begin{aligned} &\left( \frac{\pi_{wI,t}}{\pi} - 1 \right) \frac{\pi_{wI,t}}{\pi} \\ &\quad = E_t \left[ \beta_I \frac{\lambda_{I,t+1}}{\lambda_{I,t}} \left( \frac{\pi_{wI,t+1}}{\pi} - 1 \right) \frac{\pi_{wI,t+1}}{\pi} \frac{\pi_{wI,t+1}}{\pi_{t+1}} \frac{n_{I,t+1}}{n_{I,t}} \right] - \frac{(\eta_w - 1)(1-\tau_{yI})}{\kappa_w} (1 - \theta_w \Omega_{nI,t}) \\ &\quad \text{where } \pi_{wI,t} = \frac{W_{I,t}}{W_{I,t-1}} \end{aligned} \tag{E.15}$$

$$\frac{\pi_{wI,t}}{\pi_t} = \frac{w_{I,t}}{w_{I,t-1}} \tag{E.16}$$

$$1 - \mu_t = \Omega_{dI,t} + \Omega_{rI,t} R_t^F \tag{E.17}$$

$$\Omega_{dI,t}+\Omega_{rI,t}R^M_t=E_t\left[\beta_I\frac{\lambda_{I,t+1}}{\lambda_{I,t}}\left(\frac{(1-\tau_{yI})\,R^M_t+\kappa+(1-\kappa)\left\{\Omega_{dI,t+1}+\Omega_{rI,t+1}R^M_t\right\}}{\pi_{t+1}}\right)\right] \tag{E.18}$$

$$\Omega_{rI,t}=E_t\left[\beta_I\frac{\lambda_{I,t+1}}{\lambda_{I,t}}\left(\frac{1-\tau_{yI}+(1-\kappa)\,\Omega_{rI,t+1}}{\pi_{t+1}}\right)\right] \tag{E.19}$$

## E.3 Renter Households

$$\frac{\upsilon_t}{x_{R,t}}=(1+\tau_c)\,\lambda_{R,t} \tag{E.20}$$

$$p_{h,t}=\frac{\upsilon_t\xi_h}{\lambda_{R,t}h_{R,t}} \tag{E.21}$$

$$\upsilon_t\xi_n n^{\vartheta}_{R,t}=\lambda_{R,t}\Omega_{nR,t}\,(1-\tau_{yR})\,w_{R,t} \tag{E.22}$$

$$\begin{aligned}&\left(\frac{\pi_{wR,t}}{\pi}-1\right)\frac{\pi_{wR,t}}{\pi}\\&=E_t\left[\beta_R\frac{\lambda_{R,t+1}}{\lambda_{R,t}}\left(\frac{\pi_{wR,t+1}}{\pi}-1\right)\frac{\pi_{wR,t+1}}{\pi}\frac{\pi_{wR,t+1}}{\pi_{t+1}}\frac{n_{R,t+1}}{n_{R,t}}\right]-\frac{(1-\tau_{yR})\,(\eta_w-1)}{\kappa_w}\,(1-\theta_w\Omega_{nR,t})\\&\text{where } \pi_{wR,t}=\frac{W_{R,t}}{W_{R,t-1}}\end{aligned} \tag{E.23}$$

## E.4 Non-residential, Residential investment, and Rental services Producers

$$\begin{aligned}&q_{k,t}-\kappa_{ik}q_{k,t}\left(\frac{i_{k,t}}{i_{k,t-1}}-1\right)\frac{i_{k,t}}{i_{k,t-1}}-q_{k,t}\frac{\kappa_{ik}}{2}\left(\frac{i_{k,t}}{i_{k,t-1}}-1\right)^2\\&+E_t\left[\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\kappa_{ik}q_{k,t+1}\left(\frac{i_{k,t+1}}{i_{k,t}}-1\right)\left(\frac{i_{k,t+1}}{i_{k,t}}\right)^2\right]=1\end{aligned} \tag{E.24}$$

$$\begin{aligned}&q_{h,t}-\kappa_{ih}q_{h,t}\left(\frac{i_{h,t}}{i_{h,t-1}}-1\right)\frac{i_{h,t}}{i_{h,t-1}}-q_{h,t}\frac{\kappa_{ih}}{2}\left(\frac{i_{h,t}}{i_{h,t-1}}-1\right)^2\\&+E_t\left[\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\kappa_{ih}q_{h,t+1}\left(\frac{i_{h,t+1}}{i_{h,t}}-1\right)\left(\frac{i_{h,t+1}}{i_{h,t}}\right)^2\right]=1\end{aligned} \tag{E.25}$$

$$\left(\frac{\pi_{h,t}}{\pi}-1\right)\frac{\pi_{h,t}}{\pi}$$
$$= E_t\left[\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\left(\frac{\pi_{h,t+1}}{\pi}-1\right)\frac{\pi_{h,t+1}}{\pi}\frac{\pi_{h,t+1}}{\pi_{t+1}}\frac{h_{R,t+1}}{h_{R,t}}\right]-\frac{\eta_h-1}{\kappa_{ph}}\left(1-\theta_h\frac{r_{h,t}}{p_{h,t}}\right) \tag{E.26}$$
$$\text{where } \theta_h=\frac{\eta_h}{\eta_h-1}$$

## E.5 Non-housing goods producers

$$\Omega_{n,t}\left(1-\alpha\right)\psi_P\left(\frac{y_{n,t}+f_{n,t}}{n_{P,t}}\right)=w_{P,t} \tag{E.27}$$

$$\Omega_{n,t}\left(1-\alpha\right)\psi_I\left(\frac{y_{n,t}+f_{n,t}}{n_{I,t}}\right)=w_{I,t} \tag{E.28}$$

$$\Omega_{n,t}\left(1-\alpha\right)\psi_R\left(\frac{y_{n,t}+f_{n,t}}{n_{R,t}}\right)=w_{R,t} \tag{E.29}$$

$$\Omega_{n,t}\alpha\frac{y_{n,t}+f_{n,t}}{k_{t-1}}=r_{k,t}+\frac{\kappa_u}{1+\varpi}\left(u_t^{1+\varpi}-1\right) \tag{E.30}$$

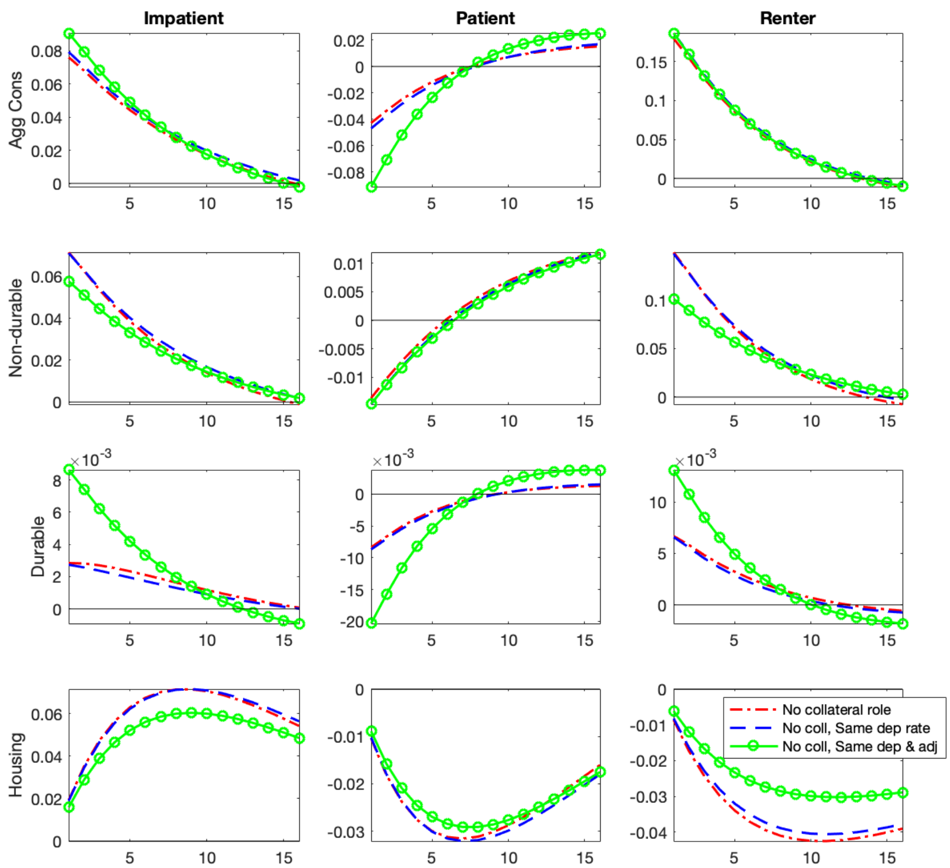
$$\Omega_{n,t}\alpha\frac{y_{n,t}+f_{n,t}}{u_t}=\kappa_u u_t^{\varpi}k_{t-1}$$
$$\text{where } u=1,\ \kappa_u=\frac{\alpha}{k/y_n} \tag{E.31}$$

$$\left(\frac{\pi_t}{\pi}-1\right)\frac{\pi_t}{\pi}=E_t\left\{\beta_P\frac{\lambda_{P,t+1}}{\lambda_{P,t}}\left(\frac{\pi_{t+1}}{\pi}-1\right)\frac{\pi_{t+1}}{\pi}\frac{y_{n,t+1}}{y_{n,t}}\right\}-\frac{\eta_n-1}{\kappa_{pn}}\left(1-\theta_n\Omega_{n,t}\right) \tag{E.32}$$
$$\text{where }\ \theta_n=\frac{\eta_n}{\eta_n-1}$$

# F Model with durables

## F.1 Alternative parameterization exercise

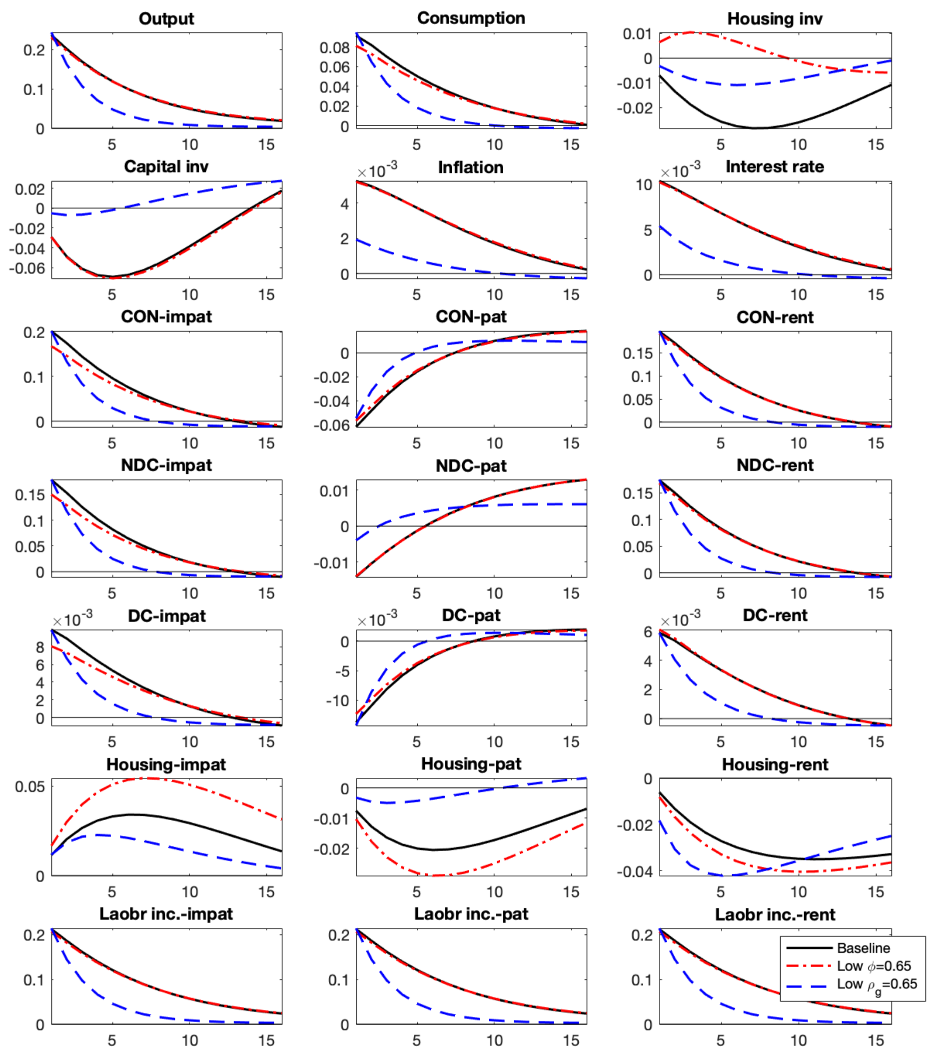
Figure F.1: Impulse responses in the model with **durable** goods




Note: Figure F.1 shows the effects of alternative parameterization for the model with durable goods. Red dotted line represents with no collateral role on housing and the blue dash-dotted line indicates identical depreciation rate on housing and durable stock. Green circled line represents higher share on non-durable goods.

## F.2 Transmission mechanisms

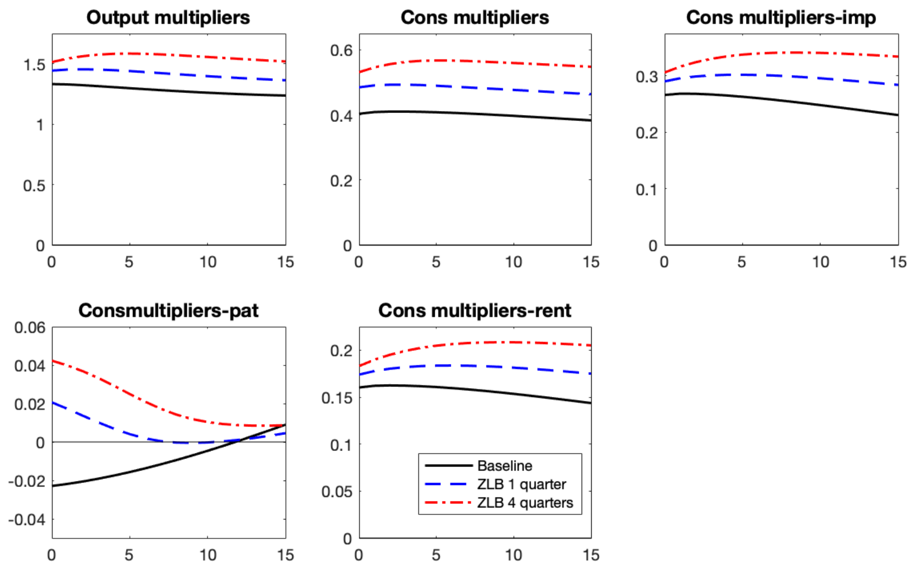
Figure F.2: Impulse responses in the model with **durable** goods




Note: Figure F.2 shows the dynamic effects on key variables for the model with durable goods. Black solid line represents the baseline case. Red dash-dotted line represents low LTV case with $\phi = 0.65$ and blue dashed line represents lower shock persistence with $\rho_g = 0.65$.

# G Multipliers in normal times and during ZLB periods

Figure G.1: Cumulative output and consumption multipliers




Note: Figure G.1 plots the cumulative output and consumption multipliers in and out of ZLB periods. Black solid line represents multipliers during normal times. Blue dashed line is the cumulative multipliers under ZLB binding for one quarter and red dash-dotted line indicates multipliers under ZLB for four quarters.