European Economic Review 141 (2022) 103989

Contents lists available at ScienceDirect

European Economic Review

journal homepage: www.elsevier.com/locate/eer

Fiscal spending multipliers over the household leverage cycle☆

Mathias Klein [a], Hamza Polattimur [b,*], Roland Winkler [c,d]

[a] Sveriges Riksbank, Sweden
[b] Universität Hamburg, Germany
[c] Friedrich Schiller University Jena, Germany
[d] University of Antwerp, Belgium

ARTICLE INFO

JEL classification:
E32
E44
E62
H31

Keywords:
Occasionally binding constraints
Government spending multiplier
Household leverage cycle
State-dependence

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.

1. Introduction

We study fiscal spending multipliers across the household leverage cycle in a calibrated two-agent New Keynesian DSGE model with savers and borrowers facing a borrowing constraint whose tightness is closely related to the household leverage cycle. In particular, we investigate the model's ability to replicate empirical evidence of noticeable differences in the effectiveness of government spending expansions at the ups and downs of the U.S. household leverage cycle. Estimating local projections on both a sample of artificial data generated through the model and post-WWII U.S. data shows that the model can successfully replicate the empirical finding of fiscal multipliers being considerably 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.

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

☆ We thank the editor, Florin O. Bilbiie, an associate editor, and two anonymous referees as well as Christian Matthes, Gert Peersman, and participants of the 25th International Conference in Computing in Economics and Finance (Ottawa, 2019) and the 2021 Annual Conference of the International Association for Applied Econometrics for their valuable comments and discussions. We gratefully acknowledge financial support from the German Research Foundation (DFG, Project No. 268475812) and from BOF-University of Antwerp, Belgium (Project No. 41658). The opinions expressed in this article are the sole responsibility of the authors and should not be interpreted as reflecting the views of Sveriges Riksbank.

* Correspondence to: H. Polattimur, Universität Hamburg, Faculty of Business, Economics and Social Sciences, Von-Melle-Park 5, 20146 Hamburg, Germany.
E-mail addresses: mathias.klein@riksbank.se (M. Klein), Hamza.Polattimur@uni-hamburg.de (H. Polattimur), roland.winkler@uni-jena.de (R. Winkler).

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

https://doi.org/10.1016/j.euroecorev.2021.103989
Received 11 November 2020; Received in revised form 28 July 2021; Accepted 7 November 2021
Available online 5 December 2021

relationship between the state of the household leverage cycle and the effectiveness of fiscal policy interventions (Bernardini and Peersman, 2018; Bernardini et al., 2020; Demyanyk et al., 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, which we review below, lacks a comprehensive theoretical framework that quantitatively accounts for state-dependent fiscal multipliers across the ups and downs of the household leverage cycle. Such a theoretical setup 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 quantitatively reproduces the empirical government spending multipliers across the alternating phases of the household leverage cycle.

We build on the two-agent New Keynesian (TANK) model by Guerrieri and Iacoviello (2017), which itself builds on the NK model with financially constrained and unconstrained agents as proposed by Galí et al. (2007) and Bilbiie (2008), 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 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 exogenous fiscal policy interventions, in particular, depend on the endogenous degree of financial frictions. More precisely, the endogenous change of the state of the borrowing constraint over time translates into time-varying marginal propensities to consume (MPCs) out of disposable income and, thereby, time-varying government spending multipliers. 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. Taken together, the model offers an appropriate toolkit for our quantitative analysis on how fluctuations in the leverage cycle affect the size of the fiscal spending multiplier.

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 0.6 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 these 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 leverage is low. When household leverage is high, and borrowing constraints are binding, impatient households find themselves at their borrowing limit such that their consumption decisions are substantially affected by their current disposable income. In this situation, a fiscal expansion that induces a redistribution of income away from unconstrained (low-MPC) households towards constrained (high-MPC) households will boost consumption and output, in line with the analytical insights provided by Bilbiie (2021) and Bilbiie (2020). In our model, the multiplier effect is accelerated through an increase in house prices, which, in turn, loosens borrowing limits and enables impatient households to consume more, pushing up output further. Importantly though, when household leverage is low, and borrowing constraints are slack, patient *and* impatient households are at their unconstrained optimum such that both household types are largely insensitive to changes in current disposable income. In other words, both household types have low MPCs of similar size. Consequently, the income redistribution brought about by an increase in government spending does not trigger significant changes in aggregate consumption and has no discernible consequences for fiscal spending multipliers. Thus, the endogenous state of the household leverage cycle matters significantly for the quantitative impact of fiscal policy.

The size of the multiplier during periods of binding borrowing constraints (high household leverage) depends on the endogenous redistribution of profit income and the distribution of taxes raised to finance the fiscal spending increase. In particular, if borrowing households incur part of the negative income effect of declining profits, their disposable income increases by less, resulting in a smaller increase in consumption expenditures and smaller spending multipliers. Relatedly, assuming a more progressive (regressive) tax schedule to finance the fiscal expansion leads to a relative gain (loss) in terms of constrained agents' disposable income and thus an increase (decrease) in consumption and multipliers. Importantly, we show that the income redistribution channel matters for determining the size of the fiscal multiplier only during periods when household leverage is high. In contrast, amplification effects through redistribution are significantly reduced when household leverage is low. This again highlights the importance of the state of the household leverage cycle for our quantitative investigation.

We confront the model prediction of larger multipliers during periods of high household leverage 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 through 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 are in line with the empirical estimates. The multiplier is above one over the horizon of three years when household leverage is high, while in low leverage states, it is always below one. 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 quantitatively replicates the household-leverage dependent fiscal multipliers found in the data.

Related literature. Our work is related to several partially intertwined strands of the literature. First, the paper relates to the literature on the state-dependent effects of fiscal policy, exploring whether fiscal multipliers vary depending on economic circumstances. For example, Auerbach and Gorodnichenko (2012) and Caggiano et al. (2015), amongst others, provide empirical evidence for multipliers being larger during periods of economic slack. However, others do not find evidence for multipliers being significantly different across states of the business cycle (e.g., Owyang et al., 2013; Ramey and Zubairy, 2018). Barnichon et al. (2021) find that the direction of the spending change matters: while contractionary spending shocks have state-dependent effects, expansionary ones do not. Motivated by these empirical findings, several papers have developed theoretical models that can explain why fiscal multipliers may be larger during economic contractions. For example, Michaillat (2014) shows that the crowding out of private employment is smaller in recessions due to a milder increase in labor market tightness. Canzoneri et al. (2016) and McManus et al. (2021) consider endogenous variations in the degree of financial frictions to account for state-dependence of fiscal multipliers, as we do. Relatedly, Corsetti et al. (2012) argue that their finding of higher fiscal multipliers during a financial crisis can be explained by an increase in the share of credit-constrained agents.

This paper focuses on fiscal spending multipliers across the ups and downs of the household leverage cycle.[2] Several studies have emphasized private leveraging and deleveraging as central elements to understand the boom and bust period that ultimately ended with the Great Recession (e.g., Mian and Sufi, 2011; Mian et al., 2013; Mian et al., 2013; Jordà et al., 2013; Jordà et al., 2016). Jones et al. (2020) partially challenge this household leverage view of the Great Recession but show that household deleveraging helps account for the slow recovery of employment in the aftermath of the Great Recession. Concerning the leverage cycle dependence of fiscal multipliers, the existing empirical evidence – to the best of our knowledge – is uncontroversial: fiscal multipliers are considerably larger (smaller) when household leverage is high (low), irrespective of the state of the business cycle (Bernardini and Peersman, 2018; Bernardini et al., 2020; Demyanyk et al., 2019; Klein, 2017).

Finally, our paper belongs to the burgeoning literature on fiscal policy and heterogeneity. Using heterogeneous-agent New Keynesian models, this literature emphasizes the importance of the interplay of differences in marginal propensities to consume and income redistribution for fiscal multipliers (see, e.g., Auclert et al., 2018; Bilbiie, 2021; Bilbiie, 2020; Broer et al., 2021; Cantore and Freund, 2021; Ferriere and Navarro, 2020; Hagedorn et al., 2019). In a series of papers, Bilbiie uses analytically tractable two-agent New Keynesian models with constrained hand-to-mouth agents to show that heterogeneity shapes equilibrium outcomes through a cyclical-inequality channel, that is, how the distribution of income between constrained and unconstrained households changes in response to shocks (Bilbiie, 2008; Bilbiie, 2021; Bilbiie, 2020). He shows that a Keynesian fiscal multiplier effect arises if income is redistributed from unconstrained (low-MPC, high-income) households to constrained (high-MPC, low-income) households. Galí et al. (2007), Andrés et al. (2021), and Bilbiie et al. (2008) show, using quantitative models, that the size of the fiscal multiplier depends positively on the fraction of constrained agents in the economy. In our quantitative TANK model, the share of agents in the population stays constant over time, but households face a borrowing constraint that is tied to the value of housing wealth and binds only occasionally rather than at all times, giving rise to asymmetric effects of fiscal policy over the household leverage cycle.

A few papers have already studied the relationship between household debt, borrowing constraints, and the efficacy of fiscal policy in heterogeneous-agent models. 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 et al. (2015) study 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, study the effectiveness of fiscal policy along the model economy's household leverage cycle, confront the model with empirical data, and assess whether our model quantitatively matches the observed 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 and provide 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 (TANK) 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 by Guerrieri and Iacoviello (2017) builds itself on earlier contributions by Galí et al. (2007) and Bilbiie (2008) highlighting the importance of the distinction between financially constrained and unconstrained agents for the transmission of fiscal and monetary policy. 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.

[2] Others have studied empirically the dependence of fiscal policy effects on the monetary policy regime, the degree of an economy's openness, the exchange rate regime, the level of public debt, or the prevalence of a financial crisis (see, e.g., Ilzetzki et al., 2013, Corsetti et al., 2012, Klein and Winkler, 2021).

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.

Before describing the model in detail, we start by providing the basic intuition for state-dependent fiscal policy effects within our TANK model with occasionally binding borrowing constraints. The shock propagation crucially depends on the tightness of the borrowing constraint. In particular, if the borrowing constraint binds, the two household types have distinctly different marginal propensities to consume (MPC) out of their current disposable incomes. Constrained agents (borrowers) have a high MPC, and unconstrained agents (savers) have a low MPC. In our basic model setup, a government spending expansion induces a redistribution of income towards (constrained) high-MPC households, resulting in a disproportionate increase in their disposable income which, in turn, leads to a rise in the consumption of constrained households strong enough to cause a crowding-in of aggregate private economic activity. The crowding-in effect is magnified by an increase in the value of housing (the collateral) enabling constrained agents to borrow and consume more. Thus, fiscal spending multipliers will exceed one if the spending expansion occurs in a period of binding borrowing constraints.

By contrast, if the borrowing constraint is slack, there are no significant differences in MPCs across households. This is because both patient and impatient households are at their unconstrained optimum.[3] Consequently, a temporary redistribution of disposable income does not trigger significant changes in consumption. At the same time, both household types are relatively insensitive to disposable income changes when the borrowing constraint is slack. They both behave Ricardian and save more in response to a government spending expansion associated with a negative wealth effect through a future increase in taxes. Further, when the borrowing constraint is slack, housing loses its collateral value, and a rise in house prices would not translate into higher borrowing and consumption of impatient households. Thus, there will be no crowding-in of private economic activity, and fiscal spending multipliers will be below one if spending expansions occur during periods of slack borrowing constraints.

Thus far, our explanation has put aside one crucial feature of the model for simplification purposes: borrowing constraints are occasionally binding. Thus, the impatient household's behavior depends on the expectations of switching to the other regime. Our quantitative analysis will expose the economy to a set of economic shocks and show how the model economy switches endogenously between periods of slack and binding borrowing constraints. In addition, we will show how the difference in multipliers across binding and slack regimes depends on the regimes' duration. Finally, we will demonstrate that episodes of binding borrowing constraints tend to coincide with periods of above-average household leverage ratios. In contrast, periods in which borrowing constraints are slack tend to coincide with episodes of below-average household leverage ratios.

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: $n_{*,t} = \left(\int_0^1 n_{*,t}(j)^{\frac{\epsilon_w-1}{\epsilon_w}}dj\right)^{\frac{\epsilon_w}{\epsilon_w-1}}$. Optimal bundling of differentiated labor services implies the demand function $n_{*,t}(j) = \left(\frac{W_{*,t}(j)}{W_{*,t}}\right)^{-\epsilon_w} n_{*,t}$, 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

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

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

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

where $u(x_{*,t}) = (1-\psi_x)^{\mu^x} \frac{(x_{*,t}-\psi_x x_{*,t-1})^{1-\mu^x}}{1-\mu^x}$ for $x \in \{c,h\}$, 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 $\varepsilon_t^{c(h)} \sim n.i.d.\left(0, \sigma^2_{c(h)}\right)$, $\rho_{c(h)} \in [0,1)$, and $z^{c(h)} = 1$. Note that all variables without time subscript denote steady-state values. The parameter $\mu^c > 0$ denotes the inverse of the intertemporal elasticity of substitution in consumption, $\mu^h > 0$ is the curvature of utility in housing, and $\mu^n > 0$ is the inverse of the Frisch elasticity of labor supply, while $\gamma^h > 0$ denotes the housing weight in utility and $\gamma^n > 0$ the weight of labor disutility. In the following, we first describe the problem of a representative patient household and then the one of a representative impatient household.

[3] The two household types differ in their degree of patience which leads to marginally different MPCs without noticeable differences in consumption patterns.

Patient households. In equilibrium, patient households are the savers in our model. They can invest their savings in physical capital, $k_{p,t+1}$, housing, $h_{p,t}$, government bonds, $b^G_{p,t}$, and loans to impatient borrowers, $b_{p,t}$. The budget constraint of a representative patient household in period t (in real terms) is given by

$$c_{p,t} + nfs_{p,t} + i_{p,t} + i^h_{p,t} = y_{p,t}, \tag{2}$$

where $y_{p,t}$ denotes disposable income, and $c_{p,t}$ are expenditures for consumption. Savings consist of net financial savings in the form of bonds and loans, $nfs_{p,t} = b_{p,t} - b_{p,t-1}/\pi_t + b^G_{p,t} - b^G_{p,t-1}/\pi_t$ (where $\pi_t = P_t/P_{t-1}$ denotes the gross inflation rate), investment in physical capital, $i_{p,t}$, and investment in housing, $i^h_{p,t} = \left(1+\kappa_h\right) p_{h,t}h_{p,t} - p_{h,t}h_{p,t-1}$, where $p_{h,t}$ is the real price of housing. Following Bajari et al. (2013), we assume that housing is associated with transaction costs that are proportional to the value of the newly purchased house.[4] Moreover, we assume that housing entails linear maintenance costs as in Cocco (2005). For simplicity, both of these costs are pooled in the term $\kappa_h p_{h,t} h_{p,t}$.

Real disposable income of a patient household consists of interest income from bond holdings, $\left(R^G_{t-1} - 1\right) b^G_{p,t-1}/\pi_t$ (with R^G_t being the gross nominal bond yield), interest rate income from loans, $\left(R_{t-1} - 1\right) b_{p,t-1}/\pi_t$ (with R_t denoting the gross nominal loan rate), 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, $r^k_t k_{p,t}$ (with r^k_t denoting the rental rate of physical capital), and profits of firms and retailers, $\delta_{p,t}$, less lump-sum taxes, $\tau_{p,t}$:

$$y_{p,t} = \frac{R^G_{t-1} - 1}{\pi_t} b^G_{p,t-1} + \frac{R_{t-1} - 1}{\pi_t} b_{p,t-1} + \int_0^1 w_{p,t}(j)n_{p,t}(j)dj + r^k_t k_{p,t} + \delta_{p,t} - \tau_{p,t}. \tag{3}$$

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

$$k_{p,t+1} = z^K_t \left[1 - \frac{\kappa}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] i_t + \left(1 - \delta_k\right) k_{p,t}, \tag{4}$$

where $\delta_k > 0$ is the depreciation rate of physical capital, $\kappa > 0$ is a parameter reflecting the size of adjustment costs, and z^K_t is an investment-specific technology shock that follows the process $\log\left(z^K_t\right) = \rho_K \log\left(z^K_{t-1}\right) + \varepsilon^K_t$, with $\varepsilon^K_t \sim n.i.d.\left(0, \sigma^2_K\right)$, $\rho_K \in [0,1)$, and $z^K = 1$.

Impatient households. Since impatient households value current consumption more than patient ones, they will become borrowers in equilibrium. 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

$$b_{i,t} \leq \gamma^b \frac{b_{i,t-1}}{\pi_t} + \left(1 - \gamma^b\right) \phi E_t \left\{ \frac{p_{h,t+1} h_{i,t} \pi_{t+1}}{R_t} \right\}, \tag{5}$$

where $0 < \gamma^b < 1$ denotes inertia in the borrowing limit and $\phi > 0$ 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 borrowing constraint outperforms a model in which the constraint always binds. From the complementary slackness conditions, we can observe the state of the borrowing constraint, binding or slack.[5] More precisely, when the Lagrange multiplier on (5), ω_t, takes a value larger than zero it indicates that the constraint is binding, whereas ω_t equals zero when the constraint becomes slack.

The budget constraint of an impatient household i reads

$$c_{i,t} + nfs_{i,t} + i^h_{i,t} = y_{i,t}. \tag{6}$$

An impatient household i has expenditures for consumption, $c_{i,t}$, housing investment, $i^h_{i,t} = \left(1+\kappa_h\right) p_{h,t}h_{i,t} - p_{h,t}h_{i,t-1}$, and net financial savings, $nfs_{i,t} = -\left(b_{i,t} - b_{i,t-1}/\pi_t\right)$, which, in equilibrium, will be negative since impatient households are borrowers. Disposable income of an impatient household is given by

$$y_{i,t} = \int_0^1 w_{i,t}(j)n_{i,t}(j)dj - \tau_{i,t} - \frac{R_{t-1} - 1}{\pi_t} b_{i,t-1}, \tag{7}$$

where $\int_0^1 w_{i,t}(j)n_{i,t}(j)dj$ is labor income, $\tau_{i,t}$ are lump-sum taxes, and $\left(R_{t-1} - 1\right) b_{i,t-1}/\pi_t$ are interest payments on loans.

It will be useful to define income inequality, γ_t, as the ratio of the disposable incomes of patient and impatient households:

$$\gamma_t = y_{p,t}/y_{i,t}. \tag{8}$$

As patient households have, on average, a higher income than impatient households, a decline in γ_t implies a reduction in income inequality.

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

[5] For details, see equilibrium conditions (A.14) and (A.15) in the Appendix A.1.

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

$$y_t(l) = z_t^p \left(n_{i,t}(l)^\sigma n_{p,t}(l)^{1-\sigma}\right)^\alpha k_t(l)^{1-\alpha}, \tag{9}$$

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 $\log\left(z_t^p\right) = \rho_p \log\left(z_{t-1}^p\right) + \varepsilon_t^p$, 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

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

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

$$(\tau_t - \tau)/y = \rho_\tau \cdot (b_{t-1}^G - b^G)/y. \tag{10}$$

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 $\log(g_t) = (1-\rho_g)\log(g) + \rho_g \log(g_{t-1}) + \varepsilon_t^G$, where $\varepsilon_t^G \sim n.i.d.\left(0, \sigma_G^2\right)$ 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

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

where $\rho_R \geq 0$ measures the strength of interest rate smoothing, and $\varepsilon_t^r \sim n.i.d.\left(0, \sigma_G^2\right)$ 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 the Appendix A.1.

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.[6]

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%.

[6] For the role of heterogeneity in wage stickiness in New Keynesian models see Eijffinger et al. (2020) 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 et al., 2012 and Sigurdsson and Sigurdardottir, 2016).

The following parameters are calibrated such that empirical observations are matched. 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 et al. (1988) estimate that transaction costs make up $8-10\%$ of the value of the house. Bajari et al. (2013) use a slightly lower value of 6% in their study. As for maintenance costs, Harding et al. (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. Below, we will investigate the impact of alternative financing schemes, like varying how much of the tax burden falls on both household types, for our simulation results. 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 $\sigma_r = 0.00065$.[7]

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 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 demonstrate 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. We explore the transmission mechanism and discuss how our results depend on the tax system. Finally, we show that the borrowing constraint's tightness is closely linked to the households' leverage ratio: the constraint is more likely to bind and fiscal multipliers tend to be large when household leverage is high, whereas the constraint is more likely to be slack and fiscal multipliers tend to be small when household leverage is low.

3.1. 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 a set of variables of interest, including, amongst others, real GDP, y_t, real government spending, g_t, household leverage, $b_{i,t}/(p_{h,t+1}h_{i,t})$, and real consumption, c_t:

$$\{A_t\}_{t=1}^T = \left\{ y_t, g_t, \frac{b_{i,t}}{p_{h,t+1}h_{i,t}}, c_t, \dots \right\}_{t=1}^T . \tag{11}$$

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 the Appendix A.2. The data is HP-filtered to remove the secular trend. The simulated data is similarly filtered. Table 1 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 1) to what we find in the data (columns labeled 'Data' in Table 1).

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.

The model overestimates the volatility of household leverage and its countercyclicality. But, at the same time, it understates the volatility of house prices and overstates house price procyclicality. Table A.3 in the Appendix A.3 shows the results when varying model parameters that turned out to be key for cyclical fluctuations in household leverage and house prices (housing transaction costs κ_h, housing habits, ψ_h, inertia in borrowing, γ^b, and the autocorrelation of the housing demand shock, ρ_h). Since leverage is

[7] Table A.1 in the Appendix A.1 summarizes the parameter calibration.

Table 1
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 $\lambda = 1600$ 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.

defined as the ratio of debt to housing value, i.e. $b_{i,t}/(p_{h,t+1}h_{i,t})$, we face a trade-off between matching the volatility of leverage and house prices. More precisely, calibrations that make leverage less volatile (as in the data) will also be associated with a decline in the model-implied volatility of house prices (departing even further from the data). Our baseline calibration balances this trade-off and ensures that the ranking of model-implied volatilities is identical to the one in the 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.

3.2. 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 four consecutive periods.[8] This definition implies that approximately 56% of our sample are defined as slack periods. The median (average) duration of the slack regime is 17 (20) quarters, with a standard deviation of 12. The median (average) duration of the binding regime is 4 (8) quarters, with a standard deviations of 4. Thus, the regime with no financial frictions lasts, 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 $\left\{A_t\right\}_{t=1}^{T}$ in (11), 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 ($j_B = 1,\dots,n_B$) and n_S slack regimes ($j_S = 1,\dots,n_S$), depending on whether the period when the government spending shock occurs, t^*, belongs to a binding or slack regime. For each replication j_X in one of the regimes $X \in \{B,S\}$, we can isolate the effects of a one standard deviation government spending shock on the variables of interest by computing $\Delta_{j_X,t} = A^G_{j_X,t} - A_{j_X,t}$.

Let $\Delta_{j_X,y,t}$ and $\Delta_{j_X,g,t}$ denote the isolated effects of the government spending shock on output and government spending in period t and replication j_X assigned to regime X. From this, we can compute government spending multipliers for both regimes to compare how the effectiveness of government spending depends on the state of the borrowing constraint, binding vs. slack. More precisely, for a replication j_X, 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, t^*, to a reported horizon $h \in \{t^*,\dots,T\}$:[9]

$$M_{j_X,h} = \left[\frac{\sum_{t=t^*}^{h} \Delta_{j_X,y,t}}{\sum_{t=t^*}^{h} \Delta_{j_X,g,t}}\right]. \tag{12}$$

Further, we construct for each replication j_X impulse response functions as relative deviations of the simulation with the additional government spending shock from the simulation without, i.e. $\left(A^G_{j_X,t} - A_{j_X,t}\right)/A_{j_X,t} = \Delta_{j_X,t}/A_{j_X,t}$.

The solid lines in Fig. 1 show the medians of the distributions of cumulative government spending multipliers, as defined in Eq. (12), in the regimes of binding, $M_{B,h}$, and slack borrowing constraints, $M_{S,h}$.[10] Accordingly, the dotted lines show the 5th

[8] We choose four consecutive periods to rule out too frequent transitions between states and to ensure consistency with the empirical analysis.

[9] 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).

[10] More precisely, $M_{B,h}$ denotes the median of all multipliers $M_{j_B,h}$ in the $j_B = 1,\dots,n_B$ replications assigned to the binding regime and $M_{S,h}$ the median of all multipliers $M_{j_S,h}$ in the $j_S = 1,\dots,n_S$ replications assigned to the slack regime. Note that the within-regime variation of multipliers stems from the likelihood of regime changes, as will be explained in detail below.

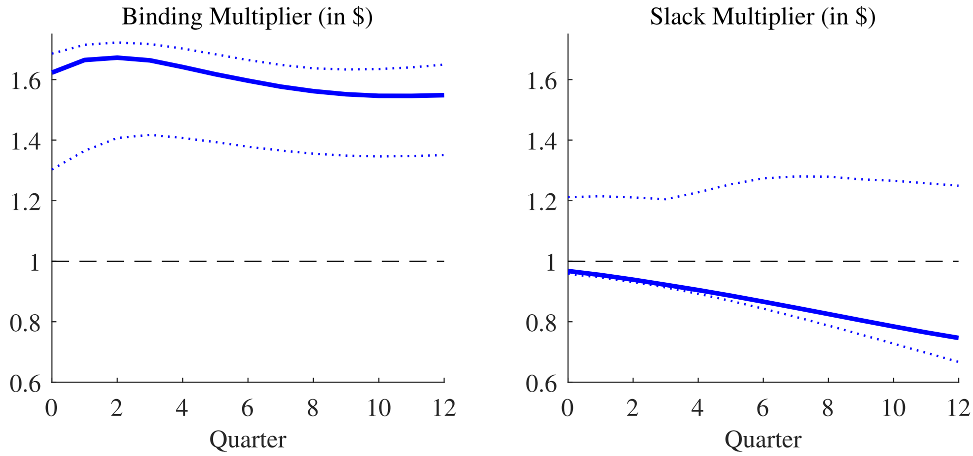

Fig. 1. Cumulative output multipliers. *Notes*: Cumulative output multipliers in the model-inherent states of binding vs. slack borrowing constraints. Solid lines show medians and dotted lines show the 5th and 95th percentiles of the distribution of multipliers within regimes. The x-axis shows quarters after the government spending shock.

and 95th percentiles of the within-regime distribution of multipliers. The x-axis gives the horizon h, with 0 denoting the impact period t^*. Note that the simulated multipliers capture the average transition from one regime to another triggered by the government spending expansion.

As 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 three years. The 90% confidence band ranges from 1.3 to 1.7 over the entire horizon under consideration. 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, with a 90% confidence band ranging from 0.96 to 1.21 on impact and from 0.67 to 1.25 after three years.

As can be seen, the distribution of multipliers is skewed: the median of the multiplier distribution in the binding (slack) regime lies close to the 95th (5th) percentile. To understand this, note that the within-regime uncertainty stems mainly from variations in the duration of staying in the current regime. Under our baseline regime definition, both regimes' average and median lengths are relatively high to rule out frequent regime shifts. However, due to the high standard deviation of the regimes' durations, our simulations include cases of very short regime spells. Short regimes spells, though, tend to raise fiscal multipliers in the slack regime and lower fiscal multipliers in the binding regime. The rationale is that regime spells are closely linked to the expectations of agents of staying in the current regime or switching to the other. For example, if borrowing constraints are currently binding but agents expect a switch to the non-binding regime soon, multipliers will shrink considerably. Likewise, if borrowing constraints are slack and agents expect them to become binding soon, this will increase the multiplier relative to our baseline scenario. On the other hand, the simulations pertaining to even more extended than baseline regime spells do not raise (lower) the binding (slack) multiplier in a noticeable way, as can be seen by the small difference between the median and the 95th (5th) percentile in the binding (slack) regime.

To explore this further, Fig. 2 plots impact output multipliers as a function of the minimum duration of states, binding or slack, when the government spending shock occurs. Recall that in our baseline scenario, we classified a regime as binding (slack) when the borrowing constraint is binding (non-binding) for a minimum of four consecutive quarters. In the figure, we show the distribution of multipliers when varying the minimum duration from one quarter to 12 quarters. Crosses depict medians, circles, and dots 5th and 95th percentiles, which are connected by lines covering the 90% confidence bands.

We observe that for a longer duration in one of the regimes, confidence bands become smaller. At the same time, median multipliers only slightly change – binding multipliers become somewhat larger and slack ones marginally smaller. Likewise, the 5th percentile in the slack regime and the 95th percentile in the binding regime barely change. By contrast, the 95th percentile in the slack regime strongly decreases if the regime duration rises, while the 5th percentile in the binding regime strongly increases. In our baseline, indicated by the black rectangle, the median impact binding multiplier is 1.62 with a band between 1.3 and 1.69, while the median slack multiplier is 0.97 with a band between 0.96 and 1.21. If we, for example, increase the minimum regime duration to 12 periods, the median binding multiplier is 1.64 with a band between 1.43 and 1.69. Likewise, the median slack multiplier is 0.96 with a band between 0.96 and 1.12.

In sum, increasing the minimum regime duration reduces the within-regime variation in multipliers by shrinking the mass of low (high) multipliers in binding (slack) regimes that stem from households' expectations of swift regime changes.

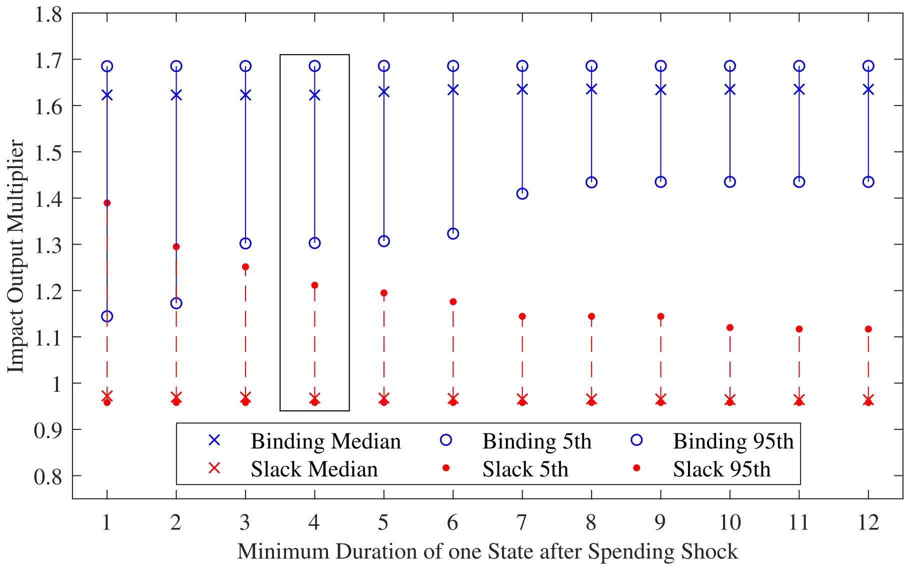

Fig. 2. Duration of state vs. impact output multiplier. *Notes*: Impact output multipliers depending on the minimum duration of binding/slack state when the government spending shock occurs. Multipliers for the binding (slack) state are depicted in blue (red). Crosses depict median multipliers, circles and dots 5th and 95th percentiles connected by lines covering the 90% confidence bands. The x-axis shows the minimum number of consecutive quarters in which the borrowing constraint is slack or binding, respectively, when the spending shock occurs. The black rectangle indicates our baseline, in which the binding/slack state lasts for a minimum of four consecutive quarters. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3.3. Inspecting the mechanism

Our findings suggest that a government spending expansion crowds in private demand when the borrowing constraint is binding. In contrast, there seems to be no crowding-in of private economic activity when the constraint turns slack. To corroborate this, Fig. 3 shows the median impulse response functions of consumption, house prices, real wages, disposable incomes, income inequality (defined as the ratio of the disposable incomes of patient and impatient households), and net financial savings to a government spending shock.[11] As shown in the left panel of Fig. 3, consumption of impatient households, house prices, and real wages strongly increase when government spending increases during periods in which the borrowing constraint is binding. Further, the disposable income of impatient households increases disproportionately, leading to a reduction in income inequality.

To understand this, note that the surge in aggregate demand brought about by the rise in government spending induces firms to produce more (due to sticky prices), which pushes up real wages. But, at the same time, profits decline due to declining price mark-ups. As a result, the impatient household's disposable income goes up disproportionately because patient households entirely bear the decline in profits. Thus, there is a redistribution of income away from patient savers towards impatient borrowers, leading to reduced income inequality.

Under a binding borrowing constraint, impatient households' marginal propensity to consume out of disposable income is high because they are at their constrained optimum. By contrast, patient households, who are unconstrained, have a low marginal propensity to consume. The disproportionate increase in disposable income of high-MPC households leads to a further rise in aggregate demand, setting in motion the chain of events described above which ultimately leads to a further disproportionate increase in the constrained agent's disposable income. Thus, the initial stimulus is magnified. This multiplier effect is amplified by the rise in house prices caused by an increase in impatient households' demand for housing services in our model. The increase in house prices positively affects consumption because higher housing values enable impatient households to borrow more, which is reflected in the fall in the net financial savings of impatient households. In sum, we observe a significant consumption crowding-in that leads to an output multiplier considerably greater than one when the borrowing constraint is binding.

When the spending expansion occurs while borrowing constraints are slack, impatient households are unconstrained and relatively insensitive to disposable income changes. As a result, the redistribution of income towards impatient households does not play an essential role in shaping aggregate demand as both households' MPCs do not differ considerably. Instead, the negative wealth effect associated with higher future taxes dominates, inducing patient *and* impatient households to save more rather than consume more, despite the increase in their current disposable incomes. Moreover, for a slack constraint, housing loses its role in serving as collateral. This is why house prices barely react (or even slightly fall) to government spending changes.

[11] Figure A.1 in the Appendix A.3 provides impulse response functions for hours worked, housing investment, investment, profit income, the real interest rate, and inflation.

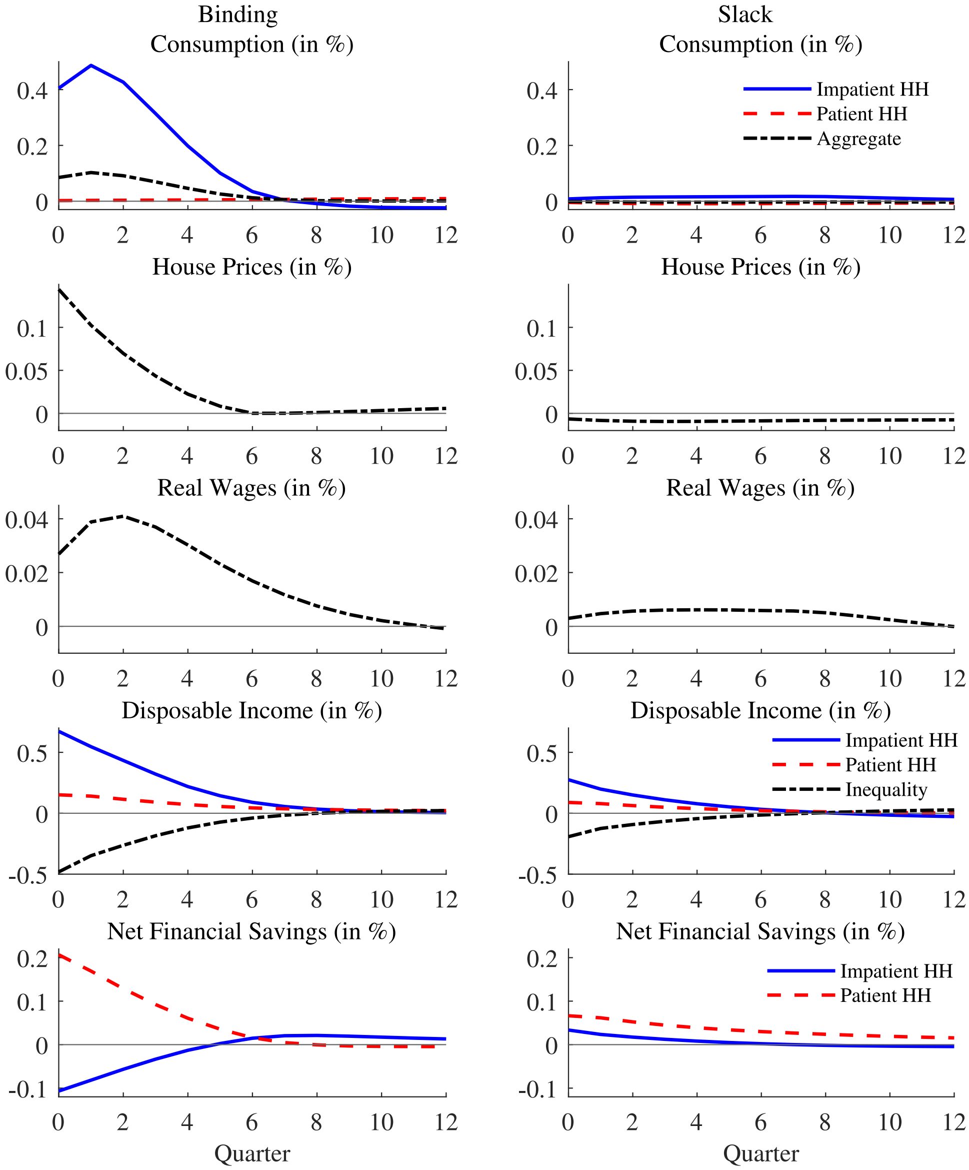

Fig. 3. Impulse response functions. *Notes*: Median impulse response functions to a one standard deviation government spending shock in the model-inherent states of binding vs. slack borrowing constraints. Blue solid (red dashed) lines depict reactions of variables belonging to impatient (patient) households. Black dashed–dotted lines show responses of prices and aggregate variables. All reactions are given in percentage deviations from the counterfactual scenario without additional government spending shock. The x-axis shows quarters after the government spending shock. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Alternative taxes. The literature has demonstrated that the size of the crowding-in effect in a heterogeneous-agents model populated by agents with different MPCs depends crucially on the endogenous redistribution of profit income and the distribution of taxes raised to finance the spending increase, see, e.g., Bilbiie (2020), Broer et al. (2021), Auclert et al. (2018), Ferriere and Navarro (2020). In our baseline, we assume that only patient households own firms and receive the profit income (or bear the burden of falling profits). Moreover, we assume that both households equally share the additional tax burden. In the following, we show how changes in these assumptions affect our findings.

Fig. 4 shows how the results are affected in the presence of an endogenous redistribution of profits from savers to borrowers. To investigate this, the budget constraint of patient households (2) is modified by including expenditures for profit taxes of $\tau_d \delta_{p,t}$, which are redistributed to impatient households and thus appear on the income side of their budget constraint (6). In the following, we set $\tau_d = 0.2$ for the sake of illustration. The blue lines in Fig. 4 show our baseline scenario, and the red dashed lines the case of

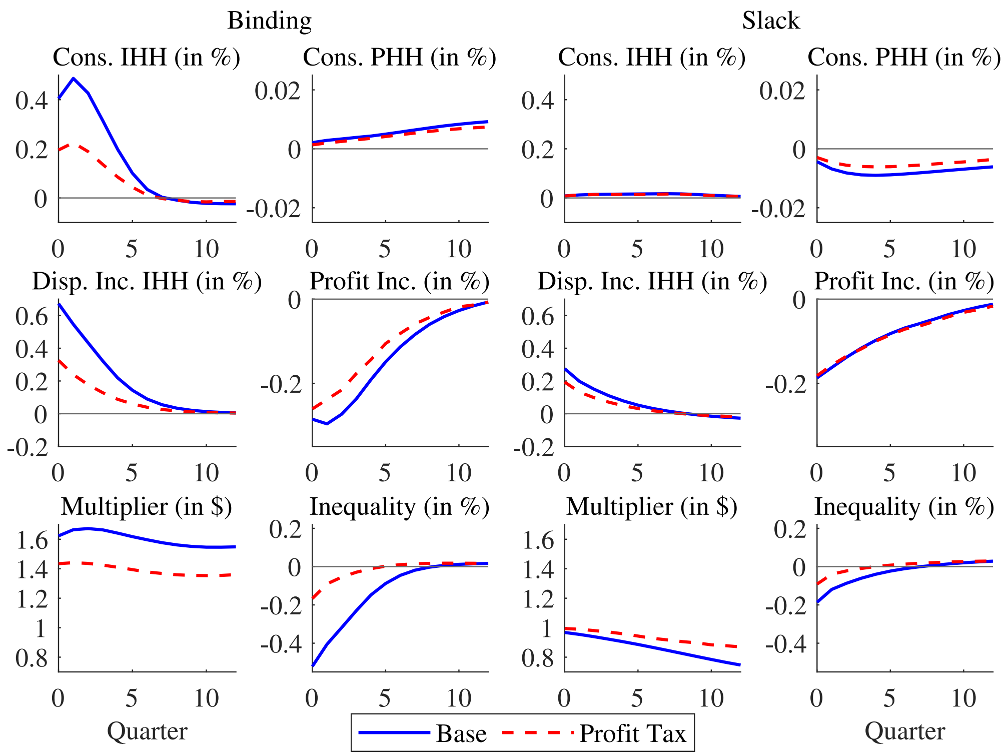

Fig. 4. Profit income tax. *Notes*: Median impulse response functions and cumulative output multipliers in the model-inherent states of binding vs. slack borrowing constraints. Blue solid lines show baseline, red dashed lines show the alternative case of redistributed profit taxes. IHH denotes the impatient household, PHH denotes the patient household. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

profit redistribution. In the regime of binding borrowing constraints, profit redistribution leads to a noticeable decline in the fiscal spending multiplier. The rationale is that under profit redistribution, the impatient household incurs part of the negative income effect of declining profits, inducing a smaller decline of income inequality than in our baseline scenario with no profit redistribution. In other words, the impatient household's disposable income increases less strongly, which dampens the push to aggregate demand stemming from a rise in consumption of constrained (high-MPC) households.

Fig. 5 shows how the results change when modifying how the government finances the spending stimulus. To analyze this, we change the tax rule (10) to

$$(\tau_t - \tau)/y = \rho_\tau \cdot (b^G_{t-1} - b^G)/y + \rho_{\tau g} \cdot (g_t - g)/y, \tag{13}$$

such that taxes may react directly to government spending via $\rho_{\tau g}$. Further, taxes of both types may differ according to

$$\tau_p = \tau_i + \rho_{\tau p} \cdot (\tau_t - \tau). \tag{14}$$

If $\rho_{\tau p} = 0$, taxation is uniform (as in our baseline). If $\rho_{\tau p} > 0$, the tax burden falls more heavily on patient (high-income, unconstrained) households. Therefore, we label this scenario as progressive taxation. If $\rho_{\tau p} < 0$, the tax burden falls more heavily on impatient (low-income, constrained) households, so that we label this case as regressive taxation. The blue solid lines in Fig. 5 show our baseline scenario following (10), i.e., uniform taxation where taxes do not directly depend on spending and a large part of spending is debt financed ($\rho_{\tau g} = 0$, $\rho_{\tau p} = 0$, and $\rho_\tau = 0.0075$). The red dashed lines show the case when an increase in g directly increases taxes ($\rho_{\tau g} = 0.5$) and the tax scheme is unchanged, i.e., we consider equal taxes for both types (ETF, $\rho_{\tau p} = 0$). The black dashed–dotted lines show the case with $\rho_{\tau g} = 0.5$ and progressive taxation (PTF, $\rho_{\tau p} = 0.8$) and the green dotted lines the case with $\rho_{\tau g} = 0.5$ and regressive taxation (RTF, $\rho_{\tau p} = -0.8$).

As can be seen in the left panels of Fig. 5, changes in the tax system can lead to noticeable changes in the effects of spending expansions in a regime of binding borrowing constraints. First, we compare our debt-financed baseline stimulus to more tax-financed spending increases, keeping in place our assumption of equal taxes (ETF). The uniform hike in taxes reduces disposable incomes of both household types. As a result, (impatient) high-MPC households raise their consumption by less than in the baseline. This dampens the multiplier effect of higher aggregate demand that leads to higher real wages and, thus, a rise in the disposable income of impatient households, leading, in turn, to increased consumption of impatient households and hence aggregate demand. Consequently, the relative increase of the disposable income of impatient households is less pronounced, or, in other words, inequality falls less firmly. As a result, the fiscal multiplier now takes a value of around 1.2, which is about 40 cents less than in our baseline scenario.

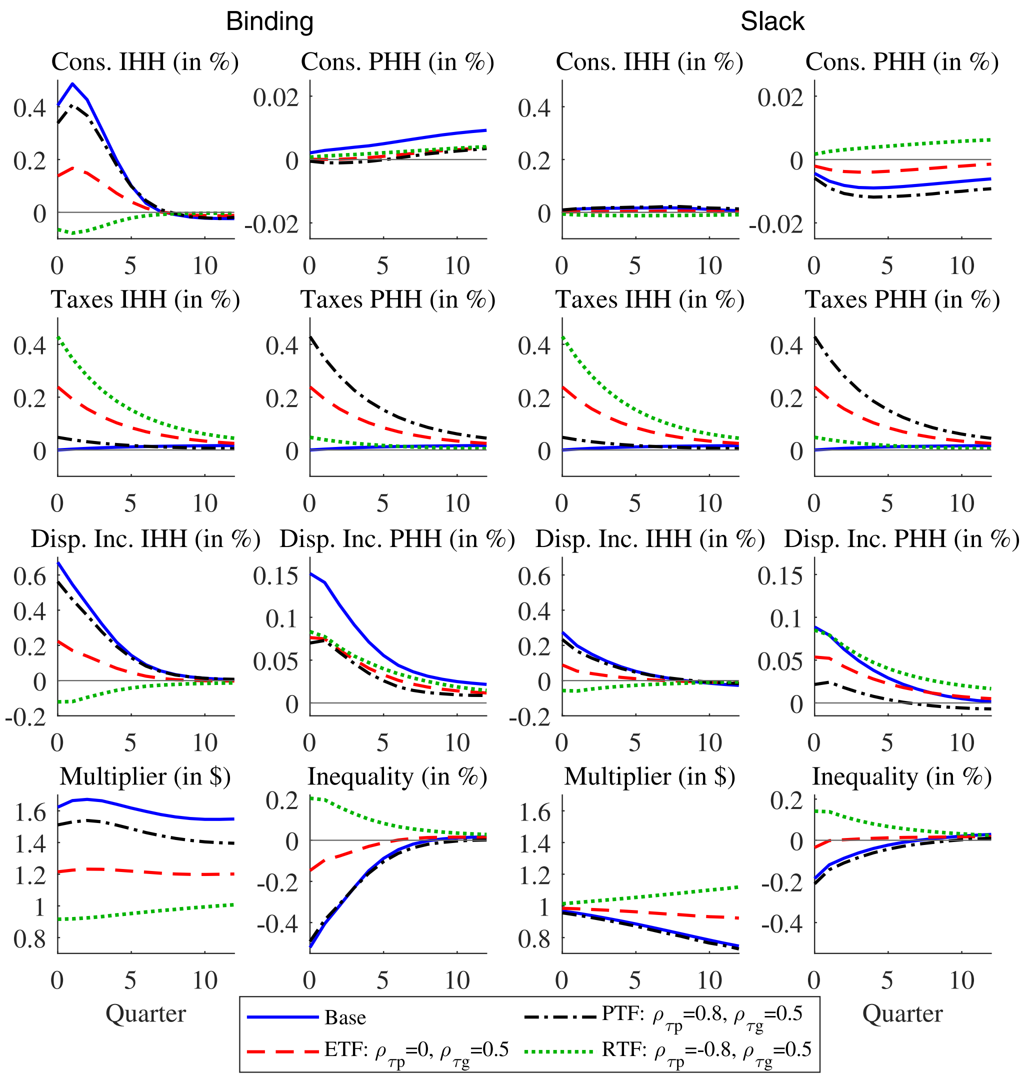

Fig. 5. Tax financing. *Notes*: Median impulse response functions and cumulative output multipliers in the model-inherent states of binding vs. slack borrowing constraints. Blue solid lines show our baseline (uniform taxation, debt-financed stimulus). The red dashed lines show higher tax financing with equal taxes for both types (ETF), black dashed–dotted lines higher tax financing with progressive taxation (PTF), and green dotted lines with regressive taxation (RTF). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fiscal spending multipliers are again large when we consider progressive taxation (PTF). The reason is that the most significant part of the additional tax burden now falls on patient households. Thus, the impatient household's disposable income is barely affected by the rise in taxes required to finance the fiscal spending stimulus. Consequently, the reduction in inequality is almost similar to the baseline, and so is the multiplier. Next, let us consider regressive taxation (RTF). Impatient households bear a more significant part of the tax burden, which reduces their disposable income, increases inequality, and leads to a decline in the fiscal spending multiplier to values below one, in line with Bilbiie (2020), who has shown that countercyclical (procyclical) inequality is associated with fiscal multipliers above (below) unity.[12]

In contrast, changes in the tax system have no discernible consequences for fiscal spending multipliers in periods of slack borrowing constraints; see the right panels of Fig. 5. Multipliers are around unity for all taxation schemes considered, even though the current disposable incomes of households vary considerably. The rationale is that now impatient households tend to behave Ricardian, too, rendering fluctuations in current disposable income less relevant for their spending decisions.

[12] Our results are also in line with Ferriere and Navarro (2020), who show that fiscal multipliers can be large when spending is financed with higher tax progressivity, i.e., when the tax burden falls more heavily on higher-income earners.

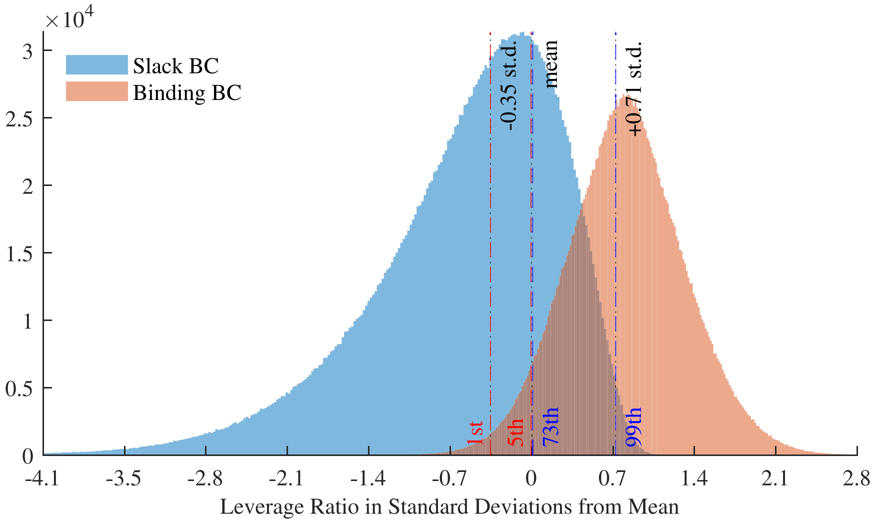

Fig. 6. State of borrowing constraint vs. leverage ratio. *Notes*: Distribution of the demeaned leverage ratio, expressed in standard deviations from mean, for all periods with slack borrowing constraint (blue) and for all periods with binding borrowing constraint (orange). Red dashed lines show 1st and 5th percentiles of the distribution of binding periods, while blue dashed lines show 73th and 99th percentiles of the distribution of slack periods. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3.4. 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 and ultimately significantly influences the size of the fiscal multiplier.

To see this, let us define the household leverage ratio (or loan-to-value ratio) as $LR_t = b_{i,t}/\left(p_{h,t+1}h_{i,t}\right)$. Consider, for the sake of argument, a simplified version of the borrowing constraint (5): $b_{i,t} \leq \phi p_{h,t+1}h_{i,t}$, 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 $LR_t^B = b_{i,t}/\left(p_{h,t+1}h_{i,t}\right) = \phi$. Let us compare this to the case of a slack borrowing constraint with $\omega_t = 0$ and $LR_t^S = b_{i,t}/\left(p_{h,t+1}h_{i,t}\right) < \phi$. 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 Fig. 6, 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 in 95% of all cases above average for periods in which the borrowing constraint is binding (the 5th percentile of distribution of binding states coincides with the mean of the leverage ratio). In periods of a slack constraint, the leverage ratio tends to be below its average (in 73% of all cases). As can be seen, there is only a small overlap of the two histograms. In fact, a Kolmogorov–Smirnov test shows that the two distributions are significantly different at the one percent significance level. The probability of being in a state of slack borrowing constraints is below 1%, if we consider an increase of the leverage ratio from its mean by 0.71 standard deviations (which is the 99th percentile of the distribution of slack states, see Fig. 6). Likewise, the probability of being in a state of binding borrowing constraints is below 1%, if we consider a decline of the leverage ratio from its mean by 0.35 standard deviations (which is the 1st percentile of the distribution of binding states, see Fig. 6). Thus, the mapping from slack to low leverage is already suitable for small negative deviations of the leverage ratio from its mean. However, one needs more significant positive deviations for a proper mapping from the binding regime to high-leverage states. This is why in our subsequent analysis – where we estimate our model on a large sample of artificial data generated through the model – we will observe that the estimate for the high-leverage multiplier tends to be smaller than what we found for the multiplier in the binding regime. In contrast, low-leverage multipliers will be close to the ones in the slack regime.

Fig. 7 illustrates how the impact output multiplier depends on the leverage ratio, expressed again in standard deviations from its mean. As can be seen, median multipliers increase in S-shape fashion in leverage. Median multipliers are at about 0.96 for below-average leverage ratios. If the leverage ratio increases, multipliers tend to grow but are still below or around unity for minor positive deviations from the mean. However, for larger deviations, median multipliers increase sharply. If the leverage ratio exceeds its mean by more than 0.4 standard deviations, the median impact multiplier starts taking on values markedly above unity.

Regarding confidence bands, we observe that for significant deviations from the mean, either negative or positive, bands become relatively narrow. For example, the confidence bands range from 0.96 to 0.99 if the leverage ratio is −2.3 standard deviations below its average and from 1.54 to 1.69 for an above-average level of the leverage ratio equal to 2.8 standard deviations. Starting from

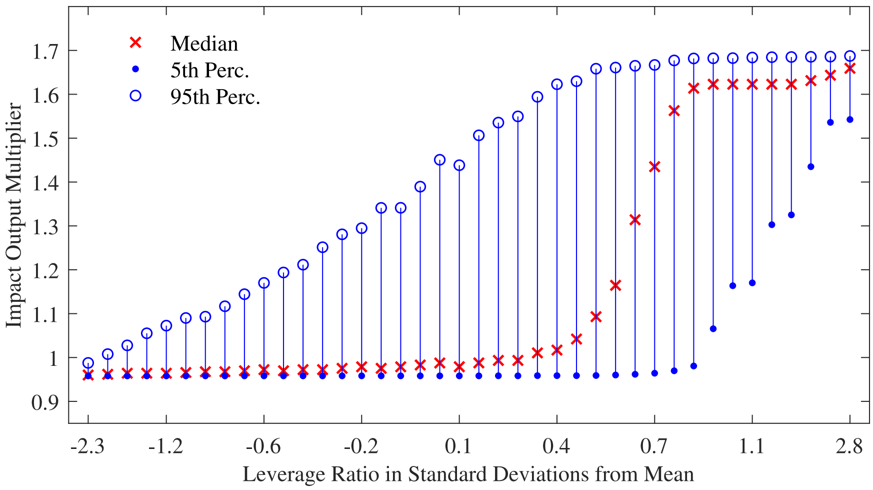

Fig. 7. Leverage ratio vs. impact multiplier. *Notes*: Impact output multipliers in dependence of leverage ratios in standard deviations from mean. Observations are sorted according to leverage ratio and collected in intervals each covering 1000 elements. Labels on x-ticks show upper bounds of these intervals. Crosses show medians, dots 5th, and circles 95th percentiles such that the lines connecting those depict 90% confidence bands.

the far left, an increase in the leverage ratio increases the upper bound while the lower bound remains unchanged. This reflects that the number of cases in which the borrowing constraint is binding increases in the leverage ratio. On the other hand, we observe that for significant above-average leverage ratios, the lower bound of the confidence band goes up, while the upper bound changes barely. This reflects the disappearance of cases in which high leverage coincides with a regime of slack borrowing constraints.

In sum, the model suggests that government spending multipliers significantly depend on the state of the household leverage cycle: they are high around the peaks of the household leverage cycle, whereas they are 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.

4.1. 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 of h quarters. In particular, we follow Ramey and Zubairy (2018) and estimate the following equation for each horizon h:

$$\begin{aligned}\sum_{j=0}^{h}\frac{Y_{t+j}-Y_{t-1}}{Y_{t-1}} =& I_{t-1}\left[\gamma_{H,h}+\phi_{H,h}(L)V_{t-1}+M_{H,h}\sum_{j=0}^{h}\frac{G_{t+j}-G_{t-1}}{Y_{t-1}}\right]\\ &+(1-I_{t-1})\left[\gamma_{L,h}+\phi_{L,h}(L)V_{t-1}+M_{L,h}\sum_{j=0}^{h}\frac{G_{t+j}-G_{t-1}}{Y_{t-1}}\right]\\ &+\rho_1 t+\rho_2 t^2+\omega_{t+h},\end{aligned} \tag{15}$$

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 household leverage cycle, 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

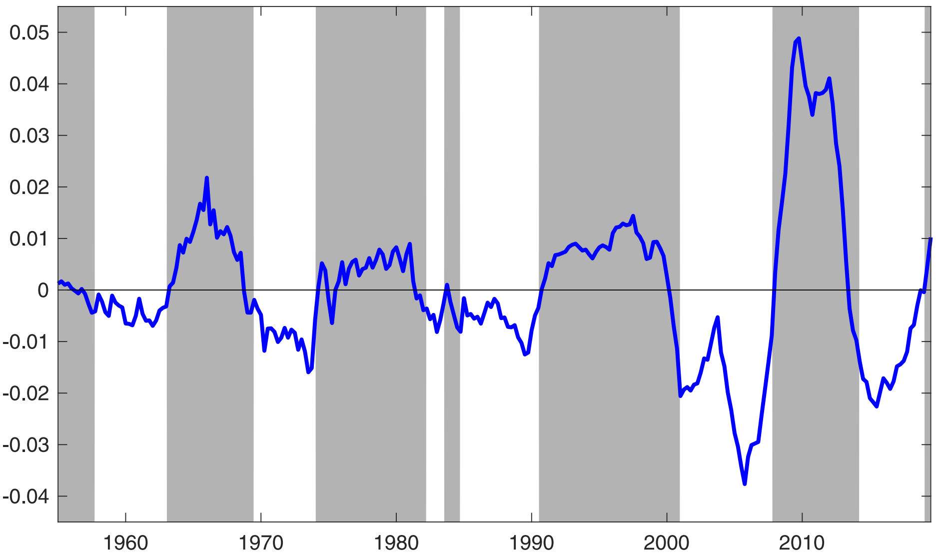

Fig. 8. Household leverage cycle. *Notes*: Detrended mortgages-to-real estate ratio (HP-filtered, $\lambda = 10,000$).

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.[13] The exogenous government-spending innovation $shock_t$ is then given by current government spending, which we express in real per-capita log levels. Importantly, our $shock_t$ measure provides a strong instrument for changes in government spending in both states of the household leverage cycle. For all horizons considered, the first-stage F-statistic is well above the critical value of 20, suggesting that weak instruments are unlikely to be a concern for our analysis.

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.[14] 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.

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.[15] 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 et al. (2012), the credit cycle is significantly longer and has a much greater amplitude than the standard business cycle. Therefore, Drehmann et al. (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.[16]

[13] Some canonical studies on the state-dependence of multipliers have used this identification assumption, e.g., Auerbach and Gorodnichenko (2012), Ilzetzki et al. (2013), and Bernardini and Peersman (2018).

[14] A detailed description of the data sources and definitions can be found in the Appendix A.2.

[15] Justiniano et al. (2015) and Dynan (2012) use the same indicator for household leverage to study the impact of household leveraging and deleveraging on personal consumption.

[16] 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.

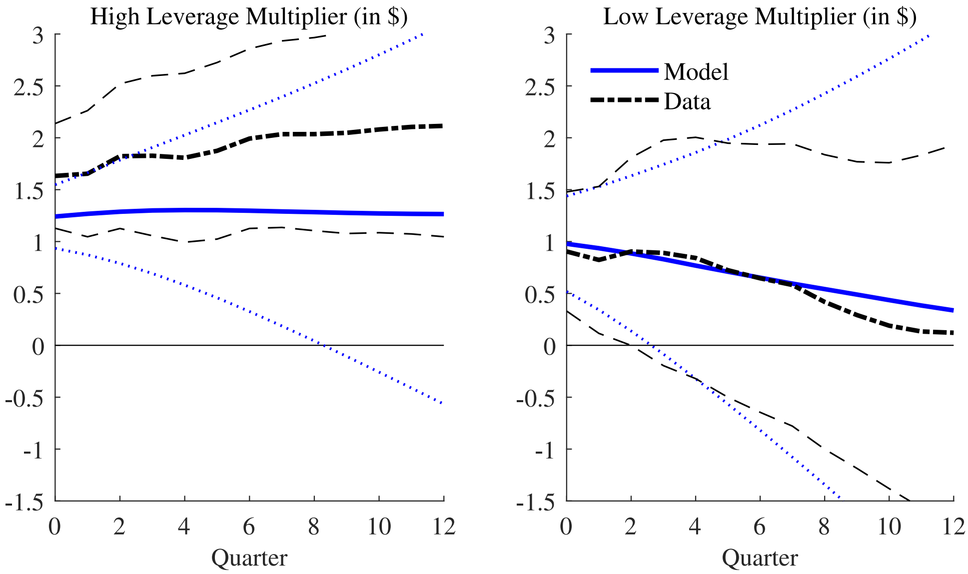

Fig. 9. Estimated cumulative output multipliers. *Notes*: Estimated cumulative output multipliers in high-leverage and low-leverage states. Blue solid lines show means of estimates based on a sample of artificial data generated through the model, and blue dotted lines show associated 90% confidence bands. Black dashed–dotted lines show means of estimates based on U.S. data, and black dashed lines show associated 90% confidence bands. The x-axis shows quarters after the government spending shock. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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.[17] 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. Fig. 8 shows the U.S household leverage cycle. Shaded areas indicate periods of high household leverage that are given by five distinct long-lasting episodes: 1955Q1–1957Q3, 1963Q2–1969Q2, 1974Q2–1982Q1, 1990Q4–2000Q4, 2008Q1–2014Q1.[18] Household leverage 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 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.

4.2. Estimation of simulated data

Before we estimate fiscal policy effects on U.S. data, we first estimate leverage-dependent spending multipliers on a sample of artificial data generated through our model, using the local projection approach described above.[19]

Fig. 9 presents the estimated cumulative government spending multipliers in high-leverage states (left panel) and low-leverage states (right panel). The mean of the estimated responses based on artificial data are shown by the blue solid line and the blue dotted lines show 90% confidence bands. We use the Newey and West (1987) correction to calculate standard errors to account for possible serial correlation in the error terms. Moreover, the standard errors are adjusted to take into account instrument uncertainty. Numbers on the horizontal axes denote quarters after the shock. The figure also shows estimates based on empirical U.S. data (black lines), which we further discuss below.

We observe that results differ substantially across states of the household leverage cycle. In high leverage states, the mean of the estimated cumulative multiplier based on artificial data is larger than one over the entire horizon, with mean estimates between 1.2 and 1.3. For example, the mean impact multiplier is $M_{H,0} = 1.24$, with a confidence band ranging from 0.93 to 1.55. Moreover, the output multiplier is estimated to be significantly different from zero for eight quarters after the shock.

By contrast, when household leverage is low, estimates of cumulative multipliers are, on average, below one for all periods under consideration. For example, the fiscal multiplier falls to about $M_{L,12} < 0.6$ at the end of the third year after the stimulus took effect. The mean impact multiplier is $M_{L,0} = 0.98$, with a confidence band ranging from 0.52 to 1.44. In low-leverage states, cumulative multipliers are significantly different from zero for only the first two quarters after the shock.

[17] Our empirical results are robust to using deviations from trend for three or two consecutive quarters to define both states.

[18] Guerrieri and Iacoviello (2017) detect a similar evolution of household leverage during the Great Recession episode.

[19] We simulate artificial data as summarized in Eq. (11) with $T = 5000$, $\tilde{t} = 100$, and $N = 1000$.

When we compare the model-implied multipliers across states of the leverage cycle to the results we documented for binding and non-binding borrowing constraints (see Fig. 1), we can observe that our estimates for the low-leverage state resemble our findings for slack regimes quite closely. On the other hand, our estimates for high-leverage states tend to be below the multipliers associated with binding borrowing constraints. This can be explained by the more significant "contamination" of high-leverage states with slack periods, documented in Fig. 6.

In the Appendix A.3, we provide further insights into the state-dependent fiscal transmission mechanism by showing how changes in selected deep model parameters and policy rules affect fiscal spending multipliers across the household leverage cycle; see Figure A.2 and its discussion.

4.3. Empirical results

The black lines in Fig. 9 present the estimated cumulative government spending multiplier in high-leverage states (left panel) and low-leverage states (right panel) based on empirical data. The black dashed–dotted lines show empirical mean responses and the dashed lines 90% confidence bands.

As can be seen in Fig. 9, 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 large and statistically significant for all periods of the forecast horizon during high household leverage periods. The point estimate is well above one in all periods, indicating a crowding-in of private demand. In contrast, in low-leverage states, the output multiplier is estimated to be significantly different from zero only for the first two quarters after the shock. The point estimate of the low-leverage multiplier is below one, indicating that there is no crowding-in of private economic activity. 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.[20]

While the multiplier in high-leverage states is estimated relatively precisely, estimation uncertainty is quite large when household leverage is low. Therefore, the implied difference between both multipliers is estimated to be borderline insignificant. For example, on impact, we can reject the null hypothesis of equal multipliers across both states only at the 11% confidence level. However, when relying on the broader one standard error confidence bands, the multipliers differ significantly at all horizons considered.

In the Appendix A.4, we show that our empirical results are robust to controlling for fiscal foresight, using alternative ways to define high and low household leverage states, dropping the Great Recession from the estimation sample, and using the shadow federal funds rate for constructing the real interest rate. Furthermore, we exploit cross-sectional variation at the U.S. state level to estimate private-leverage dependent effects of government spending, following Nakamura and Steinsson (2014). We show that the main finding of large high-leverage multipliers can also be observed when identification relies on regional variation in military buildups that are exogenous to regional economic conditions.

As can be seen in Fig. 9, 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. 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. The reason is, as discussed before, 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 Fig. 6, mainly to the high-leverage state. Almost all of the periods defined as low leverage turn out to be periods with slack borrowing constraints, while only about three quarters 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.

5. Conclusion

We have shown that a two-agent New Keynesian DSGE model with occasionally binding borrowing constraints can successfully replicate 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.

[20] Household leverage-dependent impulse responses are available upon request.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.euroecorev.2021.103989.

References

Andrés, J., Boscá, J.E., Ferri, J., 2015. Household debt and fiscal multipliers. Economica 82, 1048–1081.
Andrés, J., Boscá, J.E., Ferri, J., Fuentes-Albero, C., 2021. Households' balance sheets and the effect of fiscal policy. J. Money Credit Bank..
Auclert, A., Rognlie, M., Straub, L., 2018. The intertemporal keynesian cross. Stanford University, Northwestern University, Harvard University.
Auerbach, A.J., Gorodnichenko, Y., 2012. Measuring the output responses to fiscal policy. Am. Econ. J. Econ. Policy 4, 1–27.
Bajari, P., Chan, P., Krueger, D., Miller, D., 2013. A dynamic model of housing demand: estimation and policy implications. Internat. Econom. Rev. 54 (2), 409–442.
Barnichon, R., Debortoli, D., Matthes, C., 2021. Understanding the size of the government spending multiplier: It's in the sign. Rev. Econom. Stud..
Bernardini, M., Peersman, G., 2018. Private debt overhang and the government spending multiplier: Evidence for the United States. J. Appl. Econometrics 33 (4), 485–508.
Bernardini, M., Schryder, S.D., Peersman, G., 2020. Heterogeneous government spending multipliers in the era surrounding the great recession. Rev. Econ. Stat. 102 (2), 304–322.
Bilbiie, F.O., 2008. Limited asset markets participation, monetary policy and (inverted) aggregate demand logic. J. Econom. Theory 140 (1), 162–196.
Bilbiie, F.O., 2020. The new Keynesian cross. J. Monetary Econ. 114, 90–108.
Bilbiie, F.O., 2021. Monetary policy and heterogeneity: An analytical framework. University of Lausanne.
Bilbiie, F.O., Meier, A., Müller, G.J., 2008. What accounts for the changes in U.S. fiscal policy transmission? J. Money Credit Bank. 40 (7), 1439–1470.
BIS, 2010. Basel committee on banking supervision: Guidance for national authorities operating the countercyclical capital buffer. Bank for International Settlements.
Blanchard, O., Perotti, R., 2002. An empirical characterization of the dynamic effects of changes in government spending and taxes on output. Q. J. Econ. 117 (4), 1329–1368.
Borio, C., 2014. The financial cycle and macroeconomics: What have we learnt? J. Bank. Financ. 45, 182–198.
Broer, T., Krusell, P., Öberg, E., 2021. Fiscal multipliers: A heterogenous-agent perspective. Paris School of Economics, IIES, Uppsala University.
Caggiano, G., Castelnuovo, E., Colombo, V., Nodari, G., 2015. Estimating fiscal multipliers: News from a non-linear world. Econ. J. 125, 746–776.
Calvo, G.A., 1983. Staggered prices in a utility-maximizing framework. J. Monetary Econ. 12 (3), 383–398.
Cantore, C., Freund, L.B., 2021. Workers, capitalists, and the government: Fiscal policy and income (Re)distribution. J. Monetary Econ. 119, 58–74.
Canzoneri, M., Collard, F., Dellas, H., Diba, B., 2016. Fiscal multipliers in recessions. Econom. J. 126 (590), 75–108.
Cocco, J.F., 2005. Portfolio choice in the presence of housing. Rev. Financ. Stud. 18 (2), 535–567.
Corsetti, G., Meier, A., Müller, G.J., 2012. What determines government spending multipliers? Econ. Policy 27 (72), 521–565.
Demyanyk, Y., Loutskina, E., Murphy, D., 2019. Fiscal stimulus and consumer debt. Rev. Econ. Stat. 101, 728–741.
Drehmann, M., Borio, C., Tsatsaronis, K., Anchoring countercyclical capital buffers: the role of credit aggregates. BIS Working Papers. no. 355. Bank for International Settlements.
Drehmann, M., Borio, C., Tsatsaronis, K., Characterising the financial cycle: don't lose sight of the medium term!. BIS Working Papers no. 380. Bank for International Settlements.
Drehmann, M., Tsatsaronis, K., 2014. The credit-to-GDP gap and countercyclical capital buffers: questions and answers. BIS Quarterly Rev. March 2014, 55–73.
Druant, M., Fabiani, S., Kezdi, G., Lamo, A., Martins, F., Sabbatini, R., 2012. Firms' price and wage adjustment in Europe: Survey evidence on nominal stickiness. Labour Econ. 19 (5), 772–782.
Dynan, K., 2012. Is a household debt overhang holding back consumption. Brook. Pap. Econ. Act. 43 (1 (Spring), 299–362.
Eggertsson, G.B., Krugman, P., 2012. Debt, deleveraging, and the liquidity trap: A Fisher-Minsky-koo approach. Q. J. Econ. 127, 1469–1513.
Eijffinger, S.C.W., Grajales-Olarte, A., Uras, B.R., 2020. Heterogeneity in wage setting behavior in a new keyenesian model. Macroecon. Dyn. 24 (6), 1512–1546.
Ferriere, A., Navarro, G., 2020. The heterogeneous effects of government spending: It's all about taxes. Paris School of Economics.
Flavin, M., Nakagawa, S., 2008. A model of housing in the presence of adjustment costs: A structural interpretation of habit persistence. Amer. Econ. Rev. 98 (1), 474–495.
Galí, J., López-Salido, J.D., Vallés, J., 2007. Understanding the effects of government spending on consumption. J. Eur. Econom. Assoc. 5 (1), 227–270.
Guerrieri, L., Iacoviello, M., 2015. OccBin: A toolkit for solving dynamic models withoccasionally binding constraints easily. J. Monetary Econ. 70, 22–38.
Guerrieri, L., Iacoviello, M., 2017. Collateral constraints and macroeconomic asymmetries. J. Monetary Econ. 90, 28–49.
Hagedorn, M., Manovskii, I., Mitman, K., 2019. The Fiscal Multiplier. Working Paper Series. 25571. National Bureau of Economic Research.
Harding, J.P., Rosenthal, S.S., Sirmans, C., 2007. Depreciation of housing capital, maintenance, and house price inflation: Estimates from a repeat sales model. J. Urban Econ. 61 (2), 193–217.
Iacoviello, M., Pavan, M., 2013. Housing and debt over the life cycle and over the business cycle. J. Monetary Econ. 60 (2), 221–238.
Ilzetzki, E., Mendoza, E.G., Vegh, C.A., 2013. How big (small?) are fiscal multipliers? J. Monetary Econ. 60, 239–254.
Jones, C., Midrigan, V., Philippon, T., 2020. Household leverage and the recession. Federal Reserve Board, New York University.
Jordà, O., 2005. Estimation and inference of impulse responses by local projections. Amer. Econ. Rev. 95, 161–182.
Jordà, O., Schularick, M., Taylor, A.M., 2013. When credit bites back. J. Money Credit Bank. 45, 3–28.
Jordà, O., Schularick, M., Taylor, A.M., 2016. The great mortgaging: Housing finance, crises, and business cycles. Econ. Policy 131, 107–152.
Justiniano, A., Primiceri, G., Tambalotti, A., 2015. Household leveraging and deleveraging. Rev. Econ. Dyn. 18 (1), 3–20.
Klein, M., 2017. Austerity and private debt. J. Money Credit Bank. 49, 1555–1585.
Klein, M., Winkler, R., 2021. The government spending multiplier at the zero lower bound: International evidence from historical data. J. Appl. Econometrics 36 (6), 744–759.
McManus, R., Özkan, F.G., Trzeciakiewicz, D., 2021. Why are fiscal multipliers asymmetric? The role of credit constraints. Economica 88 (349), 32–69.
Mian, A.R., Rao, K., Sufi, A., 2013. Household balance sheets, consumption, and the economic slump. Q. J. Econ. 128, 1687–1726.
Mian, A.R., Sufi, A., 2011. House prices, home equity-based borrowing, and the US household leverage crisis. Amer. Econ. Rev. 101, 2132–2156.
Michaillat, P., 2014. A theory of countercyclical government multiplier. Am. Econ. J. Macroecon. 6 (1), 190–217.
Nakamura, E., Steinsson, J., 2014. Fiscal stimulus in a monetary union: Evidence from US regions. Amer. Econ. Rev. 104 (3), 753–792.
Newey, W.K., West, K.D., 1987. A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica 55 (3), 703–708.
Owyang, M.T., Ramey, V.A., Zubairy, S., 2013. Are government spending multipliers greater during periods of slack? evidence from twentieth-century historical data. Amer. Econ. Rev. 103, 129–134.
Perotti, R., 2008. In search of the transmission mechanism of fiscal policy. In: NBER Macroeconomics Annual 2007, Volume 22. In: NBER Chapters, National Bureau of Economic Research, Inc, pp. 169–226.
Ramey, V.A., Zubairy, S., 2018. Government spending multipliers in good times and in bad: Evidence from US historical data. J. Polit. Econ. 126, 850–901.
Sigurdsson, J., Sigurdardottir, R., 2016. Time-dependent or state-dependent wage-setting? Evidence from periods of macroeconomic instability. J. Monetary Econ. 78, 50–66.
Smith, L.B., Rosen, K.T., Fallis, G., 1988. Recent developments in economic models of housing markets. J. Econ. Lit. 26 (1), 29–64.
Tagkalakis, A., 2008. The effects of fiscal policy on consumption in recessions and expansions. J. Public Econ. 92 (5–6), 1486–1508.