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Abstract

This paper investigates household leverage-dependent fiscal policy effects in a two-agent New Keynesian DSGE model with occasionally binding borrowing constraints. Our model successfully replicates empirical evidence showing that fiscal policy's effectiveness differs significantly across the household leverage cycle. Fiscal multipliers are persistently above unity when government spending rises at the peak of the household leverage cycle. In contrast, increases in government spending at the trough of the household leverage cycle imply fiscal multipliers below unity. We test the model's predictions on post-WWII U.S. data.

Keywords: Occasionally Binding Constraints, Government Spending Multiplier, Household Leverage Cycle, State-Dependence.
JEL classification: E32; E44; E62; H31.

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1 Introduction

Since the beginning of the 2000s, the U.S. household leverage cycle has fluctuated substantially. The average household's loan-to-value ratio increased from 33% in 2001 to 50% amid the Great Recession. Due to the massive subsequent deleveraging, the ratio fell back to 32% in 2019.[1] At the peak of the leverage cycle in 2009, the U.S. government enacted the American Recovery and Reinvestment Act (ARRA) to spur economic growth in response to a deepening economic recession. The ARRA stimulus package amounted to about $800 billion, which made up more than 5% of annual GDP in 2009. Recent empirical studies detect a significant relationship between the state of the household leverage cycle and the effectiveness of fiscal policy interventions (Bernardini and Peersman 2018; Bernardini, Schryder, and Peersman 2020; Demyanyk, Loutskina, and Murphy 2019; Klein 2017): fiscal multipliers are considerably larger (smaller) when household leverage is high (low), irrespective of the state of the business cycle. This finding suggests that policymakers should take the leverage cycle into account when debating about stabilization measures.

While the empirical literature broadly agrees on the close relationship between the state of the household leverage cycle and the effectiveness of fiscal policy interventions, the literature lacks a comprehensive theoretical framework that accounts for state-dependent fiscal multipliers across the ups and downs of the households' leverage cycle. Such a theoretical set up is of great interest as it provides an evaluation tool to conduct proper counterfactual scenarios for academics and policymakers alike. This paper fills this gap by showing that a model with *occasionally* binding borrowing constraints on the household side successfully replicates the empirical findings of pronounced nonlinearities in the effects of fiscal policy across the household leverage cycle. The model quantitatively reproduces the empirical government

[1] We measure the loan-to-value ratio as the ratio of aggregate housing debt to aggregate housing value.

spending multipliers across the alternating phases of the leverage cycle.

We build on the two-agent New Keynesian (TANK) model by Guerrieri and Iacoviello (2017) and extend it by integrating a fiscal sector. On top of the standard New Keynesian ingredients, the model features financial frictions on the household side. The model provides us with a framework in which the interrelation between household leverage, borrowing constraints, and fiscal policy can be investigated in great detail. The model features two types of households with heterogeneous saving-consumption preferences, which generates borrowing and lending. Borrowing households face a housing collateral constraint that limits borrowing to a maximum fraction of housing wealth. Importantly, this constraint binds only occasionally rather than at all times, implying that the propagation and amplification of economic shocks in general and of exogenous fiscal policy interventions, in particular, depend on the endogenous degree of financial frictions.

We calibrate the model to post-WWII U.S. data and show that the tightness of the borrowing constraint is linked to the household leverage cycle: periods with binding borrowing constraints are associated with above-average household leverage, while periods with slack borrowing constraints are associated with a below-average household leverage ratio. Studying the model-implied effects of government spending shocks shows that their output effects are significantly larger at the peak of the household leverage cycle than at its trough. More precisely, the output multiplier exceeds one over the horizon of three years when a fiscal stimulus occurs during periods in which household leverage is high and borrowing constraints are more likely to bind. By contrast, the output multiplier is below one on impact and falls to about 0.5 at the end of the third year when a government spending expansion occurs during episodes of low household leverage with a higher likelihood of the borrowing constraint being slack.

The decisive factor for this state-dependent effects of fiscal policy are different consumption responses across the leverage cycle: higher government spending crowds in private consumption when household leverage is high, whereas consumption barely responds when household leverage is low. The rationale behind this are different average marginal propensities to consume out of current income across the leverage cycle. In states of low household leverage borrowing constraints are more likely to be slack. Consequently, patient and impatient households are largely insensitive to the rise in disposable income brought about by an increase in government spending. By contrast, when household leverage is high and borrowing constraints are more likely binding, impatient households find themselves at their borrowing limit and their consumption decisions are substantially affected by their current disposable income. In this situation, a fiscal expansion that increases impatient households' disposable income will boost consumption and output. The boost in output is accelerated through an increase in house prices, which, in turn, loosens borrowing limits and enables impatient households to consume more, which then pushes up output further.

In the second part of the paper, we confront the model predictions with the data. To do so, we use local projections to estimate household leverage-dependent fiscal multipliers on a post-WWII U.S. sample. To facilitate a comparison between model and data, we generate artificial data from the model and apply the same identification strategy for high-leverage and low-leverage states and the same local projection approach to calculate model-implied fiscal multipliers. In the empirical data, we find that the multiplier is above one when household leverage is high and below unity when household leverage is low. The estimated multipliers based on the artificial dataset lie within the confidence bands of the empirical estimates. The median multiplier is above one over the horizon of three years when household leverage is high, ranging between 1.3 and 1.2, while in low leverage states it is always below one and falls to about 0.6 at the end of the third year after the fiscal stimulus. While the theoretical model matches the data exceptionally well when household leverage is low, it slightly underestimates the size of the multiplier in the high-leverage regime. All in all, our theoretical model successfully replicates the household-leverage dependent fiscal multipliers found in the data.

We contribute to the literature on the theoretical relationship between household debt, borrowing constraints, and the efficacy of fiscal policy. Eggertsson and Krugman (2012) and Tagkalakis (2008) demonstrate, using stylized models with occasionally binding borrowing constraints, that household debt may shape the size of fiscal multipliers through its impact on households' marginal propensity to consume. Andrés, Boscá, and Ferri (2015) study, in a model with always binding borrowing constraints, how structural changes that lead to permanent adjustments in the (long-run) steady-state level of private debt influence the fiscal transmission mechanism. We endogenize the household leverage cycle and study how fiscal multipliers depend on household leverage's endogenous short-run fluctuations. Our aim is to quantify the effectiveness of fiscal policy along the model economy's household leverage cycle, confront the model with empirical data, and assess whether our model is successful in qualitatively and quantitatively matching the empirical relationship between fiscal multipliers and the household leverage cycle.

The rest of the paper is organized as follows. In Section 2, we describe the model and its calibration. Section 3 presents the results of our model simulations. In particular, we describe our simulation strategy, present business cycle statistics, and demonstrate the relationship between borrowing constraints, household leverage, and fiscal multipliers. We test this relationship in Section 4 by providing empirical evidence on the link between fiscal multipliers and the household leverage cycle. Section 5 concludes.

2 The Model

We consider a two-agent New Keynesian model with occasionally binding financial frictions on the household side to analyze how the household leverage cycle shapes fiscal spending multipliers. We build on the model by Guerrieri and Iacoviello (2017) and extend it by integrating a fiscal sector. The model economy is composed of a household sector, a firm sector, and the government. The household sector consists of two types of agents, patient and impatient ones. Both types of households supply differentiated labor services, set wages in a Calvo framework, and demand consumption goods and housing. While patient households will provide savings, impatient households will be borrowers in equilibrium. Their borrowing is collateralized by housing due to costly enforcement, and the collateral constraint on borrowing binds only occasionally, rather than at all times. This implies that the propagation and amplification of economic shocks depend on the endogenous degree of financial frictions. The production sector produces goods – used for investment, consumption, and government spending – under monopolistically competitive conditions and faces a fixed probability of being allowed to change prices. The supply of housing is fixed, and households pay linear housing transaction and maintenance costs. The treasury finances its expenditures by collecting lump-sum taxes and issuing one-period bonds. A monetary authority sets the policy rate according to a Taylor-type feedback rule.

2.1 Household Sector

The household sector consists of two types of infinitely-lived households that differ in their degree of impatience. There is a large number of identical patient households, indexed with p, and a large number of identical impatient households, indexed with i, with discount factors $1 > \beta^p > \beta^i > 0$. Each household type is made up of a continuum of members, each specialized in a different labor service, and indexed by j. Labor decisions are made by a household's union, which supplies its members' differentiated labor services to labor bundlers under monopolistically competitive conditions. Unions are restricted in their ability to reoptimize wages: in each period, only a fraction $1-\theta_*^w$ of households/unions may adjust their wage, where $* \in \{i, p\}$. The other fraction $\theta_*^w \in [0,1)$ indexes the price to the steady state inflation rate. Labor bundlers bundle the differentiated labor services, $n_{*,t}(j)$, into aggregate labor services according to the following technology: $n_{*,t} = \left(\int_0^1 n_{*,t}(j)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} dj\right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}$. Optimal bundling of differentiated labor services implies the demand function $n_{*,t}(j) = \left(\frac{W_{*,t}(j)}{W_{*,t}}\right)^{-\varepsilon_w} n_{*,t}$, where $W_{*,t}(j)$ denotes the nominal wage rate for labor services of type j and $W_{*,t}$ is the wage index.

Let $c_{*,t}$ denote consumption and $h_{*,t}$ housing. A representative household of type $* \in \{i, p\}$ maximizes the infinite sum of expected utility, given by

$$E_0 \sum_{t=0}^{\infty} (\beta^*)^t \, u(c_{*,t}, h_{*,t}, \{n_{*,t}(j)\}). \tag{1}$$

We consider the following specification of the utility function with habit formation in consumption and housing services

$$z_t^c \left[(1-\psi_c)^{\mu^c} \frac{(c_{*,t} - \psi_c c_{*,t-1})^{1-\mu^c}}{1-\mu^c} + z_t^h \gamma^h (1-\psi_h)^{\mu^h} \frac{(h_{*,t} - \psi_h h_{*,t-1})^{1-\mu^h}}{1-\mu^h}\right] - \gamma^n \int_0^1 \frac{n_{*,t}(j)^{1+\mu^n}}{1+\mu^n} dj,$$

where z_t^c is an intertemporal shock affecting households' willingness to spend today and z_t^h is a housing demand shock. The processes follow $\log\left(z_t^{c(h)}\right) = \rho_{c(h)} \log\left(z_{t-1}^{c(h)}\right) + \varepsilon_t^{c(h)}$ with $\varepsilon_t^{c(h)} \sim n.i.d.\left(0, \sigma_{c(h)}^2\right)$, $\rho_{c(h)} \in [0,1)$, and $z^{c(h)} = 1$. Note that all variables without time subscript denote steady state values. The parameter μ^c denotes the inverse of the intertemporal elasticity of substitution in consumption, and μ^n is the inverse of the Frisch elasticity of labor supply. We assume that $\mu^{c,h,n} > 0$ and $\gamma^{h,n} > 0$. In the following, we first describe the problem of a representative patient household and then the one of a representative impatient household.

Patient Households In equilibrium, patient households are the savers in our model. They can invest their savings in physical capital $k_{p,t+1}$, hold government bonds $b^G_{p,t}$, and lend to impatient borrowers $b_{p,t}$. The rental rate for physical capital is denoted by r^k_t, the gross nominal bond yield is R^G_t, and the gross nominal loan rate is R_t. The budget constraint of a representative patient household in period t (in real terms) is given by

$$\begin{aligned} & c_{p,t} + i_{p,t} + (1+\kappa_h)\, p_{h,t} h_{p,t} + b^G_{p,t} + b_{p,t} + \tau_{p,t} \\ = \; & p_{h,t} h_{p,t-1} + \frac{R^G_{t-1}}{\pi_t} b^G_{p,t-1} + \frac{R_{t-1}}{\pi_t} b_{p,t-1} + \int_0^1 w_{p,t}(j) n_{p,t}(j) dj + r^k_t k_{p,t} + \delta_{p,t} \end{aligned} \tag{2}$$

where the left hand side contains expenditures for consumption, $c_{p,t}$, investment in physical capital, $i_{p,t}$, purchases of housing, $(1+\kappa_h)\, p_{h,t} h_{p,t}$, and lump sum taxes, $\tau_{p,t}$. The real price of housing is denoted by $p_{h,t}$. Following Bajari, Chan, Krueger, and Miller (2013), we assume that housing is associated with transaction costs that are proportional to the value of the newly purchased house.[2] Moreover, we assume that housing entails linear maintenance costs as in Cocco (2005). For simplicity, both of these costs are pooled in the term $\kappa_h p_{h,t} h_{p,t}$.

On the right hand side, we have the revenues from selling the previous period's stock of housing at the current price, $p_{h,t} h_{p,t-1}$, revenues from bond holdings, $\frac{R^G_{t-1}}{\pi_t} b^G_{p,t-1}$ (with $\pi_t = P_t / P_{t-1}$ being the gross inflation rate), repayment of previous period's loans, $\frac{R_{t-1}}{\pi_t} b_{p,t-1}$, labor income, $\int_0^1 w_{p,t}(j) n_{p,t}(j) dj$ (with $w_{p,t}(j) = W_{p,t}(j)/P_t$ being the real wage of type-j labor), capital income, $r^k_t k_{p,t}$, and profits of firms and retailers, $\delta_{p,t}$.

Physical capital is due to investment adjustment costs and accumulates according to

$$k_{p,t+1} = z^K_t \left[1 - \frac{\kappa}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t + (1-\delta_k)\, k_{p,t}, \tag{3}$$

where $\delta_k > 0$ is the depreciation rate of physical capital, and $\kappa > 0$ is a parameter reflecting

[2] For further examples for nonconvex housing adjustment costs see e.g. Flavin and Nakagawa (2008) and Iacoviello and Pavan (2013).

the size of adjustment costs. The term z_t^K is an investment-specific technology shock that follows the process $\log\left(z_t^K\right) = \rho_K \log\left(z_{t-1}^K\right) + \varepsilon_t^K$, with $\varepsilon_t^K \sim n.i.d.\,(0, \sigma_K^2)$, $\rho_K \in [0,1)$, and $z^K = 1$.

Impatient Households Since impatient households value current consumption more than patient ones, they will become borrowers in equilibrium and do not hold any financial assets. When a household i borrows a real amount $b_{i,t-1} > 0$ in period $t-1$, it has to pay back $\frac{R_{t-1}}{\pi_t} b_{i,t-1}$ in period t. Following Guerrieri and Iacoviello (2017), an impatient household i can only borrow up to a limit given by

$$b_{i,t} \leq \gamma^b \frac{b_{i,t-1}}{\pi_t} + \left(1 - \gamma^b\right) \phi E_t \left\{ \frac{p_{h,t+1} h_{i,t} \pi_{t+1}}{R_t} \right\}, \tag{4}$$

where $0 < \gamma^b < 1$ denotes inertia in the borrowing limit and ϕ the (exogenous) pledgeable fraction of housing. This more flexible specification of the borrowing constraint is more realistic since it captures the sluggish response of mortgage debt to house prices (Guerrieri and Iacoviello, 2017). We allow the borrowing constraint to bind only occasionally, rather than at all times. Thus, changes in the value of collateral have asymmetric effects on the economy, depending on whether the constraint is binding or not. Guerrieri and Iacoviello (2017) show that a model with an occasionally binding constraints outperforms a model in which the constraints always binds. Whether the constraint is binding or not can be measured by the Lagrange multiplier on the borrowing constraint, ω_t. When ω_t takes a value larger than zero it indicates that the constraint is binding, whereas the multiplier equals zero when the constraint becomes slack.

The budget constraint of an impatient household i reads

$$c_{i,t} + (1 + \kappa_h)\, p_{h,t} h_{i,t} + \frac{R_{t-1}}{\pi_t} b_{i,t-1} + \tau_{i,t} = p_{h,t} h_{i,t-1} + b_{i,t} + \int_0^1 w_{i,t}(j) n_{i,t}(j) dj. \tag{5}$$

An impatient household i has expenditures for consumption, $c_{i,t}$, housing, $(1+\kappa_h)\, p_{h,t} h_{i,t}$, lump-sum taxes, $\tau_{i,t}$, and pays back previous period's loans, $\frac{R_{t-1}}{\pi_t} b_{i,t-1}$. On the income side it has revenues from selling the previous period's stock of housing, $p_{h,t} h_{i,t-1}$, labor income, $\int_0^1 w_{i,t}(j) n_{i,t}(j) dj$, and new loans, $b_{i,t}$.

2.2 Firm Sector

A continuum of measure 1 of monopolistically competitive firms, indexed with l, produces differentiated intermediate goods using labor and capital with technology

$$y_t(l) = z_t^p \left(n_{i,t}(l)^{\sigma} n_{p,t}(l)^{1-\sigma} \right)^{\alpha} k_t(l)^{1-\alpha}, \tag{6}$$

where the parameter $\alpha \in (0,1)$ measures the labor income share, the parameter $\sigma \in (0,1)$ measures the labor income share that accrues to impatient households, and z_t^p is a productivity shock with $\log(z_t^p) = \rho_p \log(z_{t-1}^p) + \varepsilon_t^p$, where $\varepsilon_t^p \sim n.i.d.\left(0, \sigma_p^2\right)$, $\rho_p \in [0,1)$, and $z^p = 1$.

Firms sell their output $y_t(l)$ at the price $P_t(l)$ to perfectly competitive bundlers who bundle them to the final good $y_t = \left(\int_0^1 y_t(l)^{\frac{\epsilon-1}{\epsilon}} dl \right)^{\frac{\epsilon}{\epsilon-1}}$, where $\epsilon > 1$, and sell it at the price P_t. Optimal bundling of differentiated goods implies the demand function $y_t(l) = \left(P_t(l)/P_t\right)^{-\epsilon} y_t$. Following Calvo (1983), we assume that each period only a fraction $1-\theta$ of intermediate good firms is allowed to change its price. The other fraction $\theta \in [0,1)$ indexes the price to the steady state inflation rate according to $P_t(l) = \pi P_{t-1}(l)$.

2.3 The Government

The treasury has expenditures which it finances by collecting lump-sum taxes and issuing one-period bonds, held by patient households: $b_t^G = b_{p,t}^G$. The government budget constraint reads

$$g_t + \frac{R^G_{t-1} b^G_{t-1}}{\pi_t} = b^G_t + \tau_{p,t} + \tau_{i,t}.$$

We assume that lump sum taxes are identical for both household types ($\tau_{p,t} = \tau_{i,t} = \tau_t$) and evolve according to the rule

$$(\tau_t - \tau)/y = \rho_\tau \cdot (b^G_{t-1} - b^G)/y.$$

The term $\rho_\tau > 0$ is the feedback parameter for the reaction of taxes to debt: the larger (smaller) ρ_τ, the more of an increase in government spending is tax (debt) financed. Government spending, g_t, evolves according to $\log(g_t) = (1 - \rho_g)\log(g) + \rho_g \log(g_{t-1}) + \varepsilon^G_t$, where $\varepsilon^G_t \sim n.i.d.\,(0, \sigma^2_G)$ with $\rho_g \in [0, 1)$ being the parameter for the persistence of government spending.

The policy rate R_t is set by the central bank following a feedback rule given by

$$R_t = R^{\rho_R}_{t-1} R^{1-\rho_R} \left(\pi_t/\pi\right)^{\rho_\pi(1-\rho_R)} \left(y_t/y_{t-1}\right)^{\rho_y(1-\rho_R)} \exp \varepsilon^r_t,$$

where $\rho_R \geq 0$ measures the strength of interest rate smoothing, and $\varepsilon_{r,t} \sim n.i.d.\,(0, \sigma^2_G)$ is a monetary policy shock. The parameters $\rho_\pi \geq 0$ and $\rho_y \geq 0$ measure the responsiveness of the nominal interest rate to consumer price inflation and aggregate output, respectively.

2.4 Market Clearing

The consolidation of budget constraints delivers the aggregate resource constraint $y_t = c_t + g_t + i_{p,t} + \kappa_h p_{h,t} H$, where $c_t = c_{p,t} + c_{i,t}$, and the term $\kappa_h p_{h,t} H$ captures total housing transaction and maintenance costs, with $H = h_{p,t} + h_{i,t}$ being the fixed level of housing supply. The full set of equilibrium conditions can be found in Appendix A1.

2.5 Calibration

The model's parametrization is a combination of using parameter values in line with the estimates by Guerrieri and Iacoviello (2017) and matching empirical observations. One time period is assumed to be a quarter, and the total housing stock is normalized to $H = 1$. We set the discount factor of patient households to $\beta^p = 0.995$, which, together with a gross quarterly steady-state inflation rate of $\pi = 1.005$, implies an annual real interest rate of 2%. We set the capital depreciation rate to $\delta_k = 0.025$ and the investment adjustment cost parameter to $\kappa = 4$. The impatient households' discount factor is set to $\beta^i = 0.99$, the parameter ϕ, governing the maximum loan-to-value ratio, to $\phi = 0.9$, and the parameter for borrowing inertia to $\gamma^b = 0.5$. The labor income share that accrues to impatient households is equal to $\sigma = 0.44$.

The preference parameters are set to $\mu^c = \mu^h = 2$, and $\mu^n = 1$, implying a Frisch labor supply elasticity of one. The parameter for habit in housing is equal to $\psi_h = 0.88$, while the parameter for habit in consumption is set to $\psi_c = 0.5$. The elasticity of substitution between labor types is equal to $\varepsilon_w = 6$, implying a steady-state wage mark-up of 20%. We set the Calvo parameter for wages of patient households to $\theta_p^w = 0.9$. The Calvo parameter for wages of impatient households is set to $\theta_i^w = 2/3$, implying that impatient households' wages are more flexible than those of patient households, in line with empirical evidence.[3]

The labor share in production is equal to $\alpha = 2/3$, and the Calvo parameter for prices is set to $\theta = 0.9$. The substitution elasticity between differentiated intermediate goods is set $\varepsilon_p = 6$, implying a steady-state price mark-up of 20%.

The following parameters are calibrated such that empirical observations are matched.

[3] For the role of heterogeneity in wage stickiness in New Keynesian models see Eijffinger, Grajales-Olarte, and Uras (2019) and references therein for its empirical relevance. Empirical evidence suggests that wages of less-skilled (blue-collar) workers are more flexible than those of high-skilled (white-collar) workers (see, e.g., Druant, Fabiani, Kezdi, Lamo, Martins, and Sabbatini, 2012 and Sigurdsson and Sigurdardottir, 2016).

We calibrate the weight of housing in utility, γ^h, such that the mean ratio of total housing wealth to GDP is $\frac{p^h H}{4y} = 1.15$, as observed in the data. This implies $\gamma_h = 5.6571$. The weight of labor in utility, γ^n, is set to $\gamma^n = 168.1162$ such that total hours worked equal 0.33 in the steady state. We set the housing cost parameter κ_h to a value of 0.07, implying that transaction and maintenance costs amount to 7% of the housing value. Smith, Rosen, and Fallis (1988) estimate that transaction costs make up $8 - 10\%$ of the value of the house. Bajari, Chan, Krueger, and Miller (2013) use a slightly lower value of 6% in their study. As for maintenance costs, Harding, Rosenthal, and Sirmans (2007) report for a sample from the American Housing Survey average annual costs of 1.4% of the house's value, implying quarterly maintenance costs of about 0.35%.

We set the policy parameters to values that are in line with what is typically used in the literature: $\rho_R = 0.8$, $\rho_\pi = 1.3$, and $\rho_y = 0.08$. The responsiveness of taxes to public debt is set to $\rho_\tau = 0.0075$, implying that an increase in government spending is mostly debt-financed. The persistence of the government spending process is set to $\rho_g = 0.8$. The steady-state ratio of government spending to GDP is set to 20%, in line with our data.

Finally, if available, we set the autocorrelation coefficients of the shock processes and their standard deviations to values in the range of estimates by Guerrieri and Iacoviello (2017): $\rho_h = 0.95$, $\rho_c = 0.75$, $\rho_p = 0.9$, and $\rho_K = 0.79$, as well as $\sigma_h = 0.037$, $\sigma_c = 0.0075$, $\sigma_p = 0.015$, $\sigma_K = 0.018$, $\sigma_g = 0.005$, and $\sigma_r = 0.00065$.

Table 1 summarizes the parameter calibration.

3 Model Simulation

In this section, we simulate the model and describe its implications. We start by comparing the simulated data's business cycle statistics to actual U.S. data and find that the model

Table 1: Parameter Calibration.

Description	Parameter	Value
Discount factor of patient households	β^p	0.995
Discount factor of impatient households	β^i	0.99
Pledgeable fraction of housing	ϕ	0.9
Labor income share of impatient households	σ	0.44
Inverse of Frisch elasticity	μ^n	1
Inverse of IES in consumption	μ^c	2
Curvature of housing in utility	μ^h	2
Weight of housing in utility	γ^h	5.6571
Weight of labor in utility	γ^n	168.1162
Habit in consumption	ψ_c	0.5
Habit in housing	ψ_h	0.88
Inertia in borrowing constraint	γ^b	0.5
Investment adjustment costs	κ	4
Capital depreciation rate	δ_k	0.025
Housing transaction & maintenance costs	κ_h	0.07
Output elasticity of labor	α	2/3
Price rigidity	θ	0.9
Wage rigidity of patient households	θ_p^w	0.9
Wage rigidity of impatient households	θ_i^w	2/3
Elasticity of substitution (prices & wages)	$\varepsilon_p, \varepsilon_w$	6
Taylor rule: responsiveness to inflation	ρ_π	1.3
Taylor rule: responsiveness to output	ρ_y	0.08
Taylor rule: interest rate smoothing	ρ_R	0.8
Tax rule: responsiveness to debt	ρ_τ	0.0075
Persistence of government spending	ρ_G	0.8
Persistence of housing demand shock	ρ_h	0.95
Persistence of intertemporal shock	ρ_c	0.75
Persistence of productivity shock	ρ_p	0.9
Persistence of investment-specific technology shock	ρ_K	0.79
Standard deviation: government spending	σ_g	0.005
Standard deviation: housing demand shock	σ_h	0.037
Standard deviation: intertemporal shock	σ_c	0.0075
Standard deviation: productivity shock	σ_p	0.015
Standard deviation: investment-specific technology shock	σ_K	0.018
Standard deviation: monetary policy shock	σ_r	0.00065

satisfactorily replicates the empirical facts. We then study the effects of government spending shocks depending on the endogenous degree of financial frictions, i.e., whether the borrowing constraint is binding or slack. We show that a fiscal stimulus has a more considerable impact on the economy during periods of binding borrowing constraints than during periods when borrowing constraints are slack. Finally, we show that the borrowing constraint's tightness is closely linked to the households' leverage ratio: the constraint is more likely to bind when household leverage is high, whereas it is more likely to be slack when household leverage is low.

Business Cycle Statistics We derive the nonlinear solution of the model with occasionally binding borrowing constraints by computing the piecewise-linear perturbation solution suggested by Guerrieri and Iacoviello (2015). Based on our parameter calibration and the given shock processes, we generate artificial time series $\{A_t\}_{t=1}^T$ for real GDP, y_t, real government spending, g_t, household leverage, $b_{i,t}/(p_{h,t+1}h_{i,t})$, real consumption, c_t, real investment, i_t, the government debt-to-GDP ratio, $b_t^g/(4y_t)$, the real interest rate, R_t/π_{t+1}, house prices, $p_{h,t}$, real wages, w_t, and the Lagrange multiplier on the borrowing constraint, ω_t:

$$\{A_t\}_{t=1}^T = \left\{ y_t, g_t, \frac{b_{i,t}}{p_{h,t+1}h_{i,t}}, c_t, i_t, \frac{b_t^g}{4y_t}, \frac{R_t}{\pi_{t+1}}, p_{h,t}, w_t, \omega_t \right\}_{t=1}^T. \tag{7}$$

We generate the artificial time series $\{A_t\}_{t=1}^T$ by drawing random shocks for $T + \tilde{t}$ periods, where the first $\tilde{t}$ periods serve as burn-in. We replicate this N times. The time series contain periods in which the borrowing constraint becomes slack, which is indicated by a Lagrange multiplier of $\omega_t = 0$. The time-varying nature of ω_t implies that the propagation and amplification of economic shocks becomes state-dependent, as we will discuss below.

We first show that the artificial time series successfully reproduce the second moments of the corresponding series from U.S. data. Our data set covers the period 1955Q1-2019Q3. A detailed discussion of how we define household leverage in the data is provided in Section 4. Data sources and variable construction can be also found in Appendix A2. The data is HP-filtered to remove the secular trend. The simulated data is similarly filtered. Table 2

Table 2: Business Cycle Statistics.

Variable	Rel. STD to y		Correlation with y		Autocorrelation	
	Model	Data	Model	Data	Model	Data
Output	1.0000	1.0000	1.0000	1.0000	0.7856	0.8477
Consumption	0.8173	0.5620	0.8348	0.7927	0.8214	0.8326
Investment	2.0699	3.2508	0.7603	0.8703	0.9316	0.9148
Household Leverage	1.9984	1.0078	−0.5744	−0.1208	0.8428	0.9732
House Prices	2.0590	2.9975	0.8232	0.4236	0.7226	0.9741

Notes: The numbers in the columns 'Data' represent the empirically observed relative standard deviations and correlations, the numbers in the columns 'Model' are computed from the simulated data and show the medians over all replications ($T = 5000$, $\tilde{t} = 100$, and $N = 1000$). The empirical moments are obtained by detrending the variables with an HP-trend using a smoothing parameter of $\lambda = 1,600$ for output, consumption, and investment, and a smoothing parameter of $\lambda = 10,000$ for leverage and house prices. The same filtering is applied to the simulated data.

compares the business cycle statistics of our simulated data to their empirical counterparts. In particular, we compute for output, consumption, investment, household leverage, and house prices the standard deviation in relation to output, the respective cross-correlation with output, and the autocorrelation of each variable and compare these numbers (columns labeled 'Model' in Table 2) to what we find in the data (columns labeled 'Data' in Table 2).

Overall, the model matches the empirical data quite well. In line with the empirics, consumption is less volatile than output, while household leverage, house prices, and investment are more volatile than output. The ranking of model-implied volatilities is identical to the one in the data, with the highest volatility in investment and the lowest volatility in consumption. The model reproduces the empirically observed negative correlation between household leverage and GDP and the procyclicality of house prices. The persistence of the simulated data series, as measured through the autocorrelations, exhibits only marginal discrepancies compared to the empirical data. Based on the match between simulated and observed second moments, we conclude that the proposed model offers a useful toolbox for analyzing possible non-linear effects of government spending shocks across the household leverage cycle.

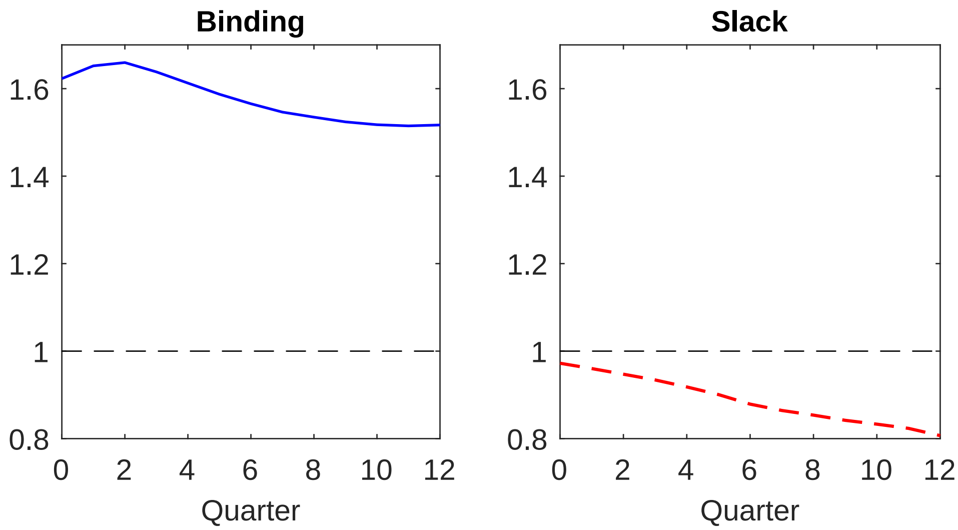
Borrowing Constraints and Fiscal Multipliers We now illustrate the fundamental nonlinearity in the effects of government spending shocks introduced by occasionally binding borrowing constraints using our artificial time series data. We analyze the state-dependent effects of a one-standard-deviation government spending shock by computing the impulse responses of the variables of interest, depending on whether the increase in government spending occurs during a period of binding borrowing constraints or during a period in which borrowing constraints are slack. A regime is labeled slack (binding) when the Lagrange multiplier on the borrowing constraint equals (exceeds) zero in two consecutive periods.[4] This definition implies that approximately 65% of our sample are defined as slack periods. The average duration of a slack period is 16.5 quarters, with a standard deviation of 12. Thus, the regime with no financial frictions last, on average, for more than four years, which is in line with the empirical literature showing that financial cycles are significantly longer than the typical business cycle (e.g., Drehmann and Tsatsaronis 2014).

To compute the responses to an increase in government spending, we use the same shocks that generate $\{A_t\}_{t=1}^{T}$ in (7), add a one standard deviation government spending shock in a particular period t^*, and generate a second time series $\left\{A_t^G\right\}_{t=1}^{T}$. As before, this procedure is replicated N times. We then partition the N replications into n_B binding and n_S slack regimes, depending on whether the period when the government spending shock occurs, t^*, belongs to a binding or slack regime. For each replication in one of the regimes $X \in \{B, S\}$, the changes in the variables of interest in response to a one standard deviation government spending shock are then given by $\Delta_{X,t} = A_{X,t}^G - A_{X,t}$.

Let $\Delta_{j,y,t}$ and $\Delta_{j,g,t}$ denote the level impulse responses for output and government spending in period t and in a replication j assigned to regime X. Then, we compute the cumu-

[4] We chose two consecutive periods to rule out a too frequent transition between both states.

Figure 1: Cumulative Government Spending Multipliers.



Notes: Median cumulative output multipliers in the model-inherent states of binding vs. slack borrowing constraints, where the x-axis shows quarters after the government spending shock.

lative government spending multipliers for each of the replications in the respective regimes $X \in \{B, S\}$ to compare the effectiveness of government spending in the two regimes. The cumulative multiplier measures the cumulative change in output relative to the cumulative change in government spending from the time of the government spending innovation to a reported horizon $h \in \{t^*, ..., T\}$:[5]

$$M_{j,h} = \left[\frac{\sum_{t=t^*}^{h} \Delta_{j,y,t}}{\sum_{t=t^*}^{h} \Delta_{j,g,t}} \right]. \tag{8}$$

Further, we construct impulse response functions as the absolute change of a variable x normalized by the standard deviation of the government spending shock which corresponds to the change of government spending in the period of the shock, t^*: $\Delta_{j,x,t}/\Delta_{j,g,t^*} = \Delta_{j,x,t}/\sigma_g$.

Figure 1 shows the medians of the distributions of cumulative government spending multipliers, as defined in Equation (8), in the regimes of binding, $M_{B,h}$, and slack borrowing constraints, $M_{S,h}$. The x-axis gives the horizon h with 0 denoting the impact period t^*. As

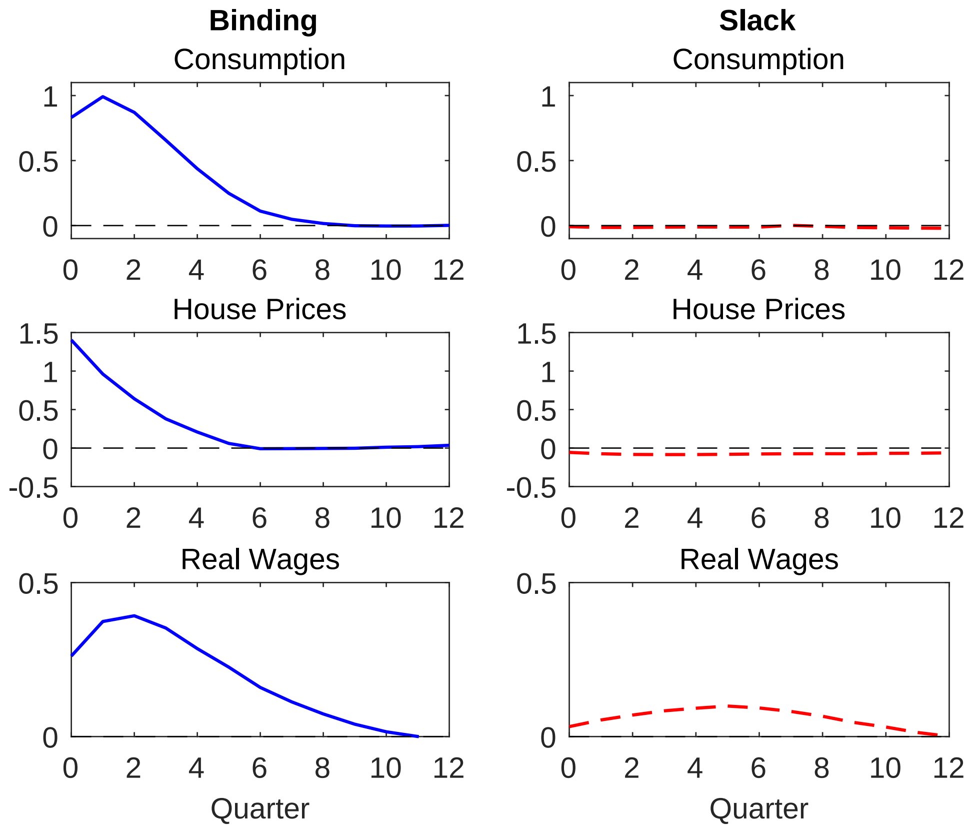
[5]This metric is frequently used in the empirical literature to measure the effectiveness of a government spending innovation, see, e.g., Ramey and Zubairy (2018).

can be seen, the effectiveness of government spending shocks is highly state-dependent. If the government spending expansion occurs when borrowing constraints are binding, the median output multiplier exceeds one considerably on impact, $M_{B,0} > 1.6$, and remains above 1.5 for the horizon of 3 years. If the shock occurs when borrowing constraints are slack, the median output multiplier is below one on impact, $M_{S,0} < 1$, and falls to about 0.8 after three years. Note that we do not force the economy to stay in the binding or slack regime in the periods after the fiscal shock has occurred. On the contrary, the simulated multipliers capture the average transition from one regime to another triggered by the government spending expansion.

Our findings suggest that a fiscal stimulus crowds-in private demand when financial frictions are binding. In contrast, there is no crowding-in of private economic activity when the constraint turns slack. To corroborate this, Figure 2 shows the median impulse response functions of consumption, house prices, and real wages to a government spending shock. As shown in the left panel of Figure 2, private consumption, house prices, and real wages increase considerably when government spending increases during periods in which the borrowing constraint is binding. Under a binding borrowing constraint, impatient households' marginal propensity to consume out of disposable income is high because they are at their constrained optimum. Hence, the increase in their current wage income induces impatient households to consume more goods and services and demand more housing services, which, in turn, puts upward pressure on house prices. The rise in house prices positively affects consumption because higher housing values enable impatient households to borrow more. Therefore, we observe a significant consumption crowding-in that leads to an output multiplier considerably greater than one when the constraint is binding.

When the spending expansion occurs while borrowing constraints are slack, impatient

Figure 2: Impulse Response Functions.



Notes: Median impulse response functions for consumption, house prices, and real wages to a one standard deviation government spending shock in the model-inherent states of binding vs. slack borrowing constraints, where the x-axis shows quarters after the government spending shock.

households are at their unconstrained optimum and hence relatively insensitive to changes in their disposable income. Consequently, impatient households do not raise their consumption, despite the increase in their wage income. Moreover, housing loses its role in serving as collateral. This is why consumption and house prices barely react (or even slightly fall) to the change in government spending. The negative wealth effect associated with government spending dominates, leading to a multiplier below unity.

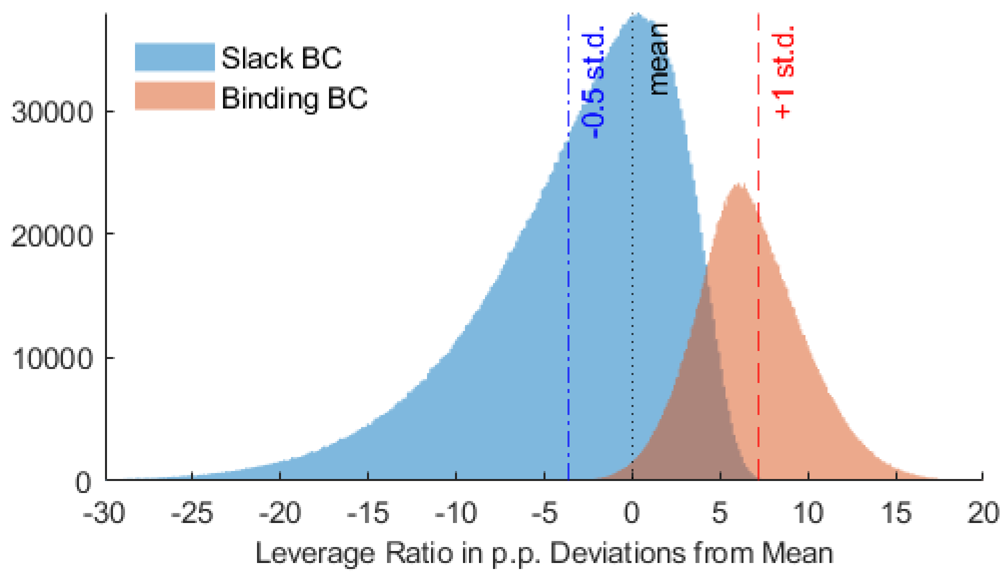
Borrowing Constraints and the Household Leverage Cycle We now demonstrate that periods of binding borrowing constraints tend to coincide with boom phases of the household leverage cycle, defined as episodes of above-average household leverage ratios.

In contrast, below-average leverage ratios indicate periods of slack borrowing constraints. Put differently, the household leverage cycle is a valid proxy for the tightness of collateral constraints.

To see this, let us define the household leverage ratio (or loan-to-value ratio) as $LR_t = \frac{b_{i,t}}{p_{h,t+1}h_{i,t}}$. Consider, for the sake of argument, a simplified version of the borrowing constraint (4): $b_{i,t} \leq \phi p_{h,t+1} h_{i,t}$, which we can derive by setting $\gamma^b = 0$ and $R_t/\pi_{t+1} = 1$. Now consider the case of a binding borrowing constraint, where $\omega_t > 0$ and the leverage ratio $LR_t^B = \frac{b_{i,t}}{p_{h,t+1}h_{i,t}} = \phi$. Let us compare this to the case of a slack borrowing constraint with $\omega_t = 0$ and $LR_t^S = \frac{b_{i,t}}{p_{h,t+1}h_{i,t}} < \phi$. Thus, under the simplified borrowing constraint, the household leverage ratio in the slack regime will be strictly smaller than the leverage ratio in the binding regime: $LR_t^S < LR_t^B = \phi$. In other words, the household leverage ratio is a proper measure for the endogenous degree of financial frictions.

Going back to the more elaborate formulation of the borrowing constraint we use in the model simulations, in Figure 3, we plot the distribution of the deviation of the leverage ratio from its stochastic mean during states of slack (blue) and binding (orange) borrowing constraints. The figure shows that the leverage ratio is almost always above average for periods in which the borrowing constraint is binding. In periods of a slack constraint, the leverage ratio tends to be below its average. The median (mean) of the distribution of the deviation of the leverage ratio from its mean during slack states is -2.1 (-3.3), whereas it is 6.6 (6.8) during episodes of binding borrowing constraints. As can be seen, there is only a small overlap of the two histograms. If we consider a one-standard-deviation (7.24) increase of the leverage ratio from its mean, indicated by the dashed line in Figure 3, the probability of being in a state of slack borrowing constraints is about 0.01%. Likewise, the probability of being in a state of binding borrowing constraints is below 0.01%, if we consider

Figure 3: **State of Borrowing Constraint vs. Leverage Ratio.**



Notes: Distribution of the demeaned leverage ratio for all periods with slack borrowing constraint (blue) and for all periods with binding borrowing constraint (orange).

a one-half standard deviation decline of the leverage ratio from its mean, indicated by the dashed-dotted line in Figure 3. The mapping from slack to low leverage is already suitable for small negative deviations of the leverage ratio from its mean. In contrast, one needs larger positive deviations for a proper mapping from binding states to high leverage. A Kolmogorov–Smirnov test shows that the two distributions are significantly different at the one percent significance level.

In sum, the model suggests that government spending multipliers should be high around the peaks of the household leverage cycle, whereas they should be small around its troughs.

4 Estimation: Household Leverage and Fiscal Multipliers

We now provide direct empirical evidence supporting the model's prediction concerning the relationship between the household leverage cycle and fiscal spending multipliers. To do so, we estimate leverage-dependent government spending multipliers on both U.S. data and artificial time series resulting from our model. We show that model-implied fiscal multipliers match their empirical counterparts well, both in qualitative and quantitative terms.

Methodology We estimate household leverage-dependent government spending multipliers using the local projection instrumental variable approach that builds on Jordà (2005). In particular, we are interested in the dynamics of the cumulative spending multiplier, which measures the cumulative change in GDP relative to the cumulative change in government spending from the time of the government spending innovation to a reported horizon h, where h captures the time dimension, quarters in our case. In particular, we follow Ramey and Zubairy (2018) and estimate the following equation for each horizon h:

$$\begin{aligned}\sum_{j=0}^{h} \frac{Y_{t+j} - Y_{t-1}}{Y_{t-1}} =& I_{t-1} \left[\gamma_{A,h} + \phi_{A,h}(L) V_{t-1} + M_{H,h} \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} \right] \\ &+ (1 - I_{t-1}) \left[\gamma_{B,h} + \phi_{B,h}(L) V_{t-1} + M_{L,h} \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} \right] \\ &+ \rho_1 t + \rho_2 t^2 + \omega_{t+h},\end{aligned} \tag{9}$$

where $\sum_{j=0}^{h} \frac{Y_{t+j} - Y_{t-1}}{Y_{t-1}}$ is the sum of GDP changes from $t-1$ to $t+h$ and $\sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}}$ is the sum of the changes in government spending, scaled by lagged GDP, from $t-1$ to $t+h$. I_t is a dummy variable that equals one when household leverage is high and is zero otherwise. We include a one-period lag of I_t in the regressions to minimize contemporaneous correlations between fiscal shocks and the state of the household leverage cycle. Thus, $M_{H,h}$ indicates the cumulative government spending multiplier in high household leverage states, while $M_{L,h}$ measures the cumulative spending multiplier in low leverage states. Note that the estimates incorporate the average transition of the economy from one state to another. If a government spending change affects the state of the private leverage cycles, this effect is then absorbed into the estimated coefficients $M_{H,h}$ and $M_{L,h}$.

We use $I_{t-1} \times shock_t$ and $(1 - I_{t-1}) \times shock_t$ as the instruments for the respective interaction of cumulative government spending with the indicator variable. This instrumental variable approach has the advantage that the multiplier's standard error can be estimated directly, and no bootstrapping procedure is required. We identify government spending shocks by employing the recursive structure as originally proposed by Blanchard and Perotti (2002). The underlying assumption is that government spending does not react to changes in the economy within a quarter. Typically it takes longer than a quarter for government spending to respond to economic circumstances due to decision lags and the absence of automatic stabilizers affecting government purchases. Recent studies by Auerbach and Gorodnichenko (2012), Ilzetzki, Mendoza, and Vegh (2013), and others have used this identification assumption. Moreover, it is also applied by Bernardini and Peersman (2018) to investigate household-leverage dependent fiscal multipliers. The exogenous government-spending innovation $shock_t$ is then given by current government spending, which we express in real per-capita log levels.

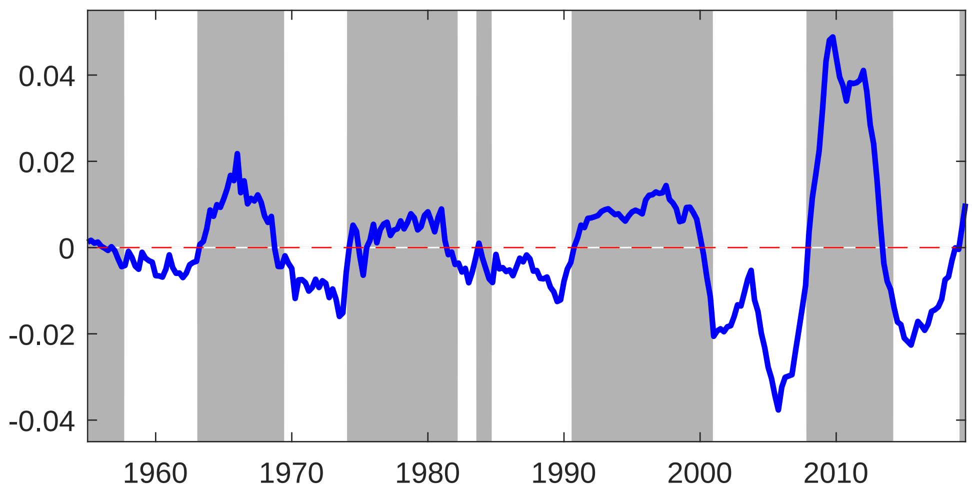
Our baseline data set covers the period 1955Q1-2019Q3. The starting date avoids the episode from 1945 to the Korean war, commonly considered turbulent from a fiscal point of view (see Perotti 2008, for a discussion). Moreover, some of the control variables, particularly government debt, are just available from 1955Q1 onwards. The vector of control variables V includes lags of GDP and government spending, both expressed in real per-capita log levels, the real interest rate, constructed as the difference between the T-Bill rate and the GDP deflator, the inflation rate, and the government debt to GDP ratio.[6] The real interest rate and the government debt-to-GDP ratio are included to control for the monetary policy stance and the effects of the government budget's financing side, respectively. The number of lags is set equal to four.

[6] A detailed description of the data sources and definitions can be found in Appendix A2.

A central component of our analysis lies in the definition of low and high private household leverage periods. As an indicator of household leverage, we use the home mortgages-to-real estate ratio. This loan-to-value ratio expresses the amount of outstanding debt in the mortgage market relative to its housing collateral. It is, therefore, closely related to the traditional leverage ratio of assets to net worth used in the corporate finance literature. A high mortgages-to-real estate ratio indicates a period in which households take on high levels of debt relative to their housing value, making them more vulnerable to changes in their collateral. Justiniano, Primiceri, and Tambalotti (2015) and Dynan (2012) use the same indicator for household leverage to study the impact of household leveraging and deleveraging on personal consumption. Importantly, this definition of household leverage mirrors the measure of leverage used in the paper's previous theoretical part.

To differentiate between high-leverage and low-leverage states, we remove a smooth Hodrick-Prescott (HP) trend from the mortgages-to-real estate ratio, where the smoothing parameter, λ, is set to $10,000$. The relatively high smoothing parameter ensures that the filter removes even the lowest frequency variations in the private mortgages-to-real estate ratio. Indeed, the implementation of the Third Basel Accord (Basel III) includes a similar approach for the construction of a credit gap indicator (BIS 2010). As shown by Borio (2014) and Drehmann, Borio, and Tsatsaronis (2012), the credit cycle is significantly longer and has a much greater amplitude than the standard business cycle. Therefore, Drehmann, Borio, and Tsatsaronis (2011) propose the use of a smooth HP-trend to capture the low frequency of financial cycles. In particular, our choice of λ assumes that the leverage cycle is twice as long as the business cycle. Bernardini and Peersman (2018) and Klein (2017) use a similar approach to identify episodes of private debt overhang, defined as periods in which private debt-to-GDP is above its long-run trend.

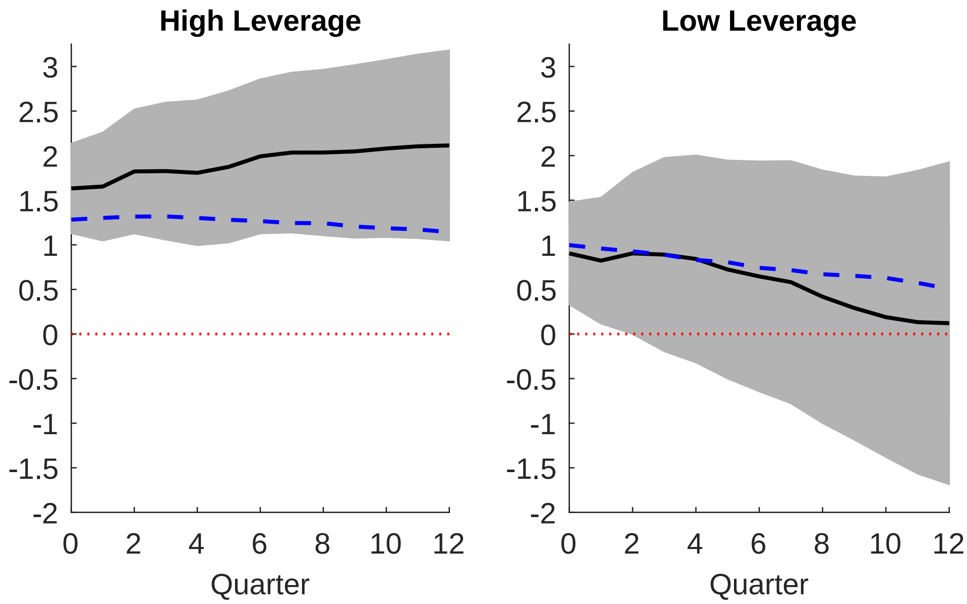
Figure 4: Household Leverage Cycle.



Notes: Detrended mortgages-to-real estate ratio (HP-filtered, $\lambda = 10,000$).

We define low household leverage states as periods with negative deviations of the mortgages-to-real estate ratio from its trend for at least four consecutive quarters. This procedure implies that out of the 259 periods considered in our analysis, 140 or 54% are detected as high household leverage periods, while the remaining 119 episodes or 46% indicate periods of low household leverage. Figure 4 shows the U.S household leverage cycle. Shaded areas indicate periods of high household leverage. High household leverage states correspond with five distinct long-lasting episodes: 1955Q1-1957Q3, 1963Q2-1969Q2, 1974Q2-1982Q1, 1990Q4-2000Q4, 2008Q1-2014Q1. Guerrieri and Iacoviello (2017) detect a similar evolution of household leverage during the Great Recession episode. It was below its long-run trend until the end of the housing boom. It spiked up until the beginning of the housing crash, which led to a period of household leverage overhang. In the subsequent periods, household leverage dropped again as debt declined more than house prices, resulting in a low household leverage episode. Note that our household leverage series differs from the commonly used debt-to-GDP ratio (e.g., Bernardini and Peersman 2018), which shows a higher increase

Figure 5: Cumulative Government Spending Multipliers.



Notes: Cumulative government spending multipliers in the two states of high leverage and low leverage. Solid lines show empirical mean responses and shaded areas 90% confidence bands based on Newey and West (1987) standard errors. Dashed lines show median responses based on artificial data from the DSGE model.

in indebtedness, especially in the years proceeding the housing collapse. However, because house prices increased substantially during these years, our series implies a smaller rise in household leverage in the 2000s.

Results Figure 5 presents the estimated cumulative government spending multipliers in high leverage states (left panel) and low leverage states (right panel). The solid lines show empirical mean responses and the shaded areas 90% confidence bands. We use the Newey and West (1987) correction to calculate standard errors to take account for possible serial correlation in the error terms. Moreover, the standard errors are adjusted to take into account instrument uncertainty. Dashed lines show median responses based on artificial data from the DSGE model. Numbers on the horizontal axes denote quarters after the shock.

As can be seen in Figure 5, there are pronounced nonlinearities in the aggregate effects of government spending shocks, in the sense that the results differ substantially across states of the household leverage cycle. The government spending multiplier is considerably larger during high household leverage periods. On average, the multiplier is around twice as high during high leverage periods compared to low leverage episodes. In low-leverage states, the output multiplier is estimated to be significantly different from zero only for the first two quarters after the shock. In contrast, the high leverage-multiplier is statistically significant for all periods of the forecast horizon. The point estimate of the high-leverage multiplier is above one in all periods of the forecast horizon, indicating a strong crowding-in of private demand. In contrast, the low-leverage multiplier is below one for most periods considered. We corroborated these findings by estimating the empirical impulse response of private consumption, which, as argued above, plays a crucial role in the fiscal transmission mechanism. When household leverage is above its long-run trend, an expansionary fiscal policy shock significantly increases private consumption. In contrast, when household leverage is low, private consumption barely reacts to the fiscal expansion, as predicted by our theoretical model. Besides, the empirical responses of house prices and wages also match the theoretical predictions. House prices and wages increase in response to the fiscal expansion when household leverage is high. In contrast, they fall (in the case of house prices) or barely respond (in the case of wages) when household leverage is low.[7]

As can be seen in Figure 5, the estimations based on artificial data from our model resemble the empirical responses quite well – the median estimates lie within the 90% confidence bands of the empirical estimates. In high leverage states, the median of the estimated cumulative multiplier based on artificial data is above one for all periods considered, ranging between 1.3 and 1.2. At the same time, it is below one for all periods when household leverage is low, falling to about 0.6 at the end of the third year after the fiscal stimulus. While

[7]Household leverage-dependent impulse responses of these additional variables are available upon request.

the theoretical model matches the data exceptionally well when household leverage is low, it slightly underestimates the size of the multiplier in the high-leverage regime.

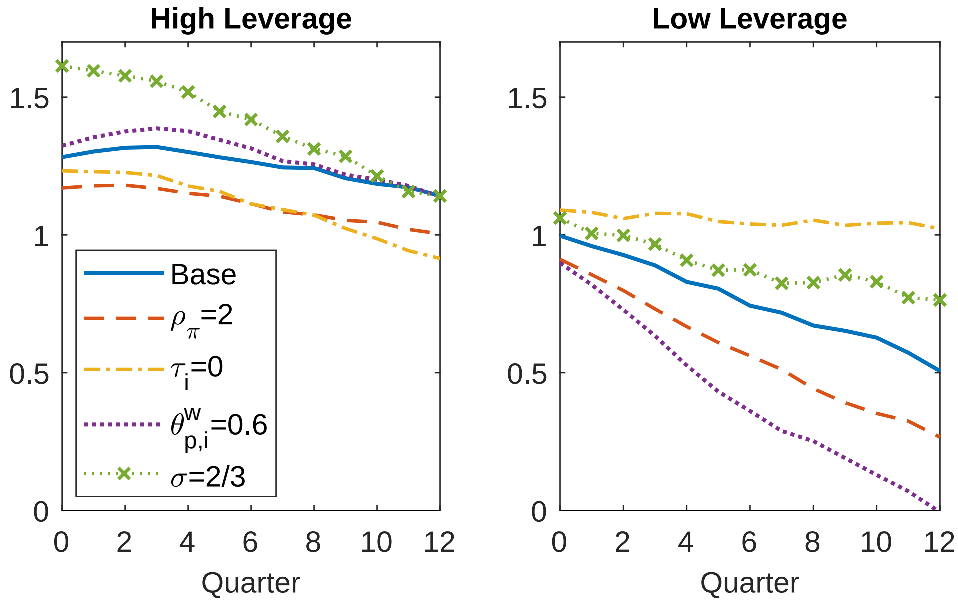
The reason is that the definition of the states of the leverage cycle that we also apply to the simulated time series assigns the overlap in the distribution of binding and slack borrowing constraints, shown in Figure 3, mainly to the high-leverage state. Almost all of the periods defined as low leverage turn out to be periods with slack borrowing constraints. About half of the periods defined as high leverage turn out to be periods with binding borrowing constraints. This makes the estimated high-leverage multiplier smaller because the high-leverage state contains periods of slack borrowing constraints in which multipliers are small.

In sum, model-implied and empirical responses show that fiscal policy's effectiveness depends on the household leverage cycle. While an increase in government expenditures has only small effects on the economy around the troughs of the leverage cycle, government spending is more effective in stimulating the economy during periods around the leverage cycle's peak.

Sensitivity Analysis We now conduct a sensitivity analysis to investigate how changes in selected deep model parameters and policy rules affect fiscal spending multipliers across the household leverage cycle. This analysis will provide further insights into the state-dependent fiscal transmission mechanism. For each sensitivity check, we simulate, as before, artificial data with $T = 5000$, $\tilde{t} = 100$, and $N = 1000$ and estimate high and low leverage multipliers using local projections on our simulated data. Figure 6 shows the results, together with the multipliers for the baseline specification (solid lines), for the sake of comparison.

First, we consider a more aggressive response of the central bank to inflationary pressure by setting $\rho_\pi = 2$. The dashed lines in Figure 6 present cumulative government spending

Figure 6: Robustness Checks.



Notes: Median cumulative output multipliers in the two states of high and low leverage for a different specification or calibration of the model. The x-axis shows quarters after the government spending shock.

multipliers in high-leverage and low-leverage states for this specification. When the central bank reacts more strongly to inflation, both high-leverage and low-leverage multipliers are smaller. As the central bank leans strongly against the price increase induced by the fiscal expansion, nominal and real interest rates rise by more than in the baseline specification, which depresses private demand and lowers multipliers.

Second, we investigate the role of how the government finances its spending. In particular, we drop the assumption that the tax burden of higher spending is shared equally by both types of households. Instead, we consider the case in which only lenders pay taxes, and borrowers do not (i.e., we set $\tau_{i,t} = 0$ for all t). In a stylized way, this captures a scenario in which the government finances its spending by increasing the tax system's progressivity. The dashed-dotted lines show multipliers for this specification. As can be seen, the high-leverage multiplier is now smaller than in the baseline. To understand this, recall that the increase in government spending is mainly debt-financed. Thus, the change in the tax system barely affects the current disposable income of both impatient and patient households. Borrowers' consumption, which mainly depends on current disposable income when leverage is high, does not change compared to the baseline scenario. Lenders now have to bear the whole tax burden and reduce their consumption more as their lifetime income declines. Hence, the spending multiplier is smaller than in the baseline. When leverage is low, though, borrowers' consumption decisions depend much more on their lifetime income than when leverage is high, as borrowing constraint tends to become non-binding. Compared to the baseline, borrowers now have a lower tax burden and consume more, while lenders have a higher tax burden and consume less. Overall consumption rises by more than in the baseline because impatient borrowers have a higher marginal propensity to consume out of lifetime income than lenders, explaining why the low-leverage multiplier is now higher.

Next, we reduce the average degree of nominal wage rigidity by setting $\theta_p^w = \theta_i^w = 0.6$. The dotted lines in Figure 6 show that the high-leverage multiplier is slightly higher than in the baseline, whereas it is considerably smaller for the low-leverage state. Two countervailing mechanisms are at work that can explain the different effects of varying the degree of nominal wage rigidity across leverage cycle phases. On the one hand, a lower degree of nominal wage rigidity reduces multipliers as wage markups' countercyclicality declines. Households are less willing to supply more labor for a given real wage when labor demand increases. Thus, employment and output rise by less in response to a government spending expansion. On the other hand, a lower degree of nominal wage stickiness tends to reinforce the upward pressure on real wages following a government spending expansion. In isolation, this raises the disposable income of workers, which tends to raise fiscal multipliers. Suppose household indebtedness is high and borrowing constraints tend to bind. In that case, the disposable income channel dominates, and multipliers get bigger when nominal wages become more flexible. By contrast, low household indebtedness associated with, on average, slack borrowing constraints renders the disposable income channel less powerful. Consequently, the markup-channel dominates, and fiscal multipliers decrease with the degree of wage rigidity.

Finally, we increase the weight of impatient households in the economy by raising the impatient household's labor income share to $\sigma = 2/3$ (from 0.44 in our baseline calibration). Multipliers for this specification are shown by the dotted lines with crosses in Figure 6. As can be seen, multipliers in both states are higher than in the baseline. The change relative to the baseline is most notable if government spending increases during periods in which household leverage is high. As discussed before, impatient households' consumption increases considerably in response to a government spending shock in boom phases of the leverage cycle. With a larger weight of borrowers in the economy, aggregate consumption increases more strongly, which pushes up the output multiplier relative to our baseline scenario.

Interestingly, for all changes in the model's parameters the spending multiplier remains above unity when household leverage is high. In contrast, the picture is more mixed for low leverage periods with some changes implying a multiplier above unity (tax progressivity and weight of impatient households) and others leading to a stronger crowding out of private demand (a lower degree of nominal wage stickiness and more aggressive monetary policy).

5 Conclusion

We have shown that a two-agent New Keynesian DSGE model with occasionally binding borrowing constraints can successfully replicate recent empirical evidence pointing towards pronounced differences in fiscal multipliers over the household leverage cycle. In particular, the model predicts fiscal multipliers to be significantly above one when an increase in government spending occurs during periods in which household leverage is relatively high. In contrast, the output effects of fiscal policy are small when the rise in government spending materializes during episodes of relatively low household leverage. We have provided additional empirical evidence on the leverage dependence of fiscal policy to test the model's predictions directly. Our theoretical framework might be used as a toolkit to inform policymakers about how the state of the household leverage cycle affects fiscal stabilization measures. Accounting for the phase of the leverage cycle may help increase the effectiveness of stimulus packages.

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Appendix

A1 Equilibrium Conditions

A rational expectations equilibrium is a set of sequences $\{c_{p,t},\ h_{p,t},\ n_{p,t},\ k_t,\ i_t,\ c_{i,t},\ h_{i,t},\ n_{i,t},\ p_{h,t},\ w_t,\ w_{p,t},\ w_{i,t},\ \pi_t,\ \pi^w_{p,t},\ \pi^w_{i,t},\ \omega_t,\ b_{i,t},\ R_t,\ n_t,\ mc_t,\ \widetilde{Z}_t,\ \widetilde{Z}_{p,t},\ \widetilde{Z}_{i,t},\ Z_{1,t},\ Z_{1,p,t},\ Z_{1,i,t},\ Z_{2,t},\ Z_{2,p,t},\ Z_{2,i,t},\ y_t,\ v_t,\ v^w_{p,t},\ v^w_{i,t},\ g_t,\ b^G_t,\ \tau_t,\ \tau_{p,t},\ \tau_{i,t},\ r^k_t,\ \xi_t\}_{t=0}^{\infty}$ satisfying the optimality conditions of patient households

$$u^h_{p,t} = u^c_{p,t} p_{h,t} \left(1+\kappa_h\right) - \beta^p E_t u^c_{p,t+1} p_{h,t+1}, \tag{A.1}$$

$$u^c_{p,t}\xi_t = \beta^p E_t u^c_{p,t+1} \left(r^k_{t+1} + \xi_{t+1}\left(1-\delta_k\right)\right), \tag{A.2}$$

$$\begin{aligned} 1 = {} & \xi_t z^K_t \left[1 - \frac{\kappa}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 - \kappa\left(\frac{i_t}{i_{t-1}} - 1\right)\frac{i_t}{i_{t-1}}\right] \\ & + \beta^p E_t \frac{u^c_{p,t+1}}{u^c_{p,t}} \xi_{t+1} z^K_{t+1} \kappa \left(\frac{i_{t+1}}{i_t} - 1\right)\left(\frac{i_{t+1}}{i_t}\right)^2, \end{aligned} \tag{A.3}$$

$$u^c_{p,t} = \beta^p E_t u^c_{p,t+1} R_t / \pi_{t+1}, \tag{A.4}$$

$$v^w_{p,t} = (1-\theta^w_p)\widetilde{Z}_{p,t}^{-\epsilon_w} + \theta^w_p (\pi^w_{p,t}/\pi^w_p)^{\epsilon_w} v^w_{p,t-1}, \tag{A.5}$$

$$1 = (1-\theta^w_p)\widetilde{Z}_{p,t}^{1-\epsilon_w} + \theta^w_p (\pi^w_{p,t}/\pi^w_p)^{\epsilon_w - 1}, \tag{A.6}$$

$$\widetilde{Z}_{p,t}^{1+\epsilon_w \mu_n} = \epsilon_w / \left(\epsilon_w - 1\right) Z_{1,p,t}/Z_{2,p,t}, \tag{A.7}$$

$$Z_{1,p,t} = z^c_t \gamma_n n_{p,t}^{1+\mu_n} + \theta^w_p \beta_p E_t (\pi^w_{p,t+1}/\pi^w_p)^{\epsilon_w(1+\mu_n)} Z_{1,p,t+1}, \tag{A.8}$$

$$Z_{2,p,t} = u^c_{p,t} w_{p,t} n_{p,t} + \theta^w_p \beta_p E_t (\pi^w_{p,t+1}/\pi^w_p)^{\epsilon_w - 1} Z_{2,p,t+1}, \tag{A.9}$$

$$w_{p,t} = w_{p,t-1}\pi^w_{p,t}\pi_t, \tag{A.10}$$

impatient households

$$u^h_{i,t} = u^c_{i,t} p_{h,t}\left(1+\kappa_h\right) - \beta^i E_t u^c_{i,t+1} p_{h,t+1} - \omega_t \left(1-\gamma^b\right) \phi E_t p_{h,t+1}\pi_{t+1}/R_t, \tag{A.11}$$

$$u^c_{i,t} = \beta^i E_t u^c_{i,t+1} R_t/\pi_{t+1} + \omega_t - \gamma^b \beta^i E_t \omega_{t+1}/\pi_{t+1}, \quad (A.12)$$

$$c_{i,t} + (1+\kappa_h)\, p_{h,t} h_{i,t} + b_{i,t-1} R_{t-1}/\pi_t + \tau_{i,t} = p_{h,t} h_{i,t-1} + b_{i,t} + w_{i,t} n_{i,t}, \quad (A.13)$$

$$b_{i,t} = \gamma^b b_{i,t-1}/\pi_t + \left(1-\gamma^b\right) \phi E_t p_{h,t+1} h_{i,t} \pi_{t+1}/R_t \text{ if } \omega_t > 0, \quad (A.14)$$

$$\text{or } b_{i,t} < \gamma^b b_{i,t-1}/\pi_t + \left(1-\gamma^b\right) \phi E_t p_{h,t+1} h_{i,t} \pi_{t+1}/R_t \text{ if } \omega_t = 0, \quad (A.15)$$

$$v^w_{i,t} = (1-\theta^w_i) \widetilde{Z}^{-\epsilon_w}_{i,t} + \theta^w_i (\pi^w_{i,t}/\pi^w_i)^{\epsilon_w} v^w_{i,t-1}, \quad (A.16)$$

$$1 = (1-\theta^w_i) \widetilde{Z}^{1-\epsilon_w}_{i,t} + \theta^w_i (\pi^w_{i,t}/\pi^w_i)^{\epsilon_w - 1}, \quad (A.17)$$

$$\widetilde{Z}^{1+\epsilon_w \mu_n}_{i,t} = \epsilon_w / (\epsilon_w - 1)\, Z_{1,i,t}/Z_{2,i,t}, \quad (A.18)$$

$$Z_{1,i,t} = z^c_t \gamma_n n^{1+\mu_n}_{i,t} + \theta^w_i \beta_i E_t (\pi^w_{i,t+1}/\pi^w_i)^{\epsilon_w(1+\mu_n)} Z_{1,i,t+1}, \quad (A.19)$$

$$Z_{2,i,t} = u^c_{i,t} w_{i,t} n_{i,t} + \theta^w_i \beta_i E_t (\pi^w_{i,t+1}/\pi^w_i)^{\epsilon_w - 1} Z_{2,i,t+1}, \quad (A.20)$$

$$w_{i,t} = w_{i,t-1} \pi^w_{i,t} \pi_t, \quad (A.21)$$

firms

$$y_t = z^p_t n^\alpha_t k^{1-\alpha}_t / v_t, \quad (A.22)$$

$$w_{p,t} = z^p_t \alpha (1-\sigma) n^\alpha_t / n_{p,t} k^{1-\alpha}_t mc_t, \quad (A.23)$$

$$w_{i,t} = z^p_t \alpha \sigma n^\alpha_t / n_{i,t} k^{1-\alpha}_t mc_t, \quad (A.24)$$

$$r^k_t = z^p_t n^\alpha_t (1-\alpha)\, k^{-\alpha}_t mc_t, \quad (A.25)$$

$$n_t = n^{1-\sigma}_{p,t} n^\sigma_{i,t}, \quad (A.26)$$

$$w_t = w^{1-\sigma}_{p,t} w^\sigma_{i,t}, \quad (A.27)$$

$$k_{t+1} = z^K_t \left[1 - \frac{\kappa}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] i_t + (1-\delta_k)\, k_t, \quad (A.28)$$

$$\widetilde{Z}_t = \epsilon / (\epsilon - 1)\, Z_{1,t}/Z_{2,t}, \quad (A.29)$$

$$Z_{1,t} = u^c_{p,t} y_t mc_t + \theta \beta^p E_t \left(\pi_{t+1}/\pi\right)^\epsilon Z_{1,t+1}, \quad (A.30)$$

$$Z_{2,t} = u^c_{p,t} y_t + \theta \beta^p E_t \left(\pi_{t+1}/\pi\right)^{\epsilon - 1} Z_{2,t+1}, \quad (A.31)$$

$$v_t = (1-\theta)\,\widetilde{Z}_t^{-\epsilon} + \theta v_{t-1}\left(\pi_t/\pi\right)^{\epsilon}, \tag{A.32}$$

$$1 = (1-\theta)\,\widetilde{Z}_t^{1-\epsilon} + \theta\left(\pi_t/\pi\right)^{\epsilon-1}, \tag{A.33}$$

the public sector conditions

$$g_t + b_{t-1}^G R_{t-1}/\pi_t = b_t^G + \tau_{p,t} + \tau_{i,t}, \tag{A.34}$$

$$\left(\tau_t - \tau\right)/y = \rho_\tau\left(b_{t-1}^G - b^G\right)/y, \tag{A.35}$$

$$\log\left(g_t/g\right) = \rho_g \log\left(g_{t-1}/g\right) + \varepsilon_t^G, \tag{A.36}$$

$$\tau_t = \tau_{p,t} + \tau_{i,t}, \tag{A.37}$$

$$\tau_{p,t} = \tau_{i,t}, \tag{A.38}$$

$$R_t = R_{t-1}^{\rho_R} R^{1-\rho_R}\left(\pi_t/\pi\right)^{\rho_\pi(1-\rho_R)}\left(y_t/y_{t-1}\right)^{\rho_y(1-\rho_R)}\exp\varepsilon_t^r, \tag{A.39}$$

the market clearing conditions

$$y_t = c_{p,t} + c_{i,t} + g_t + i_t + \kappa_h p_{h,t} H, \tag{A.40}$$

$$H = h_{p,t} + h_{i,t}, \tag{A.41}$$

and transversality conditions, given the fixed housing supply $H > 0$, and given initial values $b_{-1}^G > 0$, $k_{-1} > 0$, $\pi_{-1} > 0$, $v_{-1} = 1$. Further, the exogenous AR(1) processes for $\{z_t^h, z_t^c, z_t^p, z_t^K\}_{t=0}^{\infty}$ with coefficients of autoregression of $\{\rho_h, \rho_c, \rho_p, \rho_K\}$ and i.i.d. innovations with mean zero $\{\varepsilon_t^h,\ \varepsilon_t^c,\ \varepsilon_t^p,\ \varepsilon_t^K,\ \varepsilon_t^G,\ \varepsilon_t^r\}_{t=0}^{\infty}$ are given. Finally, $u_{*,t}^j = \partial u/\partial j_{*,t}$ denote marginal utilities with respect to $j \in \{c,h\}$ for an agent of type $* \in \{p,i\}$, i.e. $u_{*,t}^c = \partial u/\partial c_{*,t} = z_t^c(1-\psi_c)^{\mu_c}(c_{*,t} - \psi_c c_{*,t-1})^{-\mu_c}$, $u_{*,t}^h = z_t^c z_t^h \gamma_h (1-\psi_h)^{\mu_h}(h_{*,t} - \psi_h h_{*,t-1})^{-\mu_h}$. Variables without subscript refer to the corresponding steady-state values.

A2 Data

Table A1: Data Definitions and Sources

Variable	Series ID/ Weblink/ Construction
(1): Gross Domestic Product	GDP
(2): Government Consumption Expenditures and Gross Investment	GCE
(3): 3-Month Treasury Bill: Secondary Market Rate	TB3MS
(4): Gross Domestic Product: Implicit Price Deflator	GDPDEF
(5): Total Population: All Ages including Armed Forces Overseas	POP
(6): Federal Government Debt: Net	NFDEBT
(7): Federal Debt: Total Public Debt as Percent of Gross Domestic Product	GFDEGDQ188S
(8): Households and Nonprofit Organizations; Home Mortgages	HHMSDODNS
(9): Households and Nonprofit Organizations; Real Estate at Market Value	REABSHNO
(10): Real GDP	$[(1)/(4)]\,/(5)$
(11): Real Government Spending	$[(2)/4)]\,/(5)$
(12): Real Interest Rate	$[(3)/100 - log\,[(4)/(4(-1))] * 4]$
(13): Private Household Leverage	$(8)/(9)$
(14): Inflation	$log\,[(4)/(4(-1))] * 4$
(15): Government Debt-to-GDP	1955q1-1998q4: (6)/(1) 1999q1-2019q3: (7)