Inequality, Leverage and Crises

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Abstract

The paper studies how high household leverage and crises can be caused by changes in the income distribution. Empirically, the periods 1920-1929 and 1983-2008 both exhibited a large increase in the income share of high-income households, a large increase in debt leverage of low- and middle-income households, and an eventual financial and real crisis. The paper presents a theoretical model where higher leverage and crises are the endogenous result of a growing income share of high-income households. The model matches the profiles of the income distribution, the debt-to-income ratio and crisis risk for the three decades preceding the Great Recession.

1   Introduction

The United States experienced two major economic crises over the past century – the Great Depression starting in 1929 and the Great Recession starting in 2008. A striking and often overlooked similarity between these two crises is that both were preceded, over a period of decades, by a sharp increase in income inequality, and by a similarly sharp increase in debt-to-income ratios among lower- and middle-income households. When debt levels started to be perceived as unsustainable, they contributed to triggering exceptionally deep financial and real crises.

In this paper, we first document these facts, both for the period prior to the Great Depression and the period prior to the Great Recession, and we then present a dynamic stochastic general equilibrium model in which a crisis driven by greater income inequality arises endogenously. To our knowledge, our model is the first to provide an internally consistent mechanism linking the empirically observed rise in income inequality, the increase in debt-to-income ratios, and the risk of a financial crisis. In doing so it provides a useful theoretical framework, including a new methodology for its calibration, that can be used to investigate the role of income inequality as an independent source of macroeconomic fluctuations.

The model is kept as simple as possible in order to allow for a clear understanding of the mechanisms at work. The crisis is the ultimate result, after a period of decades, of permanent shocks to the income shares of two groups of households, top earners who represent the top 5% of the income distribution, and whose income share increases, and bottom earners who represent the bottom 95% of the income distribution.[1] The key mechanism is that top earners, rather than using all of their increased income for higher consumption, use a large share of it to accumulate financial wealth in the form of loans to bottom earners.[2] They do so because, following Carroll (2000) and others, financial wealth enters their utility function directly, which implies a positive marginal propensity to save out of permanent income shocks. By accumulating financial wealth, top earners allow bottom earners to limit the drop in their consumption, but the resulting large increase of bottom earners' debt-to-income ratio generates financial fragility that eventually makes a financial crisis much more likely.

The crisis is the result of an endogenous and rational default decision on the part of bottom earners, who trade off the benefits of relief from their growing debt load against output and utility costs associated with default. Lenders fully expect this behavior and price loans accordingly. The crisis is characterized by partial household debt defaults and an abrupt output contraction, a mechanism that is consistent with the results of Midrigan and Philippon (2011) and Gärtner (2013) for the Great Recession and the Great Depression, respectively. When a rational default occurs, it does provide relief to bottom earners. But because it is accompanied by a collapse in real activity that hits bottom earners especially hard, and because of higher post-crisis interest rates, the effect on their debt-to-income ratios is small, and debt quickly starts to increase again if income inequality remains unchanged.

When the shock to income inequality is permanent, consistent with the time series properties of U.S. top 5% income shares, the preferences for wealth of top earners, and thus their positive marginal propensity to save following a permanent income shock, are key to our results on debt growth. We show in a baseline simulation that, when preferences for wealth of top earners are calibrated to match a marginal propensity to save of around 0.4, an empirical estimate that is

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[1]Note that our paper focuses only on the macroeconomic implications of increased income inequality, rather than taking a stand on the fundamental reasons for changes in the income distribution.

[2]In a more elaborate model, physical investment is a third option. See Kumhof and Rancière (2010).

based on independent microeconomic data, a series of permanent negative shocks to the income share of bottom earners, of exactly the magnitude observed in the data, generates an increase in the debt-to-income ratio of bottom earners very close to the magnitude observed in the 1983-2007 data. Because the evolution of the debt-to-income ratio of bottom earners is not a target of our calibration, this constitutes an empirical success of our model. Furthermore, the increase in debt leads to a significant increase in crisis risk, of approximately the magnitude found in the recent work of Schularick and Taylor (2012). In section 2.6 we discuss other explanations for the 1983-2007 increase in debt levels and crisis risk that focus on domestic and global asset market imbalances in the decade prior to the Great Depression. We also show, in an alternative simulation, that when the shock to income inequality is modelled as transitory, the same model parameterized without preferences for wealth among top earners can generate an increase in debt and crisis risk purely based on a consumption smoothing motive.

The central argument of the paper links two strands of the literature[3] that have largely been evolving separately, the literature on income and wealth distribution,[4] and the literature on financial fragility and financial crises.[5] In addition, our modeling approach takes elements from the literature on preferences for wealth,[6] to explain the rise of household debt leverage when the increase in income inequality is permanent, and from the literature on rational default, to endogenize financial crises.[7]

Rajan (2010) and Reich (2010) share with this paper an emphasis on income inequality as a long-run determinant of leverage and financial fragility. In contrast to these authors, we study this issue in the context of a general equilibrium model. This permits a quantification of the importance of this channel, and an identification of the respective roles of credit demand and credit supply in the rise of household leverage and crisis risk.[8] Another literature has related increases in income inequality to increases in household debt (Krueger and Perri (2006), Iacoviello (2008)). In these authors' approach an increase in the variance of idiosyncratic income shocks across all households generates a higher demand for insurance through credit markets, thereby increasing household debt. This approach emphasizes an increase in income inequality experienced within household groups with similar characteristics, while our paper focuses on the empirically well-documented rise in income inequality between two specific household groups, the top 5% and the bottom 95% of the income distribution.

In theory, if increasing income inequality was accompanied by an increase in intra-generational income mobility, the dispersion in lifetime earnings might be much smaller than the dispersion in annual earnings, as agents move up and down the income ladder throughout their lives. However, a recent study by Kopczuk, Saez and Song (2010) shows that short-term and long-term income mobility in the United States has been either stable or slightly falling since the 1950s. These authors also find that virtually all of the increase in the variance of earnings over recent decades has been due to an increase in the variance of permanent earnings rather than of transitory earnings.[9] These results provide support for one of our simplifying modeling choices, the assumption of two income

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[3]In the interest of space, we only provide here an abriged version of the literature review. The long version is presented in the online appendix.

[4]See Piketty and Saez (2003) and Piketty and Zucman (2014).

[5]See Levitin and Wachter (2012) and the references therein.

[6]See Carroll (2000), Reiter (2004), Francis (2009) and the references therein. As discussed in the online appendix, preferences for wealth have been used by this literature because models with standard preferences have difficulties accounting for the saving behavior of the richest households.

[7]See Arellano (2008) and Pouzo and Presno (2012) and the references therein.

[8]Using local measures of inequality and credit, Coibion et al. (2014) find empirical evidence consistent with supply-side interpretations of debt accumulation patterns during the 2000s.

[9]Similar results are found by DeBacker et al. (2013)

groups with fixed memberships. They also provide additional support for our calibration, whereby shocks to the income distribution are permanent.

There is little guidance from the literature on how to calibrate the preference for wealth specification. But there is a small literature on the marginal propensity to save (MPS) of different income groups. The key paper is Dynan, Skinner and Zeldes (2004), who find that MPS are steeply increasing in the level of permanent income, and reach values of 0.5 or even higher for the highest income groups. We show that these results can be mapped directly into a calibration of the preference for wealth parameters. This calibration methodology is another contribution of our paper.

The rest of the paper is organized as followed. Section 2 discusses key stylized facts for the Great Depression and the Great Recession. Section 3 presents the model. Section 4 discusses model calibration and the computational solution method. Section 5 shows model simulations that study the effects of increasing income inequality on debt levels and crises. Section 6 concludes.

2 Stylized Facts

This section documents five key stylized facts that characterize, for the U.S. economy, the periods prior to the Great Recession and, where available, the Great Depression. These facts are relevant to the nexus between inequality, leverage and crises. Some will inform the specification and calibration of our model, and others will be used to evaluate the empirical support for the model. We conclude this section with a discussion of the empirical evidence associated with the two main alternative explanations for high and growing household debt that have been advanced in the literature.

2.1 Income Inequality and Aggregate Household Debt

In the periods prior to both major crises, rapidly growing income inequality was accompanied by a sharp increase in aggregate household debt.

Pre-Great-Recession   The left panel of Figure 1 plots the evolution of U.S. income inequality and household debt-to-GDP ratios between 1983 and 2008. Income inequality experienced a sharp increase, as the share of total income commanded by the top 5% of the income distribution increased from 21.8% in 1983 to 33.8% in 2007. During the same period the ratio of household debt to GDP doubled, from 49.1% to 98.0%.

Pre-Great-Depression   The right panel of Figure 1 plots the evolution of U.S. income inequality and household debt-to-GDP ratios between 1920 and 1929. Between 1920 and 1928, the top 5% income share increased from 27.5% to 34.8%. During the same period, the ratio of household debt to GDP more than doubled, from 16.9% to 37.1%.

2.2 Debt by Income Group

The periods prior to both major crises were characterized by increasing heterogeneity in debt-to-income ratios between high-income households and all remaining households. For the period prior to the Great Depression data availability is very limited, but some evidence exists, and is consistent with the period prior to the Great Recession.

Pre-Great-Recession   The left panel of Figure 2 plots the evolution of debt-to-income ratios for the top 5% and bottom 95% of households, ranked by income, between 1983 and 2007.[10] In

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[10]Debt-to-income ratios are constructed using data from the Survey of Consumer Finances (SCF), which starts in 1983, and became triennial starting in 1989, making 2007 the last pre-crisis observation.
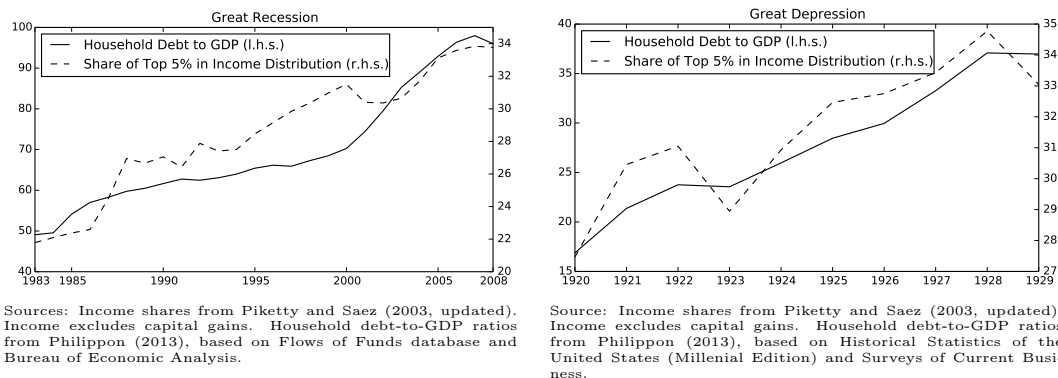
Great Recession / Great Depression

Figure 1: Income Inequality and Household Leverage

1983, the top income group was more indebted than the bottom income group, with a gap of around 20 percentage points. In 2007, the situation was reversed. The debt-to-income ratio of the bottom group, at 147.3% compared to an initial value of 62.3%, was now more than twice as high as that of the top group, which remained fluctuating around 60%. As a consequence almost all of the increase in the aggregate debt-to-income ratio shown in Figure 1 is due to the bottom group of the income distribution. A similar pattern to the debt-to-income ratios in Figure 2 is also observed in debt-to-net-worth ratios (Figure 3, left panel), and in unsecured debt-to-income ratios (Figure 3, right panel).[11]

<u>Pre-Great-Depression</u>   According to Olney (1991) and Olney (1999), the ratio of non-mortgage consumer debt to income increased from 4.6% in 1919 to 9.3% in 1929. Around two-thirds of this was installment debt, especially for the purchase of cars. Between 1919 and 1929, the percentage of households buying new cars increased from 8.6% to 24.0%.

For this period, only two BLS surveys, from 1917/1919 and 1935/1936, are available to study differences in borrowing across income groups. The 1935/1936 survey was taken several years after the crisis of 1929. But the data are nevertheless informative, for two reasons. First, the top 5% income share in 1936 was still high (32.5%), implying that income inequality had only very partially been reversed since 1929. And second, by 1936 the number of new cars sold and the percentage of households buying cars on installment, after having collapsed between 1929 and 1934, had recovered to reach very comparable levels to 1927 (Olney (1991)).

We use the income thresholds provided by Piketty and Saez (2003) to classify the respondents of both surveys into either the top 5% or the bottom 95% of the income distribution. To make the results of the two surveys comparable, we confine the analysis to installment credit. The surveys do not report stocks of debt but rather flows of new debt associated with installment purchases in the last twelve months. The right panel of Figure 2 presents the results. In the 1917/1918 survey, the new installment debt to income ratios are both low and similar for both groups, at 3.0% and 3.8% for the top and bottom income groups. In the 1935/1936 survey, the ratios are much higher

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[11]It is sometimes argued that the more recent increases in household debt (2000-2007), which consisted to a large extent of mortgage loans, represented borrowing against houses whose fundamental value had risen. However several recent empirical papers (Mian and Sufi (2009), Favara and Imbs (2010), Adelino, Schoar and Severino (2012)) show that causation ran from credit to house prices, specifically that credit supply shocks caused house prices to increase above fundamental values.

Great Recession: Debt-to-Income Ratios

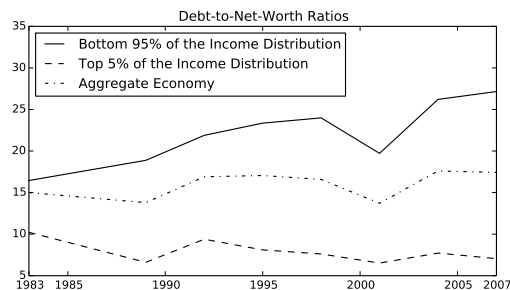Great Depression: New Loans Relative to Income
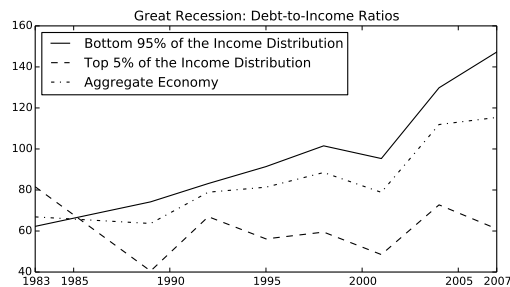
Sources: Survey of Consumer Finance (triennial), 1983–2007. Debt corresponds to the stock of all outstanding household debt liabilities. Income corresponds to annual income before taxes, in the year preceding the survey.
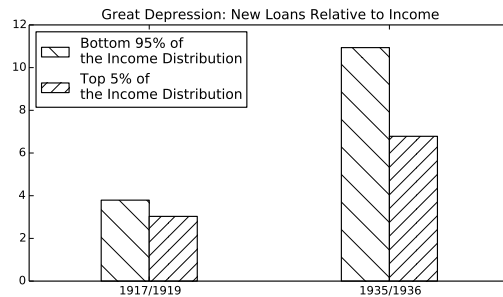
Source: Bureau of Labor Statistics, 1917/1919 Consumer Purchase Survey (CPS) and 1935/1936 Study of Consumer Purchases in the United States. The 1917/1919 survey covers 13,000 non-farm families. The 1935/1936 survey covers 60,000 farm and non-farm non relief families.

Figure 2: Debt-to-Income Ratios by Income Group

Debt-to-Net-Worth Ratios

Unsecured Debt-to-Income Ratios

Source: Survey of Consumer Finance (triennial), 1983–2007. Debt corresponds to the stock of all outstanding household debt liabilities. Net worth corresponds to the difference between the total value of household assets and the stock of all outstanding household debt liabilities.
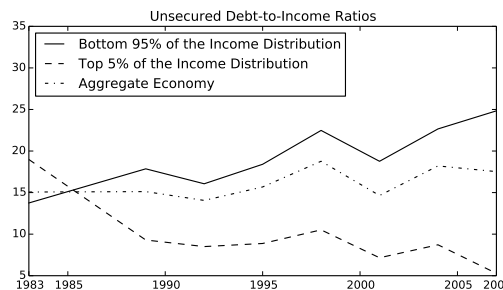
Source: Survey of Consumer Finance (triennial), 1983–2007. Unsecured debt corresponds to the difference between the stock of all outstanding household debt liabilities and the amount of outstanding household debt liabilities secured by residential properties. Income corresponds to annual income before taxes, in the year preceding the survey.

Figure 3: Alternative Debt Ratios

and, more importantly, much more dissimilar across income groups, at 6.8% and 10.9% for the top and bottom income groups. In 1935/1936, the ratio of average incomes between borrowers in the top and bottom groups was 3.25, while the ratio of average amounts borrowed was only 1.6. To the extent that these data are representative of other years during this period, it indicates a significantly higher growth in debt-to-income ratios among the bottom income group.[12]

2.3 Wealth by Income Group

In the periods prior to both major crises, the rise in income inequality was associated not only with divergent debt levels across income groups, but also with divergent shares of overall wealth.

Pre-Great-Recession   The left panel of Figure 4, which is based on SCF data, plots the share of wealth held by the top 5% of the income distribution between 1983 and 2007. Except for a brief

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[12]Alternative sources for the period immediately prior to 1929 exist and are broadly consistent with the 1935/1936 survey, but they are much more limited in quality or scope. See Plummer (1927) and Bureau of Labor Statistics (1929).
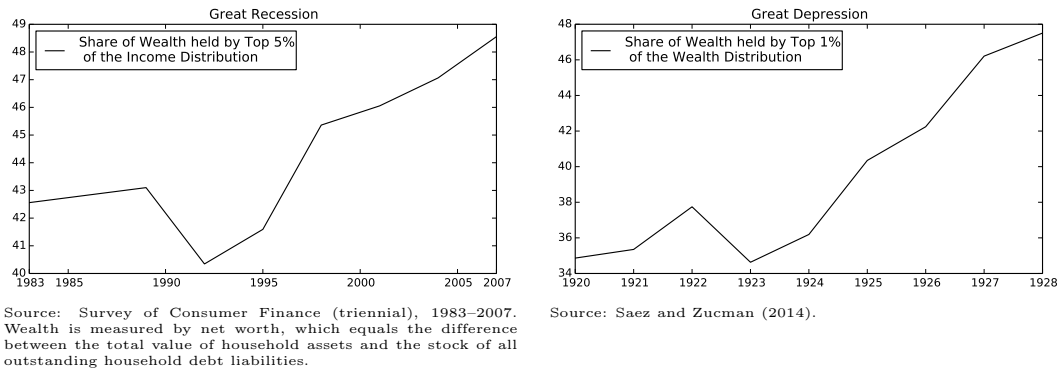
Figure 4: Wealth Inequality

period between 1989 and 1992, this wealth share increased continuously, from 42.6% in 1983 to 48.6% in 2007.

Pre-Great-Depression   The right panel of Figure 4, which is based on the dataset of Saez and Zucman (2014), plots the share of wealth held by the top 1% of the wealth distribution between 1920 and 1928. Except for 1923, this wealth share increased continuously, from 34.9% in 1920 to 47.5% in 1928.

2.4   Leverage and Crisis Probability

To quantify the link between household leverage and crisis probabilities, we use the dataset of Schularick and Taylor (2012), which contains information on aggregate credit and crises for 14 countries between 1870 and 2008. We follow these authors' methodology by running, on the full dataset, a logit specification in which the binary variable is a crisis dummy, and the latent explanatory variables include five lags of the aggregate loans-to-GDP ratio. The estimated logit model is used to predict crisis probabilities over the full cross-section and time series sample. Figure 5 reports the estimated probabilities for the United States. We observe that, in the periods prior to both major crises, there was a sizeable increase in crisis probabilities, even though a crisis remained a low probability event.

Pre-Great-Recession   The left panel of Figure 5 shows that the estimated crisis probability started at 2.0% in 1983 and increased to 5.2% by 2008. Between 2001 and 2008, the crisis probability increased by two percentage points.

Pre-Great-Depression   The right panel of Figure 5 shows that the estimated crisis probability almost doubled between 1925 and 1928, from 1.6% to 3.0%, before reaching 4.0% in the year of the crisis.

2.5   Household Defaults During Crises

Both major crises were characterized by high rates of default on household loans. Their magnitudes matter because the share of loans defaulted on in a crisis is an important parameter of our model.
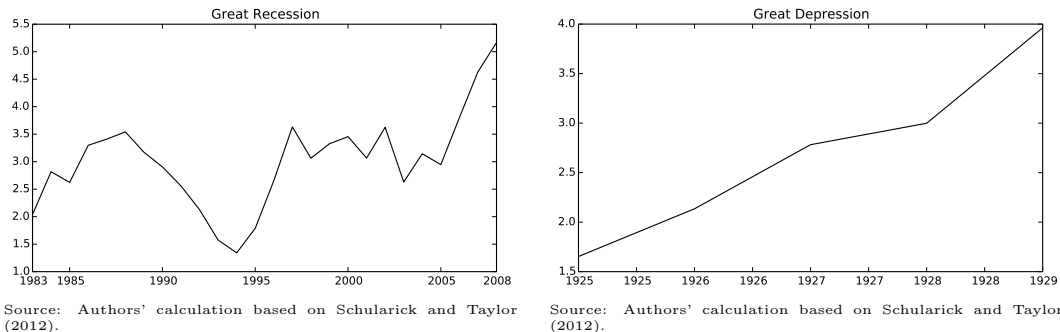
Figure 5: Crisis Probabilities

<u>Great Recession</u>   We compute delinquency rates as ratios of the balance of deliquent loans (defined as being past due by 90 days or more) to the total loan balance.[13] Between 2006 and 2010 mortgage delinquency rates increased dramatically, from 0.9% to 8.9%, and so did unsecured consumer loan delinquency rates, from 8.8% to 13.7% for credit card loans, from 2.3% to 5.3% for auto loans, and from 6.4% to 9.1% for student loans (the delinquency rate for student loans reached 11.7% in 2013). The above-mentioned figures apply to all households. Default rates among bottom earners can be shown to have been higher.

<u>Great Depression</u>   The crisis of 1929 was followed by a wave of defaults on automobile installment debt contracts (Olney (1999)). The percentage of cars repossessed increased from 4.1% in 1928 to 10.4% in 1932. Furthermore, repossession rates were significantly higher for used cars than for new cars (13.2% versus 5.7% in 1932). Combined with the fact that wealthy households were much more likely to buy new cars than middle and lower class households (Calder (1999)), this suggests that default rates on installment debt were higher among the bottom income group. Mortgage default rates were also high during the Great Depression. According to a study of 22 cities by the Department of Commerce, by January 1934, 43.8% of homes with a first mortgage were in default (Wheelock (2008)).

2.6   Alternative Explanations for the Increase in Household Debt

The literature has advanced a number of alternative explanations for the rapid increase in household debt prior to the Great Recession. In this subsection we briefly look at the empirical evidence for the two most important alternative explanations, financial innovation and the global saving glut.

<u>Financial Sector Growth and Financial Innovation</u>   The stylized facts pertaining to the evolution of the U.S. financial industry over the last 125 years have recently been documented by Philippon (2013). For the purpose of our paper, the key facts are: 1. The finance industry's share of GDP increased by roughly 50% in the two periods of interest, from 2.8% to 4.6% between 1920 and 1928, and from 5.5% to 7.9% between 1983 and 2007. 2. Most of these variations can be explained by corresponding changes in the quantity of intermediated assets. 3. Intermediation is produced under constant returns to scale with an annual average cost of around 2% of outstanding assets. 4. The unit cost of intermediation has not decreased over the past 30 years. This implies that the substantial increase in the GDP share of the financial sector can be explained by the simple

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[13]Source: Federal Reserve Bank of New York, Household Debt and Credit Reports.

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growth of balance sheets, without a necessary role for financial innovation.[14] In our model, that growth of balance sheets is due to an increase in household credit to bottom earners, following an increased supply of savings by top earners after they experience a permanent increase in income. According to Philippon (2013), household credit represented only around one quarter of the stock of outstanding intermediated assets between 1983 and 2007. Financial activities that relate to non-household credit remain outside our model. Nevertheless, the rough doubling of household credit over the 1983-2007 period contributed substantially to the overall increase in the GDP share of the financial sector.

The facts stated above do not however rule out that financial innovation could have been an additional source of financial fragility. According to Levitin and Wachter (2012), several financial product innovations that spread during the last phase of the mortgage credit boom (2004-2007) led to significant under-pricing of credit-risk due to the complexity and opacity of these products.[15] Interestingly, the seemingly safe senior tranches of these securities attracted many foreign investors, contributing to the global saving glut to which we turn next.

Global Saving Glut   The global saving glut, which links the large current account surpluses of Asian countries and the large current account deficit of the United States, emerged in 1998, in the aftermath of the Asian crisis. An empirical challenge is that we cannot directly, from the data, measure the contribution of foreign inflows to the build-up of household credit. We can however approximate this contribution, by considering the broad category of private credit market instruments in the U.S. Flow of Funds, and by drawing on the model-based estimation results of Justiniano, Primiceri and Tambalotti (2014).

In Flow of Funds data, the ratio of private domestic credit to GDP increased from 130.4% to 292.3% between 1983 and 2007. Meanwhile the ratio of foreign private credit assets to GDP increased from 2.8% to 34%. The contribution of foreign asset accumulation to private domestic debt accumulation differs widely between the pre-saving glut period (1983-1998) and the saving glut period (1998-2007). In the earlier period, private credit grew by 71 percentage points, with foreign asset accumulation only accounting for around 5% of this. In the later period, private credit grew by 90.6 percentage points, with foreign asset accumulation accounting for around 25%. Justiniano, Primiceri and Tambalotti (2014) perform a quantitative model-based exercise that assesses the role of foreign capital flows in explaining the accumulation of U.S. household credit over the period 1998-2006. They find that between one quarter and one third of the increase in U.S. household debt can be explained by the dynamics of capital flows. In Section 5.4 we will show that these findings are consistent with the empirical performance of our model over the period 1998-2007.

3   The Model

The model economy consists of two groups of infinitely-lived households, referred to respectively as top earners, with population share χ, and bottom earners, with population share $1 - \chi$. Total aggregate output y_t is given by an autoregressive stochastic process

$$y_t = (1 - \rho_y)\, \bar{y} + \rho_y y_{t-1} + \epsilon_{y,t} \; , \tag{1}$$

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[14]As stated by Philippon (2013): "Since the unit cost appears to be roughly constant, the question becomes: how do we explain the large historical variations in the ratio of intermediated assets over GDP?"

[15]This aspect cannot be captured in our model, in which investors correctly price default risk.

where a bar above a variable denotes its steady-state value. The share of output received by top earners z_t is also an autoregressive stochastic process, and is given by

$$z_t = (1 - \rho_z)\,\bar{z} + \rho_z z_{t-1} + \epsilon_{z,t}\;. \tag{2}$$

The standard deviations of $\epsilon_{y,t}$ and $\epsilon_{z,t}$ are denoted by σ_y and σ_z.

3.1   Top Earners

Top earners maximize the intertemporal utility function

$$U_t = E_t \sum_{k \geq 0}^{\infty} \beta_\tau^k \left\{ \frac{\left(c_{t+k}^\tau\right)^{1-\frac{1}{\sigma}}}{1 - \frac{1}{\sigma}} + \varphi \frac{\left(1 + b_{t+k}\frac{1-\chi}{\chi}\right)^{1-\frac{1}{\eta}}}{1 - \frac{1}{\eta}} \right\}\;, \tag{3}$$

where c_t^τ is top earners' per capita consumption, $b_t \frac{1-\chi}{\chi}$ is top earners' per capita tradable financial wealth, which takes the form of loans to bottom earners, β_τ is the discount factor, σ and η parameterize the curvature of the utility function with respect to consumption and wealth, and φ is the weight of wealth in utility. These preferences nest the standard case of CRRA consumption preferences for $\varphi = 0$.

When top earners lend to bottom earners, they offer p_t units of consumption today in exchange for 1 unit of consumption tomorrow in case bottom earners do not default. In case bottom earners do default, top earners receive $(1 - h)$ units of consumption tomorrow, where $h \in [0, 1]$ is the haircut parameter, the proportion of loans defaulted on in a crisis. Bottom earners default only rarely, because doing so entails large output and utility losses, as explained in Sections 3.2 and 3.3. Consumption of each top earner is given by

$$c_t^\tau = y_t z_t \frac{1}{\chi} + (l_t - b_t p_t) \frac{1-\chi}{\chi}\;, \tag{4}$$

where b_t is the amount of debt per bottom earner issued in period t at price p_t, to be repaid in period $t + 1$, while l_t is the amount of debt per bottom earner repaid in period t. The decision to default is given by $\delta_t \in \{0, 1\}$, where $\delta_t = 0$ corresponds to no default and $\delta_t = 1$ corresponds to default. Then we have

$$l_t = b_{t-1}\left(1 - h\delta_t\right)\;. \tag{5}$$

Top earners maximize (3) subject to (4) and (5). Their optimality condition is given by

$$p_t = \beta_\tau E_t \left[\left(\frac{c_{t+1}^\tau}{c_t^\tau}\right)^{-\frac{1}{\sigma}} \left(1 - h\delta_{t+1}\right) \right] + \varphi \frac{\left(1 + b_t\frac{1-\chi}{\chi}\right)^{-\frac{1}{\eta}}}{\left(c_t^\tau\right)^{-\frac{1}{\sigma}}}\;. \tag{6}$$

This condition equates the costs and benefits of acquiring an additional unit of financial wealth. The cost equals the current utility loss from foregone consumption. The benefit equals not only next period's utility gain from additional consumption, but also the current utility gain from holding an additional unit of financial wealth.

3.2 Bottom Earners

Bottom earners' utility from consumption c_t^b has the same functional form, and the parameter σ takes the same value, as for top earners. They do not derive utility from wealth.[16] Their lifetime utility is given by

$$V_t = E_t \sum_{k \geq 0}^{\infty} \beta_b^k \left\{ \frac{\left(c_{t+k}^b\right)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} \right\} . \tag{7}$$

Bottom earners' budget constraint is

$$c_t^b = y_t \left(1 - z_t\right) \left(1 - u_t\right) \frac{1}{1-\chi} + \left(b_t p_t - l_t\right) , \tag{8}$$

where u_t is the fraction of bottom earners' endowment that is absorbed by a penalty for current or past defaults. The output penalty $y_t \left(1 - z_t\right) u_t$ represents an output loss to the economy. The fraction u_t is given by

$$u_t = \rho_u u_{t-1} + \gamma_u \delta_t , \tag{9}$$

where the impact effect of a default is given by γ_u, while the decay rate, in the absence of further defaults, is ρ_u.

Bottom earners maximize (7) subject to (8) and (9). Their optimality condition for consumption is given by

$$p_t = \beta_b E_t \left[\left(\frac{c_{t+1}^b}{c_t^b}\right)^{-\frac{1}{\sigma}} \left(1 - h\delta_{t+1}\right) \right] . \tag{10}$$

3.3 Endogenous Default

At the beginning of period t bottom earners choose whether to default on their past debt b_{t-1}. This, together with the haircut parameter h, defines the amount l_t that bottom earners repay during period t, according to equation (5). Their lifetime consumption utility V_t is a function of the state of the economy $s_t = (l_t, y_t, z_t, u_t)$, and is recursively defined by

$$V(s_t) = \frac{\left(c_t^b\right)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} + E_t \left[V(s_{t+1})\right] .$$

The decision to default δ_t is a rational choice made at the beginning of the period, given a pre-default state $\hat{s}_t = (b_{t-1}, y_t, z_t, u_{t-1})$, by comparing the lifetime consumption utility values of defaulting $V_t^D = V(\hat{s}_t, \delta_t = 1)$ and not defaulting $V_t^N = V(\hat{s}_t, \delta_t = 0)$. Bottom earners default when $V_t^D - V_t^N$ is higher than an i.i.d. additive utility cost of default ξ_t, as in Pouzo and Presno (2012). We can therefore write the decision to default as:

$$\delta_t = argmax_{\delta_t \in \{0,1\}} \left\{ V_t^D - \xi_t, V_t^N \right\} , \tag{11}$$

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[16]Heterogeneity in preferences between lenders and borrowers is a common assumption in the literature, but has so far mostly taken the form of assuming different rates of time preference combined with borrowing constraints (e.g. Iacoviello (2005)). In Bakshi and Chen (1996), the preference for wealth is specific to a social-wealth index, which captures the social group of reference, and is assumed to be increasing with the income of the group.

where $V_t^D = V(b_{t-1}(1-h), y_t, z_t, \rho_u u_{t-1} + \gamma_u)$ and $V_t^N = V(b_{t-1}, y_t, z_t, \rho_u u_{t-1})$. The distribution of δ_t depends upon the distribution of ξ_t. We have the simple formula

$$prob(\delta_t = 1|\hat{s}_t) = \Xi(V_t^D - V_t^N) \quad , \tag{12}$$

where Ξ is the cumulative distribution function of ξ_t. We assume that Ξ takes the modified logistic form

$$\Xi(x) = \left\{ \begin{array}{ll} \frac{\psi}{1+e(-\theta x)} & \text{if } x < \infty \ , \\ 1 & \text{if } x = \infty \ . \end{array} \right\} , \tag{13}$$

where $\psi < 1$. This implies that, over the economically relevant range, default occurs with positive probability but never with certainty.[17] The parameters ψ, θ, γ_u and ρ_u are calibrated to match the empirical evidence for the probability of crises, but with γ_u and ρ_u in addition constrained by the need to at least approximately match the evidence on the depth and duration of such crises. The parameter ψ helps to determine the mean level of crisis probability over the sample, while θ determines the curvature of crisis probability with respect to the difference $V_t^D - V_t^N$.

3.4   Equilibrium

In equilibrium top earners and bottom earners maximize their respective lifetime utilities, the market for borrowing and lending clears, and the market clearing condition for goods holds:

$$y_t(1 - (1 - z_t)u_t) = \chi c_t^\tau + (1 - \chi)c_t^b . \tag{14}$$

3.5   Analytical Results

A small number of key parameters of our model affects the speed at which bottom earners' debt accumulates following a drop in their income share. Before discussing the calibration, it is therefore useful to analytically derive some relationships that clarify the role of these parameters.

3.5.1   Debt Supply and Debt Demand

One implication of preferences for wealth is that a unique, stable deterministic steady state for financial wealth b_t exists. In this steady state, the Euler equations (6) and (10) can be interpreted as the hypothetical prices at which top earners and bottom earners would be willing to buy and sell debt while keeping their consumption constant. These equations therefore represent steady-state supply and demand functions for debt. Bottom earners' demand price as a function of debt, $p(b)$, is flat at[18]

$$p(b) = \beta_b , \tag{15}$$

while top earners' supply price as a function of debt is implicitly given by

$$p(b) = \beta_\tau + \frac{\varphi\left(\bar{y}\bar{z}\frac{1}{\chi} + b(1-p(b))\frac{1-\chi}{\chi}\right)^{\frac{1}{\sigma}}}{\left(1 + b\frac{1-\chi}{\chi}\right)^{\frac{1}{\eta}}} . \tag{16}$$

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[17]The cost takes an infinite value with probability $1 - \psi$, and finite values distributed according to the c.d.f. $1/(1 + e(-\theta x))$ with probability ψ.

[18]The simplification of abstracting from default, for the purpose of this exercise, is justified by the fact that default has a negligible effect on the Euler equations in the neighborhood of the original steady state.
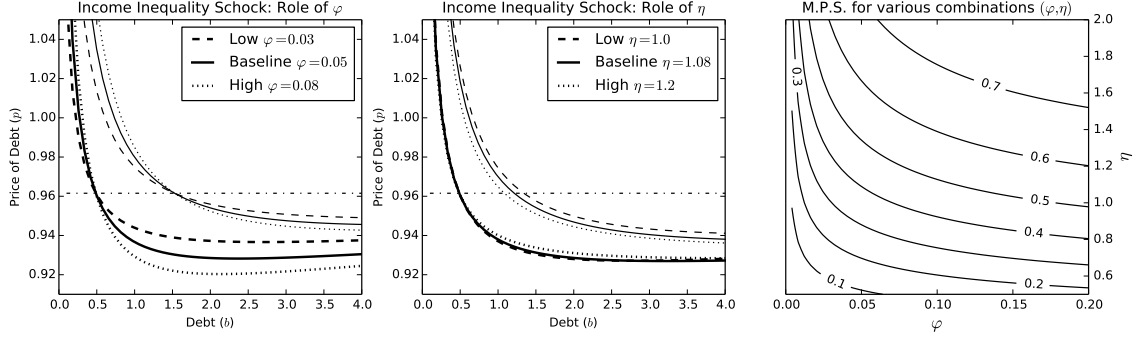
Figure 6: Preferences for Wealth and Steady-State Debt

By combining (15) and (16), one obtains the steady state relationship

$$\frac{\beta_b - \beta_\tau}{\varphi} = \frac{\left(\bar{y}\bar{z}\frac{1}{\chi} + \bar{b}\left(1 - \beta_b\right)\frac{(1-\chi)}{\chi}\right)^{\frac{1}{\sigma}}}{\left(1 + \bar{b}\frac{(1-\chi)}{\chi}\right)^{\frac{1}{\eta}}} \ . \tag{17}$$

The numerator on the right-hand side, which equals $(\bar{c}^\tau)^{1/\sigma}$, is always positive because consumption utility satisfies the Inada conditions. Equation (17) therefore shows that for any model with preferences for wealth ($\varphi > 0$), a steady state with positive debt of bottom earners ($\bar{b} > 0$) requires the condition $\beta_b > \beta_\tau$, which is therefore always satisfied in our calibration. However, this does not mean that top earners are more impatient than bottom earners. The reason is that their effective impatience is given by $p(b)$ rather than simply by β_τ. Effective impatience is therefore endogenous to the level of debt, and the effective steady state impatience of top earners is equal to the impatience of bottom earners.

3.5.2 Changes in Steady-State Income and Preferences for Wealth

Differentiating (17), we can derive the effect of an increase in top earners' output share $\bar{z}$ on the steady-state debt level $\bar{b}$,

$$\frac{d\log\left(\bar{b}\right)}{d\log\left(\bar{z}\right)} = \frac{\frac{1}{\sigma}\left(\bar{y}\bar{z}\frac{1}{\chi}\right)}{\frac{1}{\eta}\frac{\bar{b}\frac{(1-\chi)}{\chi}}{1+\bar{b}\frac{(1-\chi)}{\chi}}\bar{c}^\tau - \frac{1}{\sigma}\bar{b}\left(1 - \beta_b\right)\frac{(1-\chi)}{\chi}} \ , \tag{18}$$

which can be shown to be positive for any plausible calibration, implying that an increase in income inequality raises the steady-state equilibrium level of debt.

The left and middle subplots of Figure 6 show initial credit demand (15) as the horizontal dash-dotted line at a price of debt of approximately 0.96. Initial credit supply (16) is shown as thick lines, and increased credit supply after a 10 percentage point increase in the top 5% income share as thin lines. The solid lines represent the baseline, and the dashed and dotted lines show the effects of varying, relative to the baseline, the parameters φ or η, while adjusting β_τ to remain consistent

with an unchanging initial level of steady-state debt. The left subplot shows that, while the size of the increase in steady-state debt following the increase in credit supply is independent of φ, a higher φ increases the slope of the credit supply schedule. Therefore, with debt starting out at its initial low-debt steady state, a higher φ implies that top earners are willing to more aggressively lower interest rates on debt (raise the price of debt) to move towards the new high-debt steady state at a higher speed. The middle subplot shows that a higher η, meaning a lower curvature of the utility function with respect to wealth, leads to more financial wealth accumulation. The reason is that a higher η reduces the rate at which marginal utility falls in response to increases in wealth, so that top earners limit the increase in their consumption more strongly in order to accumulate more wealth.

3.5.3   The Marginal Propensity to Save

At shorter horizons of 20-40 years the effects of higher φ and higher η are hard to distinguish, because both tend to increase the rate at which debt increases following a permanent increase in income inequality. The marginal propensity to save (MPS) of top earners following a permanent income shock is a function of both φ and η. The model-based formula for the MPS is derived in the online appendix of this paper. The right subplot of Figure 6 shows how different combinations of φ and η translate into different MPS in that formula.

4   Calibration and Solution Method

4.1   Calibration

We calibrate the model at the annual frequency. Top earners and bottom earners correspond to the top 5% and the bottom 95% of the income distribution, respectively, $\chi = 0.05$. The model combines two key mechanisms, the accumulation of debt by bottom earners following a permanent increase in income inequality, and a rational default decision, with default probabilities increasing in the level of debt. An increase in the default probability interacts with the speed of debt accumulation through an increase in default risk premia. However, default is partial, and default probabilities are low, ranging from 2.2% in 1983 to 5.1% in 2008, when calibrated based on the empirical evidence of Schularick and Taylor (2012). This implies that the effects of default risk on debt accumulation are very limited during the 1983-2008 period. The calibration exercise is therefore made more transparent by separating parameters related to debt accumulation and to the default mechanism.

4.1.1   Debt Accumulation

Preferences   Following many papers in the business cycle literature, the curvature of the utility function with respect to consumption is fixed at $\sigma = 0.5$ for both top and bottom earners. The detailed calibration procedure for the preference for wealth parameters φ and η is described in the online appendix. We first use our theoretical model to derive an approximate formula for top earners' MPS out of permanent income shocks. We then use the empirical methodology of Dynan, Skinner and Zeldes (2004) to estimate the empirical counterpart of this formula, using SCF and PSID data. Finally, the model's preference for wealth parameters φ and η are calibrated by equating the model-based MPS to the data-based MPS. We find that saving rates are a steeply increasing function of income, and obtain a baseline MPS of top earners of 0.397, with a lower bound of

0.248 and an upper bound of 0.505.[19] The resulting baseline parameter values are $\varphi = 0.05$ and $\eta = 1.09$.[20] Because we are matching one MPS using two parameters, these values are not unique, but as shown in Section 5.4, changing the combination of φ and η at a given MPS has a very small effect on our results.

Initial Steady State   Steady-state output is normalized to one, $\bar{y} = 1$. The steady-state net real interest rate is fixed at 4% per annum, similar to values typically used in the real business cycle literature, by fixing bottom earners' discount factor at $\beta_b = 1.04^{-1}$. We calibrate the initial steady state of the debt-to-income ratio λ_t and of the top 5% income share τ_t to be equal to their 1983 counterparts. In the model, λ_t is given by[21]

$$\lambda_t = \frac{(1 - \chi)\, l_t}{y_{t-1}\, (1 - z_{t-1})\, (1 - u_{t-1})}\ . \tag{19}$$

We choose β_τ to replicate $\bar{\lambda}$ in 1983, which equals 62.3%. To calibrate the 1983 value of τ_t we use the data computed by Piketty and Saez (2003, updated), which include interest income but exclude interest payments in the computation of annual gross incomes. The model counterpart is given by

$$\tau_t = \frac{y_t z_t + (1 - \chi)\, l_t\, (1/p_{t-1} - 1)}{y_t\, (1 - u_t\, (1 - z_t)) + (1 - \chi)\, l_t\, (1/p_{t-1} - 1)}\ . \tag{20}$$

We choose $\bar{z}$ to replicate $\bar{\tau}$ in 1983, which equals 21.8%.

Exogenous Shock Processes   We estimate the exogenous stochastic process for output y_t using the detrended series of U.S. real GDP from 1983 to 2010 obtained from the BEA. Our estimates are $\rho_y = 0.669$ and $\sigma_y = 0.012$. For the years 1983-2008 of the baseline simulation we calibrate the shocks $\epsilon_{y,t}$ to exactly match the detrended data, while all subsequent shocks are set to zero.

The exogenous stochastic process for the top 5% output share z_t is parameterized by specifying ρ_z and σ_z such that the behavior of τ_t matches that of the updated Piketty and Saez (2003) data series from 1983 to 2010. Using standard tests, the hypothesis that this data series has a unit root cannot be rejected. In the baseline model, we therefore calibrate $\rho_z = 1$, and then estimate $\sigma_z = 0.008$ from the data. For the years 1983-2008 of the baseline simulation we calibrate the shocks $\epsilon_{z,t}$ such that τ_t exactly matches the data, with all subsequent shocks set to zero.

Targeted and Non-targeted Facts   Table 1 summarizes the calibration of the model, with the exception of the default parameters. This part of the model has 10 exactly identified parameters and 2 (φ and η) that are matched using empirical estimates of the MPS of top earners. Importantly, the use of empirical estimates to independently calibrate the preference for wealth parameters of top earners implies that matching the post-1983 evolution of the debt-to-income ratio of bottom earners is not a target of the calibration. A comparison of its simulated evolution with the data will therefore serve to evaluate the empirical success of our model.[22]

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[19]By considering a wide range of different MPS estimates, we have taken into account the inevitable uncertainty associated with alternative methods of estimating this magnitude.

[20]We note that the relationship $\eta > \sigma$ is consistent with the preference for wealth specification of Carroll (2000).

[21]This ratio is defined to be consistent with SCF data, where debt liabilities are measured during the first semester of the Survey – at the time of the interview – while income refers to income in the year prior to the survey.

[22]The ability of our simple endowment model to match the behavior of the interest rate, which is also non-targeted, if of course very limited.

	Source / Target	Implied Values
Directly Calibrated Parameters		
Steady-State Output Level	Normalization	$\bar{y} = 1$
Population Share of Top Earners	5%	$\chi = 0.05$
Steady-State Real Interest Rate	Literature	$\beta_b = 1.04^{-1}$
IES in Consumption	Literature	$\sigma = 0.5$
Indirectly Calibrated Parameters		
Top Earners' Weight on Wealth in Utility	MPS of Top Earners	$\varphi = 0.05$
Top Earners' Wealth Elasticity	MPS of Top Earners	$\eta = 1.09$
Steady-State Top 5% Income Share $\bar{\tau}$	Data: 21.8% in 1983	$\bar{z} = 0.1807$
Steady-State Debt-to-Income Ratio $\bar{\lambda}$	Data: 62.3% in 1983	$\beta_\tau = 0.912$
Exogenous Stochastic Processes		
Output	Estimated	$\rho_y = 0.669$
		$\sigma_y = 0.012$
Output Shares	Estimated	$\rho_z = 1$
		$\sigma_z = 0.008$

Table 1. Calibration of the Baseline Model Except Default

4.1.2 Default Mechanism

The haircut, or percentage of loans defaulted upon during the crisis, is set to $h = 0.1$, which is approximately consistent with the empirical evidence in Section 2.5. The size of default $\gamma_u = 0.04$ and the depth of the crisis $\rho_u = 0.65$ are calibrated to give rise to default events that are reasonably close to what has been observed during the Great Depression, while triggering default decisions that are consistent with the estimated probabilities of crises. Our calibration implies a slightly less than 3% loss in aggregate output on impact, and a cumulative output loss of around 8% of annual output, less than what was observed during the Great Recession. However, what matters for the default decision is the *expected* depth of the contraction. Few observers had anticipated the Great Recession, and once it had started, most observers initially underestimated its full severity (Dominguez and Shapiro (2013)).

The random utility cost parameters $\psi = 0.15$ and $\theta = 18$ are chosen so that, combined with the output cost parameters γ_u and ρ_u, they closely match the Schularick and Taylor (2012) probability of crises in 1983 and 2008[23], thereby also approximating the trend in its evolution between these two dates. Our calibration implies that the maximum theoretically possible default probability, at extremely high debt levels, is 15%, with actual default probabilities generally well below that.[24] It can be shown that, at debt and income levels where default occurs with a probability of 5%, roughly the magnitude reached just prior to the Great Recession, the random utility cost of default needed to trigger the financial crisis is a negative utility cost equivalent to an approximately 3.3% change in the consumption of bottom earners.

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[23]The crisis probabilities in our calibrated model are 2.19% in 1983 and 5.08% in 2008, while the probabilities estimated according to Schularick and Taylor (2012) are 2.04% in 1983 and 5.16% in 2008.

[24]Between 1900 and 2008, the maximum probability of a U.S. crisis, estimated according to Schularick and Taylor (2012), is 5.7%.

	Source / Target	Implied Values
Default Parameters		
Haircut (% of Loans Defaulted)	Data (cf. Section 2.5)	$h = 0.1$
Output Penalty	Output Costs of 2008 Crisis	$\gamma_u = 0.04$
	Size and Depth	$\rho_u = 0.65$
Random Utility Cost of Default	Schularick and Taylor (2012)	$\psi = 0.15$
	Default Probabilities (1983-2008)	$\theta = 18$

Table 2. Calibration of the Model's Default Parameters

4.2 Solution Method

Our model has two features that advise against the application of conventional perturbation methods. The first is the presence of default, which implies large discrete jumps in state variables. The second is the fact that the stochastic process for income shares z_t is random walk, which in our simulations implies that bottom earners' debt-to-income ratio permanently drifts far away from its original steady state. We therefore use a global solution technique that adapts the time-iterative policy function algorithm described by Coleman (1991). The computational procedure is detailed in the online appendix.[25]

5 Results

Figures 7–13 present simulation results that first explore the properties of the model, and then its ability to match the behavior of key historic time series that pertain to the inequality-leverage-crises nexus.

5.1 Default Regions

In our model, due to random utility costs, the state space is divided into regions with a continuum of probabilities of default. Figure 7 contains a visual representation that divides the state space into regions whose boundaries represent default probabilities that increase in equal increments of 2 percentage points. Each subplot shows the debt-to-income ratio[26] on the horizontal axis and output on the vertical axis. The effect of variations in the third state variable, the top output share, is illustrated by showing two separate subplots, corresponding to the 1983 and 2008 top output shares.

We observe that higher debt levels imply a higher crisis probability, by increasing the benefits of defaulting without affecting the costs. Over the historically observed range of debt levels, the implied crisis probabilities range from 2.2% to 5.1%. As is standard in this class of models, default is more likely to occur when output is low, because at such times the insurance benefits of default are high while the output costs of default are low. Small drops in income start to have a significantly larger effect on default probabilities as we move from regions of low debt to regions of very high debt. For the same reasons as for lower output, higher top output shares also lead to higher crisis probabilities. But their direct effect, beyond the effect that operates through higher debt accumulation, is very modest.

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[25]The documented codes to replicate the numerical results are available at http://www.mosphere.fr/files/krw2014/
[26]We show the debt-to-income ratio rather than the state variable debt because the former is a key variable in our model. Its units are therefore more intuitive and easier to interpret.
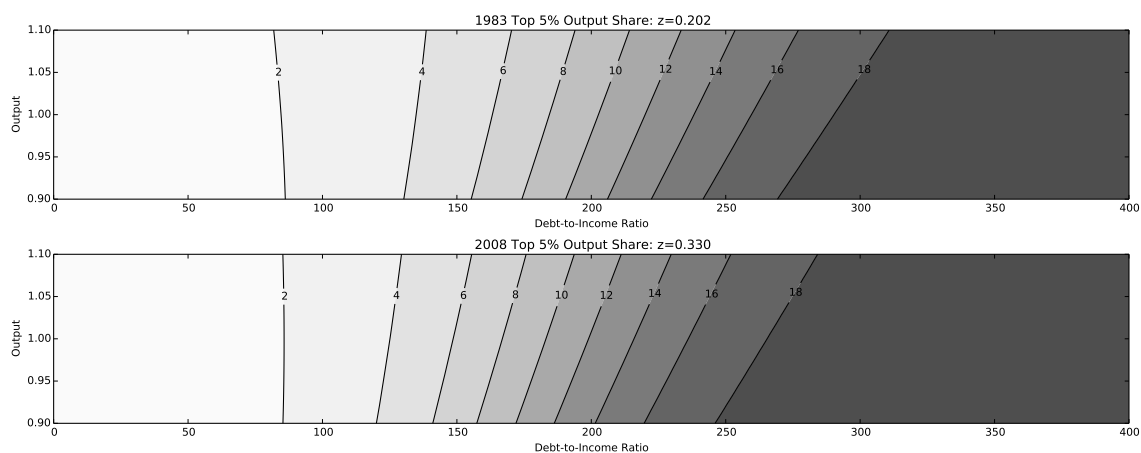
Figure 7: Default Regions
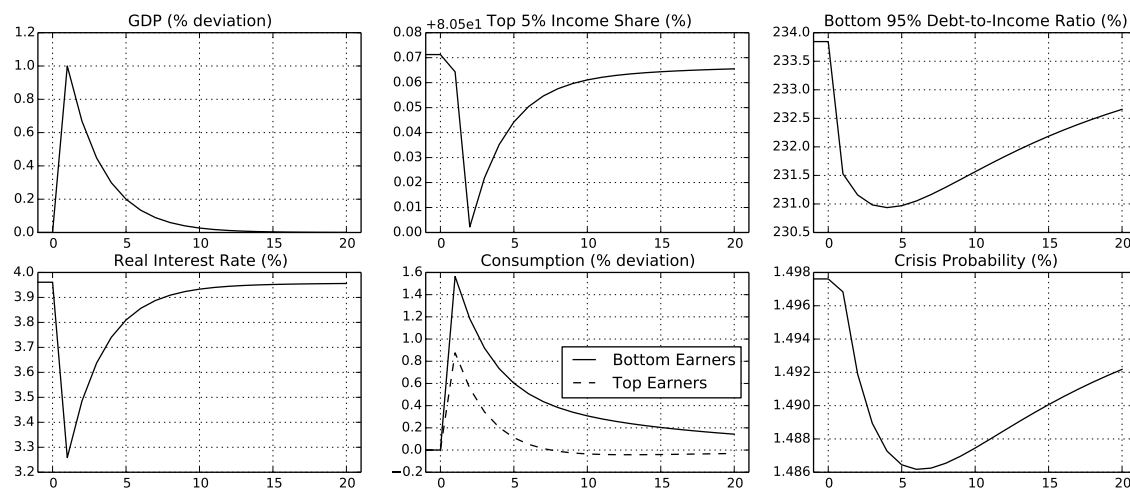
5.2 Impulse Responses

Figure 8: Impulse Responses - Output Shock

Figure 8 shows a one standard deviation positive shock to aggregate output y_t. This shock allows both top earners and bottom earners to increase their consumption, so that the equilibrium loan interest rate drops by around 85 basis points on impact, with a subsequent increase back to its long-run value that mirrors the gradual decrease in output. The drop in the interest rate represents an additional income gain for bottom earners relative to top earners, so that the top 5% income share falls by around 0.35 percentage points. Bottom earners smooth their income gain over time by decreasing their debt-to-income ratio by around 0.8 percentage points on impact, while still
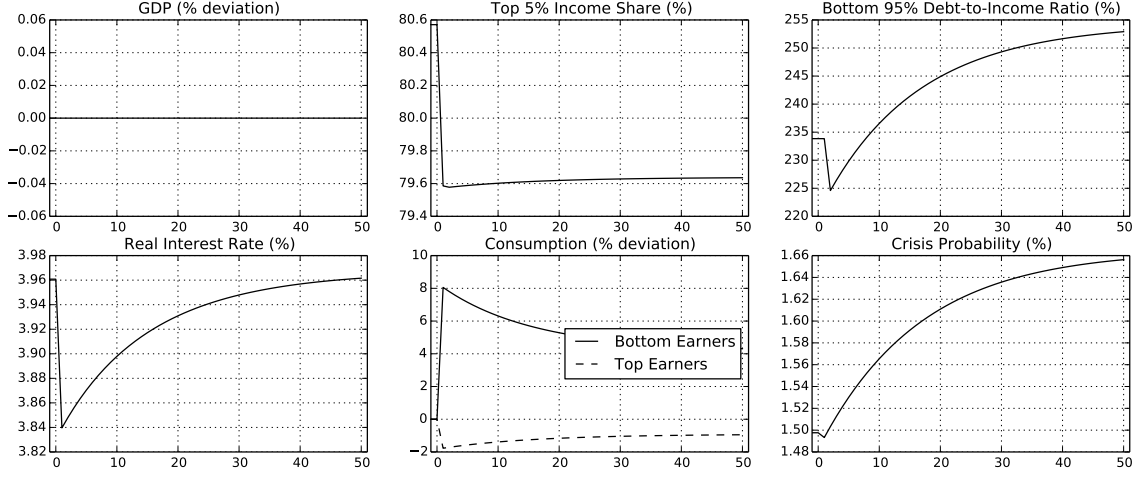
18

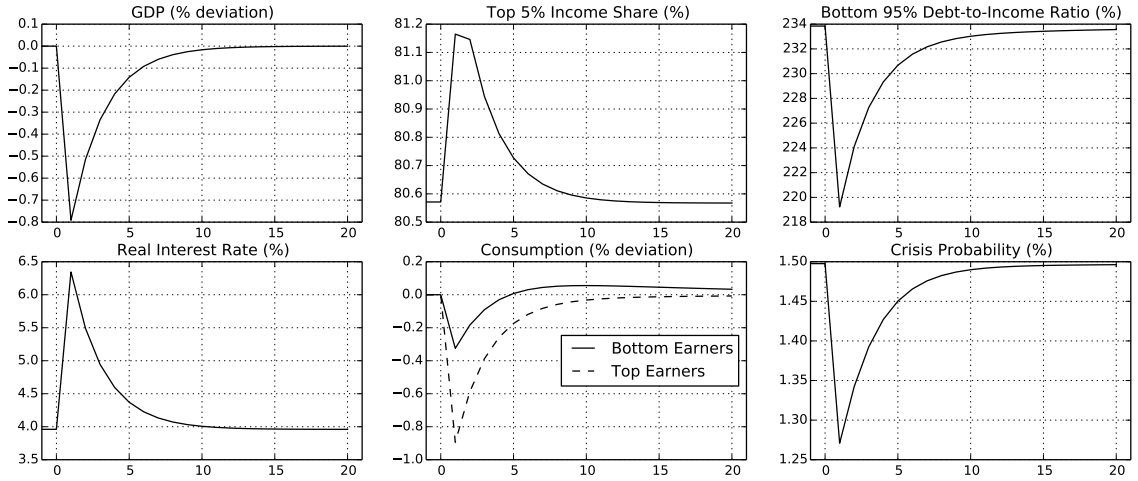Figure 9: Impulse Responses - Income Distribution Shock

Figure 10: Impulse Responses - Crisis

increasing their consumption by more than twice as much as top earners.

Figure 9 shows a one standard deviation permanent shock to the output share z_t. The top 5% income share τ_t immediately increases by 0.8 percentage points, accompanied by a downward jump of 0.5% in bottom earners' consumption and an upward jump of 1.9% in top earners' consumption. The long-run increase in top earners' consumption is even larger, because they initially limit their additional consumption in order to accumulate additional financial wealth. The process of debt accumulation takes several decades, with bottom earners' debt-to-income ratio increasing by around 7 percentage points in the very long run, accompanied by an increase in crisis probability of 0.13 percentage points. The real interest rate falls on impact by 9 basis points, due to the increase in

credit supply from top earners that initially limits the drop in consumption of bottom earners. The top 5% income share τ_t, because it includes not only the output share z_t but also the interest earnings on increasing financial wealth, increases in the long run by approximately another 0.1 percentage points, and top (bottom) earners' long-run increase (decrease) in consumption is correspondingly larger. We note that the one standard deviation income distribution shock in Figure 9 is small compared to what occurred over the period 1983-2008.

Figure 10 shows the impulse response for a crisis shock. Bottom earners default on 10% of their loans, but they also experience a 4% loss in income due to the output costs of default, which are suffered exclusively by this group of agents. As a result their debt-to-income ratio only drops by around 3.9 percentage points. The impact effect on the real economy is a 3.2% loss in GDP, followed by a V-shaped recovery. The real interest rate mirrors developments in output, with an initial increase of 2.4 percentage points followed by a return to the original interest rate level after about a decade. Consumption of top earners and bottom earners follows an almost identical profile after the crisis. Top earners suffer a loss on their financial wealth, but this is more than compensated by the temporary increase in the real interest rate, so that the top 5% income share increases by around 1.2 percentage points on impact. Top earners lend after the crisis, in order to return their financial wealth to the desired level. The counterpart of this is reborrowing by bottom earners.[27] As a result, bottom earners' debt-to-income ratio is almost back to its original level after about one decade.

5.3   Baseline Scenario

Figure 11 shows the central simulation of the paper. The variables shown are the same, and are shown in the same units, as in the impulse responses in Figures 8–10. The horizontal axis represents time, with the simulation starting in 1983 and ending in 2030. The red circular markers represent U.S. data, while the black lines represent model simulations. The data for GDP and for the top 5% income share are used as forcing processes that pin down the realizations of the shocks $\epsilon_{y,t}$ and $\epsilon_{z,t}$ between 1983 and 2008. Post-2008 data for GDP and the top 5% income share are shown but are not used as forcing processes. Because this is an endowment economy, interest rate fluctuations mirror output fluctuations. We assume that a crisis shock hits in 2009. The crisis event in 2009 is, as discussed above, characterized by output losses that are somewhat lower than observed during the Great Recession. Starting in 2009, the model is simulated assuming a random sequence of utility cost shocks, but no further nonzero realizations of output or output share shocks. Because the preceding shocks imply further increases in debt after 2009, this means that future endogenous crises remain a possibility, and in fact become increasingly likely.

The key forcing variable is the increase in the top 5% income share from 21.8% in 1983 to 33.8% in 2008. In the baseline calibration, the marginal propensity to save of top earners is equal to 0.397. Therefore, top earners save a sizeable share of their additional income in order to acquire additional financial wealth, in other words to lend to bottom earners. Bottom earners' debt-to-income ratio therefore increases from 62.3% in 1983 to 131.9% in 2007 and 138.8% in 2008, accompanied by an increase in crisis probability from 2.2% in 1983 to 5.1% in 2008. In the data, the debt-to-income ratio increases from 62.3% in 1983 to 147.3% in 2007. Potential explanations for the 15.4 percentage point 2007 difference between model and data are discussed in the next subsection.

While the initial debt-to-income ratio in the model and in the data were matched through the

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[27]A model with borrowing constraints would limit reborrowing. However, data from the crisis period show that, while the crisis stopped mortgage debt from increasing further, unsecured debt kept increasing.
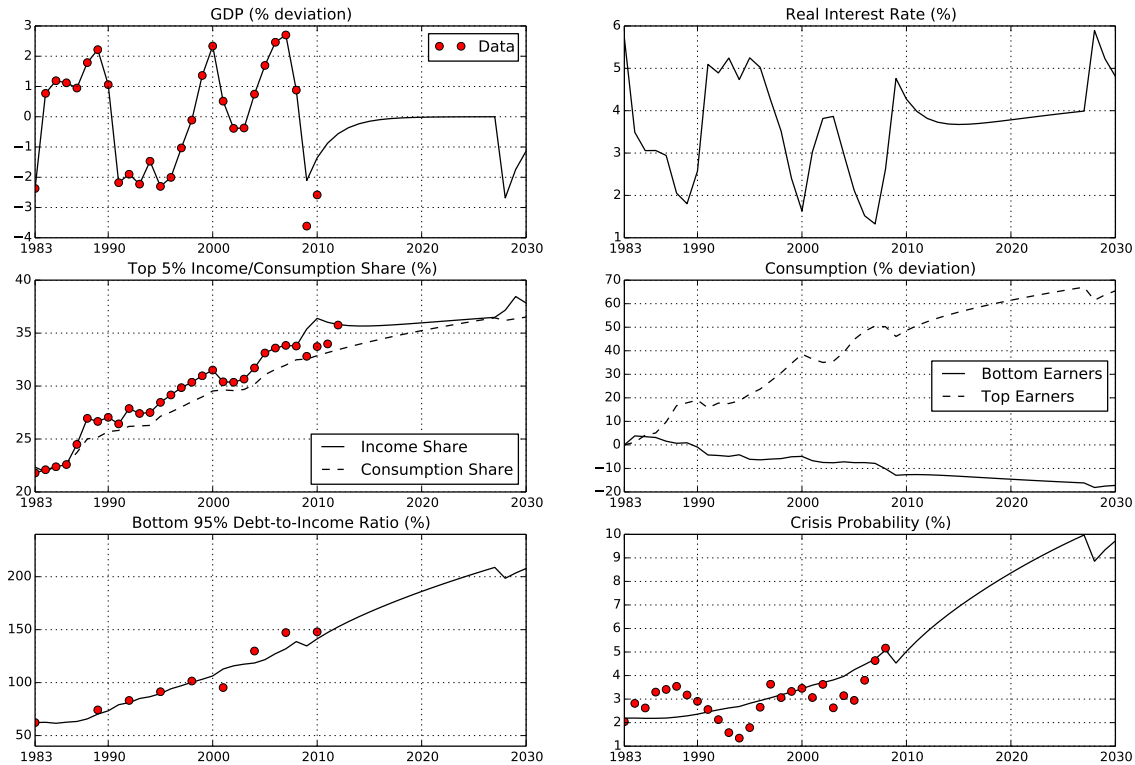
Figure 11: Baseline Scenario

calibration of the initial steady state, its post-1983 evolution was not targeted in our calibration. The fact that we nevertheless closely match it, after calibrating the preference for wealth specification on the basis of independent microeconomic evidence, is therefore a measure of the empirical success for our model. By matching the increase in debt we also match the increase in crisis probability, but this is not an additional independent success of the model, since the default mechanism was calibrated so as to replicate the empirical link between leverage and crisis probabilities.

In the baseline scenario, top earners increase their consumption by a cumulative 50% until just prior to the Great Recession, while bottom earners reduce their consumption by 10%. The simulated top 5% consumption share, which is shown in the same subplot as the top 5% income share, also increases between 1983 and 2008, but by less than the income share. This is a necessary consequence of the fact that top earners are lending, and are therefore maintaining lower consumption levels than what their income alone would permit. There is an ongoing debate in the empirical literature about the relative evolution of consumption inequality and income inequality.[28] The results of this literature are however not directly comparable to our results, because it has so far not produced an

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[28]Krueger and Perri (2006) argue that consumption inequality increased by much less than income inequality between 1983 and 2003. These results have recently been challenged by Aguiar and Bils (2011), who estimate that the increases in consumption and income inequality mirror each other much more closely. Attanasio, Hurst and Pistaferri (2012) confirm the results of Aguiar and Bils (2011). By contrast, Meyer and Sullivan (2013) find that the rise in income inequality has been more pronounced than the rise in consumption inequality.

empirical estimate of the top 5% consumption share that would correspond to our model simulations.

For the future, the model predicts a further increase of the income share of top earners, not because of further increases in their output share z_t but rather because of further increases in debt and associated interest charges. Bottom earners' simulated debt-to-income ratio increases from around 140% to around 180% over the post-crisis decade, accompanied by an increase in crisis probability from around 5% to around 8%. Under the random sequence of utility cost shocks used in our simulation, the model generates one subsequent crisis in 2028.

The effect of the crisis on bottom earners' debt-to-income ratio in the model is modest, it drops by around 4 percentage points on impact but then immediately resumes its upward trajectory. The reason is the continuing upward trend in top earners' financial wealth accumulation, as a result of previous favorable shocks to their income share.

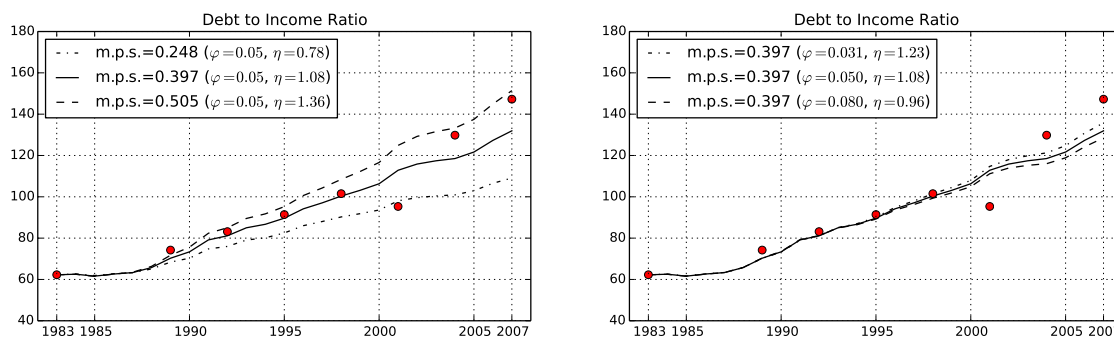## 5.4   Empirical Performance of the Model

Figure 12: Sensitivity Analysis

The crucial implication of the MPS-based calibration is that the 1983-2007 evolution of the debt-to-income ratio of bottom earners can be used to evaluate the quantitative performance of the model.[29] The left subplot of Figure 12 illustrates that this performance depends on the calibrated value of the MPS. For this figure, we calibrate the model based on the baseline MPS of 0.397, the upper bound MPS of 0.505, and the lower bound MPS of 0.248. Our baseline simulation is reproduced as the solid line, the data as red circular markers, and lower and upper bound MPS as dash-dotted and dotted lines. Differences in MPS are calibrated by holding φ at its baseline value of 0.05 and varying η, with a higher η (higher MPS) implying that top earners allocate a larger share of their additional income to financial wealth accumulation. The interest rate adjusts to ensure that this higher credit supply is taken up by bottom earners, who end up with a higher debt-to-income ratio.

The baseline model tracks the overall trend in the data well. By 2007, the model predicts a debt-to-income ratio of 131.9%, versus 147.1% in the data. The upper-bound model slightly over-predicts over the period 1992-1998 but is closer to the data towards the end of the period. The lower-bound model under-predicts throughout. However, even this calibration predicts a 1983-2007 increase in bottom earners' debt-to-income ratio of around 47 percentage points, which equals well over half of the increase observed in the data. Overall the baseline model explains close to 100%

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[29]We focus on this period because the model is simulated over 1983-2008 for a series of inequality and output shocks that exactly reproduce the data. 2007 is the last pre-crisis data point in SCF.

of the increase in the debt-to-income ratio of bottom earners over the first 15 years of the period of interest (1983-1998), and approximately 70% over the last 9 years (1998-2007). This suggests a possible role for complementary explanations over the latter period. As discussed in Section 2.6, the global saving glut can explain around one quarter of the increase in U.S. household debt over this period. This is roughly the share of household debt that is left unexplained by our model.

The right subplot of Figure 12 shows that, once a MPS has been chosen, in this case the baseline MPS of 0.397, differences in the combinations of φ and η that give rise to that MPS have only a very small effect on the model's predictions. We note that the combinations of φ and η shown in Figure 12 differ by a very substantial margin, with the upper bound φ 60% larger than the baseline (0.08), and the lower bound φ 60% smaller than the baseline (0.031). Yet the implied differences in the behavior of the debt-to-income ratio are very small. What matters is therefore primarily the MPS itself, for which we have produced solid empirical evidence in the online appendix.

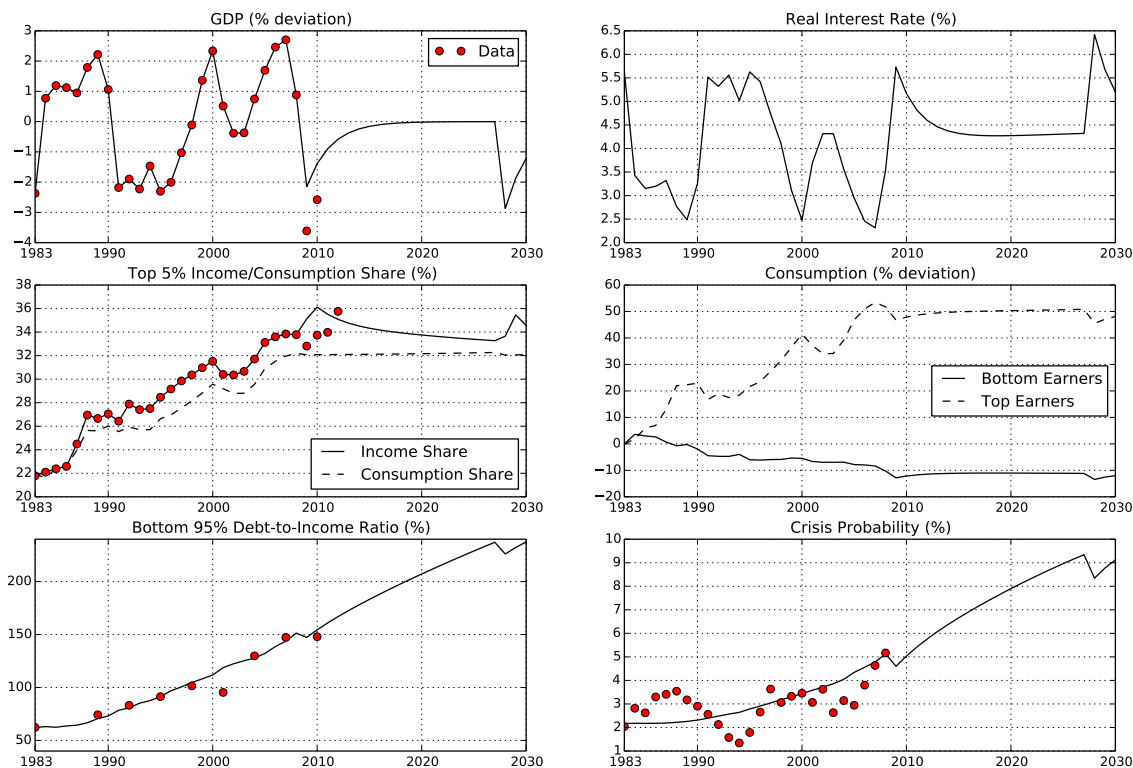## 5.5   Pure Consumption Smoothing and Shock Persistence

Figure 13: Consumption Smoothing Scenario

In our baseline scenario the increase in bottom earners' debt is due to increased credit supply from top earners. The reason is that shocks to the income distribution are permanent, so that neither bottom earners nor top earners have an incentive to smooth consumption, while top earners

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have a strong incentive to accumulate wealth.

The permanence of shocks to the income distribution is consistent with the evolution of income inequality between 1983 and 2008, and with the evidence of Kopczuk, Saez and Song (2010) and DeBacker et al. (2013). It is nevertheless interesting to ask what quantitative role pure consumption smoothing, in the complete absence of a wealth accumulation motive, could play if shocks to the income distribution were perceived to be more temporary. In that case top earners would have no motive to accumulate wealth for its own sake, while both bottom and top earners would have a stronger incentive to borrow and lend to smooth consumption. In other words, in such a world there would be an increased role for credit demand relative to credit supply.

For this exercise we perform another variation of our baseline simulation in which wealth does not enter the utility function of top earners ($\varphi = 0$), both income groups have the same discount factor ($\beta_b = \beta_\tau = 1.04^{-1}$), and shocks to the inequality process are highly persistent but not permanent. The initial values of all endogenous variables are identical to the baseline case. The results are shown in Figure 13, under the assumption $\rho_z = 0.98$.

We observe that for this particular persistence parameter the effects of consumption smoothing are similar to those of preferences for wealth in the baseline, with both debt and crisis probability increasing by similar magnitudes prior to the crisis. But this would change dramatically for a less persistent z_t. In that case the consumption smoothing motive would become very much stronger, because it would imply that bottom earners continually expect their income to revert to a much higher level over a fairly short period. The cumulative effect of this perception, which would represent large and one-sided forecast errors over the 1983-2008 period, would be a much larger build-up of debt.

6 Conclusions

This paper has presented stylized facts, a theoretical framework, and an empirical methodology for calibrating it, that explore the nexus between increases in the income share of high-income households, higher debt leverage among poor and middle-income households, and vulnerability to financial crises. We provide evidence which suggests that this nexus was prominent prior to both the Great Depression and the Great Recession. In our baseline theoretical model higher debt leverage arises as a result of permanent positive shocks to the income share of high-income households who, due to preferences for wealth, lend part of their additional income back to poor and middle-income households. This increase in credit supply allows poor and middle-income households to sustain higher consumption levels. But the result is that loans keep growing, and therefore so does the probability of a crisis that, when it happens, is accompanied by a contraction in the real economy. This contraction, together with a desire of high-income households to accumulate further wealth while their income share remains high, implies that the effect of a crisis on debt leverage and therefore on the probability of further crises is quite limited.

It is possible to use our framework to simulate alternative scenarios for the future of the U.S. economy. One alternative, studied in Kumhof, Rancière and Winant (2013), looks at the consequences of a reversal of the post-1983 increase in income inequality over a period of 10 years. We find that this would lead to a sustained reduction in leverage that would significantly reduce the probability of further crises.

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