The Rise in Inequality, the Decline in the Natural Interest Rate, and the Increase in Household Debt*

Ansgar Rannenberg
National Bank of Belgium

I investigate the effect of rising income inequality on the natural rate of interest in an economy with "rich" households who have "capitalist spirit" type preferences over their wealth, "non-rich" households, and housing and credit markets. Simulating the increase in U.S. income inequality over the 1981–2016 period generates a downward trend in the natural rate in line with recent empirical estimates. The model also broadly captures the upward trend in the debt-to-income ratio and loan-to-value ratio of the bottom 90 percent of households, as well as the upward trend in the value of the housing stock during this period.

JEL Codes: E25, E52, E43, D14.

1. Introduction

The objective of this paper is to examine to what extent rising income inequality can explain the downward trend in (estimates of) the natural rate of interest, i.e., the real interest rate consistent with a closed output gap and stable inflation, in the United States since the 1980s. Figure 1 (first panel) suggests that the decline in the

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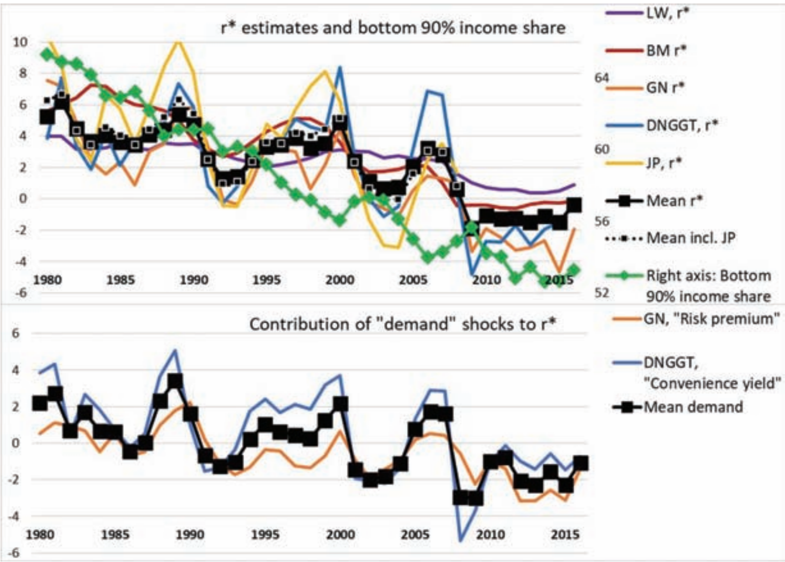
Figure 1. The Trend in Income Inequality and Estimates of the Natural Rate



Note: The r* values are annual averages of quarterly values. LW: Laubach and Williams (2016), updated estimates downloaded from the Federal Reserve Bank of New York webpage. BM: Brand and Mazelis (2019) modify the Laubach and Williams (2016) approach by, inter alia, closing the model with an interest feedback role and including the federal funds rate as an observable, using the unemployment rate to discipline the output gap estimate and the use of Bayesian estimation techniques. GN: Gerali and Neri (2019), DSGE model, r*: interest rate in the flexible-price economy, "Risk premium" shock: Increases the demand for government bonds at the expense of consumption and physical capital, first introduced by Smets and Wouters (2007). DNGGT: Del Negro et al. (2017), DSGE model, r*: interest rate in the flexible-price economy. "Convenience yield" shock: This shock has qualitatively the same impact on consumption and the demand for physical capital as the GN risk premium shock, but the estimation uses additional observables to identify the shock, and the estimated model differs in some respects from Gerali and Neri (2019). JP: Justiniano and Primiceri (2010), DSGE model, r*: interest rate in the flexible-price economy. The authors do not report a historical decomposition of r*. Mean r*: Unweighted average across all estimates except JP, as the latter is available only during 1980–2008. Bottom 90 percent income share: Share of the bottom 90 percent of households in net national income, World Inequality Database (WID); see Alvaredo et al. (2020).

natural rate has been large.[1] It also shows that the income share of the bottom 90 percent of U.S. households declined by about 12 percent from 1980 to 2016 (see Figure 1, first panel, the green diamond line; Alvaredo et al. 2020; and Piketty, Saez, and Zucman 2018). These two coinciding trends raise the possibility that the redistribution of income towards income-rich households might have increased the aggregate supply of savings and thus depressed the natural rate, as argued by Summers (2014) and Rachel and Smith (2017).

Another finding consistent with this conjecture is the major role of aggregate demand shocks in the downward trend of the estimates of Del Negro et al. (2017) and Gerali and Neri (2019) (see Figure 1, the bottom panel), which are based on estimated dynamic stochastic general equilibrium (DSGE) models.

I formalize the mechanism suggested by Summers (2014) and Rachel and Smith (2017) in a model with two distinct groups of households. One group represents the top 10 percent of the income distribution (referred to as "the rich"), and the other the remainder. Crucially, the rich derive utility from their wealth, i.e., they have "capitalist spirit type preferences" (CSP), a motive first suggested by Weber (1958), implying that they will increase their saving in response to a permanent income increase, in line with the evidence of Dynan, Skinner, and Zeldes (2004). In the model, income inequality may rise due to higher wage dispersion or an increase in the price markup of firms owned by rich households.

I first show that in an economy where the non-rich do not borrow, with CSP, the natural rate declines strongly in response to a decline in the bottom 90 percent income share. The non-rich lower their consumption by the amount of their income decline, while at the initial interest rate, the rich attempt to save part of the increase in their permanent income. Thus the interest rate needs to decline to equilibrate the government bond market. By contrast, without CSP, rich households do not attempt to save in response to the inequality increase and thus the interest rate remains unchanged.

[1] Moreover, Rachel and Summers (2019) argue that available estimates tend to mask an even more dramatic decline in the "private sector" natural rate of about 7 percent across advanced economies since the 1970s, which was partially offset by the expansionary effects of the simultaneous increase in government debt, as well as the obligations implied by the presence of pay-as-you-go pension systems and government-funded health care.

I then extend the model by allowing for homeownership, a credit market subject to frictions where the non-rich borrow from the rich via financial intermediaries using their home as collateral, and physical capital as an additional factor of production owned by the rich. In this setup, in the presence of CSP, an increase in inequality lowers the natural rate and also increases borrowing, as the non-rich use the decline in their cost of credit to postpone the decline in their consumption and housing demand. Furthermore, the lower interest rate increases the relative housing demand of both rich and non-rich households, thus increasing house prices. The increase in house prices becomes stronger if I assume that non-rich housing demand is subject to a "consumption cascade," meaning it depends positively on the total consumption of the rich, in line with the evidence of Bertrand and Morse (2016).

I then replicate the decline in the bottom 90 percent of wage earners' share in labor income and the decline in the labor share over the 1980–2016 period using the aforementioned wage dispersion and price markup shocks. The simulated increase in inequality generates a decline in the natural interest rate of between 3 and 4 percentage points, in line with what the aforementioned empirical estimates tend to attribute to "aggregate demand" type shocks. The simulation also broadly captures the upward trend in the debt-to-income ratio and loan-to-value ratio (LTV) of the bottom 90 percent of households observed over the 1983–2007 period. This scenario of an increase in bottom 90 percent indebtedness funded by saving on the part of the top 10 percent, which is in turn fueled by an increase in their income share, is consistent with the empirical findings of Mian, Straub, and Sufi (2020b) of a "saving glut of the rich." Furthermore, the simulation matches much of the rising trend in the value of the housing stock relative to gross domestic product (GDP) once non-rich housing demand is subject to a consumption cascade. Finally, the markup increase ensures that the simulation matches the empirically observed absence of a downward trend of measures in the real return on business capital noted by Caballero, Farhi, and Gourinchas (2017), Eggertsson, Robbins, and Wold (2018), and Farhi and Gourio (2018).

There is an evolving literature modeling a link between the increase in inequality and the decline in the natural rate, to which my analysis contributes as follows. I study a permanent increase in income inequality, while in the models used in most existing contributions, only transitory increases in inequality cause a decline in the natural rate. For instance, Eggertsson, Mehrotra, and Robbins (2019) show that an increase in inequality within the middle generation of a three-generation overlapping generations (OLG) model with credit constraints may reduce the natural rate.[2] Furthermore, in the heterogeneous agent models of Auclert and Rognlie (2018) and Rachel and Summers (2019), an increase in inequality driven by higher income uncertainty increases precautionary saving and thus lowers the interest rate. Contributions in this literature attribute between 0.8 and 1 percentage point of the decline in the natural rate to the increase in income inequality. However, Kopczuk, Saez, and Song (2010) and DeBacker et al. (2013) provide evidence that increases in permanent (not transitory) earnings variance drove the increase in inequality observed in recent decades in the United States. Furthermore, Kopczuk, Saez, and Song (2010) report that short- and long-term income mobility has been either stable or declining since the 1950s.

By contrast, Straub (2017) and Mian, Straub, and Sufi (2020a) consider permanent increases in income inequality. Straub (2017) analyzes a heterogeneous-agent 65-generation OLG model where all agents have non-homothetic preferences over bequests, which generates a positive relationship between permanent income and the saving rate. When replicating the increase in U.S. labor income inequality since the 1970s, he finds a 1 percentage point decline in the interest rate. However, his model abstracts from borrowing and assets other than physical capital. Perhaps for this reason, his model predicts an increase of the capital-output ratio of about 25 percentage points over the 1980–2016 period, while the ratio of the private non-residential capital stock as estimated by the Bureau of Economic Analysis (BEA) to GDP does not display such a trend. By contrast, my best-performing model version avoids this prediction. More recently, Mian, Straub, and Sufi (2020a) analyze the effect of

[2]Lancastre (2016) extends this approach by adding a bequest motive where agents care about the sum of the bequest and their children's middle-age income, and assumes that parents' and children's "middle-age" income is negatively correlated, which appears at odds with the evidence (Charles and Hurst 2003; Lee and Solon 2009; Bjoerklund and Jaentti 2011).

a permanent increase in inequality within a two-dynasty perpetual youth model with non-homothetic preferences over bequests, and find that it lowers the natural rate and increases the indebtedness of non-rich households. A key difference between my analysis and theirs is that their assumptions regarding the utility from wealth imply a downward-sloping long-run "saving supply curve," i.e., a negative steady-state relationship between the real interest rate and the wealth of the rich. Therefore, an increase in the supply of government bonds decreases the real interest rate, which is at odds with the empirical evidence of Gale and Orszag (2004), Engen and Hubbard (2005), Laubach (2009), and Krishnamurthy and Vissing-Jorgensen (2012). By contrast, in my model an increase in the supply of safe assets increases the real interest rate. Furthermore, Mian, Straub, and Sufi (2020a) do not focus on assessing the ability of the model to match long-run trends, and do not have a housing market.

A link between the increase in inequality and rising indebtedness of non-rich households has been argued by Rajan (2010) and modeled by Kumhof, Ranciere, and Winant (2015) in an endowment economy with CSP and credit to the non-rich as the *only* asset. My analysis goes beyond Kumhof, Ranciere, and Winant (2015)'s on various dimensions. Firstly, they do not analyze the effect of income inequality on the natural rate of interest.[3] Secondly, I find that Kumhof, Ranciere, and Winant (2015)'s prediction of an empirically relevant increase in non-rich debt is robust to allowing rich households to invest in assets *other than* non-rich debt. Finally, unlike their endowment economy, my model distinguishes between different sources of rising income inequality, namely wage dispersion and price markups.

Other contributions have investigated the influence of demographic shifts like the decline in population growth and the increase in life expectancy on the natural rate (e.g., Bielecki, Brzoza-Brzezina, and Kolasa 2018; Eggertsson, Mehrotra, and Robbins 2019; and Papetti 2019; and Brand, Bielecki, and Penalver 2018 for a survey). However, Mian, Straub, and Sufi (2021) cast doubt on the aspect of the demography hypothesis, emphasizing the role of

[3]Their model has no safe interest rate, and the risky interest rate paid by borrowers does not display a trend when they simulate the empirical inequality increase over the 1983–2008 period.

saving by the baby-boom generation entering working age by showing that saving rates vary little across the age distribution (while varying substantially across the income distribution). Furthermore, they document that the increase in life expectancy was associated with declining saving rates in the bottom 90 percent of the income distribution.

Zou (1994, 1995) shows that a long line of economists—including but not limited to John M. Keynes, Max Weber, Joseph Schumpeter, Karl Marx, and Adam Smith—have argued that entrepreneurs' wealth accumulation is driven by CSP. To my knowledge, the first formal macroeconomic application of CSP occurs in the context of growth models, in order to shed light on the large differences in growth rates across countries and the lack of convergence in per capita income levels. Following a technical note by Kurz (1968), Zou (1994) investigates the effect of CSP on growth in a deterministic context, while Bakshi and Chen (1996) and Smith (1999) consider stochastic environments. Cole, Mailath, and Postlewaite (1992) develop a microfoundation of CSP in an "AK" type model with status-dependent mating. Furthermore, a concept related to CSP, so-called preferences over safe assets, has been shown recently to considerably alleviate the so-called forward-guidance puzzle, i.e., the finding that in DSGE models, the effect of forward guidance is implausibly strong (e.g., Michaillat and Saez 2018; Rannenberg 2019, 2021).

Moreover, CSP has been shown to address certain counterfactual predictions of optimizing models at the micro level. Firstly, in a life-cycle context, CSP avoids the prediction that following retirement, old people decumulate assets and that their saving rates are lower (see Zou 1995 and Carroll 2000),[4] and allows to match the large wealth-to-income ratio (see Carroll 2000, Reiter 2004, and Francis 2008) and larger saving rates (Dynan, Skinner, and Zeldes 2004) of income-rich households. Secondly, models with CSP can match the empirically estimated higher marginal propensity to save out of permanent income of rich households (see Dynan, Skinner, and Zeldes 2004; Kumhof, Ranciere, and Winant 2015). Thirdly, Gechert and

[4]Relatedly, Zou (1995) and Carroll (2000) argue that a pure bequest motive (as opposed to utility from wealth at all ages) is not supported by the evidence because the childless old do not seem to dis-save faster than those with children.

Siebert (2022) provide evidence for utility from wealth in a multi-period experiment where half of the participants choose to maintain a stock of wealth even though spending all cash on hand immediately would maximize the participants' final payout.

Finally, my modeling approach forms part of a literature analyzing the macroeconomic consequences of household heterogeneity by dividing households into distinct groups which differ regarding important characteristics—for instance, their consumption smoothing opportunities, asset holdings, or impatience (see Iacoviello 2005; Gali, Lopez-Salido, and Valles 2007; Bilbiie 2008, 2020; Debortoli and Gali 2017; Sterk and Ravn 2017; and Broer et al. 2020).

The remainder of the paper is structured as follows. Section 2 develops and analyzes a stylized model. Section 3 develops the model with household borrowing and a housing market, which I refer to as the "full model." Section 4 discusses the effects of an increase in inequality in the full model, and the simulation of the empirically observed increase in inequality.

2. A Simple Model

The model features two distinct household groups, namely a mass of n_S rich and a mass of n_{CC} non-rich households, as well as monopolistically competitive firms owned by rich households and employing rich and non-rich household labor. The model thus precludes the possibility that the observed increase in income inequality might be the consequence of individual households' greater income mobility between different income groups. However, Kopczuk, Saez, and Song (2010) and DeBacker et al. (2013) provide evidence that increases in permanent (not transitory) earnings variance drove the increase in inequality observed in recent decades. Furthermore, Kopczuk, Saez, and Song (2010) report that short- and long-term income mobility has been either stable or declining since the 1950s. Throughout, $\tilde{X}_S$ (or $\tilde{x}_S$) denotes a rich household choice variable expressed in per capita terms, while the corresponding economy-wide variable is denoted as X_S (or x_S), and is computed as $X_S = \tilde{X}_S n_S$, *unless otherwise mentioned* (and analogously for non-rich households).

2.1 Households

Throughout, I index rich households with the subscript S. Rich households derive utility from (per capita) consumption $\tilde{C}_{S,t}$, and their stocks of safe real financial assets $\tilde{b}_{S,t}$ (consisting of government bonds). Their objective function is thus given by

$$E_t \left\{ \sum_{i=0}^{\infty} \beta_S^i \left[\frac{\tilde{C}_{S,t+i}^{1-\sigma_S}}{1-\sigma_S} + \frac{\tilde{\phi}_b}{1-\sigma_b} \left(\tilde{b}_{S,t+i} \right)^{1-\sigma_b} \right] \right\},$$

where β_S denotes their utility discount factor, and $\tilde{\phi}_b$, σ_S, and σ_b are non-negative constants. A rich household's budget constraint is given by

$$\tilde{b}_{S,t} = \frac{R_{t-1}}{\Pi_t} \tilde{b}_{S,t-1} + w_{S,t} \tilde{N}_{S,t} + \tilde{\Xi}_t - \tilde{T}_{S,t} - \tilde{C}_{S,t},$$

where R_t, $w_{S,t}$, $\tilde{\Xi}_t$, $\tilde{T}_{S,t}$, and Π_t denote the nominal interest rate on safe assets, the real wage, the real profits of intermediate goods firms, real lump-sum taxes, and the inflation rate, respectively. The assumption that only the rich own firms and government bonds is motivated by the extreme concentration of stocks, business ownership, and bonds (e.g., Kuhn and Rios-Rull 2016). From now on, I will refer to the model where the rich derive utility from their wealth (i.e., $\phi_b > 0$) on top of consumption as the model with "capitalist spirit" type preferences (CSP), while I refer to the $\tilde{\phi}_b = 0$ case as NOCSP. The first-order conditions (FOCs) with respect to consumption and government bonds are given by

$$\Lambda_{S,t} = \frac{1}{C_{S,t}^{\sigma_S}} \tag{1}$$

$$\Lambda_{S,t} = \beta_S E_t \left\{ \Lambda_{S,t+1} \frac{R_t}{\Pi_{t+1}} \right\} + \phi_b \left(b_{S,t} \right)^{-\sigma_b}, \tag{2}$$

where per capita variables have been eliminated using $\tilde{X}_S = \frac{X_S}{n_S}$, $\Lambda_{S,t} \equiv \frac{\tilde{\Lambda}_{S,t}}{n_S^{\sigma_S}}$ denotes the (scaled) marginal utility of consumption, and $\phi_b \equiv \frac{\tilde{\phi}_b n_S^{\sigma_b}}{n_S^{\sigma_S}}$.[5] If $\phi_b > 0$, $\phi_b \left(b_{S,t}\right)^{-\sigma_b}$ represents an extra marginal benefit from saving over and above the utility associated with the future consumption opportunity saving entails (represented by $\beta_S E_t \left\{\Lambda_{S,t+1} \frac{R_t}{\Pi_{t+1}}\right\}$). CSP weakens the effect of an increase in permanent income and thus a decline in $\Lambda_{S,t+1}$ on $\Lambda_{S,t}$, since the two become less than proportional. To gain some intuition, compare the bond market equilibrium in the CSP and NOCSP case, assuming that the economy is initially in the steady state in both period t and $t+1$. The presence of the extra benefit $\phi_b \left(b_{S,t}\right)^{-\sigma_b}$ with CSP implies that, for the bond market to clear, the present value $\beta_S \frac{R_t}{\Pi_{t+1}}$ which the household attaches to $\Lambda_{S,t+1}$—the net effect of the reward of waiting and the household's impatience—has to be smaller than in the NOCSP case, thus reducing the importance it attaches to a decline in $\Lambda_{S,t+1}$. Furthermore, this weakening of intertemporal consumption smoothing compounds the more distant in time the anticipated future consumption increase is located, as $\Lambda_{S,t+1}$ is no longer proportional to $\Lambda_{S,t+2}$ either, and so on and so forth. As a result, with CSP a 1 percent permanent increase in saver household income will ceteris paribus not cause a 1 percent increase in consumption, but instead an increase in both saving and consumption. The marginal propensity to save out of a permanent income increase will be larger the smaller the curvature parameter σ_b. Relatedly, the above implies that for $\phi_b > 0$,

$$R_t < \frac{1}{E_t \left\{\frac{\beta \Lambda_{S,t+1}}{\Lambda_{S,t} \Pi_{t+1}}\right\}} \equiv DIS_t, \tag{3}$$

i.e., the nominal interest rate may be smaller than the discount rate which the household applies to future income streams DIS_t.

[5]The FOCs with regard to per capita consumption and bonds are given by $\tilde{\Lambda}_{S,t} = \frac{1}{\left(\tilde{C}_{S,t}\right)^{\sigma_S}}$ and $\tilde{\Lambda}_{S,t} = \beta_S E_t \left\{\tilde{\Lambda}_{S,t+1} \frac{R_t}{\Pi_{t+1}}\right\} + \tilde{\phi}_b \left(\tilde{b}_{S,t}\right)^{-\sigma_b}$, respectively. Substituting $\tilde{C}_{S,t} = \frac{C_{S,t}}{n_S}$ and $\tilde{b}_{S,t} = \frac{b_{S,t}}{n_S}$, and defining $\Lambda_{S,t} \equiv \frac{\tilde{\Lambda}_{S,t}}{n_S^{\sigma_S}}$ and $\phi_b \equiv \frac{\tilde{\phi}_b n_S^{\sigma_b}}{n_S^{\sigma_S}}$ yields Equations (1) and (2).

I assume that non-rich households, denoted as CC, simply consume their disposable income. Their behavior is thus described by

$$C_{CC,t} = w_{CC,t} N_{CC,t} - T_{CC,t}. \tag{4}$$

Households are endowed with a fixed amount of hours $\tilde{N}_S$ and $\tilde{N}_{CC}$ which they supply to firms, implying that

$$N_{CC,t} = n_{CC} \tilde{N}_{CC} \tag{5}$$

$$N_{S,t} = n_S \tilde{N}_S. \tag{6}$$

2.2 Firms

A continuum of perfectly competitive final goods firms produces final consumption and investment goods by aggregating a continuum of differentiated intermediate goods using a constant elasticity of substitution (CES) technology. The differentiated goods are supplied by monopolistically competitive intermediate goods firms. Intermediate goods firm j combines the labor supplied by the two household types using a Cobb-Douglas technology:

$$Y_t(j) = \left(\frac{N(j)_{S,t}}{\eta_S} \right)^{(1-\omega_{CC}-d_{CC,t})} \left(\frac{N(j)_{CC,t}}{\eta_{CC}} \right)^{(\omega_{CC}+d_{CC,t})}, \tag{7}$$

where $d_{CC,t}$ represents a shock to the production elasticity of rich and non-rich households which I will employ to increases in labor income inequality, and $\eta_S, \eta_{CC} > 0$ denote normalizing constants.[6] A negative value of $d_{CC,t}$ lowers the demand for non-rich household labor and thus their real wage, while increasing the demand for rich household labor. The shock can be viewed as a proxy for skill-biased technological change and the "race between education and technology" (Goldin and Katz 2007). Note that under my assumption of

[6] In particular, I assume $\eta_S = N_S$ and $\eta_{CC} = N_{CC}$. Hence since $N_{S,t} = N_S$ and $N_{CC,t} = N_{CC}$ (see Equations (6) and (5)), the employment levels cancel out in the aggregate. This assumption ensures that even for $N_S \neq N_{CC}$, $d_{CC,t}$ does not affect N_t output. It follows Straub (2017), who considers exactly the same type of shock (see his Appendix E, p. 68, first equation).

flexible prices (and thus an exogenous price markup) the shock will not change the overall labor income share. The firm's first-order conditions are given by

$$w_{S,t} = mc_t \left(1 - \omega_{CC} - d_{CC,t}\right) \frac{Y_t}{N_{S,t}} \tag{8}$$

$$w_{CC,t} = mc_t \left(\omega_{CC} + d_{CC,t}\right) \frac{Y_t}{N_{CC,t}} \tag{9}$$

$$\frac{1}{\mu_P + d_{\mu,t}} = mc_t, \tag{10}$$

where μ_P denotes the steady-state markup of prices over marginal costs and $d_{\mu,t}$ a shock to the markup, which I will use to generate increases in inequality which are accompanied by a decline in the labor share.

2.3 Government

There is a government consuming G_t units of output. It levies lump-sum taxes on households in order to keep the government debt-to-GDP ratio and the GDP share of government expenditure constant at $Target_{bgov2GDP}$ and $Target_{G2GDP}$, respectively. For simplicity, I assume that fiscal policy keeps total lump-sum taxes of non-rich households constant. The central bank successfully pursues a perfect inflation target, implying that the actual real interest rate equals the natural rate. Hence policy is described by

$$b_{gov,t} = \frac{R_{t-1}}{\Pi_t} b_{gov,t-1} + G_t - T_{S,t} - T_{CC,t} \tag{11}$$

$$Target_{bgov2GDP} = \frac{b_{gov,t}}{4Y_t} \tag{12}$$

$$Target_{G2GDP} = \frac{G_t}{Y_t} \tag{13}$$

$$T_{CC,t} = T_{CC} \tag{14}$$

$$\Pi_t = \Pi. \tag{15}$$

2.4 Equilibrium

Equilibrium in goods, capital, and labor markets implies

$$Y_t = C_{S,t} + C_{CC,t} + G_t \tag{16}$$

$$b_{S,t} = b_{gov,t}. \tag{17}$$

The only exogenous variables are the shocks to the production elasticity of households $d_{CC,t}$ and the price markup $d_{\mu,t}$.

2.5 Calibration

One time period in the model corresponds to one quarter. I assume a labor endowment $\tilde{N}_{CC} = \tilde{N}_S = \frac{1}{3}$ of $\frac{1}{3}$, as well as $\eta_S = N_S$ and $\eta_{CC} = N_{CC}$. I assume a price markup μ_p of 1.05 (see Table 1). I calibrate the remaining parameters such that the steady-state values of the model match the empirical targets reported in Table 2. In the model without CSP (i.e., where $\phi_b = 0$), there are in total five parameters calibrated in this fashion, marked with an asterisk (*), namely the rich consumption utility curvature σ_S, the rich household discount factor β_S, the non-rich share in labor income ω_{CC}, and the government expenditure and debt targets $Target_{bgov2GDP}$ and $Target_{G2GDP}$. The empirical targets are the intertemporal elasticity of substitution, which I set in line with the mean estimate reported in the meta-analysis of Havranek (2015), the real ex post federal funds rate, the GDP share of government expenditure, the government debt-to-GDP ratio, and the income share of the bottom 90 percent of households, which I assume to be the real-world counterparts of the non-rich in the model. I compute all targets as averages over the 1973–80 period, as the historical simulation of Section 4.2 starts in 1981 (the bottom 90 percent income share is essentially constant during 1973–80), with the exception of the government debt-to-GDP ratio and the government expenditure share. These targets I compute as averages over the 1981–2016 period since I hold these variables constant throughout the paper. Finally, I set the share of the non-rich in the total tax burden equal to their pre-tax income share.

In the model with CSP, I calibrate the two CSP-related parameters (ϕ_b, σ_b) by using two additional empirical targets. The first target is an estimate of the "discounting wedge" θ_t, defined as $\theta_t \equiv \frac{R_t}{DIS_t}$, where DIS_t denotes the nominal individual discount

Table 1. Parameters: Simple Model

Parameter	Parameter Name	Value NOCSP ($\theta = 1$)	Value CSP ($\theta = 0.97$)
β_S	Rich Household Utility Discount Factor	0.9951*	0.9652*
σ_S	Rich Utility Curvature Consumption	2*	2*
$\tilde{N}_{CC}$, $\tilde{N}_S$	Labor Endowments	$\frac{1}{3}$	$\frac{1}{3}$
ω_{CC}	Non-rich Share in Total Labor Income	0.7*	0.7*
μ_P	Price Markup	1.05	1.05
$Target_{bgov2GDP}$	Gov. Debt-to-GDP Ratio	0.44*	0.44*
$Target_{G2GDP}$	Government Expenditure-to-GDP Ratio	0.2*	0.2*
$\frac{T_{CC}}{T_{CC}+T_S}$	Share of the Non-rich in the Total Tax Burden	67%	67%
σ_b	Rich Utility Curvature of Real Financial Assets	—	0.40*
ϕ_b	Rich Utility Weight on Real Financial Assets	0	0.51*

rate which the household applies to future nominal income streams (defined by Equation (3)), with $\theta = \beta_S \frac{R}{\Pi}$. Note that $\theta < 1$ implies a smaller value of β_S than in the NOCSP case (which corresponds to $\theta = 1$), given the unchanged target for the real interest rate. Conditional on an assumption for σ_b, the steady-state relationship implied by the Euler equation (23) allows to back out ϕ_b as

$$\phi_b = (1-\theta)\,\Lambda_S\,(b_S)^{-\sigma_b}\,. \tag{18}$$

I set $\theta = 0.97$, close to the choice of Rannenberg (2019), who obtains evidence on θ by drawing on 34 empirical estimates of the (time-varying) nominal individual discount rate which the household applies to future nominal income streams, $DIS_t = \frac{1}{E_t\left\{\frac{\beta\Lambda_{t+1}}{\Lambda_t\Pi_{t+1}}\right\}}$ (all based on choices resulting in real, rather than hypothetical, money flows).[7] Given estimates of DIS_t, Rannenberg (2019) exploits the fact that for sufficiently small weights on safe assets in the utility function (i.e., θ smaller than but close to one), $\theta_t = \frac{R_t}{DIS_t}$ is approximately constant across time in the model. This property is

[7] See his Table 2, p. 16, and the associated discussion.

Table 2. Targets: Simple Model

Target	Value NOCSP	Value CSP	Source
IES $\frac{1}{\sigma_S}$	0.5	0.5	Havranek (2015)
Real Short-Term Interest Rate $\left(\frac{R}{\Pi}\right)^4 - 1$	2%	2%	Federal Funds Rate Minus Core PCE Inflation, APR, FRED
$\frac{G}{Y}$	20%	20%	Government Expenditure GDP Share, BEA
$\frac{b_{gov,S,}}{4Y}$	44%	44%	Federal Debt Held by the Public, Percentage of GDP, FRED
Non-rich National Income Share NIS_{CC} (see note)	66%	66%	Bottom 90% Net National Income Share, Pre-tax, WID
MPS Top 5%	0	51%	Target CSP Case: Dynan, Skinner, and Zeldes (2004)
Discounting Wedge θ	1.0	0.97	Target CSP Case: Literature Discount Rates; See Discussion in the Text

Note: FRED = Federal Reserve Economic Data (Federal Reserve Bank of St. Louis). BEA = Bureau of Economic Analysis. IES = intertemporal elasticity of substitution. WID = World Inequality Database; see Alvaredo et al. (2020) and Piketty, Saez, and Zucman (2018) for the U.S. data used here for details. The non-rich national income share NIS_{CC} corresponds to the concept used in the WID. In particular, when computing the pre-tax income of an adult, the WID allocates the property income of the government $-b_{gov}\left(\frac{R}{\Pi} - 1\right)$ across adults according to the percentile's pre-tax factor income share, which in my model equals the national income share (due to the absence of pensions and transfers). The allocation of the government's property income to individuals is necessary in order to ensure that, across adults, pre-tax income adds up to national income. Hence the national income share of the non-rich households is given by $NIS_{CC} \equiv \frac{w_{CC}N_{CC} - b_{gov}\left(\frac{R}{\Pi}-1\right)NIS_{CC}}{Y}$. Solving for NIS_{CC} yields the expression in the table. $NIS_{CC} = \frac{w_{CC}N_{CC}}{Y\left(1+\frac{b_{gov}}{Y}\right)}$. The targets for $\frac{G}{Y}$ and $\frac{b_{gov}}{4Y}$ are calculated as averages over the 1981–2016 period. All other ratios for which annual data were available were calculated as averages over the 1973–80 period.

a consequence of intertemporal substitution by the household: An increase in R_t shifts consumption from t to $t+1$, thus reducing the marginal utility of future consumption and increasing DIS_t. Hence $\theta \approx \frac{R_t}{DIS_t}$, which given the assumed steady-state value of the real interest rate $\frac{R}{\Pi}$ then allows to pin down β. Among those studies used in Rannenberg (2019), the contributions of Pleeter and Warner (2001), Harrison, Lau, and Williams (2002), and Harrison et al. (2005) are of particular relevance in my context. Harrison, Lau, and Williams (2002) and Harrison et al. (2005) report estimates for (income-) rich households, while Pleeter and Warner (2001) elicit the discount rate of officers of the U.S. armed forces choosing between two severance packages during the 1992–95 military drawdown.[8] The values of θ obtained from these studies are between 0.95 and 0.97.

Finally, following Kumhof, Ranciere, and Winant (2015), the second target that I use to calibrate the CSP is an estimate of the rich households' marginal propensity to save (MPS) out of an increase in their permanent income. Here I draw on the evidence computed by Kumhof, Ranciere, and Winant (2015) based on the saving rate regressions of Dynan, Skinner, and Zeldes (2004) for households in the top 5 percent of the income distribution. Following Kumhof, Ranciere, and Winant (2015), I compute the rich household MPS in the model from microsimulation of a permanent income increase, described in Appendix A.

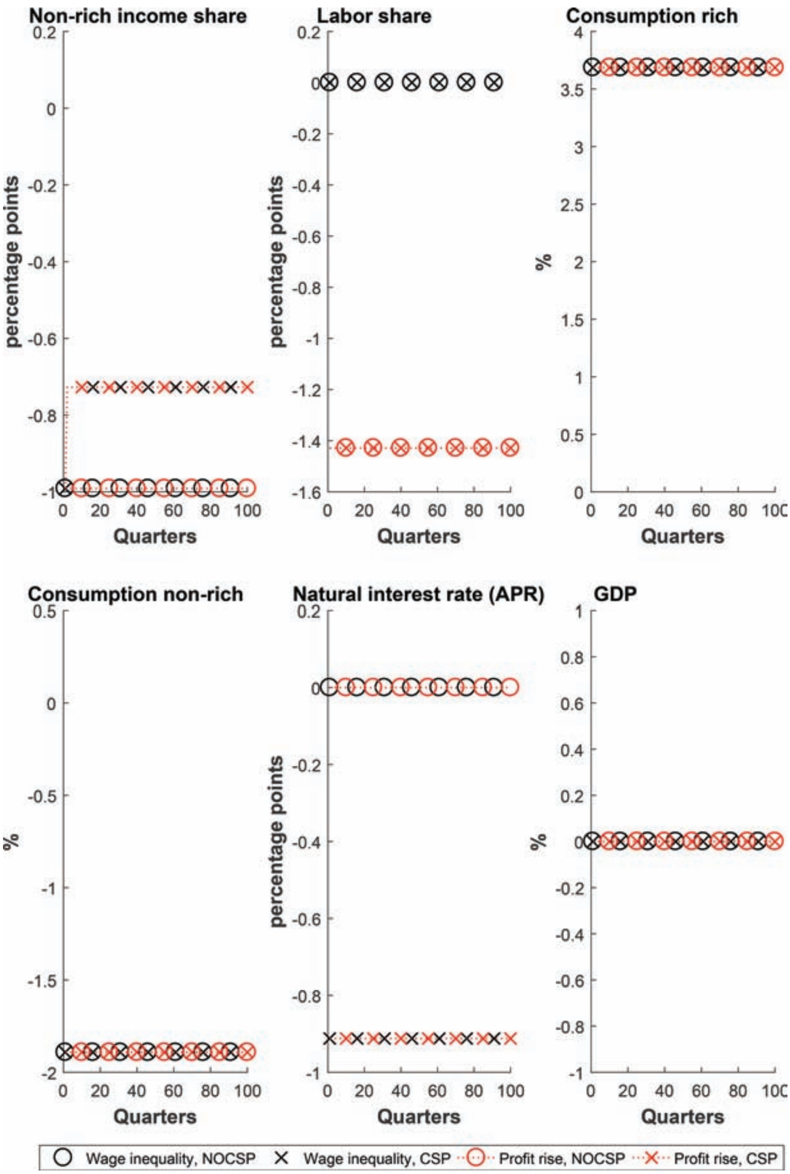
2.6 An Increase in Inequality in the Simple Model

All simulations in this paper are performed using the Newton-type solver for deterministic non-linear simulations as implemented in Dynare 4.6.3. (see Juillard 1996 and Adjemian et al. 2011).[9] Figure 2 displays separately the effect of a permanent increase in the markup (red lines) and the labor income share of rich households (black lines). Both shocks are calibrated such that the share of non-rich households in total household income declines by 1 percentage point on impact. Both inequality shocks also have effects of identical magnitudes on the consumption of rich households (which increases) and non-rich households (which decreases), while the labor share is affected only by the markup shock. Furthermore, CSP do not change the effect of the increase in inequality on any of the variables except for the interest rate and the non-rich income share. The interest rate declines by almost 1 percentage point. Hence, with CSP, the increase in rich households' permanent income does not in itself trigger an equal increase in rich household consumption. Since rich household wealth $b_{s,t}$ is constant as a result of the government's fiscal policy

[8] The authors report that virtually all of the officers in their sample have a college degree, while according to the Current Population Survey the same was true for only 24.5 percent of individuals in the same age group.

[9] This solver treats the deterministic simulation as a system of simultaneous equations in n endogenous variables in T periods.

Figure 2. Impact of a Permanent Increase in Inequality—Simple Model



(see Equation (12)), for bond and goods markets to clear, the interest rate has to decline (see Equation (2)). The interest rate decline partially compensates for the increase in the labor or profit income of the rich, implying that the non-rich income share recovers by about 0.2 percentage point in the second quarter.

3. The Full Model

In the full model rich households invest in financial intermediary deposits, physical capital, and housing (on top of government bonds) and derive utility from these assets. Non-rich households derive utility from consumption and housing and borrow from financial intermediaries. Throughout, $\tilde{X}_S$ (or $\tilde{x}_S$) denotes a rich household choice variable expressed in per capita terms, while $X_S \equiv \tilde{X}_S n_S$ denotes the corresponding economy-wide variable (and analogously for non-rich households).

3.1 Rich Households

Rich households derive utility from consumption $\tilde{C}_{S,t}$; their stocks of safe real financial assets $\tilde{b}_{S,t}$; the value of their physical capital $Q_t\tilde{K}_t$, where Q_t denotes the price of capital goods; and their housing stock $\tilde{H}_{S,t}$. Their objective function is thus given by

$$E_t\left\{\sum_{i=0}^{\infty}\beta_S^i\left[\frac{\tilde{C}_{S,t+i}^{1-\sigma_S}}{1-\sigma_S}+\frac{\tilde{\phi}_{H,S}}{1-\sigma_{H,S}}\tilde{H}_{S,t+i}^{1-\sigma_{H,S}}+\frac{\phi_{\tilde{b}}}{1-\sigma_b}\left(\tilde{b}_{S,t+i}\right)^{1-\sigma_b}\right.\right.$$
$$\left.\left.+\frac{\tilde{\phi}_K}{1-\sigma_K}\left(Q_{t+i}\tilde{K}_{t+i}\right)^{1-\sigma_K}\right]\right\}. \tag{19}$$

From now on, I will refer to the model where the rich derive utility from real safe assets and physical capital (i.e., $\tilde{\phi}_b, \tilde{\phi}_K > 0$) on top of housing and consumption as the CSP model, while I refer to the case where the rich do not derive utility from these two assets ($\tilde{\phi}_b = \tilde{\phi}_K = 0$) as the model without CSP (NOCSP). Note that, even in the presence of CSP, I assume that housing remains a durable consumption good and thus, unlike for the other two assets, utility depends on the physical housing stock $\tilde{H}_{S,t}$ rather than its market value $Q_{H,t}\tilde{H}_{S,t}$, in line with the literature (Iacoviello 2005, 2015; Iacoviello and Neri 2010; Clerc et al. 2015). However, results are robust to assuming that utility depends on the market value of the housing stock instead.

A rich household's budget constraint and capital accumulation equation are given by

$$\begin{aligned}\tilde{b}_{S,t} = \frac{R_{t-1}}{\Pi_t}\tilde{b}_{S,t-1} + w_{S,t}\tilde{N}_{S,t} + r_{K,t}\tilde{K}_{t-1} + \Xi_t \\ - Q_{H,t}\left(\tilde{H}_{S,t} - \tilde{H}_{S,t-1}\right) - \tilde{T}_{S,t} - \tilde{C}_{S,t} \\ - \left(\tilde{I}_t + \tilde{K}_{t-1}\frac{\epsilon_I}{2}\left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}} - \delta\right)^2\right) \qquad (20)\end{aligned}$$

$$\tilde{K}_t = (1-\delta)\tilde{K}_{t-1} + \tilde{I}_t, \qquad (21)$$

where $r_{K,t}$, $Q_{H,t}$, $\tilde{I}_t$, δ, and $\tilde{K}_{t-1}\frac{\epsilon_I}{2}\left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}} - \delta\right)^2$ denote the real capital rental, the real house price, investment, the depreciation rate of physical capital, and quadratic capital stock adjustment costs, respectively.

I assume that safe assets $\tilde{b}_{S,t}$ comprise both government bonds and financial intermediary deposits. The simplifying assumption that government bonds and financial intermediary deposits are perfect substitutes in equilibrium, or assumptions to that effect, are common in the DSGE literature on models with banking (e.g., Gertler and Karadi 2011, 2013; Iacoviello 2015), and appear a reasonable approximation in the context of this paper, which focuses on long-run trends. The first-order conditions with respect to consumption, safe assets, capital, investment, and housing can be written in terms of economy-wide variables as

$$\Lambda_{S,t} = \frac{1}{C_{S,t}^{\sigma_S}} \qquad (22)$$

$$\Lambda_{S,t} = \beta_S E_t\left\{\Lambda_{S,t+1}\frac{R_t}{\Pi_{t+1}}\right\} + \phi_b b_{S,t}^{-\sigma_b} \qquad (23)$$

$$Q_t = E_t\left\{\beta_S \frac{\Lambda_{S,t+1}}{\Lambda_{S,t}}\left[r_{K,t+1} + \frac{I_{t+1}}{K_t}\epsilon_I\left(\frac{I_{t+1}}{K_t} - \delta\right)\right.\right.$$
$$\left.\left. - \frac{\epsilon_I}{2}\left(\frac{I_{t+1}}{K_t} - \delta\right)^2 + (1-\delta)\,Q_{t+1}\right] + Q_t\frac{\phi_K\left(Q_tK_t\right)^{-\sigma_K}}{\Lambda_{S,t}}\right\} \tag{24}$$

$$Q_t = 1 + \epsilon_I\left(\frac{I_t}{K_{t-1}} - \delta\right) \tag{25}$$

$$Q_{H,t} = \frac{\phi_{H,S}}{H_{S,t}^{\sigma_{H,S}}\Lambda_{S,t}} + \beta_S E_t\left\{\frac{\Lambda_{S,t+1}}{\Lambda_{S,t}}Q_{H,t+1}\right\}, \tag{26}$$

where Q_t denotes the real value of an additional unit of capital to the household.[10] Finally, for future reference, I define total rich household consumption $C_{S,T,t}$ as

$$C_{S,T,t} = C_{S,t} + CH_{S,t} \tag{27}$$

$$CH_{S,t} = \frac{\phi_{H,S}}{\Lambda_{S,t}H_{S,t}^{\sigma_{H,S}}}H_{S,t}, \tag{28}$$

where $\frac{\phi_{H,S}}{\Lambda_{S,t}H_{S,t}^{\sigma_{H,S}}}$ denotes rich households' imputed or "shadow" rent, i.e., the value of an additional unit of housing to rich households expressed in consumption units. $CH_{S,t}$ denotes rich households' housing consumption as defined in the national accounts, i.e., the product of the imputed rent and $H_{S,t}$.

A key difference between my analysis and that of Mian, Straub, and Sufi (2020a) is that they assume that the wealth entering the utility function equals the present value of future income from *all* sources, including labor income if present. This assumption combined with $\sigma_S > \sigma_b$ implies that inducing rich households to hold more wealth requires a *decline* in the interest rate (see Appendix D for further details). Correspondingly, Mian, Straub, and Sufi (2020a) find that an increase in the supply of government bonds lowers

[10] The steps to replace per capita variables with economy-wide variables are analogous to the simple model (see footnote 5), with $\Lambda_{S,t} \equiv \frac{\tilde{\Lambda}_{S,t}}{n_S^{\sigma_S}}$, $\phi_K \equiv \frac{\tilde{\phi}_K n_S^{\sigma_K}}{n_S^{\sigma_S}}$ and $\phi_{H,S} \equiv \frac{\tilde{\phi}_{H,S} n_S^{\sigma_H}}{n_S^{\sigma_S}}$.

the real interest rate, which is at odds with the empirical evidence of Gale and Orszag (2004), Engen and Hubbard (2005), Laubach (2009), and Krishnamurthy and Vissing-Jorgensen (2012). By contrast, I assume that rich households derive utility from accumulated real and financial wealth only (like, e.g., Carroll 2000; Reiter 2004; Francis 2008; Piketty 2011; and Kumhof, Ranciere, and Winant 2015) and that rich households have substantial labor income, which allows my model to match this evidence. I will make use of this property when calibrating the safe asset curvature parameter σ_b in Section 3.6 below.

3.2 Borrower (Non-Rich) Households

Borrowing households are indexed with CC and derive utility from consumption and housing. The objective of a borrower household is given by

$$E_t \left\{ \sum_{i=0}^{\infty} \beta_{CC}^i \left[\frac{\tilde{C}_{CC,t+i}^{1-\sigma_{CC}}}{1-\sigma_{CC}} + \frac{\tilde{\phi}_{H,CC,t+i}}{1-\sigma_{H,CC}} \tilde{H}_{S,t+i}^{1-\sigma_{H,CC}} \right] \right\},$$

where I allow the utility weight on housing to be time varying (but exogenous to the individual borrower household). I assume that non-rich households are sufficiently impatient such that their borrowing is positive in equilibrium. Furthermore, I assume that borrowing is subject to a costly friction, possibly in the form of a default cost. The friction becomes more severe the larger a household's LTV ratio $\frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}$, possibly because the likelihood of (strategic) default increases. The financial intermediary passes on these costs in full to borrower households, implying that the borrowers' expected interest rate $E_t\{R_{L,t+1}\}$ on its period t borrowing is determined by

$$\frac{E_t\{R_{L,t+1}\}}{R_t} = \left(1 + E_t\left\{ f\left(\frac{\tilde{b}_{CC,t}}{\tilde{H}_{CC,t}Q_{H,t+1}} \right) \right\} \right) \tag{29}$$

with $f'() > 0$. These assumptions capture in a simple fashion the empirical finding that non-rich households are more likely to be subject to borrowing constraints, but that their constraint is lessened by an increase in the value of their home, as argued by Mian and Sufi (2011, 2014). Appendix J shows that a positive relationship between the household's LTV and its cost of borrowing may be microfounded by assuming idiosyncratic shocks to the value of a borrower's house, costly strategic default, and that the borrower's house serves as collateral in a state-contingent debt contract, following Lozej, Onorante, and Rannenberg (2018). The simulation results which I discuss in Section 4 of the main text are broadly robust to adopting this microfoundation (see Appendix K for details).

The budget constraint of borrowing households is given by

$$\frac{R_{L,t}}{\Pi_t}\tilde{b}_{CC,t-1} + \tilde{C}_{CC,t} + Q_{H,t}\left(\tilde{H}_{CC,t} - \tilde{H}_{CC,t-1}\right) \\ = \tilde{b}_{CC_t} + w_{CC,t}\tilde{N}_{CC,t} - \tilde{T}_{CC,t}. \quad (30)$$

The FOCs with respect to consumption $\tilde{C}_{CC,t}$, real loans $\tilde{b}_{CC,t}$, and housing $\tilde{H}_{CC,t}$, expressed in terms of economy-wide variables, are given by

$$\Lambda_{CC,t} = \frac{1}{C_{CC,t}^{\sigma_{CC}}} \quad (31)$$

$$\Lambda_{CC,t} = \beta_{CC} E_t \left\{ \Lambda_{CC,t+1} \left[\frac{R_{L,t+1}}{\Pi_{t+1}} + \frac{\frac{dR_{L,t+1}}{db_{CC,t}}\left(\frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}\right)}{\Pi_{t+1}} b_{CC,t} \right] \right\} \quad (32)$$

$$Q_{H,t} = \frac{\phi_{H,CC,t}}{\Lambda_{CC,t}H_{CC,t}^{\sigma_{H,CC}}} \\ + \beta_{CC} E_t \left\{ \frac{\Lambda_{CC,t+1}}{\Lambda_{CC,t}} \left(Q_{H,t+1} - \frac{\frac{dR_{L,t+1}}{dH_{CC,t}}\left(\frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}\right)}{\Pi_{t+1}} b_{CC,t} \right) \right\}, \quad (33)$$

where $\frac{dR_{L,t+1}}{db_{CC}}\left(\frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}\right)$ denotes the effect of an increase in borrowing $b_{CC,t}$ on the loan rate $R_{L,t+1}$ implied by the loan supply curve (29).[11] Hence when trading off today's and tomorrow's consumption,

[11]The steps to eliminate per capita variables are mostly analogous to the simple model (see footnote 5), with $\phi_{H,t} \equiv \frac{\phi_{\tilde{H},t} n_S^{\sigma_H}}{n_S^{\sigma_S}}$. For instance, the debt-FOC is

borrower households take into account both the expected interest rate on the additional unit of borrowing $\frac{R_{L,t+1}}{\Pi_{t+1}}$ and the expected increase in the interest rate burden on their existing stock of borrowing $\frac{dR_{L,t+1}}{db_{CC}}\left(\frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}\right)$ resulting from the worsening of the borrowing friction. Correspondingly, $\frac{dR_{L,t+1}}{dH_{CC,t}}\left(\frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}\right)$ denotes the implied (negative) effect of an increase in the housing stock on the loan rate (holding $b_{CC,t}$ constant). I assume that $f\,()$ is described by a simple linear function

$$f\left(LTV_t\right) = \chi_{CC} LTV_t \tag{34}$$

with $LTV_t = \frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}$. Finally, I assume that the utility weight on housing of the non-rich $\phi_{H,CC,t}$ may depend on lagged rich household total consumption (including housing consumption) $C_{T,S,t-1}$

$$\phi_{H,CC,t} = \phi_{H,CC}\left(\left(\frac{C_{T,S,t-1}}{C_{T,S}}\right)^{\nu_{cascade}}\right)^{\sigma_{H,CC}} \tag{35}$$

with $\phi_{H,CC} > 0$ and $\nu_{cascade} \geqq 0$. Hence, a 1 percent increase in lagged rich household total consumption $C_{T,S,t-1}$ increases the housing demand of the non-rich by $\nu_{cascade}$ percent. The motivation for this assumption is the so-called catching up with the richer Joneses (Drechsel-Grau and Schmid 2014) type of behavior. Specifically, there is microeconometric evidence that households care about their consumption relative to a reference group richer than themselves, and that an increase in the consumption of that richer

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given by $\tilde{\Lambda}_{CC,t} = \beta_{CC} E_t\left\{\tilde{\Lambda}_{CC,t+1}\left[\frac{R_{L,t+1}}{\Pi_{t+1}} + \frac{\frac{dR_{L,t+1}}{db_{CC,t}}\left(\frac{\tilde{b}_{CC,t}}{\tilde{H}_{CC,t}Q_{H,t+1}}\right)}{\Pi_{t+1}}\tilde{b}_{CC,t}\right]\right\}$. Substituting $\frac{E_t\left\{R_{L,t+1}\right\}}{d\tilde{b}_{CC,t}} = E_t\left\{f'\left(\frac{\tilde{b}_{CC,t}}{\tilde{H}_{CC,t}Q_{H,t+1}}\right)\right\} R_t \frac{1}{\tilde{H}_{CC,t}Q_{H,t+1}}$ yields $\tilde{\Lambda}_{CC,t} = \beta_{CC} E_t\left\{\tilde{\Lambda}_{CC,t+1}\left[\frac{R_{L,t+1}}{\Pi_{t+1}} + \frac{R_t}{\Pi_{t+1}} f'\left(\frac{\tilde{b}_{CC,t}}{\tilde{H}_{CC,t}Q_{H,t+1}}\right)\frac{\tilde{b}_{CC,t}}{\tilde{H}_{CC,t}Q_{H,t+1}}\right]\right\}$. Applying $\Lambda_{CC,t} \equiv \frac{\tilde{\Lambda}_{CC,t}}{n_{CC}^{\sigma_{CC}}}$ and $\tilde{X_S} = \frac{X_S}{n_S}$ to replace the remaining per capita variables, and then using $\frac{E_t\left\{R_{L,t+1}\right\}}{db_{CC,t}} = E_t\left\{f'\left(\frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}\right)\right\} R_t \frac{1}{H_{CC,t}Q_{H,t+1}}$ yields Equation (32).

reference group boosts their own consumption (see Kuhn et al. 2011; Drechsel-Grau and Schmid 2014; Bertrand and Morse 2016), thus giving rise to so-called consumption cascades (Frank, Levine, and Dijk 2014; Belabed, Theobald, and van Treeck 2017). I limit the consumption cascade effect to the non-rich utility from housing due to the evidence in Bertrand and Morse (2016), who find that, in response to a 1 percent increase in the (total) consumption of the top 10 percent of households in a given state, the bottom 90 percent increase both the amount of housing services that they consume and the share of housing in their consumption basket.[12] They provide evidence that the disproportional effect on non-rich housing consumption may be related to the high visibility and thus status intensity of housing consumption. In the historical simulation of Section 4.2, this feature will help the model to match the upward trend in the value of the housing stock relative to GDP and the bottom 90 percent debt-to-income ratio by boosting the effect of rising inequality on housing demand, which in turn relaxes the borrowing constraint of non-rich households by lowering their LTV_t. Finally, analogously to rich households, housing consumption is defined as[13]

$$CH_{CC,t} = \left[\frac{\phi_{H,CC,t}}{\Lambda_{CC,t} H_{CC,t}^{\sigma_{H,CC}}} - \beta_{CC} E_t \left\{ \frac{\Lambda_{CC,t+1}}{\Lambda_{CC,t}} \frac{\frac{dR_{L,t+1}}{dH_{CC,t}} \left(\frac{b_{CC,t}}{H_{CC,t} Q_{H,t+1}} \right)}{\Pi_{t+1}} b_{CC,t} \right\} \right] H_{CC,t}. \tag{36}$$

[12]See Table 2, column 3, and Internet Appendix Table A9, rows 2 and 4.

[13]Due to the borrowing friction non-rich households face, on top of $\frac{\phi_{H,CC,t}}{\Lambda_{CC,t} H_{CC,t}^{\sigma_{H,CC}}}$, their marginal benefit of increasing $H_{CC,t}$ includes the present value of a decline in their cost of borrowing $-\beta_{CC} E_t \left\{ \frac{\Lambda_{CC,t+1}}{\Lambda_{CC,t}} \frac{\frac{dR_{L,t+1}}{dH_{CC,t}} \left(\frac{b_{CC,t}}{H_{CC,t} Q_{H,t+1}} \right)}{\Pi_{t+1}} b_{CC,t} \right\}$ generated by the decline in their LTV_t caused by the increase in $H_{CC,t}$, holding $b_{CC,t}$ constant.

3.3 Firms and Total Output

The firm's technology now features physical capital, which it combines with labor using a CES technology,

$$Y_{f,t}(j) = \left[(1-\alpha_K) \left(A_N \left(\frac{N(j)_{S,t}}{\eta_S} \right)^{1-\omega_{CC}-d_{CC,t}} \left(\frac{N(j)_{CC,t}}{\eta_{CC}} \right)^{\omega_{CC}+d_{CC,t}} \right)^{\frac{\epsilon-1}{\epsilon}} + \alpha_K \left(A_K K(j)_{t-1} \right)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}, \tag{37}$$

implying the following FOCs:

$$r_{K,t} = mc_t \alpha_K \left(\frac{Y_{f,t}}{A_K K_{t-1}} \right)^{\frac{1}{\epsilon}} A_K \tag{38}$$

$$w_{S,t} = mc_t (1-\alpha_K)(1-\omega_{CC}-d_{CC,t}) \left(\frac{Y_{f,t}}{A_N N_t} \right)^{\frac{1}{\epsilon}} \frac{N_t A_N}{N_{S,t}} \tag{39}$$

$$w_{CC,t} = mc_t (1-\alpha_K)(\omega_{CC}+d_{CC,t}) \left(\frac{Y_{f,t}}{A_N N_t} \right)^{\frac{1}{\epsilon}} \frac{N_t A_N}{N_{CC,t}} \tag{40}$$

$$N_t = \left(\frac{N_{S,t}}{\eta_S} \right)^{1-\omega_{CC}-d_{CC,t}} \left(\frac{N_{CC,t}}{\eta_{CC}} \right)^{\omega_{CC}+d_{CC,t}} \tag{41}$$

$$\frac{1}{\mu_P + d_{\mu,t}} = mc_t. \tag{42}$$

GDP (or value-added) Y_t equals the sum of total firm output $Y_{f,t}$ net costs associated with the financial friction and adjusting the capital stock, and total housing services CH_t:

$$Y_t = Y_{f,t} - b_{CC,t-1} f(LTV_t) \frac{R_{t-1}}{\Pi_t} - \Phi \left(\frac{I_t}{K_{t-1}} \right) K_{t-1} + CH_t \tag{43}$$

$$CH_t = CH_{S,t} + CH_{CC,t}. \tag{44}$$

3.4 Government

I assume that the government sets the share of non-rich agents in total lump-sum taxes payable equal to their share in pre-tax national income NI_t:

$$Target_{T_{CC}2T_t} = \frac{T_{CC,t}}{T_{S,t} + T_{CC,t}} \tag{45}$$

$$Target_{T_{CC}2T_t} = NIS_{CC,t} \tag{46}$$

$$NI_t = Y_t - \delta K_{t-1} \tag{47}$$

$$NIS_{CC,t} = \frac{w_{CC,t}N_{CC,t} - b_{CC,t-1}\left(\frac{R_{L,t}}{\Pi_t} - 1\right)\frac{R_{t-1}}{\Pi_t} + \frac{H_{CC,t}}{H_t}CH_t}{\left(1 + \frac{b_{gov,t}}{NI_t}\left(\frac{R_{t-1}}{\Pi_t} - 1\right)\right)NI_t.} \tag{48}$$

These equations replace Equation (14), while the remaining equations describing the government sector are unchanged. In particular, as in the simple model, the central bank successfully pursues a perfect inflation target, implying that the actual real interest rate always equals the natural rate. The computation of the non-rich national income share $NIS_{CC,t}$ is consistent with the World Inequality Database (WID) (see Appendix B for further details).

3.5 Equilibrium

The equilibrium conditions of goods market, the market for safe assets, and the housing market are given by

$$Y_t = C_{S,t} + C_{CC,t} + CH_t + I_t + G_t \tag{49}$$

$$b_{S,t} = b_{CC,t} + b_{gov,t}$$

$$H = H_{S,t} + H_{CC,t}, \tag{50}$$

where I assume a constant economy-wide housing stock H. Thus the endogenous variables of the model are determined by (22)–(50) and (8)–(15). The only exogenous variables are the shocks to the production elasticity of households $d_{CC,t}$ and the price markup $d_{\mu,t}$.

3.6 Calibration

3.6.1 Baseline Calibration

I set the capital stock adjustment cost curvature $\epsilon_I = 7$, in line with the estimate of Cummins, Hassett, and Olinar (2006) (see Table 3) and the rate of depreciation $\delta = 0.025$. In line with the literature on housing in DSGE models, I assume a partial equilibrium income effect on housing demand of 1 percent (i.e., $\sigma_{H,S} = \sigma_{H,CC} = \sigma_{CC} = \sigma_S$; see Iacoviello 2005, 2015; Iacoviello and Neri 2010; Clerc et al. 2015). I assume an elasticity of substitution between capital and labor ϵ of 1. As in the simple model, I set the remaining parameters such that the steady-state of the model matches a range of empirical targets, reported in Table 4. In the full model without CSP, there are in total 11 parameters calibrated in this fashion (σ_S, β_S, β_{CC}, $\phi_{H,S}$, $\phi_{H,CC}$, μ_p, α_K, ω_{CC}, $Target_{G2GDP}$, $Target_{bgov2GDP}$, χ_{CC}). They are pinned down by the intertemporal elasticity of substitution, the real short-term interest rate, the borrower debt-to-annual-income ratio, the residential housing-stock-to-annual-GDP ratio, the share of borrowers in total residential real estate, the labor share, the share of private fixed investment in GDP, the national income share of the bottom 90 percent of households as reported by the WID, the GDP share of government expenditure on goods and services, the government debt-to-GDP ratio, and a measure of the spread of the mortgage rate over the risk-free rate. Appendix I shows how, given those targets, the parameter values supporting them can be computed for in (almost) closed form.

The CSP are now described by four parameters, σ_b, ϕ_b, σ_K, and ϕ_K, two more than in the simple model of Section 2. Therefore I add two additional empirical targets to calibrate the preference parameters, on top of the MPS of the rich and the discounting wedge θ already used for calibrating the simple model. The first is the spread between the return on capital $r_K - \delta$ and the real risk-free rate $\frac{R}{\Pi}$. I measure this spread as a simple average of an empirical estimate of the external finance premium and the equity risk premium (see Table 4 for details). The second is the evidence of Gale and Orszag (2004), Engen and Hubbard (2005), and Laubach (2009) on the effect of a 1 percentage point increase in the government debt-to-annual-GDP ratio on the real interest rate on U.S. government bonds, for

Table 3. Full Model, Parameter Values

Parameter	Parameter Name	Value NOCSP ($\theta = 1$)	Value CSP ($\theta = 0.97$)
β_S	Rich Utility Discount Factor	0.9951*	0.9652*
β_{CC}	Borrower Utility Discount Factor	0.9868*	0.9868*
σ_S,σ_{CC}	Utility Curvature Consumption	2*	2*
$\sigma_{S,H}$,$\sigma_{CC,H}$	Utility Curvature Housing	2	2
$\phi_{H,S}$	Rich Utility Weight on Housing	0.17*	1.30*
$\phi_{H,CC}$	Borrower Utility Weight on Housing	0.64*	0.73*
$\nu_{cascade}$	Consumption Cascade	0	0; 0.7
$\tilde{N}_{CC}$,$\tilde{N}_S$	Labor Endowments	$\frac{1}{3}$	$\frac{1}{3}$
μ_P	Price Markup	1.17*	1.06*
α_K	Output Elasticity w.r.t. Capital	0.19*	0.24*
ϵ	Elasticity of Substitution Capital/Labor	1	1; 0.3
ω_{CC}	Borrower Share in Labor Income	0.83*	0.79*
δ	Depreciation Rate Physical Capital	0.025	0.025
ϵ_I	Capital Adjustment Cost Curvature	7	7
χ_{CC}	Financial Intermediation Cost, Linear	0.015*	0.015*
$Target_{bgov2GDP}$	Government Debt Target	44%*	44%*
$Target_{G2GDP}$	Government Expenditure Share Target	20%*	20%*
σ_b	CSP: Utility Curvature, Real Financial Assets	—	0.69*; 1.16*
σ_K	CSP: Utility Curvature, Physical Capital	—	5*/1.16*
ϕ_b	CSP: Utility Weight on Real Financial Assets	0*	3.32*
ϕ_K	CSP: Utility Weight on Physical Capital	0*	222.8*

Note: Values marked with an asterisk (*) are set to match the targets reported in Table 4. Wherever a cell in the CSP column reports two values, the first refers to the baseline CSP calibration discussed in Section 3.6.1. Without loss of generality, I assume $A_K = \frac{Y}{K}$ and $A_N = \frac{Y}{N}$, where $\frac{Y}{K}$ and $\frac{Y}{N}$ refer to the initial steady state of the model. This normalization implies that in the initial steady state, Equations (38) to (40) are the same in the Cobb-Douglas and the CES case. See Appendix I.

Table 4. Targets

Target	Value Data	NOCSP	CSP	Source
Real Short-Term Interest Rate $\frac{R}{\Pi}$	2%	2%	2%	Federal Funds Rate Minus Core-PCE Inflation, APR, FRED
Intertemporal Elasticity of Substitution (IES) $\frac{1}{\sigma_S}$	0.5	0.5	0.5	Havranek (2015)
Labor Share $\frac{wN}{Y}$	66%	66%	66%	WID, % of Factor-Price Gross National Income
Non-res. Investment-to-GDP Ratio $\frac{I}{Y}$	13%	13%	13%	Share of Non-residential Fixed Investment in GDP, BEA
$\frac{K}{4Y}$ (Not Targeted)	126%	130%	130%	Private-Capital-Stock-to-Annual-GDP Ratio, BEA
$\frac{G}{Y}$	20%	20%	20%	Government Expenditure as Percentage of GDP, BEA
$\frac{b_{gov}}{4Y}$	44%	44%	44%	Federal Debt Held by the Public, Percentage of GDP, FRED
Borrower Share in Labor Income (Not Targeted) $\frac{w_{CC}N_{CC}}{w_{CC}N_{CC}+w_S N_S}$	72%	78%	79%	Bottom 90% of Wage Earners Labor Income Share, WID
Borrower National Income Share NIS_{CC}	66%	66%	66%	Bottom 90% National Income Share, Pre-tax, WID
Residential Housing Stock to GDP $\left(\frac{Q_H H}{4Y}\right)$	106%	106%	106%	Flow of Funds, FRB
Borrower Share in Residential Real Estate $\left(\frac{Q_H H_{CC}}{Q_H H}\right)$	70%	70%	70%	Bottom 90% Share in Residential Real Estate, SCF, FRB, 1983
Borrower Debt-to-Annual Income Ratio	38%	38%	38%	Debt Secured by Primary Residence, SCG, FRB, 1983
Mortgages Rate Minus Risk-Free Rate $\frac{R_L}{R}-1$	1.68%	1.68%	1.68%	30-Year Mortgage Rate Minus 30-Year Treasury, FRED
MPS Top 5%	51%	0	56%	Kumhof, Ranciere, and Winant (2015), Appendix III, Based on Dynan, Skinner, and Zeldes (2004)'s Estimates
Discounting Wedge θ	0.97	1.0	0.97	Target CSP Case: See Section 2.5
Return on Capital Minus Risk-Free Rate $ep = \frac{r_K-\delta+1}{\frac{R}{\Pi}} - 1$	4%	0	4%	Target CSP Case: See Note Below for Details
$\frac{d\text{Interest rate gov. bonds}}{d\text{Gov. Debt ratio}}$	0.03–0.06 p.p.	0	0.055 p.p.	Target CSP Case: See Note Below for Details

Note: The targets for $\frac{G}{Y}$, $\frac{b_{gov}}{4Y}$ and $\frac{R_L}{R}-1$ are calculated as averages over the 1981–2016 period. All other ratios for which annual data were available were calculated as averages over the 1973–80 period. FRED: Federal Reserve Economic Data. BEA: Bureau of Economic Analysis. SCF: Survey of Consumer Finances. WID: World Inequality Database. FRB: Federal Reserve Board. Since the FRB publishes comprehensive summary statistics for the SCF only starting in 1989, the 1983 data required to compute the bottom 90% mortgage-debt-to-income ratio, their share in residential real estate, and their LTV were computed as follows:

- Bottom 90% mean income: Computed from Table 1 in Avery et al. (1984b), Table 1, which divides the household population into different household income intervals.
- Bottom 90% mean mortgage debt (secured by primary residence): Avery et al. (1984a), Table 1 (which reports mean mortgage debt and the incidence of owing mortgage debt for selected income groups), and using the aforementioned population shares as weights.
- Bottom 90% and top 10% mean home value: From Avery et al. (1984b), Tables 5 and 7, which contain home ownership incidence and net equity of homeowners for selected household income intervals.

The target for the spread between the return on capital and the risk-free rate $r_K - \delta - \left(\frac{R}{\Pi} - 1\right)$ and the risk-free rate is a simple average of

- The spread between the yield on Moody's seasoned BAA-rated corporate bonds and 10-year Treasury bonds, 1981–2016 average, which equals 2.4%.
- The average estimate of the equity risk premium reported in Duarte and Rosa (2015), Table 7, which equals 5.7%.

The range of empirical estimates of $\frac{d\text{Interest rate gov. bonds}}{d\text{Gov. Debt ratio}}$ are obtained from Gale and Orszag (2004), Engen and Hubbard (2005), and Laubach (2009). The private capital stock used to calculate $\frac{K}{4Y}$ equals private non-residential fixed assets from the BEA's NIPA, "Table 2.1. Current-Cost Net Stock of Private Fixed Assets, Equipment, Structures, and Intellectual Property Products by Type."

which these authors find a range of 0.03 to 0.06 percentage point. I assume that the corresponding model counterpart is the effect of a 1 percentage point permanent increase in the government debt-to-annual-GDP ratio on the steady-state real interest rate. In practice, the value of $\frac{d\text{Interest rate gov. bonds}}{d\text{Gov. Debt ratio}}$ implied by the model is closely linked to the value of safe asset curvature parameter σ_b.[14] Appendix C provides further validation of the consumption and saving behavior of the households in the model by drawing on additional microeconometric evidence which the calibration does not target.

3.6.2 CSP Model Variants

On top of the baseline calibration discussed above, I consider three variants of the CSP model. Firstly, I consider an "identical curvature" version, where I drop the target for $\frac{d\text{Interest rate gov. bonds}}{d\text{Gov. Debt ratio}}$, and instead assume $\sigma_b = \sigma_K$, while keeping the target for the rich marginal propensity to save out of increases in permanent income. The approach results in $\sigma_b = \sigma_K = 1.2$. For this calibration, a given percentage increase (decline) in consumption (the marginal utility of consumption) implies the same percentage increase in the demand for safe assets and capital in the long run. Secondly, I consider a "CES" version, which assumes an elasticity of substitution between capital and labor of $\epsilon = 0.3$, as estimated by the metaregression of analysis of Gechert et al. (2019). Finally, I consider a version with an active "consumption cascade," with $\nu_{cascade} = 0.7$, in line with the evidence of Bertrand and Morse (2016), who find that a 1 percent increase in the total consumption of the top 10 percent of households increases the consumption of housing services by the bottom 90 percent of households living in the same state by about 0.7 percent.

4. Results in the Full Model

In this section, I first investigate the effect of one-off wage inequality and price markup shocks (Section 4.1), and then perform a historical

[14]Note that the value of $\frac{d\text{Interest rate gov. bonds}}{d\text{Gov. Debt ratio}}$ implied by the calibration is at the upper bound of the empirical range. Targeting a lower value would imply a smaller value of σ_b and a larger value of σ_K, and would strengthen the results discussed in Section 4.

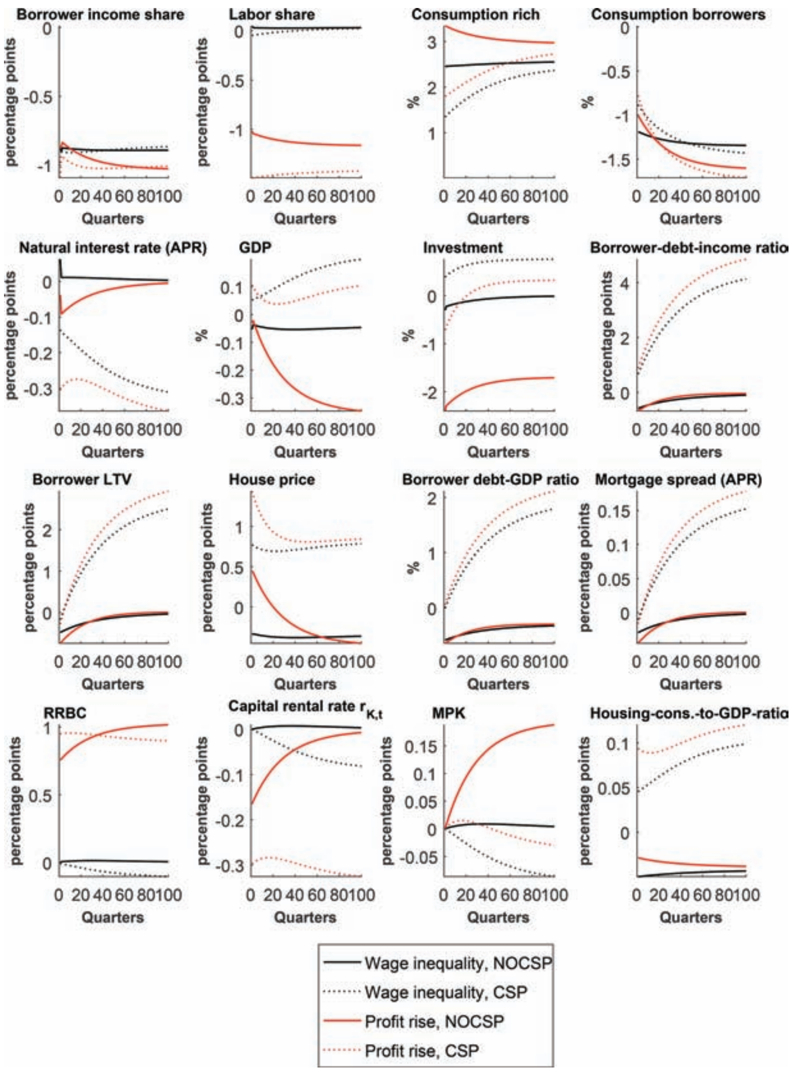
simulation which replicates the empirically observed increase in income inequality over the 1981–2016 period. The results reported below are broadly robust to assuming that rich households' capitalist spirit motive extends to their housing stock (see Appendix H) and to explicitly modeling the borrowing friction assumed above (see Appendix K).

4.1 A One-Off Permanent Increase in Inequality

I first consider the effect of a permanent decline in the share of borrower households in total labor income, caused by a permanent decline (increase) in the elasticity of output with respect to the labor supplied by borrower (rich) households, i.e., $d_{CC,t}$ becomes permanently negative (see Figure 3). I calibrate the value that $d_{CC,t}$ takes such that the on-impact decline in the borrower household income share equals approximately 1 percentage point. Without CSP (solid black line), rich households increase their consumption and housing demand on impact by approximately the magnitude of their permanent income change, similar to the simple model. Borrower households lower their consumption by approximately the decrease in their permanent income, and permanently reduce their housing demand and borrowing, implying that the household debt-to-GDP ratio declines permanently. As a result, without CSP, the effect on the natural interest rate is small, and actually positive on impact before quickly returning to zero.

By contrast, with CSP (dotted black line), rich households increase their consumption by only about half as much as without CSP, implying that in order to equilibrate asset and goods markets, the natural interest rate declines. The decline in the natural rate is initially passed on in full to borrowers, which motivates them to postpone the ultimate decline in their consumption of goods and housing services and thus to reduce their consumption on impact by only half as much as in the NOCSP case. As a result, borrower's housing demand declines more slowly than in the NOCSP case and their debt increases. At the same time, the lower interest rate increases the relative housing demand of both rich and non-rich households, implying that the value of the housing stock increases. The increase in house prices tends to relax the borrower households borrowing constraint, which tends to further strengthen their consumption and housing

Figure 3. Impact of a Permanent Increase in Inequality



Note: The black lines display the effect of a one-off permanent decline in the elasticity of output with respect to the labor supplied by non-rich (rich) households ($d_{CC,t}$ permanently declines; see Equation (37)). The red lines display the effect of a one-off increase in the price markup ($d_{\mu,t}$ permanently increases). CSP refers to the model with capitalist spirit type preferences. The safe interest rate R_t and the risk spread $E_t R_{L,t+1} - R_t$ are expressed as annualized percentage rates. The borrower debt-to-income ratio is based on annualized borrower income. The borrower debt-to-GDP ratio is based on annualized GDP. RRBC: real return on business capital, defined as $RRBC_t \equiv \frac{(1-mc_t)Y_{f,t}+(r_{K,t}-\delta)K_{t-1}}{Q_t K_t - 1}$. MPK: marginal product of capital.

demand. As a result, their debt-to-income ratio increases steeply, while their LTV actually decreases during the first year due to the higher house price before turning positive.

Apart from expanding their lending to borrower households via the financial intermediary, saver households also use their additional income to increase their investment, as the decline in the safe interest rate and the decline in the marginal utility of consumption relative to the marginal utility of physical capital renders physical capital relatively more attractive. As a result, the capital stock, GDP, and the capital-output ratio increase, and consequently the marginal product of capital, the capital rental $r_{K,t}$, and the real return on business capital all decline. Note that, in spite of the GDP increase, the effect of shock on non-rich households' welfare (as measured by their objective) is unambiguously negative due to the large decline in their consumption of goods and their housing stock. This result extends to all variants of the CSP model considered below, and extends to the price markup increase.

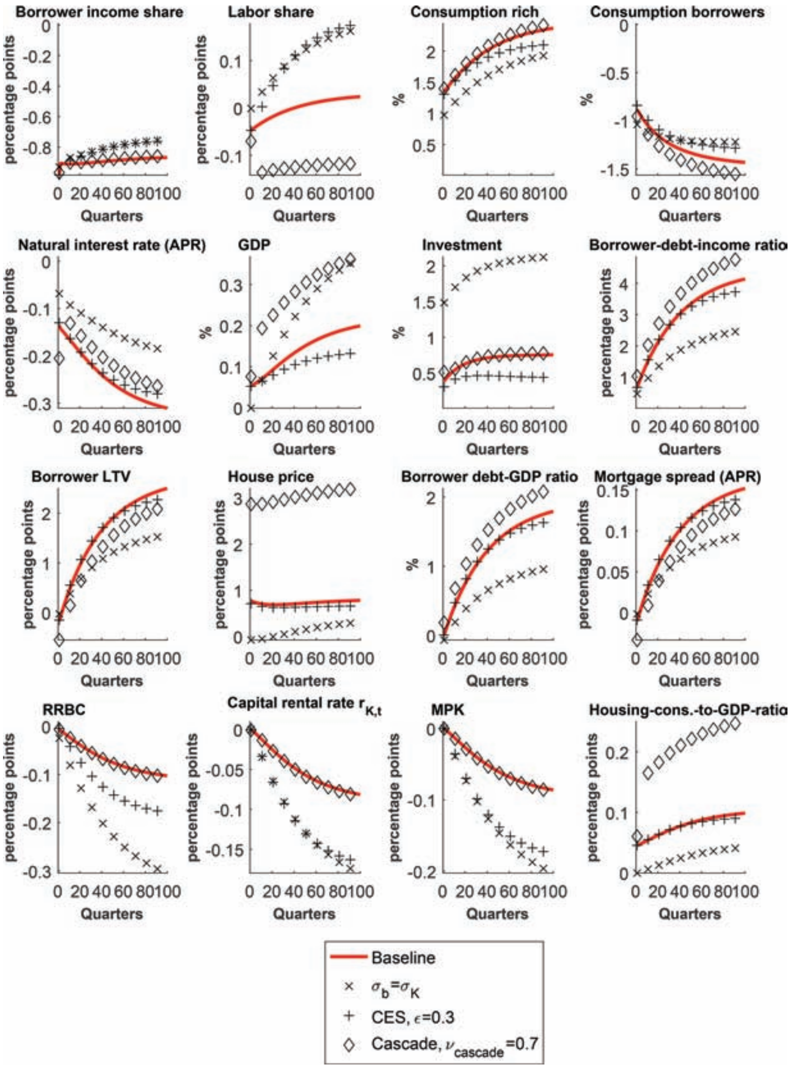
An increase in inequality driven by a permanent rise in the price markup (the red lines) differs from an increase in wage inequality in that it lowers the labor share and the demand for capital goods by the monopolistically competitive firms, and thus investment. However, GDP still increases slightly due to an increase in housing consumption CH_t.[15] Due to the decline in the demand for capital goods, the real interest rate and the capital rental $r_{K,t}$ decline more than for an increase in wage inequality (see Equations (10) and (38)), while the marginal product of capital increases subsequently due to the decline in the capital stock, though only temporarily. The real return on business capital increases due to the increased profits from monopolistic competition, which outweigh the decline in the net rental income from capital $(r_{K,t} - \delta)\, K_{t-1}$. Furthermore, the decline in their investment expenditure allows rich households to

[15]This increase due to a rise in rich households' housing consumption $CH_{S,t}$, which in turn is driven by the increase in their "imputed rent" due to the fact that their consumption increases by more than their housing stock, and thus their marginal utility of consumption declines relative to their marginal utility from housing (see Equation (28)). Compared with the wage inequality shock, the increase in rich household consumption and thus the increase in their imputed rent is enhanced by the decline in their investment spending.

increase their consumption even more than for an increase in wage inequality, implying that house prices now increase more due to a larger "wealth effect" on rich households housing demand, i.e., a sharper decline in their marginal utility of consumption relative to their marginal utility of housing. Apart from these differences, the impact of the markup shock and the wage inequality shock is very similar. The same is true for the effect of allowing for CSP, which again implies, inter alia, a decline in the natural rate, an increase in borrower household debt, an increase in house prices exceeding the increase observed in the absence of CSP, and a higher trajectory for investment than in the NOCSP case due to the lower real interest rate and the increase in the marginal utility of physical capital relative to the marginal utility of consumption.

Figure 4 compares the effect of a wage inequality increase in multiple variants of the CSP model. Assuming identical curvature ($\sigma_b = \sigma_K$) implies that an increase in safe assets reduces the marginal utility of capital (safe assets) by less (more) than in the baseline case. Hence, in the identical curvature case, a given percentage decline in the marginal utility of consumption increases the rich households' demand for capital and deposits by the same percentage. Thus, the demand for capital (bank deposits) increases more strongly (weakly) in the identical curvature case than in the baseline CSP case (see Equations (24) and (23), respectively). Correspondingly, both investment and GDP increase by substantially more than in the baseline CSP case (compare the black "X" line with the red solid line), while household borrowing increases by less and the decline in the natural rate is smaller. Furthermore, the medium-term decline in the capital rental $r_{K,t}$ now closely matches the decline in the natural interest rate, while it remains considerably smaller in the baseline case. By contrast, reducing the elasticity of substitution between capital and labor to the estimate of Gechert et al. (2019) of 0.3 (see the black "+" line) greatly reduces the increase in investment compared with the baseline case, because the optimal capital-labor ratio increases less in response to a given decline in the interest rate if capital and labor are less easily substitutable. In particular, unlike in the Cobb-Douglas case, the labor share increases, as the increase in the capital stock no longer fully compensates for the decline in the capital rental rate associated with the decline in the interest rate.

Figure 4. Impact of a Permanent Increase in Inequality: CSP Model Variants



(*continued*)

Figure 4. (Continued)

Note: The black lines display the effect of a one-off permanent decline in the elasticity of output with respect to the labor supplied by non-rich (rich) households ($d_{CC,t}$ permanently declines; see Equation (37)) for the baseline calibration of the CSP model and three variants (see Section 3.6.2 for details). "Baseline" refers to the calibration discussed in Section 3.6.1. "$\sigma_b = \sigma_K$" indicates the "identical curvature" variant. "CES" indicates the variant where the elasticity of substitution between capital and labor is set to $\epsilon = 0.3$. "Cascade" indicates that the borrowers marginal utility of housing depends on rich households' total consumption (see Section 3.2 and Equation (35) for details). The safe interest rate R_t and the risk spread $E_t R_{L,t+1} - R_t$ are expressed as annualized percentage rates. The borrower debt-to-income ratio is based on annualized borrower income. The borrower debt-to-GDP ratio is based on annualized GDP. RRBC: real return on business capital, defined as $RRBC_t = \frac{(1-mc_t)Y_{f,t}+(r_{K,t}-\delta)K_{t-1}}{Q_t K_t - 1}$. MPK: marginal product of capital.

Allowing for a spending cascade ($\nu_{cascade} = 0.7$) on top of CSP strongly raises the effect of an increase in wage inequality on household debt and the value of the housing stock (see line marked by "black diamonds"). With an active cascade, the increase in rich household consumption directly raises the housing demand of borrowers, which they fund via additional debt. The stronger rise in house prices implies that, in spite of borrowers' higher debt trajectory, their LTV is actually lower than in the absence of the spending cascade (compare the black dotted line and the black diamond line). By contrast, the observed decline in the natural interest rate is smaller. Furthermore, the increase in GDP is larger than in the baseline case, due to an increase in housing consumption CH_t compared with the baseline simulation, driven by the larger marginal utility of housing of non-rich households resulting from the cascade (see Equation (36)).

Finally, note that due to the existence of additional uses for the savings of rich households not present in the simple model of Section 2 (i.e., residential housing, physical capital, lending to the non-rich via financial intermediaries), the simulated decline in the safe real interest rate is smaller than in Figure 2. Nevertheless, as discussed in the following section, when the actual increase in inequality over the 1980–2016 period is replicated in the model, the resulting decline in the natural rate is substantial.

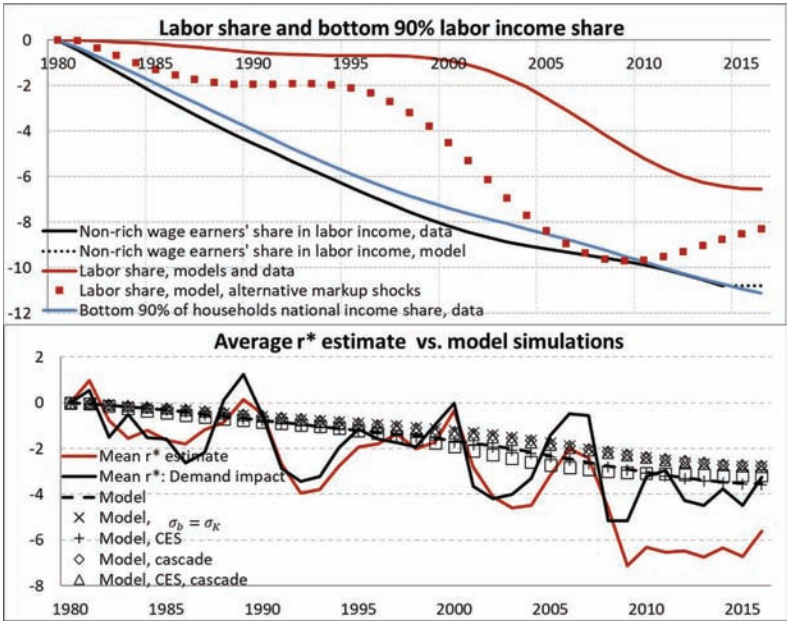
4.2 Simulation of the Empirically Observed Increase in Inequality

I now feed two stylized facts of the U.S. income distribution over the 1981–2016 period into the model with CSP. The first of these is the recent decline in the U.S. labor share, which starts at around the late 1990s (see Figure 5, first panel, the solid red line). In order to match the path of the labor share, I assume a sequence of unexpected permanent increases in the shock to the price markup $d_{\mu,t}$. This approach is similar to Caballero, Farhi, and Gourinchas (2017) and Farhi and Gourio (2018), who target the labor share to back out the path of the price markup in a simulation exercise studying the decline in the safe real interest rate and other trends. Hall (2018), Barkai (2020), and De Loecker, Eeckhout, and Unger (2020) provide evidence that pure profits (i.e., profits exceeding the opportunity cost of capital) and correspondingly price markups have indeed risen in the corporate sector. In order to focus the discussion on long-run trends, I remove fluctuations with an amplitude of 2 to 16 years from labor share series and all other annual data reported below using the asymmetric full-sample band-pass filter of Christiano and Fitzgerald (2003), assuming a unit root with drift.

The second stylized fact I reproduce in the model is the decline in the share of the bottom 90 percent of wages earners in total labor income reported in the WID over the 1980–2014 period (see the first panel of Figure 5, the solid black line), using the wage inequality shock $d_{CC,t}$.[16] Hence I implicitly assume that, as in the model, the bottom 90 percent of wage earners correspond to the bottom 90 percent of households. This assumption appears a reasonable approximation for two reasons. Firstly, the initial steady-state labor income share of non-rich households ω_{CC} implied by my calibration (and my target for the national income share of non-rich household in particular) is close to the empirical share of the bottom 90 percent of wage earners in total labor income (see Table 3), even though I do not explicitly target this value. Secondly, the share of the bottom 90 percent of wage earners in labor income and the national income share of the bottom 90 percent of households move almost

[16]Since the final data point is in 2014, for the final two years of the simulation I assume $d_{CC,2016} = d_{CC,2015} = d_{CC,2014}$.

Figure 5. Simulation 1981–2016: Income Distribution and Natural Interest Rate



Note: The label "Model" indicates the results of simulation using the model with CSP developed in Section 3. The simulation subjects the model to a sequence of unexpected but permanent shocks to the price markup $d_{\mu,t}$ and the labor income share of non-rich households $d_{CC,t}$. The trajectory of $d_{CC,t}$ is set to replicate the path of the bottom 90 percent of wage earners' share in total labor income in the data. The trajectory of $d_{\mu,t}$ is set such that the simulation replicates the path of the labor share in the data, unless the line is labeled "Model, Alternative Markup Shocks." In that case $d_{\mu,t}$ is set to replicate the path of an estimate of the pure profit share (see Appendix G for details). Changes in $d_{CC,t}$ and $d_{\mu,t}$ occur every four quarters, starting with the first simulation quarter. The corresponding 1980 value has been subtracted from all displayed series.
First Panel: The label "Labor Share, Models and Data" indicates the BLS labor share which all simulations other than the "Alternative Markup Shocks" simulation are forced to match.
Second Panel: The line labeled "Average r* Estimate" is the simple average across the r* estimates plotted in the upper panel of Figure 1 (the black squared line). The line labeled "Average Estimated Demand Impact on r*" is the simple average across the estimated impact of demand shocks on r* in Del Negro et al. (2017) and Gerali and Neri (2019) plotted in the lower panel of Figure 1 (the black squared line). The lines labeled "Model, $\sigma_b = \sigma_K$", "Model, CES", "rstar, Model, cascade" refer to the variants of the CSP model discussed in Section 3.6.2. "Model, CES, cascade" indicates an active spending cascade and an elasticity of substitution between capital and labor of $\epsilon = 0.3$.

(*continued*)

Figure 5. (Continued)

Data Sources and Treatment: Bottom 90 percent of wage earners' labor income share: WID. Labor share: Labor share non-farm business sector, Bureau of Labor Statistics. Bottom 90 percent of households' share in pre-tax national income: WID. For "Average r* Estimate" and "Average Estimated Demand Impact on r*" see the note below Figure 1. From all annual data except the rstar estimates, I remove fluctuations with an amplitude of 2 to 16 years using the asymmetric full sample band-pass filter of Christiano and Fitzgerald (2003), assuming a unit root with drift.

in parallel over the 1980–2014 period, thus suggesting substantial overlap between the two groups (compare the blue and black solid lines). Finally, the simulated path of the bottom 90 percent share in national income closely matches its empirical counterpart (see the graph in Appendix E).[17] Since the WID data are available at an annual frequency only and my focus is on the trends in any case, I assume that the changes in $d_{CC,t}$ and $d_{\mu,t}$ occur every four quarters, starting with the first simulation quarter.[18]

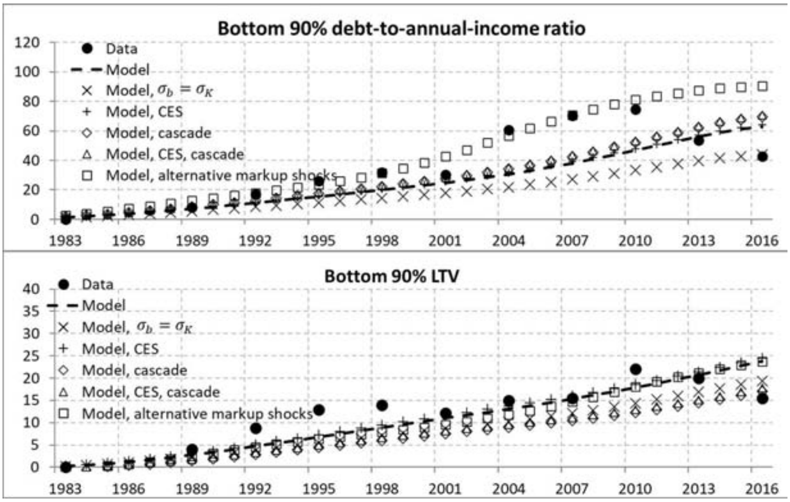
As can be seen from the second panel of Figure 5, the simulated increase in inequality generates a decline in the natural interest rate of between 3 and 4 percentage points over the 1981–2016 period, depending on the model variant. The simulation is thus able to broadly replicate the downward trend in the part of the natural rate which the aforementioned empirical estimates attribute to aggregate demand.

It should be remembered that the model's only drivers are the two aforementioned shocks to the income distribution, and that the model represents a hypothetical flexible price equilibrium, i.e., a situation where the output gap is closed. It thus abstracts from a multitude of potentially relevant influences, and would not be expected a

[17]While the model abstracts from the potential role of progressive income taxation in attenuating the effect of rising pre-tax inequality on household finances, note that the bottom 90 percent of households' post-tax disposable income share reported in the WID moves almost in parallel with the share of the bottom 90 percent of households in pre-tax national income over the 1980–2014 period.

[18]More specifically, I conduct a sequence of "perfect foresight" simulations, with one simulation corresponding to each occurrence of the shocks (i.e., 36 simulations in total). Of course, each simulation uses the fourth quarter of the preceding simulation as a starting point.

Figure 6. Simulation 1981–2016: Borrower Debt-to-Income Ratio and LTV

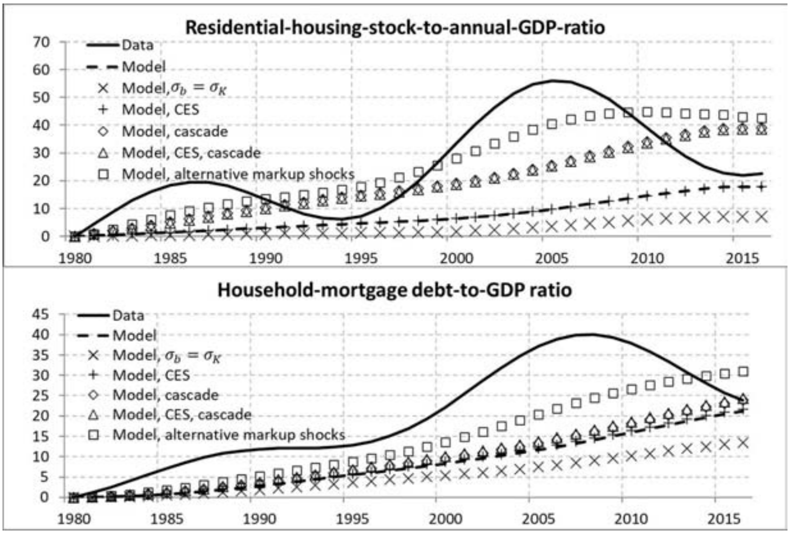


Note: This graph plots the simulated path of the non-rich debt-to-annualized-income ratio $\frac{b_{CC,t}}{4w_{CC,t}N_{CC,t}}$ 100 and LTV $\frac{b_{CC,t}}{Q_{H,t}H_{CC,t}}$ 100 and their empirical counterparts. See the note below Figure 5 for details on the model variants used in the simulation and the simulation setup. Note that the corresponding 1980 value has been subtracted from all displayed series.

Data Sources: The 1989–2016 values are computed from summary statistics provided by the Federal Reserve Board's Survey of Consumer Finances (SCF) 1989–2016. Bottom 90% debt-to-income ratio = (Bottom 90% mean mortgage debt)/(Bottom 90% mean income)*100. Bottom 90% mean income: Table 1. Bottom 90% mean mortgage debt (secured by primary residence): Table 13 and Table 13 means. Bottom 90% LTV = (Bottom 90% mean mortgage debt)/(Bottom 90% mean home value (primary residence)). Bottom 90% mean home value (primary residence): Table 13 and Table 13 means. Regarding the computation of the 1983 values, see the note below Table 4.

priori to match the data year by year. That being said, the simulation speaks to a number of important trends observed during the 1981–2016 period. All model variants closely track the upward trend in the bottom 90 percent of households' mortgage debt-to-annual-income ratio from the early 1980s until about 2001 (see Figure 6). The model variants other than the "$\sigma_b = \sigma_K$" model (see the line marked with "X") replicate between about two-thirds (for the baseline calibration) or more (CES +cascade; see the "black triangle" marked line)

Figure 7. Simulation 1981–2016: Housing Stock and Total Mortgage Debt-to-GDP Ratios

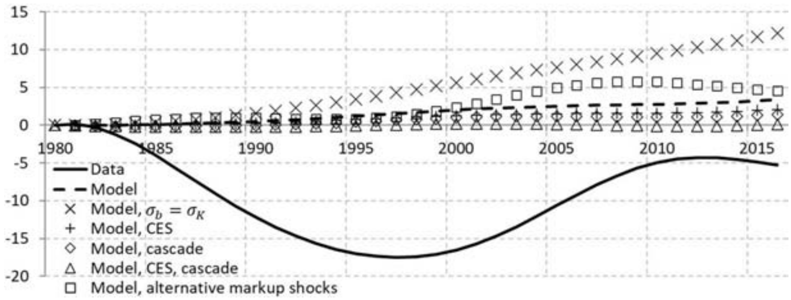


Note: This graph plots the simulated path of the housing-stock-to-annualized-GDP-ratio $\frac{Q_{H,t}H_t}{4_{Y,t}}100$ and the household-mortgage-debt-to-annualized-GDP ratio $\frac{b_{CC,t}}{4_{Y,t}}$ and their respective empirical counterparts. See the note below Figure 5 for details on the model variants used in the simulation, the simulation setup, and data treatment.
Data Sources: Federal Reserve Board/Flow of Funds, Bureau of Economic Analysis.

of the peak increase in the debt-to-income ratio compared with its 1980 value (attained in 2010). Furthermore, the simulation roughly tracks the rising trend in the bottom 90 percent LTV observed in the data.

The model also generates an empirically relevant rising trend in the ratio of nominal residential housing stock to GDP and the ratio of household mortgage debt to GDP (see Figure 7). Apart from a rising trend, in the data both variables display substantial volatility, especially post-2001, which my simple simulation exercise cannot capture. While the baseline model is able to replicate about one-fifth of the peak of the residential-housing-stock-to-GDP ratio, attained in 2005, the replicated share increases to almost one-half

Figure 8. Simulation 1981–2016: Private Non-residential Producible Capital-Stock-to-GDP Ratio



Note: This graph plots the simulated path of the private non-residential-capital-stock-to-annual-GDP ratio $\frac{K_t}{4_{Y,t}}100$ and its empirical counterpart. See the note below Figure 5 for details on the model variants used in the simulation, the simulation setup, and data treatment.
Data Sources: The private non-residential capital stock was computed from the BEA's NIPA, "Table 2.1. Current-Cost Net Stock of Private Fixed Assets, Equipment, Structures, and Intellectual Property Products by Type" as "Nonresidential equipment" + "Nonresidential structures" + "Nonresidential intellectual property products," and divided by nominal GDP. Hence it includes only producible capital, i.e., it excludes the value of land.

in the model variants with a cascade. Furthermore, the simulations other than the $\sigma_b = \sigma_K$ case replicate between a third and 40 percent of the peak of the mortgage-debt-to-GDP ratio, respectively.

Furthermore, I also compare the model's predictions regarding the ratio of non-residential capital stock to GDP with the corresponding BEA estimate (see Figure 8). In the data, the ratio of non-residential capital to GDP does not exhibit a clear trend over the 1980–2016 period but remains below its 1980 value throughout.[19]

[19]That being said, an alternative "market value" estimate of the capital stock based on the market value of corporate equity (see Piketty and Zucman 2014, and Piketty, Saez, and Zucman 2018 for the most recent data) does yield a strong upward trend of the capital-output ratio over the 1980–2016 period, driven mainly by an increase in the difference between the market and book value of corporations, i.e., an increase in Tobin's Q. The "market-value" measure circumvents some practical challenges posed by the perpetual inventory method statistical agencies like the BEA rely on to estimate the value of produced fixed assets, like the need to estimate the replacement costs of fixed assets for which no centralized

The "identical curvature" model predicts an increase of 12 percentage points by 2016, close to its prediction regarding the mortgage-debt-to-GDP ratio for that model, as a result of an identical long-run "wealth effect" on the demand for capital and bank deposits by rich households in this variant of the CSP model. By contrast, the baseline model predicts an increase of less than 3 percentage points due its smaller (larger) wealth effect on rich households' demand for capital (deposits). With a CES technology and/or an active cascade, the predicted increase in capital intensity declines to 2 percentage points or less. Hence the model simulation combines an empirically relevant decline in the natural interest rate with the absence of a trend in the capital-output ratio. Correspondingly, with a CES technology, the ratio of non-residential investment to GDP increases by merely 0.1 to 0.3 percentage point by 2016 (see Table E.2 in Appendix E). By contrast, the model by Straub (2017) predicts an increase in the capital-output ratio of about 25 percentage points over a similar period when the increase in labor income inequality is fed into the model, while at the same time predicting a decline in the natural rate of merely 1 percent. His result may be partially due to the fact that his model abstracts from household borrowing, and producible physical capital is the only asset. Furthermore, my simulation features not merely an increase in wage inequality but also an increase in the markup in order to capture the decline in the labor share. As shown in Section 4.1, in response to a markup shock the CSP model predicts a decline in investment during the first five years, followed by only slight increase in the long run (see Figure 3), even with a Cobb-Douglas technology.

Relatedly, a number of authors have noted that, in spite of the decline in safe interest rates, measures of the return of capital like the one by Gomme, Ravikumar, and Rupert (2015) have remained stable, and perhaps even increased somewhat (e.g., Caballero, Farhi, and Gourinchas 2017; Eggertsson, Robbins, and Wold 2018; Farhi

market exists (see Piketty and Zucman 2014). Unfortunately, it may also fluctuate independently of any physical capital accumulation, as stressed more recently by a team including the same two authors (see Alvaredo et al. 2020). Relatedly, Farhi and Gourio (2018), Corhay, Kung, and Schmid (2020), and Greenwald, Lettau, and Ludvigson (2021) argue that a crucial driver of the aforementioned increase in Tobin's Q is an increase in firm profits at the expense of wages, attributed by Farhi and Gourio (2018) and Corhay, Kung, and Schmid (2020) to rising market power.

and Gourio 2018). Figure F.1 in Appendix F shows that the simulation broadly matches this feature of the data as well, due to the rising price markup.

The models predict a small increase in GDP Y_t as a result of the increase in inequality, driven by an increase in housing consumption CH_t. For instance, the baseline model predicts that by 2016 (i.e., after 36 years), GDP exceeds its level in the absence of the inequality increase by 1.8 percent, or by 1.5 percent with a CES technology (see Table E.1 in Appendix E). In the presence of the consumption cascade, the GDP increase rises to 3.4 percent and 3.0 percent, since the cascade triggers a stronger increase in CH_t, as discussed in Section 4.1. Correspondingly, the predicted effect on average annual GDP growth over the 1980–2016 period ranges between merely 0.04 and 0.09 percentage point. The predicted increase in the share of housing consumption in GDP is broadly in line with the data (see Figure E.2 in Appendix E).

Finally, as a robustness check, I repeat the simulation of the model with a CES production function and consumption cascade for an alternative markup shock series. Specifically, instead of targeting the path of the labor share in the data, I set $d_{\mu,t}$ such that the simulation matches an estimate of the share of pure profits, i.e., profits in excess of the opportunity cost of capital, in firm value-added PS_t, whose model counterpart is given by $PS_t = 1 - \frac{1}{\mu_P + d_{\mu,t}}$. I compute this measure from empirical evidence of De Loecker, Eeckhout, and Unger (2020) (see Appendix G for details). This approach yields a higher $d_{\mu,t}$ trajectory than before, implying that the simulated post-1996 labor share decline is larger than in the data (see Figure 5, the red square), though the gap narrows towards the end of the simulation period. However, the interest rate declines slightly more and the simulation better matches the increase in household indebtedness (at both the macro and the micro level) and the value of the housing stock (see Figures 5 (lower panel) through 7; compare the empty square and triangle)

5. Conclusion

This paper links four empirical trends observed during the post-1980 period: The upward trend in the income share of the top 10 percent of U.S. households, the downward trend in empirical estimates of the natural rate of interest, the simultaneous increase in indebtedness of non-rich households, and the increase in the value of the residential housing stock relative to GDP. For that purpose it develops a model with two household groups, the bottom 90 percent and the top 10 percent, where rich households have capitalist spirit type preferences (CSP) over their wealth. With CSP, an increase in income inequality increases the saving of rich households and lowers the natural rate of interest, while also increasing borrowing by the non-rich, as the non-rich use the decline in the interest rate to postpone the decline in their consumption of goods and housing services. House prices increase as well.

Replicating the increase in the share of the top 10 percent of wage earners in total labor income and the decline in the labor share observed over the 1980–2016 period within the model, I find a decline in the natural rate of a magnitude in line with available empirical estimates of the impact of demand shocks on the natural rate. The simulation also replicates the major part of the increase in the bottom 90 percent debt-to-income ratio and roughly tracks the increase in the bottom 90 percent LTV ratio. At the economy-wide level, it replicates a large part of the upward trend in the value of the housing stock and total household mortgages relative to GDP.

My analysis suggests that the natural rate may remain at its current low level for a long time, as the distribution of income tends to change only slowly, and thus the scope for "conventional" monetary policy may remain limited. Furthermore, to the extent that the tax and transfer system may change the distribution of income in an efficient manner, it implies a potentially important role for fiscal policy in determining the distance of the economy from the zero lower bound (ZLB) and the overall level of household debt in the economy.

Appendix A. Microsimulation Used to Compute Saver Households' MPS

I describe the microsimulation I use to calibrate the wealth curvature parameter for the case of the simple model of Section 2. The procedure in the full model is fully analogous. For the purpose of the microsimulation (or partial equilibrium simulation), I exogenize the real interest rate $\frac{R}{\Pi}$ and denote all income exogenous to the choices of the household as $Y_{S,t}$. $Y_{S,t}$ thus equals the sum of labor income and the profits of the monopolistically competitive firms. Household behavior is then described by

$$b_{S,t} = \frac{R}{\Pi} b_{S,t-1} + Y_{S,t} - C_{S,t} \tag{A.1}$$

$$\Lambda_{S,t} = \frac{1}{C_{S,t}^{\sigma_S}} \tag{A.2}$$

$$\Lambda_{S,t} = \beta_S E_t \left\{ \Lambda_{S,t+1} \frac{R}{\Pi} \right\}) + \phi_b \left(b_{S,t} \right)^{-\sigma_b}. \tag{A.3}$$

I then simulate a permanent increase in exogenous income $Y_{S,t}$ occurring in $t = 1$. I compute the marginal propensity to save (MPS) over a horizon of six years (24 quarters) as

$$MPS_{S,1-24} = \frac{b_{S,24} - b_0}{\sum_{t=1}^{24} \left(Y_{S,t} - Y_{S,0} \right) + \left(b_{S,t} - b_0 \right) \left(\frac{R}{\Pi} - 1 \right)}. \tag{A.4}$$

The rationale for the six-year horizon is that the saving rate regression of Dynan, Skinner, and Zeldes (2004) from which the value of the MPS I target is computed measures saving as the change in net worth from 1983 to 1989 (see Kumhof, Ranciere, and Winant 2015 for further details on how to compute the MPS in a way consistent with these empirical estimates). Given the calibration of the other parameters as described in Section 2.5, I use σ_b to set $MPS_{S,1-24}$ to the empirical target value.

Note that in the presence of housing and physical capital, the numerator of (A.4) features the change in the value of the holdings of these assets as well, while the denominator features the associated change in the rental income from capital caused by the shock.

Appendix B. The Non-rich National Income Share $NIS_{CC,t}$ in the Full Model

The non-rich national income share is defined as

$$NIS_{CC,t} \equiv \frac{\begin{array}{c} w_{CC,t}N_{CC,t} - b_{CC,t-1}\left(\frac{R_{L,t}}{\Pi_t} - 1\right)\frac{R_{t-1}}{\Pi_t} \\ +\frac{H_{CC,t}}{H_t}CH_t - NIS_{CC,t}b_{gov,t}\left(\frac{R_{t-1}}{\Pi_t} - 1\right) \end{array}}{NI_t},$$

and Equation (48) in the main text is derived by solving for $NIS_{CC,t}$. The numerator represents total pre-tax income of non-rich households and arises as follows. $w_{CC,t}N_{CC,t}$ represents the non-rich households' labor income, while $-b_{CC,t-1}\left(\frac{R_{L,t}}{\Pi_t} - 1\right)$ and $\frac{H_{CC,t}}{H_t}CH_t$ represent their (negative) mortgage income and their share in total imputed rental income (from providing housing services CH_t), respectively. Note that the computation of non-rich households' capital income $-b_{CC,t-1}\left(\frac{R_{L,t}}{\Pi_t} - 1\right)\frac{R_{t-1}}{\Pi_t} + \frac{H_{CC,t}}{H_t}CH_t$, and in particular the allocation total of imputed rental income according to non-rich households' share in total housing $\frac{H_{CC,t}}{H_t}$, is consistent with the way capital income is allocated to adults in the WID. In the WID, for the United States, the share of a group of adults in economy-wide income generated by any asset class corresponds exactly to the share of that group in the total stock of that asset, meaning that their share of imputed rental income across adults equals their share in the total housing stock (see Saez and Zucman 2016 and Piketty, Saez, and Zucman 2018). Finally, the $-NIS_{CC,t}b_{gov,t}\left(\frac{R_{t-1}}{\Pi_t} - 1\right)$ term arises because the WID distributes the property income of the government $-b_{gov,t}\left(\frac{R_{t-1}}{\Pi_t} - 1\right)$ across adults according to their pre-tax national income share. The allocation of the government's property income to individual adults is necessary in order to ensure that across adults, individual pre-tax income adds up to national income.

Appendix C. Additional Validation of the Consumption and Saving Behavior of Households in the Model

This section provides additional validation of the consumption and saving behavior of households in the full model using microevidence. The second line of Table C.1 displays the MPS of rich households

Table C.1. MPS Out of Permanent Income and MPC Out of Wealth in the Full Model and the Data

	Model	Empirical
MPS Out of Permanent Income: Rich	56%	51%
MPS Out of Permanent Income: Non-rich	11%	19%/11%/14%
MPC Out of Wealth: Rich	1.3%	1.2%
MPC Out of Wealth: Non-rich	3.3%	4.3%

Note:

MPS Out of Permanent Income Changes of Non-rich and Rich Households

The empirical counterpart of the rich households MPS out of permanent income changes equals Kumhof, Ranciere, and Winant (2015)'s estimate of the MPS of the top 5 percent of households (see their Appendix III). The nearest available empirical counterpart of the non-rich MPS is the MPS of the bottom 80 percent of households, which I can compute from results in Dynan, Skinner, and Zeldes (2004). The first value is based on Dynan, Skinner, and Zeldes (2004)'s "Median instrumental variable regressions of the saving rate on income using lagged income as an instrument" (Table 5, column 2), which is based on SCF data and measures saving as the change in net worth from 1983 to 1989. This is the saving regression from which Kumhof, Ranciere, and Winant (2015) compute their estimate of the MPS of the top 5 percent. I compute the MPS for each of the first four quintiles q by applying the following formula: $\widehat{MPS}_q = \frac{\hat{\alpha}_q Median(y_q) - \hat{\alpha}_q Median(y_{q-1})}{Median(y_q) - Median(y_{q-1})}$ from Kumhof, Ranciere, and Winant (2015), where $Median\ (y_q)$ and $\hat{\alpha}_q$ denote the 1989 median household income in quintile q (obtained from the SCF, Table 1: Before-tax family income, 1989–98 surveys) and the average saving rate estimated by Dynan, Skinner, and Zeldes (2004) for that quintile, respectively. For the first quintile ($q = 1$), I set $Median(y_{q-1}) = 0$. I then calculate the bottom 80 percent MPS as a weighted average of the $\widehat{MPS}_q$ values across the first four quintiles, using the respective share in total income of the bottom 80 percent of households as a weight. The second and third empirical estimate in the "Non-rich" line I compute from the direct estimates of the MPS reported by Dynan, Skinner, and Zeldes (2004) for each quintile, which are based on PSID data (see the note below their Figure 3, and their Table 9, column 2). I then calculate a weighted average across the first four quintiles, using the median income they report in their Figure 3 to calculate the weights. The model MPS of rich and non-rich households is computed from a partial equilibrium simulation of a permanent-income increase as described in Appendix A.

MPC Out of Wealth

I compute the empirical counterpart of the rich and non-rich household wealth MPC reported above as a simple average across estimates of the wealth MPC of the top 10 percent and bottom 90 percent of households in the wealth distribution from a number of European countries. To the best of my knowledge, there are no U.S. estimates of how the MPC out of wealth varies across the wealth distribution. The estimates and sources are listed in the table below. I computed the bottom 90 percent wealth MPC as a weighted average of the respective MPC estimates for the percentiles encompassed in the bottom 90 percent. I used the share of the respective percentile in total wealth as a weight; see Arrondel, Lamarche, and Savignac (2019), Table 2, and Di Maggio, Kermani, and Majlesi (2020), Table I, financial wealth. I thank Frédérique Savignac for kindly sharing the net wealth totals of the wealth percentiles for which Garbinti et al. (2020) estimate the wealth MPC.

(*continued*)

Table C.1. (Continued)

Source	Country	MPC Out of Wealth	
		Top 10%	**Bottom 90%**
Arrondel, Lamarche, and Savignac (2019), Table 4	France	0.5%	1.4%
Garbinti et al. (2020), Table 5	Belgium	1.2%	4.8%
	Cyprus	0.3%	2.1%
	Germany	0.6%	3.5%
	Spain	0.8%	4.5%
	Italy	2.3%	5.4%
Di Maggio, Kermani, and Majlesi (2020), Table III	Sweden	2.8%	8.1%

computed from a microsimulation of a permanent income increase (see Appendix A for details) and corresponding empirical evidence computed by Kumhof, Ranciere, and Winant (2015) from Dynan, Skinner, and Zeldes (2004). Recall that this evidence was one of the targets used in Section 3.6.1 to calibrate the wealth utility curvature parameters. The third line reports the same objects for non-rich households in the model and their empirical counterparts, which I computed from Dynan, Skinner, and Zeldes (2004) (see the note below the table for details). The model and empirical values are close, even though I did not use an estimate of the non-rich household MPS as a target for the calibration of the model. Hence my assumption that only rich households have CSP is consistent with the finding that the permanent-income MPS of rich household far exceeds the permanent-income MPS of the rest of the population.

An alternative statistic which one might consider is the rich households' marginal propensity to consume (MPC) out of wealth, which Mian, Straub, and Sufi (2020a) target to calibrate their model with preferences over wealth. Table C.1 reports the MPC computed from a microsimulation of a one-off exogenous increase in rich-household wealth and a one-off exogenous increase in non-rich household wealth. It also reports an average of recent empirical estimates from European countries of the wealth MPC of the top 10 percent and the bottom 90 percent of the wealth distribution, respectively.[20] In the microsimulation for rich households, I assume that the exogenous wealth increase is split between capital (whose adjustment is subject to costs) and other assets according to their respective initial shares in total rich household assets. More formally, the budget constraint and capital accumulation equation used in the microsimulation are given by

$$\begin{aligned} b_{S,t} = &\frac{R}{\Pi} b_{S,t-1} + w_S N_S + r_K K_{t-1} + \Xi - Q_H \left(H_{S,t} - H_{S,t-1}\right) \\ &- T_S - C_{S,t} - \left(I_t + K_{t-1} \Phi\left(\frac{I_t}{K_{t-1}}\right)\right) \\ &+ \left(1 - \frac{K}{H_S Q_H + b_S + K}\right) \epsilon_{wealth,t} \\ K_t = &\left(1 - \delta\right) K_{t-1} + I_t + \frac{K}{H_S Q_H + b_S + K} \epsilon_{wealth,t} \end{aligned}$$

with $\epsilon_{wealth,1} > 0$ and $\epsilon_{wealth,t} = 1$ for $t > 1$. All variables exogenous to the individual household kept constant. I compute the MPC as the ratio of the first-year average increase in consumption to the first-year average increase in wealth:

$$MPC_{wealth,1Y} = \frac{\sum_{t=1}^{4} \left(C_{S,t} - C_{S,0}\right)}{\sum_{t=1}^{4} \left(b_{S,t} - b_{S,0}\right) + Q_H \left(H_{S,t} - H_{S,0}\right) + \left(K_t - K_0\right)}.$$

As can be seen from Table C.1, the model closely matches the empirical wealth MPC of both rich and non-rich households.[21]

Appendix D. The Long-Run Saving Supply Curve of Rich Households

This appendix derives the slope of the long-run "saving supply curve" of rich households and explains how it differs from Mian,

[20] To the best my knowledge, there are no U.S. estimates of how the MPC out of wealth varies across the wealth distribution.

[21] Garbinti et al. (2020) differ from the other studies in that they use the four-year change in consumption and wealth as dependent and independent variable, respectively. The model counterpart is given by $MPC_{wealth,4Y} = \frac{\sum_{t=13}^{16} dC_{S,t}}{\sum_{t=13}^{16} db_{S,t} + Q_H dH_{S,t} + dK_t}$. However, $MPC_{wealth,4Y}$ is with 1.46 percent very close to $MPC_{wealth,1Y}$.

Straub, and Sufi (2020a). Abstracting for simplicity and easier comparability with Mian, Straub, and Sufi (2020a) from physical capital and housing, the steady-state budget constraint and safe assets first-order condition of rich households are given by

$$C_S = \left(\frac{R}{\Pi} - 1\right) b_S + w_S N_S + \Xi - T_S$$
$$1 = \beta_S \frac{R}{\Pi} + \frac{\phi_b b_S^{-\sigma_b}}{C_S^{-\sigma_S}},$$

where $\phi_b b_S^{-\sigma_b}$ and $C_S^{-\sigma_S}$ represent the marginal utility of safe assets and consumption, respectively. Accordingly, after substituting the first equation into the second equation, the slope of the steady-state saving supply curve can be derived using implicit differentiation:

$$\frac{db_S}{d\frac{R}{\Pi}} = -\frac{\beta_S + \sigma_S \phi_b \left(\left(\frac{R}{\Pi} - 1\right) b_S + w_S N_S + \Xi - T_S\right)^{\sigma_S - 1} (b_S)^{1-\sigma_b}}{\frac{\phi_b \left(\left(\frac{R}{\Pi}-1\right) b_S + w_S N_S + \Xi - T_S\right)^{\sigma_S}}{b_S^{\sigma_b}} \left[\frac{\sigma_S \left(\frac{R}{\Pi} - 1\right)}{\left(\frac{R}{\Pi}-1\right) b_S + w_S N_S + \Xi - T_S} - \frac{\sigma_b}{b_S}\right]}. \tag{D.1}$$

Hence $\frac{db_S}{d\frac{R}{\Pi}} < 0$ (as in Mian, Straub, and Sufi 2020a) iff $\sigma_S > \sigma_b \frac{\left(\left(\frac{R}{\Pi}-1\right) b_S + w_S N_S + \Xi - T_S\right)}{\left(\frac{R}{\Pi}-1\right) b_S}$. For this inequality to hold, the utility curvature of consumption has to be smaller than that of wealth (i.e., $\sigma_S > \sigma_b$). This condition is met both in my calibration and in Mian, Straub, and Sufi (2020a). However, on top of that, the income derived from the utility-generating asset (here $\left(\frac{R}{\Pi} - 1\right) b_S$) has to be sufficiently large relative to income from alternative sources (here $w_S N_S + \Xi - T_S$). In Mian, Straub, and Sufi (2020a), income from sources other than the asset is zero.[22] Therefore $C_S = \left(\frac{R}{\Pi} - 1\right) b_S$, implying that a 1 percent increase in b_S increases C_S by 1 percent as well. With $\sigma_b < \sigma_S$, the marginal utility of consumption $C_S^{-\sigma_S}$

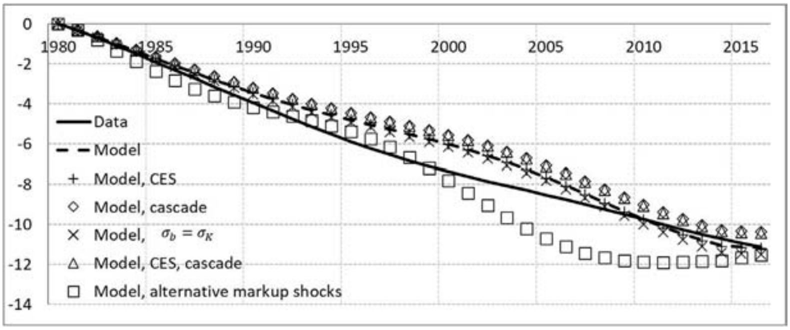
[22]In their baseline model rich household income is generated by lending to non-rich households and a "Lucas tree," with households deriving utility from the combined value of these two assets. In the variant of the model with labor and capital, the measure of wealth-generating utility equals the sum of lending to non-rich households, the value of the capital stock, and the present value of future labor income ("human capital"). Hence, the wealth concept in the utility function is always the capitalized income from all sources, including labor income.

declines by a larger percentage than the marginal utility from bonds $\phi_b b_S^{-\sigma_b}$ (the "income effect" dominates the "substitution effect"), implying that rich households would like to hold *even more* safe assets at the original interest rate. Hence, for the bond market to return to equilibrium after an increase in the supply of b_S, $\frac{R}{\Pi}$ has to decline to make bonds relatively less attractive, and to limit the consumption increase and hence the decline in marginal utility of consumption $C_S^{-\sigma_S}$. By contrast, in my model, the inequality does not hold due to the presence of substantial labor income $w_S N_S$, implying that the impact of a 1 percent increase in b_S increases C_S by much less than 1 percent, generating a much weaker "income effect." Therefore the saving-supply curve slopes upward.

This result extends to the case with physical capital. Specifically, for my calibration, an increase in any of the two rates of return $\frac{R}{\Pi}$ and r_K increases rich households steady-state demand for both safe assets and capital (i.e., $\frac{\partial b_S}{\partial \frac{R}{\Pi}}, \frac{\partial K}{\partial \frac{R}{\Pi}}, \frac{\partial b_S}{\partial r_K}, \frac{\partial K}{\partial r_K} > 0$). The positive long-run cross-effects (i.e., $\frac{\partial K}{\partial \frac{R}{\Pi}}, \frac{\partial b_S}{\partial r_K} > 0$) are the result of an "income effect." For instance, an increase in $\frac{R}{\Pi}$ increases the households interest income and thus eventually consumption, thereby increasing the marginal utility of capital relative to the marginal utility of consumption.

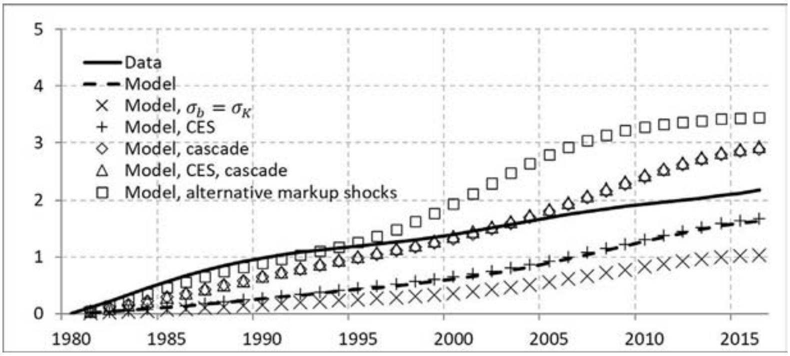
Appendix E. Further Results from the Historical Simulation of the Full Model

Figure E.1. Simulation 1981–2016: Bottom 90 Percent National Income Share



Note: This graph displays the share of the bottom 90 percent of households in national income $NIS_{CC,t}$ (see Equation (48)). See the note below Figure 5 for details on the model variants used in the simulation, the simulation setup, data treatment, and data sources.

Figure E.2. Simulation 1981–2016: Share of Housing Consumption in GDP



Note: This graph displays the share of housing consumption in GDP $\frac{CH_t}{Y,t} * 100$ and its empirical counterpart. See the note below Figure 5 for details on the model variants used in the simulation, the simulation setup, and data treatment. **Data Sources:** BEA, NIPA Table 2.5.5, Personal Consumption Expenditures by Function, line 19 "Housing."

Table E.1. Simulation 1981–2016: 2016 Values of Selected Variables

	Baseline	$\boldsymbol{\sigma_b = \sigma_K}$	**CES**	**Cascades**	**CES, Cascades**	**Alt. Markup Shocks**
Non-rich Share in Labor Income	–10.8	–10.8	–10.8	–10.8	–10.8	–10.8
Labor Share	–6.6	–6.6	–6.5	–6.6	–6.5	–8.3
Interest Rate	–3.5	–2.8	–3.6	–2.8	–2.8	–3.2
Borrower Debt-to-Income Ratio	62.8	44.0	64.0	69.5	70.7	90.7
Loan-to-Value Ratio	23.8	19.4	24.5	17.1	17.8	23.7
Housing Stock-to-GDP Ratio	17.8	7.0	17.8	39.0	38.7	42.6
Household Debt-to-GDP Ratio	21.1	13.5	21.6	23.9	24.3	30.9
Non-residential Capital-to-GDP Ratio	3.4	12.2	2.1	1.4	0.1	0.4
Non-residential-Investment-to-GDP Ratio	0.5	1.8	0.3	0.3	0.1	0.2
GDP	1.8	3.5	1.5	3.4	3.0	3.3
GDP Excluding Housing Consumption	0.0	2.3	–0.4	0.1	–0.3	–0.6

Note: This table displays the 2016 values of selected model variables implied by the simulation of Section 4.2. The column labels indicate the simulation variant. For details on the same, see the note below Figure 5. All variables are expressed as deviations from their 1980 values, with the exception of GDP, which is expressed as a percentage deviation. GDP or income appearing in the denominator of ratios is annualized. Note that GDP is defined by Equation (49), while "GDP Excluding Housing Consumption" is defined as $C_{S,t} + C_{CC,t} + I_t + G_t$.

Table E.2. Simulation 1981–2016: New Steady-State Values of Selected Variables

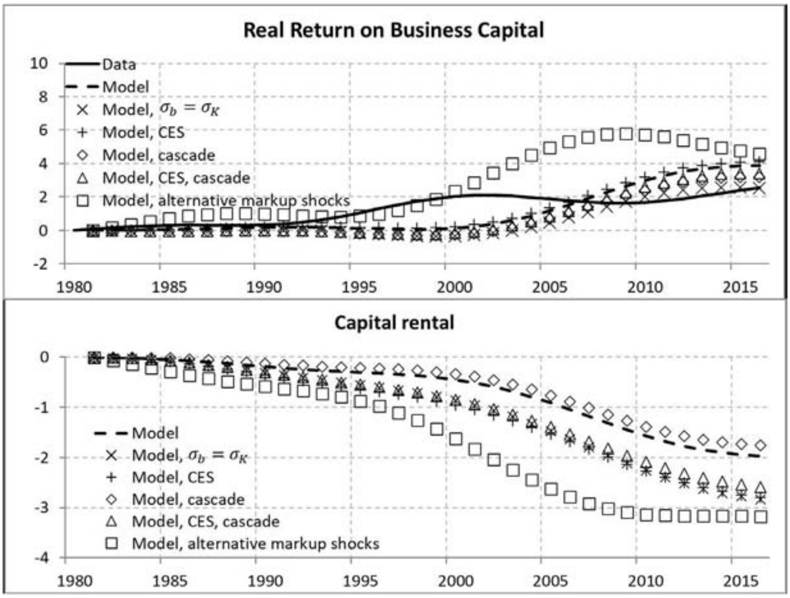
	Baseline	$\boldsymbol{\sigma_b = \sigma_K}$	CES	Cascades	CES, Cascades	Alt. Markup Shocks
Non-rich Share in Labor Income	–10.8	–10.8	–10.8	–10.8	–10.8	–10.8
Labor Share	–6.5	–6.6	–6.1	–6.5	–6.1	–8.0
Interest Rate	–4.0	–3.1	–3.9	–3.2	–3.1	–3.5
Borrower Debt-to-Income Ratio	78.2	53.8	76.6	88.7	86.5	100.6
Loan-to-Value Ratio	33.2	26.1	32.8	26.5	26.1	28.8
Housing Stock-to-GDP Ratio	17.5	7.3	17.2	38.2	37.6	42.2
Household Debt-to-GDP Ratio	27.5	17.5	27.1	31.7	31.2	35.2
Non-residential Capital-to-GDP Ratio	5.3	19.0	3.3	3.5	1.4	1.3
Non-residential-Investment-to-GDP Ratio	0.5	1.9	0.3	0.3	0.1	0.1
GDP	2.2	5.0	1.6	3.8	3.2	3.5
GDP Excluding Housing Consumption	–0.1	3.6	–0.6	0.0	–0.5	–0.7

Note: This table displays the new steady-state values of selected model variables implied by the simulation of Section 4.2. The column labels indicate the simulation variant. For details on the same, see the note below Figure 5. All variables are expressed as deviations from their 1980 values, with the exception of GDP, which is expressed as a percentage deviation. GDP or income appearing in the denominator of ratios is annualized. Note that GDP is defined by Equation (49), while "GDP Excluding Housing Consumption" is defined as $C_{S,t} + C_{CC,t} + I_t + G_t$.

Appendix F. The Return on Business Capital in the Model and the Data

A number of authors have noted that, in spite of the decline in safe interest rates, measures of the return on capital have remained stable, and perhaps even increased somewhat (e.g., Caballero, Farhi, and Gourinchas 2017; Brand, Bielecki, and Penalver 2018; Eggertsson, Robbins, and Wold 2018; and Farhi and Gourio 2018). Figure F.1 confirms this finding by displaying the widely cited measure of Gomme, Ravikumar, and Rupert (2015) (see the black solid line). All model simulations succeed in avoiding a decline in the return on business capital, though the simulated increase is somewhat delayed relative to the data. By contrast, the capital rental rate $r_{K,t}$ declines. The reason for this divergence is the rise in pure profits caused by the increase in the markup (see also the discussion of the effect of a markup shock in Section 4.1). My analysis is similar to that of Caballero, Farhi, and Gourinchas (2017), Eggertsson, Robbins, and Wold (2018), and Farhi and Gourio (2018) in that they also rely on an increase in the price markup to match the decline in the labor share and to prop up the return on capital. On top of that, in my model, CSP allows the markup increase to contribute to the decline in the risk-free rate via an increase in saving. By contrast, Caballero, Farhi, and Gourinchas (2017), Eggertsson, Robbins, and Wold (2018), and Farhi and Gourio (2018) have to rely on separate exogenous forces to match this decline, namely an increase in the household discount factor and an increase in risk.

Figure F.1. Simulation 1981–2016: Real Return on Business Capital and Real Capital Rental



Note: This graph plots the simulated path of the annualized real return on business capital (RRBC) $\frac{(1-mc_t)Y_{f,t}+(r_{K,t}-\delta)K_{t-1}}{Q_t K_{t-1}}400$, an empirical counterpart proposed by Gomme, Ravikumar, and Rupert (2015), and the simulated path of the annualized capital rental $400r_{K,t}$. See the note below Figure 5 for details on the model variants used in the simulation, the simulation setup, and data treatment. RBBC: real return on business capital.
Data Sources: Pre-tax return on business capital of Gomme, Ravikumar, and Rupert (2015) (see their Figure 2). I downloaded the updated series from Paul Gomme's webpage.

Appendix G. The Pure Profit Share in the Historical Simulation and an Alternative Parameterization of $d_{\mu,t}$

This appendix compares the simulated share of pure profits in firm value-added PS_t with empirical estimates, and also provides details on how the alternative series of markup shocks $d_{\mu,t}$ used in the robustness experiment discussed at the end of Section 4.2 is computed. "Pure profits" refers to the profits resulting from monopolistic competition, the value obtained after subtracting not just labor costs but also the (opportunity) costs of capital $r_{K,t}K_{t-1}$ from firm value-added. Hence in the model, PS_t is defined as

$$PS_t \equiv \frac{Y_{f,t} - w_{S,t}N_{S,t} - w_{CC,t}N_{CC,t} - r_{K,t}K_{t-1}}{Y_{f,t}} = 1 - \frac{1}{\mu_P + d_{\mu,t}}, \tag{G.1}$$

where the final expression is derived using Equations (37)–(42). Figure G.1 plots the simulated path of PS_t arising from my baseline simulation setup, i.e., where I invert $d_{\mu,t}$ by imposing that the labor share in the model matches the path of the trend labor share in the data as plotted in Figure 5, and two empirical estimates of PS_t. Barkai (2020) estimates the share of pure profits of the U.S. non-financial corporate sector in its gross value-added over the period 1984 to 2014 by estimating its cost of capital from BEA capital stock data and a financial-market-based estimate of the required return on capital. For their sample of publicly traded firms, De Loecker, Eeckhout, and Unger (2020) report an estimate of the average (revenue-weighted) profit rate, i.e., pure profits as a fraction of sales over the 1981–2016 period, which I convert to a fraction of value-added by multiplying it with the economy-wide gross-output-to-value-added ratio, since gross output measures economy-wide revenue.[23]

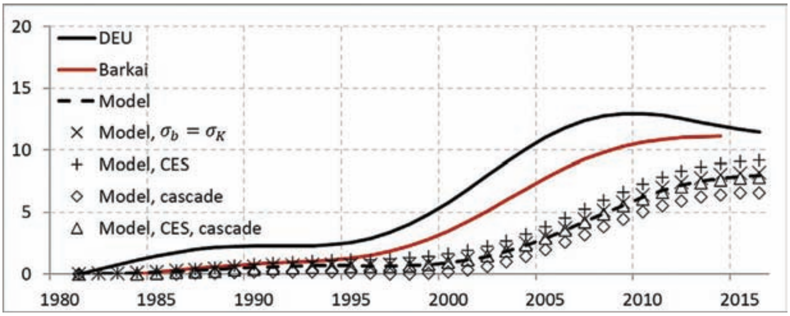
Both the estimates of Barkai (2020) and De Loecker, Eeckhout, and Unger (2020) display a gradual increase of about 1 and 2.5 percentage points, respectively, until about 1995, followed by a much

[23]Note that the validity of this conversion is *not* impaired by heterogeneity in the sales-to-value-added ratio of the firms in the De Loecker, Eeckhout, and Unger (2020) sample, since they report a *revenue-weighted* average of the profit rate. Therefore the value they report in fact equals the ratio of total profits to total sales in the sample. More formally, and using their notation, the profit rate of firm i $\pi_{i,t}$ is defined as $\pi_{it} \equiv \frac{\Pi_{i,t}}{S_{i,t}}$, where $\Pi_{i,t}$ and $S_{i,t}$ denote profits and sales, respectively. The revenue-weighted sample average of the profit rate π_t is then given by

$$\pi_t = \sum_i \left(\frac{S_{i,t}}{S_t}\right)\pi_{it} = \sum_i \frac{S_{i,t}}{S_t}\frac{\Pi_{i,t}}{S_{i,t}} = \frac{\sum_i \Pi_{i,t}}{S_t} = \frac{\Pi_t}{S_t},$$

where $\Pi_t = \sum_i \Pi_{i,t}$ and $S_t = \sum_i S_{i,t}$ denote total profits and sales, respectively. Hence I can compute the share of total profits in total value-added as $PS_t = \pi_t\left(\frac{S_t}{Y_{f,t}}\right)$. Since De Loecker, Eeckhout, and Unger (2020) do not report a $\frac{S_t}{Y_t}$ time series for their sample, I compute it as the ratio of All-industry Gross Output from the BEA's "GDP by industry" account to GDP. The ratio fluctuates between 1.7 and 1.9 over the 1980–2016 period.

Figure G.1. Simulation 1981–2016: Pure Profit Share



Note: The figure displays the path of PS_t (see Equation (G.1)) for the various model variants, and two empirical estimates. The series labeled "Barkai" is obtained from Barkai (2020) (his Figure 3B), who estimates the share of pure profits of the U.S. non-financial corporate sector in its gross value-added over the period 1984 to 2014 as the residual obtained by subtracting the cost of capital and labor from gross value-added. He estimates the cost of capital from BEA capital stock data and a financial-market-based estimate of the required return on capital. The series labeled DEU is computed from De Loecker, Eeckhout, and Unger (2020) (their Figure VIII). De Loecker, Eeckhout, and Unger (2020) report an estimate of the average (revenue-weighted) profit rate, i.e., pure profits as a fraction of sales, over the 1981–2016 period for their firm-level data set of listed companies. Their computation of profits subtracts variable costs, the opportunity costs of capital, and overhead costs from firm revenues (see their Equation (13) for details). I convert it to a fraction of value-added by multiplying it with the economy-wide gross-output-to-GDP ratio, which I computed from the BEA's "Industry Economic Account Data: GDP by Industry." I remove fluctuations with an amplitude of 2 to 16 years from all data series using the asymmetric full-sample band-pass filter of Christiano and Fitzgerald (2003), assuming a unit root with drift.

larger and steeper increase until the end of their respective samples. The PS_t trajectory in my simulation has a shape similar to the two empirical measures and tracks the estimate of Barkai (2020) closely until the second half of the 1990s. However, its inflection point is somewhat delayed compared with the two empirical measures, and the overall increase in PS_t is smaller.

Therefore, as a robustness check, I repeat the simulation of the empirical increase in inequality from Section 4.2, but now choose $d_{\mu,t}$ such that the increase in PS_t equals the path I computed from De Loecker, Eeckhout, and Unger (2020)'s results, implying that the price markup increases by more than when I target the labor share.

I limit the discussion here to the model variant with a consumption cascade and a CES technology; additional results are available upon request. The direct consequence of the stronger increase in $d_{\mu,t}$ is that the simulated post-1996 labor share decline is now larger than in the data (see Figure 5, top panel, the red square), though the difference becomes smaller towards the end of the simulation period. However, the simulated decline in the natural rate is slightly larger, and the simulation performs better at matching the increase in household indebtedness and the value of the housing stock (see Figures 5 (lower panel) through 7; compare the empty square and triangle).

Appendix H. Results with CSP Over Housing

This section examines the robustness of the results discussed in the main text to assuming that in the CSP model rich households derive utility from the market value of their housing stock $Q_{H,t}\tilde{H}_{S,t}$. Thus with CSP, the objective of rich households becomes

$$E_t\left\{\sum_{i=0}^{\infty}\beta_S^i\left[\frac{\tilde{C}_{S,t+i}^{1-\sigma_S}}{1-\sigma_S}+\frac{\tilde{\phi}_{H,S}}{1-\sigma_{H,S}}\left(Q_{H,t+i}\tilde{H}_{S,t+i}\right)^{1-\sigma_{H,S}}\right.\right.$$
$$\left.\left.+\frac{\phi_{\tilde{b}}}{1-\sigma_b}\left(\tilde{b}_{S,t+i}\right)^{1-\sigma_b}+\frac{\tilde{\phi}_K}{1-\sigma_K}\left(Q_{t+i}\tilde{K}_{t+i}\right)^{1-\sigma_K}\right]\right\} \qquad \text{(H.1)}$$

with $\tilde{\phi}_{H,S}, \tilde{\phi}_b, \tilde{\phi}_K > 0$. The economic interpretation of utility depending on $Q_{H,t}\tilde{H}_{S,t}$ is that the capitalist spirit motive extends to housing, and thus, analogously to the non-residential capital stock, it is the real *value* of the housing stock that matters for utility. By contrast, in Equation (19) in the main text, housing represents simply a durable consumption good, and thus utility depends on "the size and quality of the house," in line with the approach adopted by the literature on housing in DSGE models (Iacoviello 2005, 2015; Iacoviello and Neri 2010; Clerc et al. 2015), but not its price.

The only first-order condition affected by this change is the one for housing,

$$Q_{H,t}=\frac{Q_{H,t}^{1-\sigma_{H,S}}\phi_{H,S}}{H_{S,t}^{\sigma_{H,S}}\Lambda_{S,t}}+\beta_S E_t\left\{\frac{\Lambda_{S,t+1}}{\Lambda_{S,t}}Q_{H,t+1}\right\}, \qquad \text{(H.2)}$$

where the marginal utility from housing is now given by $\frac{Q_{H,t}^{1-\sigma_{H,S}}\phi_{H,S}}{H_{S,t}^{\sigma_{H,S}}}$ and thus with $\sigma_{H,S} > 1$ (which is what I assume) depends negatively on the house price, an effect absent from the model of the main text (see Equation (26)). Correspondingly, rich households' imputed rental income (or housing consumption) becomes

$$CH_{S,t} = \frac{Q_{H,t}^{1-\sigma_{H,S}}\phi_{H,S}}{\Lambda_{S,t}H_{S,t}^{\sigma_{H,S}}}H_{S,t}. \tag{H.3}$$

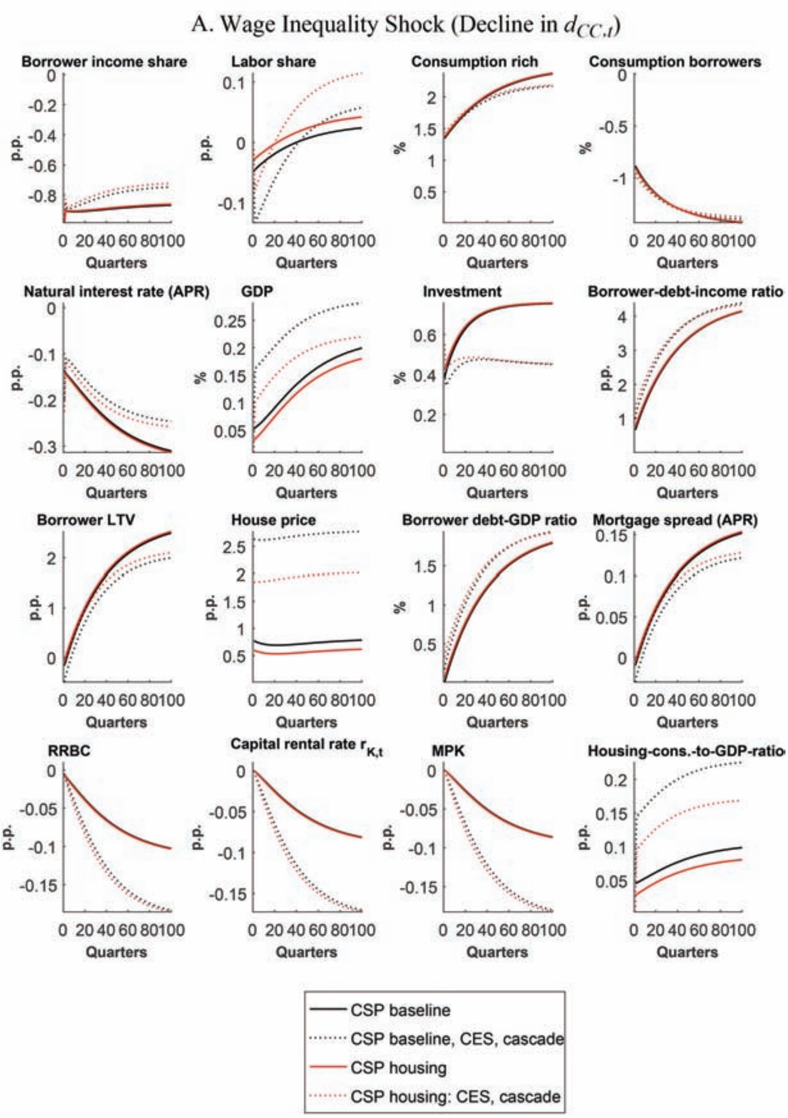
As can be obtained from Figure H.1, assuming that the capitalist spirit motive extends to housing (the lines labeled "CSP housing," in red) has a marginal impact on most variables. The exception is the house price, which increases by between one-tenth and one-quarter less than if the capitalist spirit motive does not extend to housing (the lines labeled "CSP baseline," in black), as I assume in the main text. The reason for the lower house price in the "CSP housing" model follows directly from the just-mentioned direct negative effect of the house price on the marginal utility from housing of rich households. This negative effect also dampens the increase housing consumption with respect to the baseline CSP case, implying a smaller increase in GDP Y_t.

Figures H.2–H.4 compare the results of the historical simulation in the model with baseline CSP and the model with housing CSP. Again the trajectories of the displayed variables are mostly very close across the two CSP specifications, except for the predicted increase in the value of the housing stock, which by 2016 is about one-fifth smaller with housing CSP than with baseline CSP (see Figure H.4).

In line with the discussion above, the increase in the share of housing consumption in GDP is smaller with housing CSP.

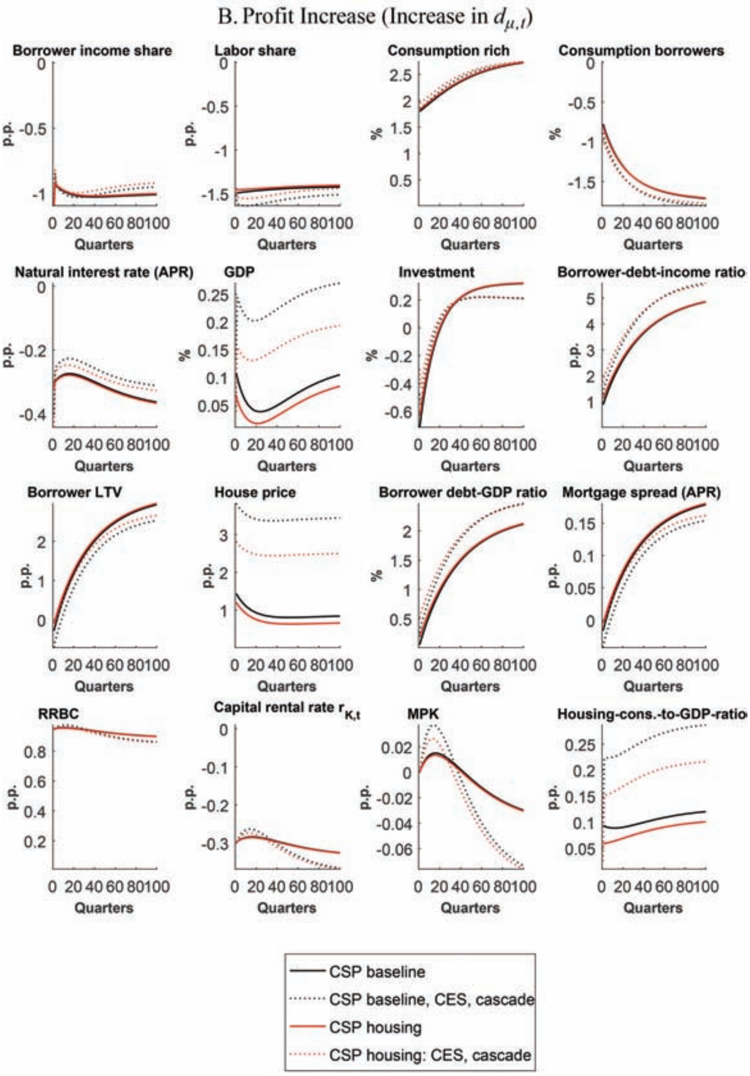
The assumption made with Equation (H.1) that, given the values of the other arguments of the utility function, rich households care *only* about the market value of their house, implying that they would be indifferent with respect to an arbitrarily large decline in their physical housing stock $\tilde{H}_{S,t+i}$ as long as its market value $Q_{H,t+i}\tilde{H}_{S,t+i}$ remains unchanged, is clearly extreme. A more plausible alternative would be to posit that utility depends on a Cobb-Douglas aggregate of the physical housing stock and its market value, i.e., $\left(Q_{H,t+i}\tilde{H}_{S,t+i}\right)$ in (H.1) would be replaced

Figure H.1. Impact of a Permanent Increase in Inequality: Role of Loan Supply Assumption



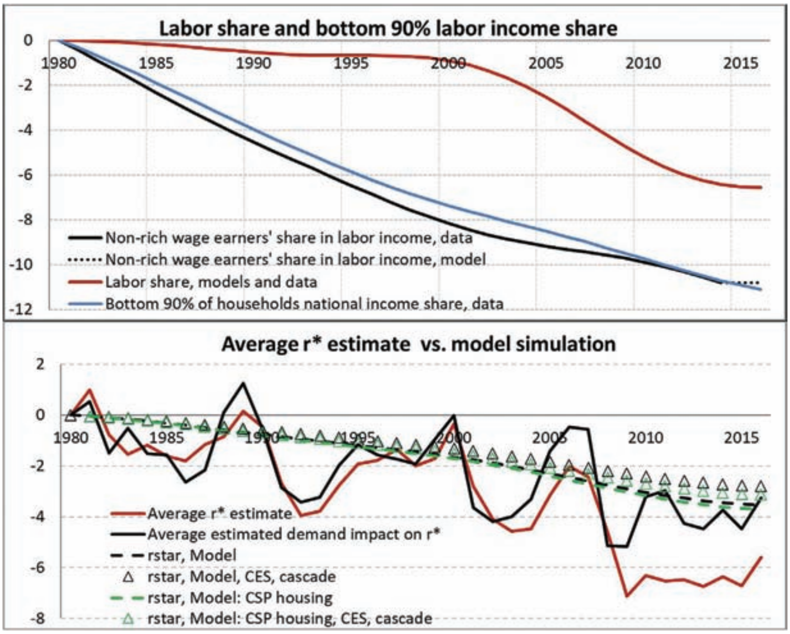
(*continued*)

Figure H.1. (Continued)



Note: The black lines ("CSP baseline") refer to results computed using the model of Section 3. The red lines ("CSP housing") refer to a modified version of the model where rich households derive utility from the market value of the housing stock (see Equation (19)). "cascade" indicates that the model allows for an effect of rich household total consumption on non-rich housing demand (i.e., $\nu_{cascade} > 0$; see Equation (35)). The safe interest rate R_t and the risk spread $E_t R_{L,t+1} - R_t$ are expressed as annualized percentage rates (APR). The borrower debt-to-income ratio is based on annualized borrower income. The borrower debt-to-GDP ratio is based on annualized GDP.

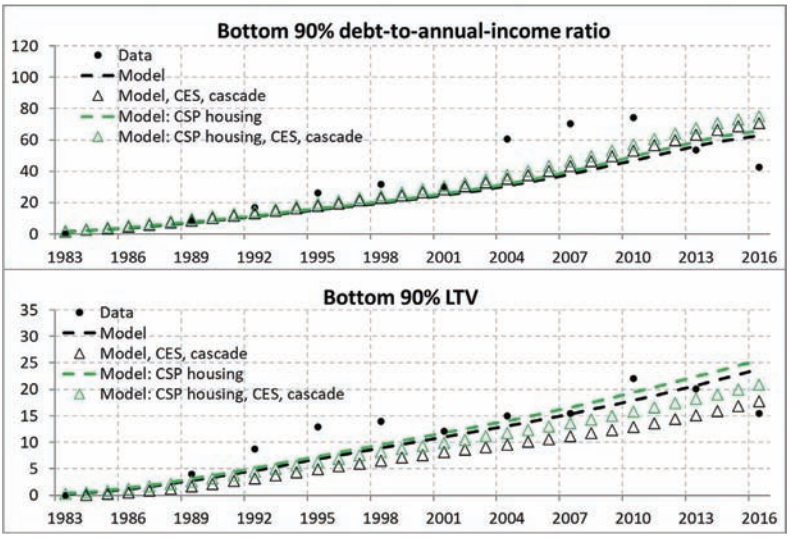
Figure H.2. Simulation 1981–2016: Income Distribution and Natural Interest Rate



Note: The label "Model: CSP housing" refers to a modified version of the model where rich households derive utility from the market value of the housing stock (see Equation (19)). For details on the meaning of the other labels, see the note below Figure 5.

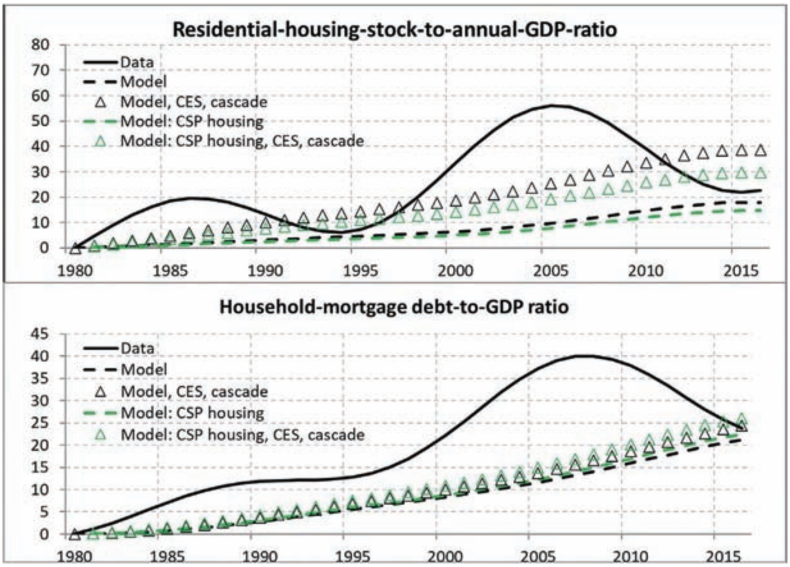
by $\left(Q_{H,t}\tilde{H}_{S,t}\right)^{\alpha_{MV}} \tilde{H}_{S,t}^{1-\alpha_{MV}} = Q_{H,t}^{\alpha_{MV}}\tilde{H}_{S,t}$, with $0 \leq \alpha_M \leq 1$. For $0 < \alpha_{MV} < 1$, simulation results (not shown) are in between those obtained for the baseline CSP and the housing CSP case.

Figure H.3. Simulation 1981–2016: Borrower Debt-to-Income Ratio and LTV



Note: See the note below Figure H.2 for details on the labels reading "Model . . .". See the note below Figure 6 for details on the data sources.

Figure H.4. Simulation 1981–2016: Housing Stock and Total Mortgage Debt-to-GDP Ratios

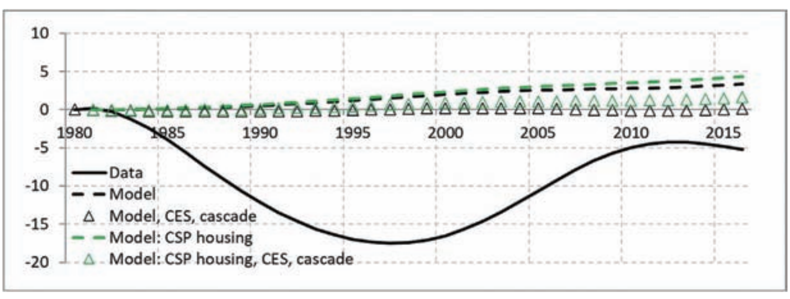


Note: See the note below Figure H.2 for details on the labels reading "Model . . .". See the note below Figure 7 for details on the data sources.

Appendix I. Steady-State Solution of the Full Model in (Almost) Closed Form

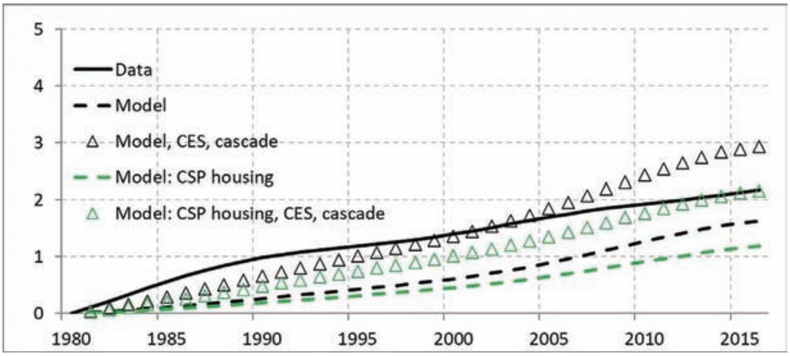
This appendix shows how to compute the steady state of the full model in almost closed form, given 13 of the 15 empirical targets listed in Table 4 (i.e., all targets except for the MPS of the rich and the effect of a permanent increase in the supply of government bonds on the safe interest rate $\frac{d\frac{R}{\Pi}}{d\text{Target}_{bgov2GDP}}$), and using 13 of the 15 parameters whose values are marked with an asterisk (*) in Table 3 (i.e., $\sigma_S/\sigma_{CC}, \beta_S, \beta_{CC}, \phi_{H,S}, \phi_{H,CC}, \phi_b, \phi_K, \chi_{CC}, \alpha_K, \mu_P, \omega_{CC}, Target_{G2GDP}, Target_{bgov2GDP}$) to support those targets. For that purpose, in the first iteration of the computation, I will set an (intermediate) target for the non-rich households' LTV $\left(\frac{b_{CC}}{Q_H H_{CC}}\right)$ instead of their debt-to-annual income ratio $\left(\frac{b_{CC}}{4w_{CC}N_{CC}}\right)$. Furthermore, in order to render the steady state identical regardless of whether I assume a CES or Cobb-Douglas production function, I assume $A_N = \frac{Y_f}{N}$ and $A_K = \frac{Y_f}{K}$.

Figure I.1. Simulation 1981–2016: Private Non-residential Producible Capital-Stock-to-GDP Ratio



Note: See the note below Figure E.2 for details on the labels reading "Model . . .". See the note below Figure 8 for details on the data sources.

Figure I.2. Simulation 1981–2016: Share of Housing Consumption in GDP



Note: See the note below Figure E.2 for details on the labels reading "Model . . .". See the note below Figure 7 for details on the data sources.

From the target for the IES, the definitions of θ and ep and the targets for θ, $\frac{R}{\Pi}$, mp, and ep follows:

$$\sigma_S = \sigma_{CC} = \frac{1}{IES} \tag{I.1}$$

$$\beta_S = \frac{\theta}{\left(\frac{R}{\Pi}\right)} \tag{I.2}$$

$$R_L = R\left(1 + ep\right) \tag{I.3}$$

$$r_K = \left(1 + ep\right)\frac{R}{\Pi} + \delta - 1. \tag{I.4}$$

From the targets for $\left(\frac{Q_H H}{4Y}\right)$ and $\left(\frac{H_{CC}}{H}\right)$,

$$\frac{Q_H H_{CC}}{Y} = \left(\frac{Q_H H}{4Y}\right) 4 \left(\frac{H_{CC}}{H}\right) \tag{I.5}$$

$$\frac{Q_H H_S}{Y} = \left(\frac{Q_H H}{4Y}\right) 4 \left(\frac{H_S}{H}\right). \tag{I.6}$$

Furthermore, multiplying the target for $\left(\frac{b_{CC}}{Q_H H_{CC}}\right)$ and $\frac{Q_H H_{CC}}{Y}$, we have

$$\frac{b_{CC}}{Y} = \left(\frac{b_{CC}}{Q_H H_{CC}}\right)\left(\frac{Q_H H_{CC}}{Y}\right). \tag{I.7}$$

Using Equations (29), (34), and (32) then allows to back out the slope of the loan supply curve χ_{CC}, $\left(\frac{dR_L}{db_{CC}}(..)\, b_{CC}\right)$, and β_{CC}, and to calculate share of the cost of the financial friction in output $\frac{b_{CC}}{Y} f(..)\, R$:

$$\chi_{CC} = \left(\frac{R_L}{R} - 1\right)\frac{1}{\left(\frac{b_{CC}}{Q_H H_{CC}}\right)} \tag{I.8}$$

$$\frac{dR_L}{db_{CC}}(..)\, b_{CC} = R\chi_{CC}\left(\frac{b_{CC}}{Q_H H_{CC}}\right) \tag{I.9}$$

$$\beta_{CC} = \frac{1}{\frac{R_L}{\Pi} + \frac{\left(\frac{dR_L}{db_{CC}}(..) b_{CC}\right)}{\Pi}} \tag{I.10}$$

$$\frac{b_{CC}}{Y} f(..)\, \frac{R}{\Pi} = \frac{\frac{dR_L}{db_{CC}}(..)\, b_{CC}}{\Pi}\left(\frac{b_{CC}}{Y}\right). \tag{I.11}$$

Furthermore, rearranging the first-order conditions with respect to housing (26) and (33) allows to find the share of housing consumption in GDP $\left(\frac{CH}{Y}\right)$ as follows:

$$Q_H H_S\,(1-\beta_S) = \frac{\phi_{H,S} H_S^{1-\sigma_{H,S}}}{\Lambda_S} = CH_S$$

$$\begin{aligned} H_{CC} Q_H\,(1-\beta_{CC}) = {} & \frac{\phi_{H,CC}}{\Lambda_{CC}} H_{CC}^{1-\sigma_{H,CC}} \\ & - \beta_{CC}\frac{\frac{dR_L}{dH_{CC}}\left(\frac{b_{CC}}{H_{CC} Q_H}\right)}{\Pi} b_{CC} = CH_{CC} \end{aligned}$$

or

$$\frac{CH_S}{Y} = \left(\frac{Q_H H_S}{Y}\right)(1-\beta_S) \tag{I.12}$$

$$\frac{CH_{CC}}{Y} = \left(\frac{H_{CC} Q_H}{Y}\right)(1-\beta_{CC}) \tag{I.13}$$

$$\frac{CH}{Y} = \left(\frac{CH_S}{Y}\right) + \left(\frac{CH_{CC}}{Y}\right). \tag{I.14}$$

From (43), we have the ratio of GDP to firm output as

$$\frac{Y}{Y_f} = \frac{1}{1 - \frac{CH}{Y} + \frac{b_{CC}}{Y} f\left(LTV\right) \frac{R}{\Pi}}. \tag{I.15}$$

I can now calculate the economy's supply side. From Equation (21) and the target for $\left(\frac{I}{Y}\right)$,

$$\frac{K}{Y_f} = \frac{\left(\frac{I}{Y}\right)}{\delta}\left(\frac{Y}{Y_f}\right). \tag{I.16}$$

From (39) and (40), and using $A_N = \frac{Y_f}{N}$ and $A_K = \frac{Y_f}{K}$,

$$\begin{aligned}\left(\frac{wN}{Y}\right)\left(\frac{Y}{Y_f}\right) &= \frac{w_S N_S + w_{CC} N_{CC}}{Y_f} \\ &= \frac{mc\left(1-\alpha_K\right)\left(\frac{Y_f}{A_N N}\right)^{\frac{1}{\epsilon}}\left[\left(1-\omega_{CC}\right) N A_N + \omega_{CC} N A_N\right]}{Y_f} \\ &= mc\left(1-\alpha_K\right).\end{aligned}$$

Combining this expression with (38) to eliminate mc and using (42) allows to back out α_K and μ_P, and finally mc:

$$\alpha_K = \frac{r_K \frac{K}{Y_f}}{\left(\frac{wN}{Y}\right)\left(\frac{Y}{Y_f}\right) + r_K \frac{K}{Y_f}} \tag{I.17}$$

$$\mu_P = \frac{1-\alpha_K}{\left(\frac{wN}{Y}\right)\left(\frac{Y}{Y_f}\right)} \tag{I.18}$$

$$mc = \frac{1}{\mu_P}. \tag{I.19}$$

Total firm output for the CES and Cobb-Douglas case are given by

$$Y_f = \left[(1-\alpha_K)(A_N N)^{\frac{\epsilon-1}{\epsilon}} + \alpha_K (A_K K)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}$$

$$Y_f = (A_N N)^{1-\alpha_K} (A_K K)^{\alpha_K}.$$

Substituting my assumptions $A_N = \frac{Y_f}{N}$ and $A_K = \frac{Y_f}{K}$ into either equation yields $Y_f = Y_f$, implying that the steady-state level of firm output is indeterminate. Hence the $A_N = \frac{Y_f}{N}$, $A_K = \frac{Y_f}{K}$ assumption yields an additional degree of freedom, which, without loss of generality, I close by fixing Y_f at an arbitrary level. I can then directly compute a range of other variables, using the values computed or calibrated above,

$$K = \left(\frac{K}{Y_f}\right) Y_f \tag{I.20}$$

$$A_K = \frac{Y_f}{K} \tag{I.21}$$

$$Y = \left(\frac{Y}{Y_f}\right) Y_f \tag{I.22}$$

$$K = \left(\frac{K}{Y_f}\right) Y_f \tag{I.23}$$

$$I = \delta K \tag{I.24}$$

$$G = \left(\frac{G}{Y}\right) Y \tag{I.25}$$

$$Q_H = \left(\frac{Q_H H}{4Y}\right) \frac{4Y}{H} \tag{I.26}$$

$$H_{CC} = \left(\frac{H_{CC}}{H}\right) H \tag{I.27}$$

$$H_S = H - H_{CC} \tag{I.28}$$

$$CH = \left(\frac{CH}{Y}\right) Y \tag{I.29}$$

$$CH_{CC} = \left(\frac{CH_{CC}}{Y}\right) Y \tag{I.30}$$

$$b_{CC} = \left(\frac{b_{CC}}{Y}\right) Y \tag{I.31}$$

$$Target_{G2GDP} = \left(\frac{G}{Y}\right) \tag{I.32}$$

$$Target_{bgov2GDP} = \left(\frac{b_{gov}}{4Y}\right) \tag{I.33}$$

$$b_{gov} = \left(\frac{b_{gov}}{4Y}\right) 4Y \tag{I.34}$$

$$T = \left(\frac{R}{\Pi} - 1\right) b_{gov} + G \tag{I.35}$$

$$NI = Y - \delta K, \tag{I.36}$$

where (I.24), (I.36), and (I.35) follow from the capital accumulation equation (21), (47,) and the government budget constraint (11), respectively.

Substituting (40) into (48) allows to back out the share of non-rich households in total labor income ω_{CC} as

$$\omega_{CC} = \frac{NIS_{CC}\left(\left(1 + \frac{b_{gov}}{NI}\left(\frac{R}{\Pi} - 1\right)\right) NI\right) + b_{CC}\left(\frac{R_L}{\Pi} - 1\right)\frac{R}{\Pi} - \frac{H_{CC}}{H} CH}{mc\left(1 - \alpha_K\right) Y_f}. \tag{I.37}$$

Using my assumption $\eta_S = N_S$ and $\eta_{CC} = N_{CC}$, total employment (from Equation (41)) and A_N are given by

$$N = 1 \tag{I.38}$$

$$A_N = \frac{Y_f}{N}. \tag{I.39}$$

From (39), (40), $A_N = \frac{Y_f}{N}$, and $A_K = \frac{Y_f}{K}$ follows

$$w_S = mc_t\left(1 - \alpha_K\right)\left(1 - \omega_{CC}\right)\frac{Y_f}{N_S} \tag{I.40}$$

$$w_{CC} = mc\left(1 - \alpha_K\right)\omega_{CC}\frac{Y_f}{N_{CC}} \tag{I.41}$$

$$w = mc\left(1 - \alpha_K\right) A_N, \tag{I.42}$$

which then allows to compute, from Equations (46), (45), (30), and (49),

$$Target_{T_{CC}2T} = NIS_{CC} \tag{I.43}$$

$$T_{CC} = Target_{T_{CC}2T}T \tag{I.44}$$

$$T_S = T - T_{CC} \tag{I.45}$$

$$C_{CC} = w_{CC}N_{CC} - T_{CC} - \left(\frac{R_L}{\Pi} - 1\right) b_{CC} \tag{I.46}$$

$$C_S = Y - C_{CC} - G - I - CH_t. \tag{I.47}$$

From the consumption FOCs (22), (31), and the investment FOC (25),

$$\Lambda_S = \frac{1}{C_S^{\sigma_C}} \tag{I.48}$$

$$\Lambda_{CC} = \frac{1}{C_{CC}^{\sigma_{CC}}} \tag{I.49}$$

$$Q = 1. \tag{I.50}$$

Using the FOCs with respect to housing ((26) and (33)), safe assets (Equation (23)), and capital (Equation (24)), and setting σ_b and σ_K for now to some arbitrary value, allows to back out the utility weights for housing $\phi_{H,S}$ and $\phi_{H,CC}$, safe assets ϕ_b, and physical capital ϕ_K as

$$\phi_{H,S} = Q_H \left(1 - \beta_S\right) \Lambda_S H_S^{\sigma_{H,S}} \tag{I.51}$$

$$\phi_{H,CC} = Q_H(1 - \beta_{CC}) \Lambda_{CC} H_{CC}^{\sigma_{H,CC}} + \beta_{CC} \frac{\frac{dR_L}{dH_{CC}}(..)}{\Pi} b_{CC}\Lambda_{CC}H_{CC}^{\sigma_{H,CC}} \tag{I.52}$$

$$\phi_b = (1 - \theta) \Lambda_S b_S^{\sigma_b} \tag{I.53}$$

$$\phi_K = \Lambda_S \left(1 - \beta_S \left[r_K + (1 - \delta)\right]\right) (K)^{\sigma_K}. \tag{I.54}$$

Finally, I adjust the target for the $\left(\frac{b_{CC}}{Q_H H_{CC}}\right)$ in order to set the implied debt-to-annual-income ratio $\left(\frac{b_{CC}}{4w_{CC}N_{CC}}\right)$ to its target value.

After pinning down the steady state as just described, I then set σ_b and σ_K to match the empirical targets for the effect of a permanent increase in the supply of government bonds on the safe interest rate $\frac{d\frac{R}{\Pi}}{d\text{Target}_{bgov2GDP}}$, and the MPS of the rich, respectively, as described in Section 3.6.1. Note that, thanks to the (almost) closed-form solution, all changes in σ_b and σ_K are absorbed by ϕ_K and ϕ_b, implying that the steady state remains unaffected.

Appendix J. A Simple Microfoundation of the Borrowing Friction

The increasing relationship between the loan rate $R_{L,t}$ and the borrower LTV assumed in the main text may be microfounded by assuming borrowing is subject to frictions similar to Lozej, Onorante, and Rannenberg (2018). Specifically, I assume that the household's housing wealth is subject to idiosyncratic uncertainty which resolves at the beginning of the period, and that a household j defaults if its housing wealth is less than its real debt $\frac{R_{Lj,,t}}{\Pi_t} b_{CC,j,t-1}$. More formally, default occurs if

$$\omega_{j,t} H_{CC,j,t-1} Q_{H,j,t} < \frac{R_{L,j,t}}{\Pi_t} b_{CC,j,t-1},$$

where $\omega_{j,t}$ denotes an i.i.d. random variable with mean one. Hence the default threshold of household j is given by

$$\overline{\omega_{j,t}} = \frac{\frac{R_{L,j,t}}{\Pi_t} b_{CC,j,t-1}}{H_{CC,j,t-1} Q_{H,j,t}}. \tag{J.1}$$

I assume that if $\omega_{j,t}$ falls below the default threshold and the household therefore defaults, the loss given default incurred by the financial intermediary is fixed at a fraction LGD of the loan, with $0 \leq LGD \leq 1$. Furthermore, in order to abstract from the effect of loan losses on the financial intermediary, I follow Bernanke, Gertler, and Gilchrist (1999) and assume that the debt contract is contingent on the realization of aggregate variables to ensure that, in every quarter, the financial intermediary earns an average nominal rate of return $R_{t-1} FIC$, where $FIC - 1$ represents non-bankruptcy related costs of financial intermediation, which I assume to be a fixed fraction of the total loan amount. Hence, the interest rate adjusts accordingly ex post and is given by

$$R_{L,j,t} = \frac{R_{t-1} FIC}{1 - LGDJ\left(\overline{\omega_{j,t}}\right)}, \tag{J.2}$$

where $J\left(\overline{\omega_t}\right)$ denotes the cumulative distribution function of $\omega_{j,t}$. This equation replaces the ad hoc loan supply relationship assumed in the main text (i.e., Equation (29)). Finally, defaulting households face a cost $LGD\frac{R_{L,j,t}}{\Pi_t} b_{CC,j,t-1}$, implying that otherwise identical defaulting and non-defaulting households face identical debt-related payments at the beginning of period t.[24] After $\omega_{j,t}$ has been revealed and some households default, resources are redistributed between borrower households such that their housing wealth is again identical before they make their consumption and saving decisions. With these assumptions, the borrowing household's budget constraint is identical regardless of default, and I therefore drop the j subscript from now on:

$$\begin{aligned} &\frac{R_{L,t}}{\Pi_t} b_{CC,t-1} + C_{CC,t} + Q_{H,t}\left(H_{CC,t} - H_{CC,t-1}\right) \\ &\qquad = b_{CC_t} + w_{CC,t} N_{CC,t} - T_{CC,t}. \end{aligned} \tag{J.3}$$

The FOCs with respect to consumption $C_{CC,t}$, real loans $b_{CC,t}$, housing $H_{CC,t}$, and the expected loan interest rate $R_{L,t+1}$ imply

$$\Lambda_{CC,t} = \frac{1}{C_{CC,t}^{\sigma_{CC}}} \tag{J.4}$$

$$\Lambda_{CC,t} = \beta_{CC} E_t \left\{ \Lambda_{CC,t+1} \left[\frac{R_{L,t+1}}{\Pi_{t+1}} + \frac{\frac{dR_{L,t+1}}{db_{CC,t}} \left(\bar{\omega}_{t+1}, R_{L,t+1}, b_{CC,t}\right) b_{CC,t}}{\Pi_{t+1}} \right] \right\} \tag{J.5}$$

[24]Specifically, at the beginning of period t, a non-defaulting households repays $\frac{R_{L,,t}}{\Pi_t} b_{CC,t-1}$, while a defaulting household repays $(1 - LGD)\frac{R_{L,,t}}{\Pi_t} b_{CC,t-1}$ but faces default costs $LGD\frac{R_{L,,t}}{\Pi_t} b_{CC,t-1}$, which amount to the same debt-related payment as that of the non-defaulting households. This assumption is necessary to ensure that a change in the lending rate caused by an increase in the expected probability of default $E_t J_{t+1}$ has an effect on household behavior.

$$Q_{H,t} = \frac{\phi_{H,t,CC}}{\Lambda_{CC,t} H_{CC,t}^{\sigma_{H,CC}}} + \beta_{CC} E_t \Bigg\{ \frac{\Lambda_{CC,t+1}}{\Lambda_{CC,t}} \left(Q_{H,t+1} - \frac{\frac{dR_{L,t+1}}{dH_{CC,t}} \left(\bar{\omega}_{t+1}, R_{L,t+1}, H_{CC,t}\right)}{\Pi_{t+1}} b_{CC,t} \right) \Bigg\}, \tag{J.6}$$

where $\frac{dR_{L,t+1}}{db_{CC,t}} \left(\bar{\omega}_{t+1}, R_{L,t+1}, b_{CC,t}\right)$ and $\frac{dR_{L,t+1}}{dH_{CC,t}} \left(\bar{\omega}_{t+1}, R_{L,t+1}, H_{CC,t}\right)$ denote the implicit function derivatives of $R_{L,t+1}$ with respect to $b_{CC,t}$ and $H_{CC,t}$, respectively, given by

$$\frac{dR_{L,t+1}\left(\bar{\omega}_{t+1}, R_{L,t+1}\right)}{db_{CC,t}} = \frac{LGDJ'\left(\bar{\omega}_{t+1}\right) \frac{\bar{\omega}_{t+1}}{b_{CC,t}} R_{L,t+1}}{\left(1 - LGDJ\left(\bar{\omega}_{t+1}\right) - LGDJ'\left(\bar{\omega}_{t+1}\right) \bar{\omega}_{t+1}\right)} \tag{J.7}$$

$$\frac{dR_{L,t+1}}{dH_{CC,t}} \left(\bar{\omega}_{t+1}, R_{L,t+1}, H_{CC,t}\right) = \frac{-LGDJ'\left(\bar{\omega}_{t+1}\right) \frac{\bar{\omega}_{t+1}}{H_{CC,t}} R_{L,t+1}}{\left(\left(1 - LGDJ\left(\bar{\omega}_{t+1}\right)\right) - LGDJ'\left(\bar{\omega}_{t+1}\right) \bar{\omega}_{t+1}\right)}. \tag{J.8}$$

For $\frac{dR_{L,t+1}(\bar{\omega}_{t+1}, R_{L,t+1})}{db_{CC,t}} > 0$ and $\frac{dR_{L,t+1}}{dH_{CC,t}} \left(\bar{\omega}_{t+1}, R_{L,t+1}, H_{CC,t}\right) < 0$ it has to be true that $\frac{1}{LGD} > J\left(\bar{\omega}_{t+1}\right) + J'\left(\bar{\omega}_{t+1}\right) \bar{\omega}_{t+1}$. For this inequality to hold, it is sufficient if its right-hand side is less than one. That condition is met under the assumptions I adopt below. I assume a logistic form for $J\left(\overline{\omega_t}\right)$:

$$J\left(\overline{\omega_t}\right) = \frac{1}{1 + e^{-\frac{\bar{\omega}_t - 1}{\sigma_h}}}. \tag{J.9}$$

Hence, loan supply is now determined by the three parameters FIC, LGD, and σ_h, while the slope parameter of the ad hoc loan supply curve χ_{CC} drops out of the model. To identify the parameters of the model, I therefore need two additional targets on top of those listed in Table 4. These two additional targets are listed in Table J.1. I pin down FIC by adopting a target value for the ratio of non-bankruptcy-related costs to net interest income $\frac{(FIC-1)}{R_L - R}$, which I estimate based on the FDIC Quarterly Banking Profile. Specifically,

Table J.1. Additional Targets Microfounded Borrowing Friction

Target	Value Data	NOCSP	CSP	Source
Mortgage Default Rate (APR) $J()$	4.2%	4.2%	4.2%	Single-Family Residential Mortgages, FRED (1991–2016)
Non-default-Costs-to-Interest-Income Ratio $\frac{(FIC-1)}{R_L-R}$	59%	59%	59%	FDIC QBP, (1984–2016); See note below for details

Note: This table lists the two additional targets I use in the model with the microfounded borrowing friction. For the other targets, see Table 4. The empirical counterpart of the non-default-costs-to-interest-income ratio $\frac{(FIC-1)}{R_L-R}$ is computed from the FDIC Quarterly Banking Profile as $\frac{\left(\frac{\text{Total noninterest expense}}{\text{Total Assets}}\right)}{\left(\frac{\text{Net interest income}}{\text{Total loans and leases}}\right)}$.

I calculate $\frac{\left(\frac{\text{Total noninterest expense}}{\text{Total Assets}}\right)}{\left(\frac{\text{Net interest income}}{\text{Total loans and leases}}\right)} \approx 59\%$. I set the steady-state default rate $J(\bar{\omega})$ equal to the average "Delinquency Rate on Single-Family Residential Mortgages, Booked in Domestic Offices, All Commercial Banks," which equals an annualized 4.2 percent. Using the (implied) values of FIC, $J(\bar{\omega})$, the (unchanged) target value for $R_L - R$ and Equation (J.2) pin down the required LGD value. Table J.2 displays the complete list of targets and parameter values. Values which differ from the model with the ad hoc borrowing friction of the main text are in bold.

Figure K.1 in Appendix K compares the loan supply curve implied by the ad hoc borrowing friction to the microfounded loan supply curve (Equation (J.2)). The curves cross at an LTV of 0.27, which is the steady-state value implied by the empirical targets.

Table J.2. Full Model, Parameter Values

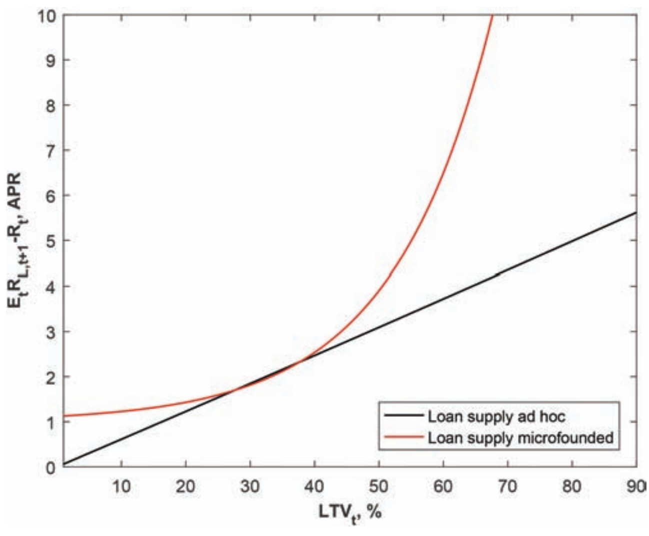
Parameter	Parameter Name	Value NOCSP ($\theta = 1$)	Value CSP ($\theta = 0.97$)
β_S	Rich Utility Discount Factor	0.9951*	0.9652*
β_{CC}	Borrower Utility Discount Factor	0.9881*	0.9881*
σ_S, σ_{CC}	Utility Curvature Consumption	2*	2*
$\sigma_{S,H}$, $\sigma_{CC,H}$	Utility Curvature Housing	2	2
$\phi_{H,S}$	Rich Utility Weight on Housing	0.16*	1.29*
$\phi_{H,CC}$	Borrower Utility Weight on Housing	0.58*	0.66*
$\nu_{cascade}$	Consumption Cascade	0	0/0.7
$\tilde{N}_{CC}$,$\tilde{N}_S$	Labor Endowments	$\frac{1}{3}$	$\frac{1}{3}$
μ_P	Price Markup	1.18*	1.06*
α_K	Output Elasticity w.r.t. Capital	0.19*	0.24*
ε	Elasticity of Substitution Capital/Labor	1	1; 0.3
ω_{CC}	Borrower Share in Labor Income	0.84*	0.8*
δ	Depreciation Rate Physical Capital	0.025	0.025
ε_{I}	Capital Adjustment Cost Curvature	7	7
FIC	**Non-default Intermediation Cost**	1.0025*	1.0025*
σ_h	**Volatility Housing Value Shock**	0.16*	0.16*
LGD	**Loss Given Default**	0.16*	0.16*
$Target_{bgov2GDP}$	Government Debt Target	44%	44%
$Target_{G2GDP}$	Government Expenditure Share Target	20%	20%
σ_b	CSP: Utility Curvature, Real Financial Assets	—	0.69*
σ_K	CSP: Utility Curvature, Physical Capital	—	5*
ϕ_b	CSP: Utility Weight on Real Financial Assets	0*	3.28*
ϕ_K	CSP: Utility Weight on Physical Capital	0*	220.43*

Note: Values marked with an asterisk (*) are set to match the targets reported in Table J.1.

Appendix K. Results with the Microfounded Loan Supply Curve

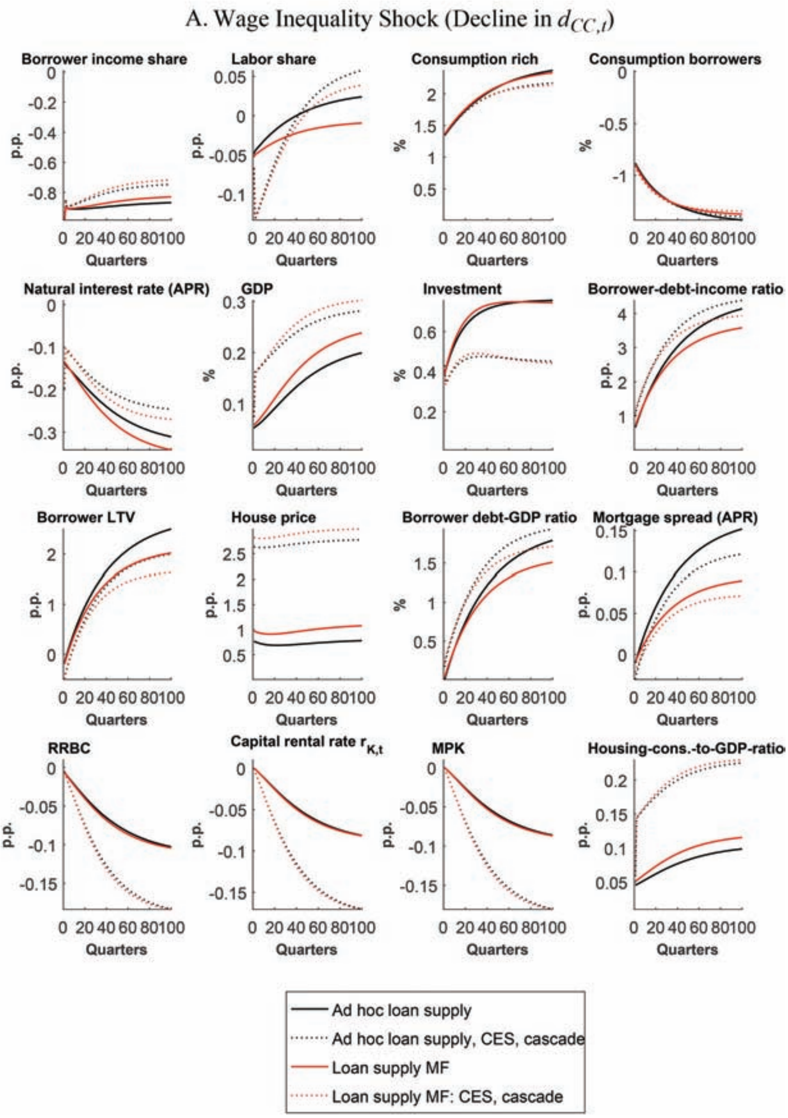
As can be seen from Figure K.2, exchanging the ad hoc loan supply curve assumed in the main text (black lines) for the more micro-founded one from Appendix J (red lines) has virtually no impact on the simulated effects of a one-off permanent increase in wage inequality or the price markup. The reason is that around the initial steady state, the slope of the ad hoc and microfounded loan supply curves are in fact quite similar (see Figure K.1).

Figure K.1. Loan Supply Curve



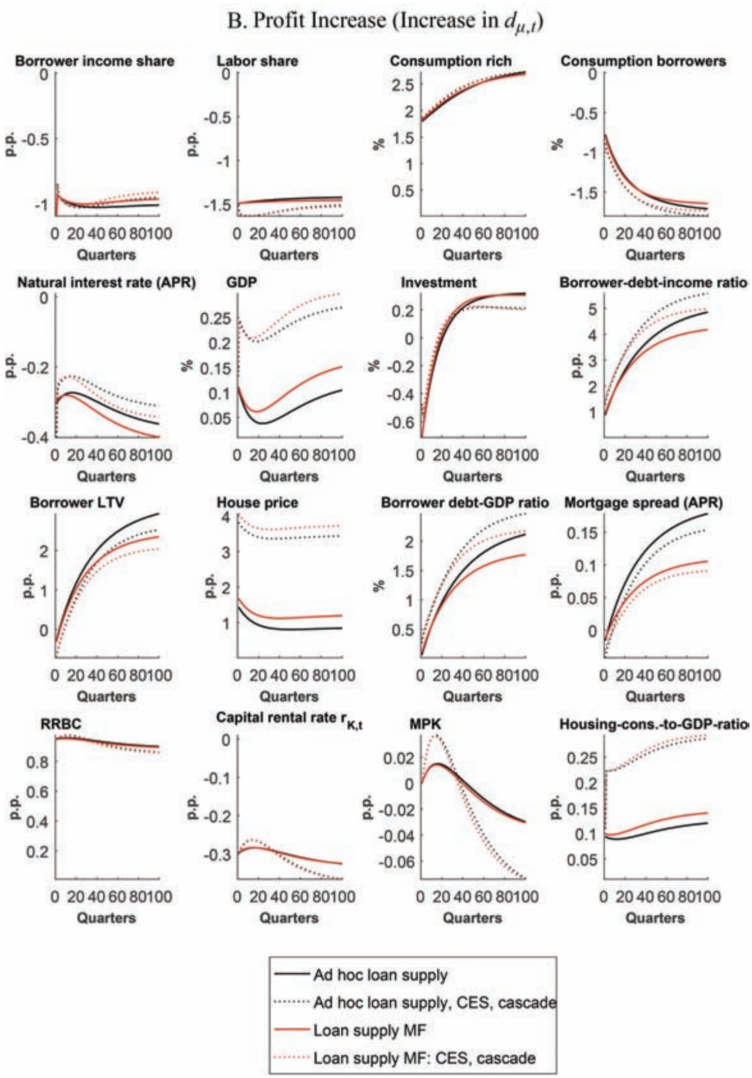
Note: The linear black line displays the relationship between the spread of the mortgage rate over the risk-free rate (i.e., $E_tR_{L,t+1}- R_t$) and the loan-to-value ratio $\left(LTV_t = \frac{b_{CC,t}}{H_{CC,t}Q_{H,t+1}}\right)$ implied by the borrowing friction assumed in the main text (see Equations (34) and (29)), with χ_{CC} as in Table 3. The non-linear red line displays the analogous relationship implied by the microfounded borrowing friction derived in Appendix J (see Equations (J.2), (J.1), and (J.9)) and the calibration discussed in Appendix K.

Figure K.2. Impact of a Permanent Increase in Inequality: Role of Loan Supply Assumption



(*continued*)

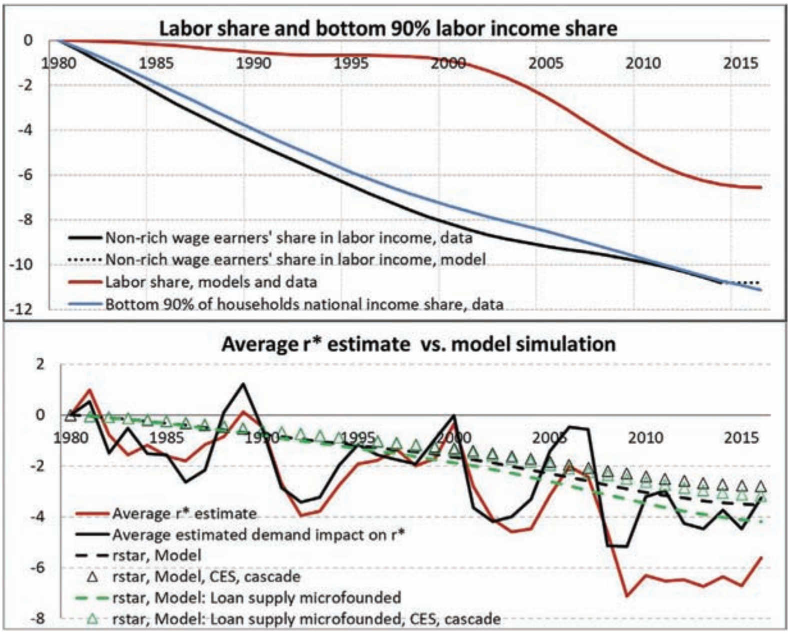
Figure K.2. (Continued)



Note: The black lines ("Ad hoc loan supply") refer to results computed using the model of Section 3. The red lines ("Loan supply MF") refer to a modified version of the model where the borrowing friction is microfounded as described in Appendix J, implying that Equations (J.1), (J.2), and (J.9) replace Equations (34) and (29). "cascade" indicates that the model allows for an effect of rich household total consumption on non-rich housing demand (i.e., $\nu_{cascade} > 0$; see Equation (35)). The safe interest rate R_t and the risk spread $E_t R_{L,t+1} - R_t$ are expressed as annualized percentage rates (APR). The borrower debt-to-income ratio is based on annualized borrower income. The borrower debt-to-GDP ratio is based on annualized GDP.

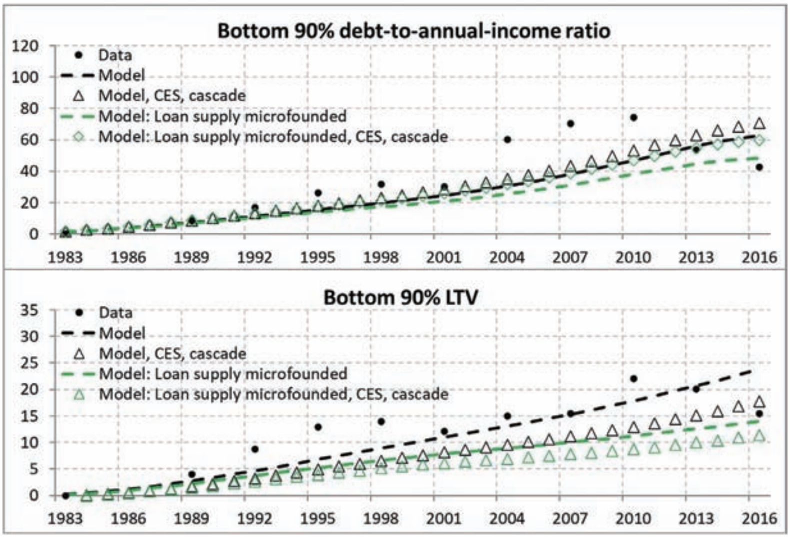
The historical simulation described in Section 4.2 yields a somewhat larger decline in the natural rate (see Figure K.3) and a somewhat smaller increase in household indebtedness than when assuming the ad hoc loan supply curve (see Figures K.4 and K.5). The reason is that, in this simulation, the model is hit by a sequence of shocks moving the economy further away from the initial steady state than in the simulation of a one-off increase in inequality. The LTV therefore moves into the region where the microfounded loan supply curve becomes substantially steeper than the ad hoc loan supply curve used in the main text (see 19), implying that borrowing does not expand as much in response to a decline in the risk-free rate. By contrast, the increase in the value of the housing stock is somewhat larger because, with the steeper loan supply curve, a given increase in house prices has a larger negative effect on $E_t R_{L,t+1}$ and thus the demand for houses via $\frac{\Lambda_{CC,t+1}}{\Lambda_{CC,t}}$. Differences between the ad hoc and microfounded loan supply cases are smaller in the model with a consumption cascade.

Figure K.3. Simulation 1981–2016: Income Distribution and Natural Interest Rate



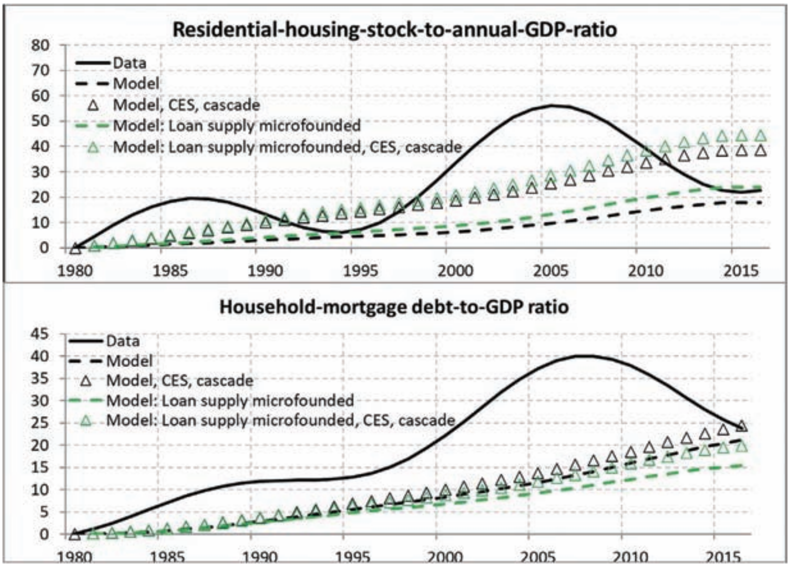
Note: The label "Model: Loan supply microfounded" refers to a modified version of the model where the borrowing friction is microfounded as described in Appendix J, implying that Equations (J.1), (J.2), and (J.9) replace Equations (34) and (29). For details on the meaning of the other labels, see the note below Figure 5.

Figure K.4. Simulation 1981–2016: Borrower Debt-to-Income Ratio and LTV



Note: See the note below Figure K.3 for details on the labels reading "Model . . .". See the note below Figure 6 for details on the data sources.

Figure K.5. Simulation 1981–2016: Housing Stock and Total Mortgage Debt-to-GDP Ratios



Note: See the note below Figure K.3 for details on the labels reading "Model . . .". See the note below Figure 7 for details on the data sources.

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