Falling Behind: Has Rising Inequality Fueled the American Debt Boom?*

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Abstract

This paper studies whether the interplay of social comparisons in housing and rising income inequality contributed to the household debt boom in the US between 1980 and 2007. We develop a tractable macroeconomic model with general social comparisons in housing to show that changes in the distribution of income affect aggregate housing demand, aggregate debt and house prices if (and only if) social comparisons are asymmetric. In the empirically relevant case of upward-looking comparisons, rising inequality can rationalize up to a quarter of the observed debt boom.

Keywords: mortgages, housing boom, social comparisons, consumption networks, external habits, keeping up with the Joneses

JEL Codes: D14, D31, E21, E44, E70, R21

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1 Introduction

Social comparisons matter for economic decision-making. People buy bigger cars when their neighbors win in the lottery (Kuhn, Kooreman, Soetevent, and Kapteyn, 2011); non-rich move their spending to visible goods (like housing) when top incomes rise in their state (Bertrand and Morse, 2016); and people spend more on home improvements when very big houses are built in their neighborhood (Bellet, 2019). While the importance of social comparisons is well-documented in empirical work, the vast majority of (macro)economic models abstracts from social interactions (Kuchler and Stroebel, 2021)—or restrict their attention to representative-agent settings with a single good.[1]

This paper studies whether the interplay of social comparisons in housing and rising income inequality contributed to the household debt boom in the US prior to the Great Recession. Between 1980 and 2007, both household indebtedness (mostly mortgages) and income inequality increased substantially (Panel A of Figure 1). Panel B shows that this aggregate relationship is also present at the state level: states that experienced a stronger increase in average top incomes also experienced a stronger increase in the mortgage-to-income ratio of non-rich households.[2] While several authors have alluded to social comparisons (keeping up with the Joneses) to link the rise in inequality and debt (e.g. Rajan, 2010; Stiglitz, 2009; Frank, 2013) we lack a framework to study how distributional changes affect aggregate indebtedness in the presence of social comparisons. This paper develops such a framework that enables us to characterize the impact of distributional changes on aggregates in closed form. We show that changes in the distribution of income affect macroeconomic aggregates if and only if social comparisons are *asymmetric*. Quantitatively, the model suggests that upward-looking comparisons and rising inequality can rationalize up to a quarter of the US household debt boom.

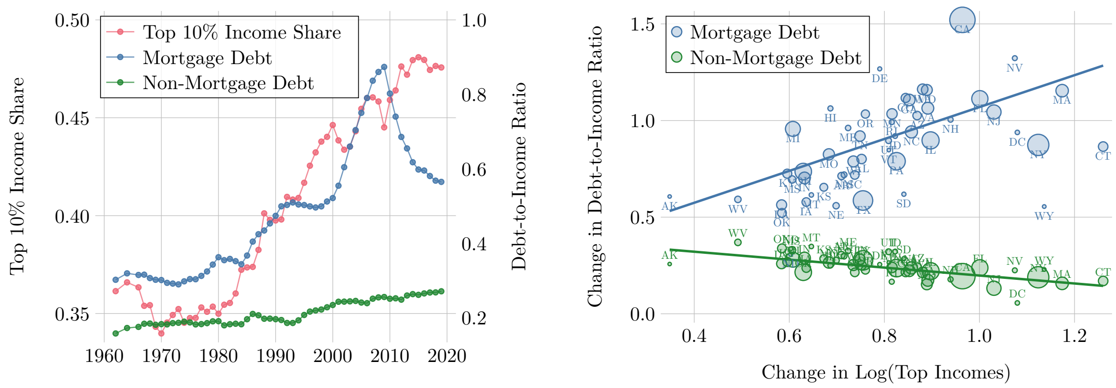
We study a dynamic macroeconomic model with two goods (non-durable consumption and durable housing), a finite number of permanent income types, and an arbitrary network of social comparisons. Agents' utility depends on status-neutral consumption and their *housing status*, which measures how their own house compares to those of their reference group (the *Joneses*). This captures that housing is arguably the most important conspicuous good—both in terms of visibility and expenditure share (e.g. Solnick and Hemenway, 2005; Bertrand and Morse, 2016).

[1] See for example Abel (1990), Gali (1994), Campbell and Cochrane (1999) and Ljungqvist and Uhlig (2000).

[2] No such relationship exists for non-mortgage debt.

Figure 1: Income Inequality and Household Debt

(a) Aggregate Inequality and Debt (b) State-Level



Notes: Panel A shows the evolution of the debt-to-income ratio and the top 10% income share in the US. Panel B plots the change in the mortgage-to-income ratio and the non-mortgage-to-income ratio of the bottom 90% of the income distribution in each state against the change in the log of average incomes of the state's top 10% between 1980-1982 and 2005-2007. The size of the markers corresponds to the state's population size in the base period.

Social comparisons give rise to social externalities: Agents' housing decisions directly affect other agents' demand for consumption, housing and debt.

We first characterize agents' optimal choices of consumption, housing and debt as linear functions of own permanent income and the incomes of other agents which they compare themselves to—directly and indirectly. More formally, the network of social comparisons gives rise to a matrix of social externalities that encodes to what extent each agent's income affects the choices of all other agents. To illustrate this, consider an increase in type i's income. Equipped with more resources, type-i agents will improve (or upsize) their houses. This lowers the housing status for all types j that compare themselves to type i. Each of these type-j agents will react to this social externality by shifting expenditures away from status-neutral consumption towards status-enhancing housing in an effort to keep up with i's housing. This response of type-j agents will induce a second round of social externality effects. Agents who compare themselves to the type-j agents will similarly increase housing demand. The effect cascades to all types that are connected to type i in the *network of social comparisons*.

Importantly, since housing is a durable good (and consumption is non-durable), agents find it optimal to smooth consumption and purchase the entire house upfront by taking on (mortgage) debt. As a consequence, agents' demand for debt will also increase in the incomes of their reference group.

We then study the effects of changes in the income distribution on aggregate housing and debt. The consequences of rising income inequality crucially depend on the nature of social comparisons. In the special case where social comparisons are homogeneous and symmetric—each agent's reference measure is the population average (*Mean Joneses*)—changes in the distribution of incomes do not affect aggregates. Incidentally, this is the case studied in the macro-finance literature on Keeping up with the Joneses.[3] However, when the network of social comparisons is asymmetric such that agents differ in their *popularity*, aggregate housing and debt increases if (and only if) income is redistributed towards more popular agents. Formally, an agent's *popularity* is the population-weighted Bonacich-Katz in-centrality, which measures how strongly other agents care about a given agent's house.[4]

Despite uncertainty about the exact structure of the comparison network, there is strong evidence that comparisons are upward-looking (Ferrer-i-Carbonell, 2005; Clark and Senik, 2010; Card, Mas, Moretti, and Saez, 2012; Bertrand and Morse, 2016; Bellet, 2019).[5] In this case—where an agent's reference group is composed of rich(er) households—rising inequality drives up aggregate demand for housing and debt. As aggregate income is unchanged by a rise in inequality, the aggregate debt-to-income ratio increases as well.

Finally, we study the effects of changes in the income distribution in general equilibrium where housing supply and house prices adjust to changes in housing demand. A redistribution of incomes towards more popular agents increases house prices.[6] Hence, in general equilibrium, upward social comparisons imply that rising inequality increases aggregate housing- and debt-to-income ratios as well as house prices. If housing and consumption are complements (substitutes), the general equilibrium effects of rising inequality are larger (smaller).

We use this framework to analyze whether rising inequality and *Keeping up with the Rich(er) Joneses* may have fueled the US debt boom between 1980 and 2007

[3]E.g. Abel (1990), Gali (1994), Campbell and Cochrane (1999), Ljungqvist and Uhlig (2000).

[4]In the knife-edge case of *Mean Joneses*, popularities are constant.

[5]The available evidence on interpersonal comparisons shows that comparisons are asymmetric, being strongest (and best documented) with respect to the rich (e.g. Clark and Senik, 2010; Ferrer-i-Carbonell, 2005; Card et al., 2012, on self-reported well-being). People buy bigger cars when their neighbors win in the lottery (Kuhn et al., 2011); non-rich move their spending to visible goods (like housing) when top incomes (but not median incomes) rise in their state (Bertrand and Morse, 2016); and spend more on home improvements when very big (but not low- or medium-sized houses) houses are built in their neighborhood (Bellet, 2019).

[6]We can analytically prove this result for an intra-temporal elasticity of substitution $e < \bar{e}$, where $\bar{e} > 1$. Thus, we cover the commonly studied case of Cobb-Douglas aggregation (Piazzesi and Schneider, 2016), but also structural estimates (e.g. Flavin and Nakagawa, 2008; Bajari, Chan, Krueger, and Miller, 2013). Simulations suggest that the result holds more generally.

using a setup with three income groups, the bottom 50%, the middle 40% and the top 10%. We study two cases of upward-looking social comparisons. First, we consider the case where all agents compare themselves directly to the rich (*rich Joneses*), which is in line with the findings in Bellet (2019). Second, we assume the bottom 50% care only about the middle 40% who in turn compare themselves to the top 10% (*Richer Joneses*) such that social externalities trickle down the income distribution.

Our baseline calibration using Cobb-Douglas aggregation of consumption and housing suggests that the model can rationalize roughly one fifth of the increase in households' debt-to-income ratio (11 p.p.), almost the entire increase in the housing expenditure share (4 p.p.), and a tenth of the increase in house prices. When assuming that agents only care about rich(er) households *within their state*, the results do not change substantially. This reflects the fact that the surge in nationwide income inequality is primarily driven by rising within-state inequality. Finally, our sensitivity analysis reveals that decreasing the strength of the comparison motive reduces the effects almost linearly, and reducing the intratemporal elasticity of substitution between housing and consumption increases the effect in general equilibrium.

Related Literature. Our paper relates to several strands of the literature. First, we contribute to the large literature on social comparisons (e.g. Luttmer, 2005; Card et al., 2012; Perez-Truglia, 2019) and economic choices (Charles, Hurst, and Roussanov, 2009; Kuhn et al., 2011; Bursztyn, Ederer, Ferman, and Yuchtman, 2014; Bertrand and Morse, 2016; Bursztyn, Ferman, Fiorin, Kanz, and Rao, 2017; Bellet, 2019; De Giorgi, Frederiksen, and Pistaferri, 2020). While the macroeconomic effects of keeping up with the Joneses have already been studied in representative agent settings (e.g. Abel, 1990; Campbell and Cochrane, 1999; Ljungqvist and Uhlig, 2000), we introduce very flexible social comparison networks into a heterogeneous agents model. We build on the macro-finance literature on keeping up with the Joneses and bring it closer to the empirical evidence. First, we distinguish between conspicuous and non-conspicuous goods. In our model households compare themselves only in their houses, arguable the most important conspicuous good (e.g. Solnick and Hemenway, 2005; Bertrand and Morse, 2016). And second, we allow for general comparison networks, to accommodate the empirically relevant case where agents compare themselves to rich(er) agents (e.g. Card et al., 2012; Bellet, 2019). This distinguishes us from Badarinza (2019) and Grossmann, Larin, Löfflad, and Steger (2021) who study heterogeneous agent models with homogeneous and symmetric comparisons in housing (*Mean Joneses*)—the case where rising inequality has no aggregate effects. Our framework can be used to study the effects of changes in the distribution of income on macroeconomic aggregates in the presence of realistic comparisons networks.

Our analytical results extend those by Ghiglino and Goyal (2010) and Ballester, Calvó-Armengol, and Zenou (2006) who show that agents' choices depend on the strengths of social links in a one-period model. We extend their network models to infinite horizon and add a durable good (housing) to show that debt is increasing in the centrality of an agent. The centrality is reinterpreted as the weighted sum of incomes of the comparison group. Ghiglino and Goyal (2010) study the effect of non-homogeneous social comparisons in a setting with two goods in a static environment with Cobb-Douglas preferences. Our theoretical analysis differs in two dimensions: Most importantly, we study a dynamic infinite horizon model with heterogeneity in initial wealth and flow income where social comparisons not only affect intra-temporal consumption decisions but also inter-temporal decisions, i.e. borrowing behavior, and is hence more suitable for macroeconomic analyses. In addition, our setup accommodates not only the special case of Cobb-Douglas preferences, but any CES utility function.

Second, we contribute to the growing literature on the aggregate effects of rising income inequality resulting from deviations from standard preference assumptions grounded in insights from empirical microeconomic research. Kumhof, Rancière, and Winant (2015) add a preference for financial wealth to a establish a link between rising inequality and higher indebtedness through lower interest rates. Straub (2018) shows that rising permanent income inequality drives down interest rates in the presence of non-homothetic preferences. Mian, Straub, and Sufi (2021) show that the same underlying heterogeneity in the propensity to consume out of permanent income gives rise to debt traps. Fogli and Guerrieri (2019) analyze the interplay between residential segregation and income inequality in the presence of local spillovers that affect the education returns. Grossmann et al. (2021) studies the distributional implications of increasing housing rents when rich and poor households differ in their housing expenditure shares. In our model, agents are linked not only through prices but also directly through social externalities of their consumption decisions. Distributional shifts can affect aggregates when some agents are more popular than others.

Third, we contribute to the literature that studies the drivers of the US household debt boom which was documented by Jordà, Schularick, and Taylor (2016) and

Kuhn, Schularick, and Steins (2017). A range of papers focuses on an increase in the foreign or domestic supply of credit that drives up household debt through a drop in the interest rate (Justiniano, Primiceri, and Tambalotti, 2014; Kumhof et al., 2015; Mian, Straub, and Sufi, 2020; Mian et al., 2021). Most notably, Mian et al. (2021) show that differences in saving rates out of permanent income can link rising income inequality to rising credit supply and falling interest rates. Other papers study the role of looser collateral constraints (e.g. Favilukis, Ludvigson, and van Nieuwerburgh, 2017) and lending limits (Justiniano, Primiceri, and Tambalotti, 2019) as well as changes in house price expectations (Adam, Kuang, and Marcet, 2012; Kaplan, Mitman, and Violante, 2020). This paper adds to this literature by exploring a demand-side mechanism that can help rationalize the link between top incomes and non-rich debt and complements the existing supply-side mechanisms. Social comparisons may be particularly useful to rationalize the state-level link between inequality and indebtedness that we document.

Finally, our empirical results in Appendix A are closely related to the the study by Bertrand and Morse (2016) who use CEX data and state-year variation to document that consumption expenditures of non-rich households respond to the incomes and consumption expenditures of the rich. Coibion, Gorodnichenko, Kudlyak, and Mondragon (2020) investigate the relationship between zip-code level income inequality (P90-P10 ratio) and household debt between 2000 and 2012 and find heterogeneous effects by income rank. Mian et al. (2020), whose data preparation steps we follow, analyze whether increasing top incomes in a state lead to an increase in the amount of non-rich household debt held as an asset by the state's rich. We analyze whether the state's non-rich take on more debt and analyze the dynamic effects of increases in top incomes. Rather looking at the *consequences* of inequality, Martínez-Toledano (2023) shows that housing booms and busts are important *determinants* of wealth inequality.

Structure of the paper The rest of the paper is structured as follows: In Section 2 we describe our model. In Section 3 we derive analytically how inequality drives debt. In Section 4 we calibrate the model and show that the relationship between inequality and debt is quantitatively significant. Section 5 concludes.

2 Model

We consider a world that is populated by a unit mass of atomistic agents that differ by their income type $i \in \{1, \dots, N\}$. Types are ordered by their permanent income $\mathcal{Y}_i$ from poor to rich,

$$\mathcal{Y}_1 < \mathcal{Y}_2 < \cdots < \mathcal{Y}_N.$$

Permanent incomes are exogenous, do not vary over time, and are the sum of an agent's flow income y_i and interest income from initial wealth: $\mathcal{Y}_i = y_i + ra_0^i$. Population shares are denoted by ω_i.

Agents' flow utility $u(c, s)$ depends on consumption c and housing status, $s(h_i, \tilde{h}_i)$, which is increasing in their own house h_i, but decreasing in the reference measure $\tilde{h}_i$, which is a weighted sum of houses of other agents to whom the agent compares herself:

$$\tilde{h}_i = \sum_{j=1}^{n} g_{ij} h_j, \quad \text{where } g_{ij} \geq 0.$$

This gives rise to a network of social comparisons where the weights $(g_{ij})_{ij}$ form the network's adjacency matrix, $G = (g_{ij})_{ij}$.[7] If an edge g_{ij} is positive, then we say that agent i's housing status is affected by agent j's house or that agent j exerts a negative externality on agent i.

Figure 2 shows four simple networks that will be used to illustrate the analytical results. For ease of exposition, we restrict ourselves to three types, poor P, middle-class M, and rich R with population weights $\boldsymbol{\omega} = (\omega_P, \omega_M, \omega_R)$.

In Panel (a), there are no links—i.e. no social comparisons. Agents' housing status does not depend on others' houses. This is implicitly assumed in the vast majority of macroeconomic models which abstract from social comparisons. In Panel (b), all agents care equally about all types according to their population share ω_j. This means that the reference house $\tilde{h}_i = \bar{h}$ is simply the average house in the economy. This case is studied in a classic macro-finance literature (e.g. Abel, 1990; Gali, 1994; Campbell and Cochrane, 1999; Ljungqvist and Uhlig, 2000) on *Keeping up with the Joneses* in models without income heterogeneity.

The remaining two networks in Panels (c) and (d) capture the empirical finding that social comparisons are *not* symmetric, but mostly upward-looking (e.g. Ferrer-i-Carbonell, 2005; Clark and Senik, 2010; Card et al., 2012; Bellet, 2019) In Panel (c), agents compare themselves to those just above them in the income distribution. And

[7]The adjacency matrix allows us to write the reference measure in vector form $\tilde{\boldsymbol{h}} = G\boldsymbol{h}$.

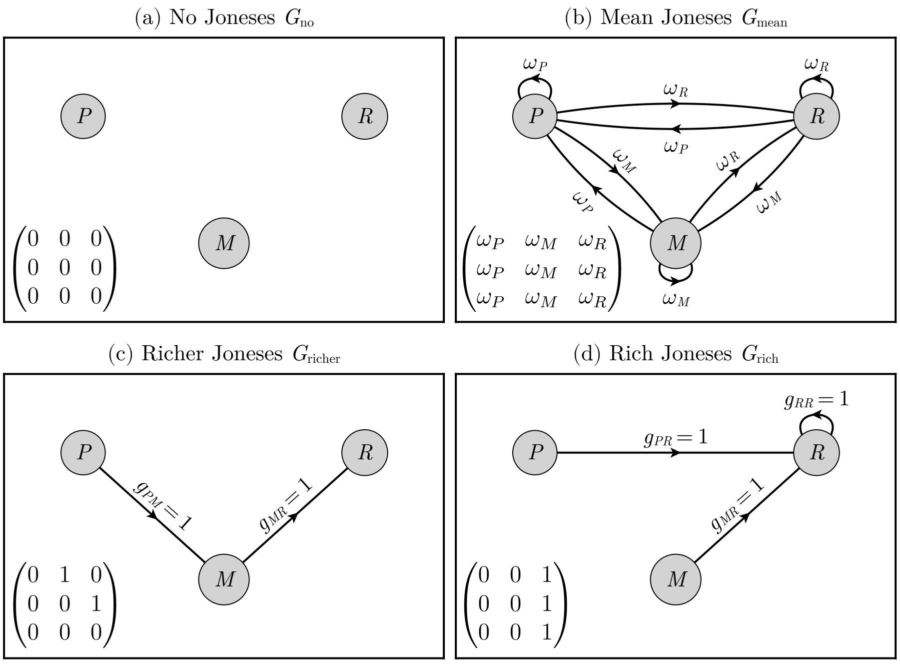


Figure 2: Four simple networks

in Panel (d), all agents, including the rich, compare themselves only to the rich. As we will show below, asymmetric comparisons are key for changes in the distribution of income to affect macro-financial aggregates such as the aggregate debt-to-income ratio.

The remaining parts of the model are standard, following the "canonical macroeconomic model with housing" in Piazzesi and Schneider (2016). Agents' expected discounted lifetime utility of streams of consumption $c_t > 0$, housing $h_t > 0$ and assets $a_t \in \mathbb{R}$ is given by

$$\sum_{t=0}^{\infty} \beta^t \frac{\left((1-\xi)c_t^{\varepsilon} + \xi s(h_t, \tilde{h}_t)^{\varepsilon}\right)^{\frac{1-\gamma}{\varepsilon}}}{1-\gamma},$$

where $\beta = \frac{1}{1+\rho}$ and $\rho \geq 0$ is the discount rate, $1/\gamma > 0$ is the inter-temporal elasticity of substitution, $1/(1-\varepsilon) > 0$ is the intra-temporal elasticity of substitution between consumption and housing status and $\xi \in (0,1)$ is the relative utility-weight for housing status.

Housing is both a consumption good and an asset. It is modeled as a homogenous, divisible good. As such, h represents a one-dimensional composite measure of housing quality (including size, location and amenities). An agent's housing stock depreciates at rate $\delta \in (0,1)$ and can be adjusted frictionlessly.[8] Home improvements and maintenance expenditures x_t have the same price as housing (p) and go into the value of the housing stock one for one.

Agents can save ($a > 0$) and borrow ($a < 0$) at the exogenous interest rate r. The flow budget constraints are

$$\begin{aligned} a_{t+1} &= y_t + (1+r)a_t - c_t - px_t, \\ x_t &= h_t - (1-\delta)h_{t-1}, \end{aligned}$$

subject to the non-negativity constraint for housing, $h_t > 0$, and given initial wealth $a_0 \in \mathbb{R}$ and $h_{-1} = 0$.

3 Analytical Results

In this section, we first characterize agents' optimal choices in the presence of social comparisons, and then derive necessary and sufficient conditions for rising income inequality to affect the aggregate debt-to-income ratio. We start by keeping house prices fixed before introducing a construction sector and requiring market clearing on the housing market.

We need two assumptions in order to obtain tractability. First, the interest rate equals the discount rate. Second, the social status function s is linear.

Assumption 1. $r = \rho$.

Assumption 2. The status function is linear, $s(h, \tilde{h}) = h - \varphi\tilde{h}$, where $\varphi \in [0, 1)$.

We further require the network of social comparisons to satisfy the following regularity condition.

Assumption 3. The Leontief inverse $(I - \varphi G)^{-1}$ exists and is equal to $\sum_{i=0}^{\infty} \varphi^i G^i$ for φ from Assumption 2.

Assumption 3 is satisfied whenever the power of the matrix converges, $G^i \to G^\infty$. For example, if G represents a Markov chain with a stationary distribution or if G is nilpotent.

[8]Frictionless adjustment is justified, because we will be comparing long-run changes.

3.1 Characterization of Agents' Optimal Choices

We analyze a partial equilibrium where the references measures are consistent with agents' choices. We show that, given prices, agent i's optimal housing and debt are increasing in the permanent income of another type j as long as there is a (direct or indirect) path from i to j in the comparison network. This condition holds whenever i compares herself to j, or whenever i compares herself to somebody that compares herself to j, and so on. We assume that agents choose streams of consumption $c_t > 0$, housing $h_t > 0$ and assets $a_t \in \mathbb{R}$ to maximize their discounted lifetime utility subject to a lifetime budget constraint, and the laws of motion for assets and housing.

Agents' optimal decisions are summarized in the following proposition.

Proposition 1. *Under assumptions 1, 2 and 3, the optimal choices* $\boldsymbol{h} = (h_1, \ldots, h_N)^T$ *and* $\boldsymbol{a} = (a_1, \ldots, a_N)^T$ *are given by*

$$\begin{aligned} \boldsymbol{h} &= \kappa_2(I + L)\boldsymbol{\mathcal{Y}}. \\ -\boldsymbol{a} &= \kappa_3(I + L)\boldsymbol{\mathcal{Y}} - \boldsymbol{a}_0 \end{aligned} \tag{1}$$

where $L = \sum_{i=1}^{\infty}(\kappa_1\varphi G)^i$ *is the social externality matrix (weighted matrix of direct and indirect paths in the network of comparisons). Moreover:*

$$\begin{aligned} \boldsymbol{c} &= \kappa_1(I + L)\boldsymbol{\mathcal{Y}} - \frac{p}{1+r}L\boldsymbol{\mathcal{Y}} \\ \kappa_0 &= \left(p\frac{\delta + r}{1+r}\frac{1-\xi}{\xi}\right)^{\frac{1}{1-\varepsilon}} > 0 \\ \kappa_1 &= \frac{\kappa_0}{p\frac{\delta+r}{1+r} + \kappa_0} \in (0,1) \\ \kappa_2 &= \frac{1}{p\frac{r+\delta}{1+r} + \kappa_0} > 0 \\ \kappa_3 &= \frac{p(1-\delta)}{1+r}\kappa_2 > 0 \end{aligned} \tag{2}$$

Proof. See appendix D.1. □

Proposition 1 states that agents' policy functions for housing, consumption and debt are linear combinations of their own permanent income and other types' permanent incomes. The extent to which others' incomes matter is encoded in the social externality matrix $L = \sum_{i=1}^{\infty}(\kappa_1\varphi G)^i$.[9]

[9]The social externality matrix L is the Leontief inverse of G minus the identity matrix. Recall

Table 1: Examples of Social Externality Matrices

(a) L_{no}	(b) L_{mean}	(c) L_{richer}	(d) L_{rich}
$\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$	$\frac{\tilde{\varphi}}{1-\tilde{\varphi}} \begin{pmatrix} \omega_P & \omega_M & \omega_R \\ \omega_P & \omega_M & \omega_R \\ \omega_P & \omega_M & \omega_R \end{pmatrix}$	$\begin{pmatrix} 0 & \tilde{\varphi} & \tilde{\varphi}^2 \\ 0 & 0 & \tilde{\varphi} \\ 0 & 0 & 0 \end{pmatrix}$	$\frac{\tilde{\varphi}}{1-\tilde{\varphi}} \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{pmatrix}$

Note: For better readability, we define $\tilde{\varphi} := \kappa_1 \varphi$.

Table 1 shows the social externality matrices for the four simple networks shown in Figure 2. In the case of *No Joneses* (a), L_{no} is a zero matrix because there are no social comparisons. In the case of *Mean Joneses* (b) there are infinitely many paths from each type to each other type. The externality of any type on agents from all other types is proportional to the respective population share. In the case of *Richer Joneses* (c) there are two paths of length 1, from P to M and from M to R, and one path of length 2 from P to R via M. This example illustrates the general result that types need not be directly linked for a social externality to emerge: Even though the poor do not compare themselves to the rich ($g_{PR} = 0$), incomes of the rich will still affect choices of the poor because the poor compare themselves to the middle-class who compare themselves to the rich. In other words, the externality trickles down the income distribution.

To better see how social comparisons affect agents' optimal consumption and housing choices, we rewrite optimal housing choices of type-i agents:

$$h_i = \kappa_2 \Big((1 + L_{ii}) \mathcal{Y}_i + \sum_{j \neq i} L_{ij} \mathcal{Y}_j \Big)$$

Without social comparisons, the housing policy function only depends on own permanent income as $L_{ij} = 0$ for all $i \neq j$. In contrast, whenever type-i agents care directly or indirectly about type-j agents, $L_{ij} > 0$, type-i agents' housing increases in type j's permanent income. The strength of the externality, L_{ij}, depends on (i) the number and strength of all direct and indirect comparison links from i to j encoded in G, and (ii) deep model parameters such as the utility weight of housing or the intra-temporal elasticity of substitution between housing and consumption.[10]

that each power G^k represents paths of length k in the network of comparisons.

[10]The higher the utility weight on housing and the more substitutable are housing and consumption, the stronger will be the externality.

Intuitively, as $\mathcal{Y}_j$ rises, type-j agents will improve (or upsize) their housing stock h_j, which increases the reference measure $\tilde{h}_i$ for all types i that care about type j, directly or indirectly. Each of these agents will optimally shift expenditures away from status-neutral consumption and towards status-enhancing housing.

As houses are durable, agents take on debt to pay for the entire house ph upfront and only replace the depreciation δph at each future point in time. By taking on debt, households shift some of their lifetime income forward to finance their house and are able to keep the stock of housing constant over time. Hence, when agents scale up their house following an increase in others' incomes, they also take on a bigger mortgage.

If housing is non-durable, housing is not debt-financed and changes in optimal housing have no effect on optimal debt. To see this, consider the case of perfectly non-durable housing ($\delta \to 1$). As the depreciation rate approaches 100% the social externality matrix disappears from the formula for optimal debt. This argument is formalized in the following Corollary.

Corollary 1. *When houses are non-durable, optimal debt does not depend on others' incomes.*

Proof. As $\delta \to 1$, so that the housing stock full depreciates in each period, $\kappa_3 \to 0$—see (2). Since all other terms in expression (1) are bounded, we have $\boldsymbol{a} \to \boldsymbol{a}_0$. $\square$

Note that the optimal housing decision remains positive and dependent on social externalities, it is just not relevant for debt any more.

Out-Centrality. Finally, note that Proposition 1 can also be interpreted in terms of network centrality. $L\boldsymbol{\mathcal{Y}}$ is the vector of permanent-income-weighted Bonacich-Katz out-centralities of the network of social comparisons. This centrality measure captures how strongly an agent cares about others, and how much permanent income these types have. Optimal choices $\boldsymbol{h}$ and $\boldsymbol{a}$ are affine functions of that centrality measure. This result is reminiscent of that in Ballester et al. (2006), where the unique Nash equilibrium in a large class of network games is proportional to the (unweighted) Bonacich-Katz centrality.

3.2 Impact on Aggregates Depends on *Popularity*

Knowing each agents' policy functions, we now derive expressions for the aggregate demand for housing and debt. To this end, we first define an agent's *popularity* and then show that aggregate housing and debt are weighted sums of agents' permanent incomes, where the weights depend on agents' popularities.

Proposition 1 reveals that the j^{th} column of the social externality matrix L captures how strongly type j's income influences the choices of all other types. We define the *popularity* of type j as the population-weighted j^{th} column sum of L.

Definition 1 (Popularity)**.** We define the vector of popularities $\boldsymbol{b}^T = (b_1, \ldots, b_N)^T$ as

$$\boldsymbol{b}^T = \boldsymbol{\omega}^T \sum_{i=1}^{\infty} (\kappa_1 \varphi G)^i = \boldsymbol{\omega}^T L,$$

and type j's popularity $b_j = \sum_{i=1}^{N} \omega_i L_{ij}$ as the j^{th} component of $\boldsymbol{b}$.

Popularity measures how many other agents are affected by j's permanent income (directly and indirectly) and how strongly they are affected. It is the weighted sum of all pairwise externalities from j onto other types.[11] The weights $\boldsymbol{\omega}$ are the types' population shares.

Table 2: Popularities for Four Example Networks

(a) $\boldsymbol{b}^{\text{no}}$	(b) $\boldsymbol{b}^{\text{mean}}$	(c) $\boldsymbol{b}^{\text{richer}}$	(d) $\boldsymbol{b}^{\text{rich}}$
$\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$	$\frac{\tilde{\varphi}}{1-\tilde{\varphi}} \cdot \begin{pmatrix} \omega_P \\ \omega_M \\ \omega_R \end{pmatrix}$	$\begin{pmatrix} 0 \\ \omega_P \tilde{\varphi} \\ \omega_P \tilde{\varphi}^2 + \omega_M \tilde{\varphi} \end{pmatrix}$	$\frac{\tilde{\varphi}}{1-\tilde{\varphi}} \cdot \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$

Note: For better readability, we define $\tilde{\varphi} := \kappa_1 \varphi$.

Table 2 shows the vector of popularities for the four social comparison networks in Figure 2. In the case of *No Joneses* (a), all types have a popularity of 0. In the case of *Mean Joneses* (b), the popularity is proportional to the population weights. In cases (c) and (d) the poor type P is not popular (no type cares about them), whereas the rich type R has a strictly positive popularity because the other types care about R.

Corollary 2 shows that aggregate housing, consumption and debt can be written as a weighted sum of lifetime incomes where the weights consist of agents' popularities and population weights.

[11] Recall a pairwise externality from j to i is the discounted sum of all weighted paths in G that start at i and end at j. Discounted means that a weighted path of length k is multiplied by $(\kappa_1 \varphi)^k$.

Corollary 2. *Aggregate housing and debt are given by*

$$H := \boldsymbol{\omega}^T \boldsymbol{h} = \kappa_2 (\boldsymbol{\omega} + \boldsymbol{b})^T \boldsymbol{\mathcal{Y}} \tag{3}$$

$$-A := -\boldsymbol{\omega}^T \boldsymbol{a} = \kappa_3 (\boldsymbol{\omega} + \boldsymbol{b})^T \boldsymbol{\mathcal{Y}} - \boldsymbol{\omega}^T \boldsymbol{a}_0. \tag{4}$$

Proof. $\boldsymbol{\omega}^T \boldsymbol{h} = \boldsymbol{\omega}^T (\kappa_2 (I + L) \boldsymbol{\mathcal{Y}}) = \kappa_2 (\boldsymbol{\omega}^T + \boldsymbol{\omega}^T L) \boldsymbol{\mathcal{Y}}) = \kappa_2 (\boldsymbol{\omega} + \boldsymbol{b})^T \boldsymbol{\mathcal{Y}}$ where the first equality follows from Proposition 1 and the final equality from Definition 1. Similar argument for debt. □

Intuitively, Corollary 2 shows that, the more popular a type, the bigger will be its influence on macroeconomic aggregates through the social externalities exerted upon other agents. This is reminiscent of the result of Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi (2012), where the influence of an industry's productivity on aggregate output is determined by the industry's centrality in the input-output network.

In-centrality vs. Out-Centrality. Note that the popularity is the population-weighted Bonacich-Katz in-centrality. It measures the paths that end at a given node: How large is the externality of a given type on all other types? Who cares about a given type and how much? By contrast, the optimal choices of each agent $\boldsymbol{h}$ and $\boldsymbol{a}$ are proportional to the income-weighted Bonacich-Katz *out*-centrality, which measures the paths that begin at a given node: How large are the externalities of all other types on that type?

3.3 Consequences of Rising Income Inequality

Next, we show how aggregate housing-to-income and debt-to-income react to changes in the income distribution. We will compare two steady states that differ only in the distribution of labor incomes $\boldsymbol{y}$.

We consider mean-preserving *redistribution* of (labor) income from type-i to type-j agents. We show that the aggregate housing-to-income ratio and the aggregate debt-to-income ratio increase if the relative difference in popularities between j and i exceeds the relative difference in population weights.

Proposition 2 (Redistribution). *Compare two steady states that differ only in disposable incomes. Let the difference in disposable incomes be* $\Delta \boldsymbol{y} = \boldsymbol{y}' - \boldsymbol{y}$, *where*

$$\omega_j \underbrace{\Delta y_j}_{>0} + \omega_i \underbrace{\Delta y_i}_{<0} = 0, \quad \textit{and } \Delta y_k = 0 \textit{ for all } k \notin \{i, j\}.$$

Then the difference in aggregate housing-to-income and aggregate debt-to-income is positive if and only if type-j agents are more popular than type-i agents, i.e.:

$$\Delta \frac{\boldsymbol{\omega}^T \boldsymbol{h}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}} > 0 \iff \frac{b_j}{\omega_j} > \frac{b_i}{\omega_i} \quad \text{and} \quad \Delta \frac{-\boldsymbol{\omega}^T \boldsymbol{a}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}} > 0 \iff \frac{b_j}{\omega_j} > \frac{b_i}{\omega_i}$$

Proof. See Appendix D.2. □

Why do we have to rescale the popularities of types i and j by the types' respective population weights? This is because we consider mean-preserving redistribution of a group of agents to another group of agents instead of from one individual to another. If all agents have the same population weight, only the difference in popularities matter. In general, however, if we redistribute a total of one dollar from type i to type j, every type-i agent loses $1/\omega_i$ dollars and every type-j agent receives $1/\omega_j$ dollars. The fewer type-j agents there are, the higher is the additional income each of these agents receives, and the stronger is the increase in their average house. Hence, we require a lower popularity of type-j agents in order to get the same increase on others' housing and debt. Hence, aggregate housing-to-income and debt-to-income ratios increase if the ratio of popularities, b_j/b_i, is larger than the ratio of the absolute values of the *average* changes in incomes, ω_j/ω_i.[12]

Proposition 2 shows that asymmetric comparisons are needed in order for changes in the income distribution to generate aggregate effects. According to the classic macroeconomic interpretation of *Keeping up with the (Mean) Joneses*, Example (b) in Figure 2 and Table 2, all types are equally popular, $b_j = b_i$ for all i, j. Under upward comparisons, however, rising income inequality can drive up aggregate housing-to-income and debt-to-income as long as the rich are sufficiently popular. In Example (d), where the rich are everyone's comparison group and hence the only type that exerts a social externality, redistribution from the non-rich to the rich increases the aggregate housing- and debt-to-income ratios. In Example (c), these ratios increase whenever the rich are sufficiently popular relative to the middle class.

3.4 Housing Market Equilibrium

We now introduce a construction sector to the model and study how rising income inequality and social comparisons affect the housing market equilibrium. There are two competitive production sectors producing the non-durable consumption good

[12] The fact that agents' policies are linear in incomes explains why we simply have to rescale with the population weight instead of a function thereof.

c, and new housing investment I_h, respectively. Total labor supply is normalized to one and we denote $N_h \in (0,1)$ the fraction of labor supplied to the housing construction sector. Following Kaplan et al. (2020), there is no productive capital in this economy.

Non-Durable Consumption Sector The final consumption good is produced using a linear production function

$$Y_c = \Theta(1 - N_h)$$

where $1 - N_h \in (0,1)$ is the share of labor supplied to the consumption good sector and Θ is labor productivity. The equilibrium wage per unit of labor is pinned down at $w = \Theta$.[13]

Construction Sector We model the housing sector following Kaplan et al. (2020) and Favilukis et al. (2017). Developers produce housing investment I_h from labor N_h and buildable land, $\bar{L}$, with a Cobb-Douglas production function

$$I_h = (\Theta N_h)^{\alpha}(\bar{L})^{1-\alpha}$$

with $\alpha \in (0,1)$. Each period, the government issues new permits equivalent to $\bar{L}$ units of land, and these are sold at a competitive market price to developers. A developer solves

$$\max_{N_h} p_t I_h - w N_h \quad \text{s.t. } I_h = (\Theta N_h)^{\alpha} \bar{L}^{1-\alpha}$$

In equilibrium, this yields the following expression for optimal housing investment

$$I_h(p) = (\alpha p)^{\frac{\alpha}{1-\alpha}} \bar{L}$$

which implies a price elasticity of aggregate housing supply of $\frac{\alpha}{1-\alpha} > 0$.

Equilibrium We showed in Proposition 1, that the total demand for housing is

$$H_d(p) = \kappa_2(p)\left(\omega + \boldsymbol{b}(p)\right)^T \boldsymbol{\mathcal{Y}}$$

[13] Neither labor supply nor the wage appear in the earnings process, because there is no aggregate risk, households inelastically supply one unit of labor, and the wage is equal to 1.

where we now make the dependence on p explicit.[14] In equilibrium, housing demand must equal housing supply, $H_d(p) = H_s(p)$. In a stationary equilibrium, the stock of housing must be constant such that housing investment equals the depreciated share of the housing stock, $I_h(p) = \delta H_d(p)$. The equilibrium house price thus solves the following equation:

$$(\alpha p)^{\frac{\alpha}{1-\alpha}} \bar{L} = \delta \kappa_2(p) \left(\omega + \boldsymbol{b}(p)\right)^T \boldsymbol{\mathcal{Y}}$$

Proposition 3 (Redistribution and House Prices)**.** *Assume that house prices adjust to clear the housing market. Compare two steady states that differ only in disposable incomes. Let the difference in disposable incomes be* $\Delta \boldsymbol{y} = \boldsymbol{y}' - \boldsymbol{y}$, *where*

$$\omega_j \underbrace{\Delta y_j}_{>0} + \omega_i \underbrace{\Delta y_i}_{<0} = 0, \quad \textit{and } \Delta y_k = 0 \textit{ for all } k \notin \{i, j\}.$$

Then, there exists $\bar{e} > 1$ *such that for all* ε *that satisfy* $\frac{1}{1-\varepsilon} < \bar{e}$, *house prices increase if and only if*

$$\frac{b_i}{\omega_i} < \frac{b_j}{\omega_j}$$

Proof. See Appendix D.3 □

The restriction that the intra-temporal elasticity of substitution between housing and consumption, $e = 1/(1-\varepsilon)$, cannot be arbitrarily high reflects the fact that we are not able to prove that housing demand is monotonically decreasing in the house price for high levels of e in the presence of social comparisons. Intuitively, it may be happen that an increase in the house price raises agents' the popularity enough to undo the initial drop in housing demand.

Note, however, that Proposition 3 covers the empirically relevant case where housing and consumption are complements ($e < 1$), as well as the frequently studied case of Cobb-Douglas preferences ($e = 1$). As Cobb-Douglas aggregation is the most common assumption in macroeconomic models with housing, we study this case in more detail. Lemma 1 shows that Cobb-Douglas preferences allow for a closed-form expression for the house price.

Lemma 1. *Under Cobb-Douglas aggregation,* $\varepsilon \to 0$, *the equilibrium house price is*

$$p = \alpha^{-\alpha} \left(\frac{\delta \xi}{\bar{L}} \frac{1+r}{\delta + r} (\boldsymbol{\omega} + \boldsymbol{b})^T \boldsymbol{\mathcal{Y}} \right)^{1-\alpha}.$$

[14] The vector of popularities is function of the house price as $\boldsymbol{b}(p) = \sum_{i=1}^{\infty} \kappa_1(p) \varphi G)^i$.

Proof. The market clearing condition is $I_h = \delta H$, where aggregate housing demand is $H = \boldsymbol{\omega}^T \boldsymbol{h} = \kappa_2(p)(\boldsymbol{\omega}+\boldsymbol{b}(p))^T \boldsymbol{\mathcal{Y}}$ and optimal housing investment is $I_h = (\alpha p)^{\frac{\alpha}{1-\alpha}} \bar{L}$. The equilibrium price is implicitly given by

$$(\alpha p)^{\frac{\alpha}{1-\alpha}} \bar{L} = \delta \kappa_2(p)(\boldsymbol{\omega} + \boldsymbol{b}(p)^T)\mathcal{Y}.$$

As $\varepsilon \to 0$, κ_1 simplifies to $1-\xi$ (hence $\boldsymbol{b}$ is independent of p), and $\kappa_2(p)$ to $\frac{\xi(1+r)}{p(\delta+r)}$. Thus, the equilibrium condition simplifies to

$$(\alpha p)^{\frac{\alpha}{1-\alpha}} p\bar{L} = \delta\xi\frac{1+r}{\delta+r}(\boldsymbol{\omega}+\boldsymbol{b})^T\boldsymbol{\mathcal{Y}}$$

Rearranging completes the proof. □

Finally, we study how aggregate debt (relative to income) changes in general equilibrium. Corollary 3 shows that the demand for debt is independent of the house price under Cobb-Douglas aggregation implying that Propositions 1 and 2 also hold in general equilibrium. Intuitively, agents want to keep housing *expenditures* (price times quantity) constant when prices change. As debt is a function of expenditures, it is unaffected by changes in the house price.

Corollary 3. *Under Cobb-Douglas aggregation, $\varepsilon \to 0$, the results for debt $(-a)$ in Propositions 1 and 2 are independent of house prices.*

Proof. Consider agents' policy functions in Proposition 1. As $\varepsilon \to 0$, $\kappa_0 \to p(r+\delta)\frac{1-\xi}{\xi}$ and is hence proportional to p. This implies that κ_3 and hence also agents' optimal choice of debt, $-a$, are independent of p. Consequently, p does not show up in the respective expressions in Propositions 1 and 2. □

4 Quantitative Analysis

In this section, we calibrate the model using data from 1980, feed in the observed change in income inequality and evaluate whether this change in the income distribution can help explain the surge in household debt (and house prices) between 1980 and 2007. Figure 3 shows the change in the income distribution over that period. The share of US pre-tax income accruing to the top 10% increased from 35 to 46 percent, while the income shares of both the middle 40% and the bottom 50% decreased by 6 percentage points. Table 3 shows that, over the same period, the aggregate debt-to-income ratio roughly doubled from 46% to 95%, the housing

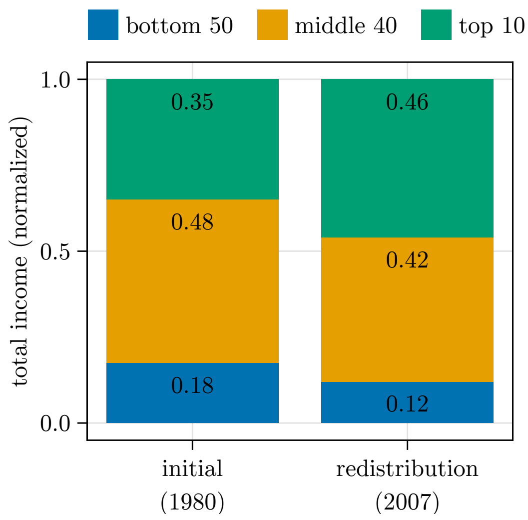


Figure 3: Changes in the US Income Distribution, 1980–2007 (Piketty et al., 2018)

Table 3: The housing and mortgage booms

Moment	1980	2007	Source
expenditure share of housing	0.162	0.2	CEX (Bertrand and Morse, 2016)
mortgage-to-income	0.462	0.947	DINA (Piketty et al., 2018)
real house price index	100.0	158.6	Case-Shiller (Shiller, 2015)

expenditure share increased by almost one quarter (4 percentage points), and the house price increased by almost 60%.

4.1 Calibration

Income Distribution. Following Piketty et al. (2018) we let the three types (P, M, R) correspond to the Bottom 50%, Middle 40% and the Top 10% of the income distribution. We match their initial income shares in the 1980 US distributional national accounts (DINA) data (Piketty et al., 2018; Mian et al., 2020), which are shown in Figure 3. We assume that initial assets are zero.

Comparison Networks. Our theoretical analysis shows that it is key, to whom agents compare themselves. While there is no evidence on the precise structure of the comparison network, empirical studies consistently find that comparisons are upward-looking. Following the examples in Section 3, we study two different versions of upward-looking comparisons along with the classic case of homogeneous and symmetric comparisons (*mean Joneses*) and the case without comparisons (*no*

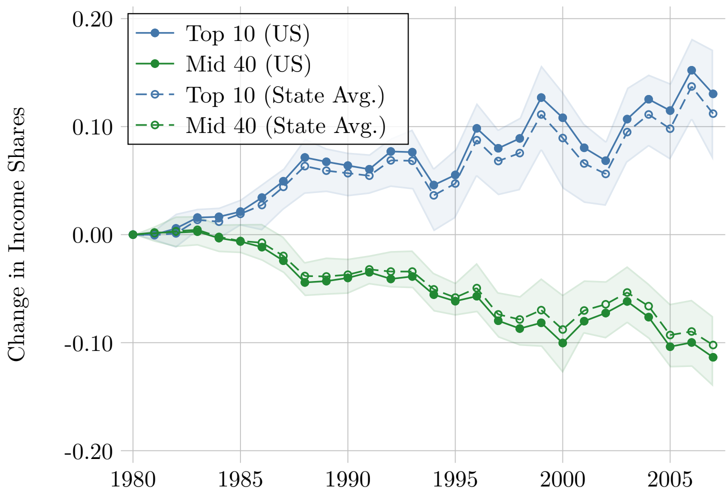


Figure 4: Within-State Changes in the Top 10% Income Share

Note: This figure plots the change in the nationwide (solid) income shares of the top 10% and middle 40% in the US computed using data from Mian et al. (2020), and the average change for the state-level top 10% and middle 40% (dashed). The shaded area shows the range between the 10th and 90th percentile across states at each point in time.

Joneses). In the case of *rich Joneses* all agents compare themselves only to the rich. In the second case of *richer Joneses*, the poor compare themselves to the middle class and the middle class to the rich.

In our baseline analysis, we use the nation-wide income distribution to define income groups—abstracting from spatial sorting on income. In an extension we study a version where agents only care about rich(er) households *within their state*. That is, households in Texas care about houses of rich Texans, but not about houses in Massachusetts. We calibrate the model separately for each network in Figure 2.

Table 4 shows the externally and internally calibrated parameters.

Externally calibrated parameters The housing supply elasticity $\frac{\alpha}{1-\alpha}$ is taken from Saiz (2010). As far as the elasticity of substitution between consumption and housing is concerned, $1/(1-\varepsilon)$, the literature has yet to converge to a common value. Estimates range from around 0.15 (from structural models; e.g. Flavin and Nakagawa, 2008; Bajari et al., 2013) up to 1.25 (Ogaki and Reinhart, 1998; Piazzesi, Schneider, and Tuzel, 2007, using estimates from aggregate data). Many papers have picked parameters out of this range, with a significant number assuming an elasticity

Table 4: A Simple Calibration

	Parameter description	comparison network no J.	 mean J.	 richer J.	 rich J.	Source
Preferences						
$\frac{1}{m}$	average life-time	45.0	45.0	45.0	45.0	working age 20–65
ρ	discount factor	0.147	0.147	0.147	0.147	internally calibrated
ξ	utility weight of housing	0.162	0.0434	0.0306	0.0434	internally calibrated
$\frac{1}{1-\varepsilon}$	elasticity of substitution (s vs c)	1.0	1.0	1.0	1.0	literature, see text
φ	strength of comparison motive	0.716	0.765	1.13	0.457	internally calibrated
Technology						
$\frac{\alpha}{1-\alpha}$	housing supply elasticity	1.5	1.5	1.5	1.5	Saiz (2010)
δ	depreciation rate of housing	0.134	0.134	0.134	0.134	internally calibrated
$\bar{L}$	flow of land permits	1.0	1.0	1.0	1.0	ad hoc

of 1.0 (Cobb-Douglas aggregation).[15] Our baseline calibration thus assumes an intratemporal elasticity of substitution of 1.0, but we also show below how the results change when we vary this parameter. The flow of land permits $\bar{L}$ is set to 1.0.

Internally Calibrated Parameters. We choose the discount rate ρ, the utility weight of housing status ξ, and the depreciation rate of housing δ to match the expenditure share of housing (shelter), the aggregate mortgage-to-income ratio and the employment share in the construction sector. The strength of the comparison motive φ is set to match the *sensitivity with respect to other's housing*

$$\text{sensitivity} = -\frac{\text{ela}_{\tilde{h}}}{\text{ela}_h} = -\frac{\frac{\partial u}{\partial s}\frac{\partial s}{\partial \tilde{h}}\frac{\tilde{h}}{u}}{\frac{\partial u}{\partial s}\frac{\partial s}{\partial h}\frac{h}{u}} = \frac{\varphi}{1}\frac{\tilde{h}}{h} \overset{!}{=} 0.8,$$

estimated by Bellet (2019). This sensitivity measures by how much an agent's own house has to improve in order to balance out the loss in utility from a 1% increase in reference housing. Our baseline calibration targets a value of 0.8, but we will vary this parameter below.

Model Fit. Table 5 shows the model fit. The model matches the empirical target moments perfectly. Note that for *No Joneses*, the sensitivity is zero by definition.

[15] Garriga and Hedlund (2020) use 0.13, Garriga, Manuelli, and Peralta-Alva (2019) use 0.5, many papers use Cobb-Douglas (that is, an elasticity of 1.0, e.g. Berger, Guerrieri, Lorenzoni, and Vavra, 2018; Landvoigt, 2017) and Kaplan et al. (2020) use 1.25.

Table 5: Model Fit

	Model					
Moment	no J.	mean J.	richer J.	rich J.	Target	Source
mortgage-to-income	0.462	0.462	0.462	0.462	0.462	DINA (1980)
expenditure share of housing	0.162	0.162	0.162	0.162	0.162	CEX (1982)
sensitivity to reference housing	0.0	0.8	0.8	0.8	0.8	Bellet (2019)
empl. share in construction sector	0.05	0.05	0.05	0.05	0.05	Kaplan et al. (2020)

4.2 Results

Having calibrated the model to match key aggregates in 1980, we now exogenously redistribute incomes from the bottom 90% to the top 10% in line with the observed shift in the US income distribution between 1980 and 2007. We keep total income unchanged to isolate the effects of changes in the distribution of income on aggregate outcomes.

Table 6: The Consequences of Rising Inequality

	1980		2007				
variable	data	model	data	no Jon.	mean Jon.	richer Jon.	rich Jon.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Partial equilibrium							
expend. share of housing	0.162	0.162	0.2	0.162	0.162	0.194	0.199
mortgage-to-income	0.462	0.462	0.947	0.462	0.462	0.556	0.569
real house price index	100.0	100.0	158.6	100.0	100.0	100.0	100.0
General equilibrium							
expend. share of housing	0.162	0.162	0.2	0.162	0.162	0.194	0.199
mortgage-to-income	0.462	0.462	0.947	0.462	0.462	0.556	0.569
real house price index	100.0	100.0	158.6	100.0	100.0	107.7	108.7

Table 6 shows the percentage point change in the aggregate debt-to-income ratio, the housing expenditure share, and the house price index for the four different networks of social comparisons introduced in Section 2.

Propositions 2 and 3 state that mean-preserving redistribution affects these aggregates if and only if income is redistributed towards more popular agents. In the absence of social comparisons (*no Joneses*), all agents have zero popularity, $b_i = 0$ for all i, and the distribution of incomes does not matter for aggregates. When comparisons are homogeneous (*mean Joneses*), the same neutrality result holds because $b_i/\omega_i > 0$ is the same for all i. Hence, each dollar gives rise to the same social externality regardless of who owns it.[16]

The key insight of our analytical results is that changes in the distribution of income matter whenever social comparisons are not perfectly symmetric. In the case of *richer Joneses* and *rich Joneses*, comparisons are upward-looking and hence asymmetric. In both cases, nobody's utility is directly affected by the housing choices of the bottom 50%. Hence, their popularity is zero. In contrast, the top 10% exert an externality on the rest of the population. In the case of *richer Joneses*, this happens indirectly for the bottom 50% who care about the housing of the middle 40%, who in turn compare themselves to the top 10%.

When all agents compare themselves only to the rich (*rich Joneses*), the increase in income inequality increases the housing expenditure share by 3.7 percentage points, the aggregate debt-to-income ratio by 10.7 percentage points (columns 2 and 7). Note that, because of Cobb-Douglas aggregation, this is the same whether we keep house prices fixed or whether we solve the model in general equilibrium. Relative to the observed changes in the data, the model can thus rationalize the entire shift towards housing expenditures, and 22% of the increase in indebtedness. House prices increase by 8.7% in the model corresponding to 15% of the 59% increase in the data. While the evidence in Bellet (2019) suggests that this is the empirically relevant case, the social externality effects are still sizeable when all agents compare themselves to the next richer income group (*richer Joneses*), such that comparisons trickle down the income distribution (columns 2 and 6). In this case, the model rationalizes 19% of the debt boom.

Figure 5 decomposes the change in total debt into the three income groups. In the case of both *no Joneses* and *mean Joneses*, debt only increases for the rich whose incomes go up. However, the social externalities in the case of *mean Joneses* substantially compresses the effects on debt, because debt is not only driven by own incomes. In contrast, the model with upward-looking comparisons predicts that all income groups, in particular the non-rich who lose income, take on more debt.

4.3 State-Level Comparisons

The baseline assumption without a spatial dimension is problematic under two conditions. First, social comparisons in housing only occur within smaller, sub-national geographical areas. This seems very plausible and is supported by empirical evi-

[16] With identical parameters (without separate calibration) the baseline (1980) levels of debt and housing demand would be higher with *mean Joneses* than with *no Joneses*. This relates to the results in Badarinza (2019).

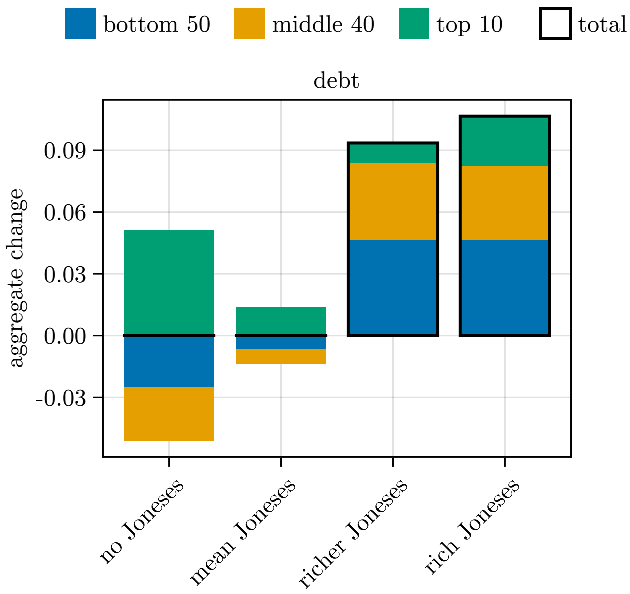


Figure 5: The consequences of redistributing incomes with Cobb-Douglas across the distribution

dence in Bellet (2019). The second condition is that changes in nation-wide income inequality is driven by increasing between-state inequality. In principle, the rise in the nation-wide top 10% income share may be driven by rising between-state inequality. If upward-looking comparisons are restricted to the local rich, this would not increase any agent's marginal utility of buying a house as there would be no within-state redistribution. Figure 4 shows, using the state-level DINA data used in Mian et al. (2020), that the increase in inequality occurred primarily *within* states.

Nevertheless, we now leverage the tractability of our model to study how rising income inequality affects aggregate debt if comparisons are local in the sense that households only care about other households in the same state. Instead of just three groups (nation-wide rich, middle class, poor), we now work with state-specific income groups. The comparison matrix G is now block-diagonal. We assume all states are identical, except of their income distribution and population weight. We assume perfectly separated housing markets.

Table 7 shows the results for this larger model with state-specific social comparisons. Aggregates are computed using population weights. The effects on housing expenditures, indebtedness and house prices get slightly stronger (relative to the baseline in Table 6). The mechanism can now explain 23–28% of the debt boom (instead of 19-22%) and 15.7–18.6% of the house price boom (instead of 12.1–14.8%).

We acknowledge that, if comparable county-level data were available, it would

Table 7: The Consequences of Rising Inequality With State-Level Comparisons

variable	1980 data (1)	1980 model (2)	2007 data (3)	2007 richer Jon. (4)	2007 rich Jon. (5)
Partial equilibrium					
expend. share of housing	0.162	0.162	0.2	0.201	0.209
mortgage-to-income	0.462	0.462	0.947	0.575	0.598
real house price index	100.0	100.0	158.6	100.0	100.0
General equilibrium					
expend. share of housing	0.162	0.162	0.2	0.201	0.209
mortgage-to-income	0.462	0.462	0.947	0.575	0.598
real house price index	100.0	100.0	158.6	109.2	110.9

be even better to repeat the analysis with even greater geographic detail. However, based on the rather small difference between the case of *rich Joneses* and *richer Joneses*, we think that it is unlikely that the effect on aggregate debt turns out to be dramatically smaller because social externalities can trickle down the income distribution.

4.4 Sensitivity Analysis

Given the high degree of uncertainty surrounding important model parameters such as the intratemporal elasticity of substitution and, more importantly, the strength of the social comparison motive, we now show how the results change when we vary these parameters. In doing so, we re-calibrate the model in order to start from the same baseline in 1980.

As we do not allow for comparisons in non-housing consumption (instead of a small but non-zero comparison motive), our baseline target of 0.8 may overstate effects of rising inequality on the shift towards housing expenditures and the increase in indebtedness triggered by the increase in housing demand.[17] We thus investigate how lowering φ affects the results. Figure 6 shows that, as expected, the effects become smaller as we reduce φ towards the atomistic case of *no Joneses*.

[17] Some non-durable consumption goods such as jewelery and clothes are also very visible and may serve as a signal of social status (Heffetz, 2011; Solnick and Hemenway, 2005; Bertrand and Morse, 2016, e.g.).

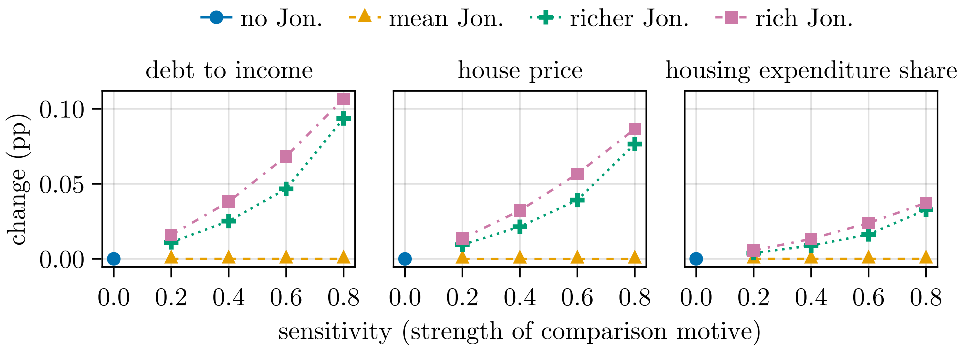


Figure 6: The consequences of redistributing incomes with varying strength of the comparison motive

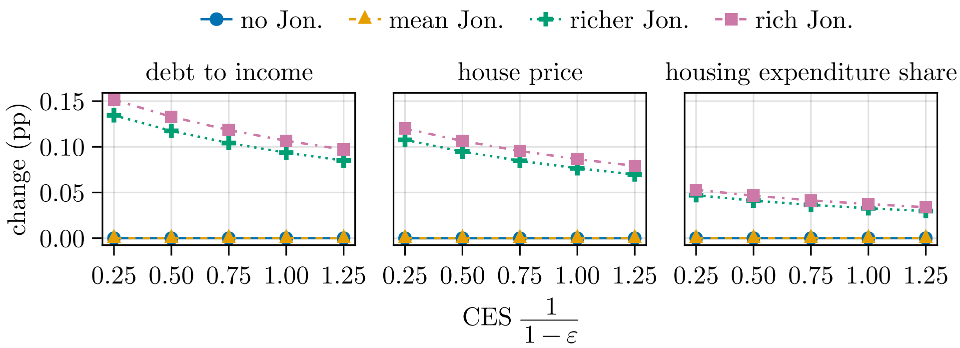


Figure 7: The consequences of redistributing incomes with varying elasticity of substitution

If everyone compares themselves only to the rich, the relationship is almost linear. For the case of *richer Joneses*, the relationship becomes more convex. This is because the indirect externality of the top 10% onto the bottom 50% is a path of length 2, which are captured by the second power of the comparison matrix G multiplied by the strength of comparisons. Hence, the term φ^2 appears in the social externality matrix (see Table 1).

In Figure 7, we vary the intratemporal elasticity of substitution between 0.25 and 1.25, i.e. the range of values used in other studies. The less agents are willing to substitute consumption for housing, the bigger the effects of rising inequality and upward-looking comparisons. Intuitively, when consumption and housing are complements and the price of housing rises because of increasing housing demand, agents will increase the expenditures share of housing. As debt is a function of housing expenditures, it also increases. In the knife-edge case of Cobb-Douglas aggregation, expenditure shares and hence debt are not affected by the house price. If the intratemporal elasticity exceeds unity, a rise in house prices will induce agents to substitute towards housing more than one-for-one such that the expenditure share of housing falls. Quantitatively, the model predicts up to 35% of the debt boom with $1/(1-\varepsilon) = 0.25$ and up to 22% with $1/(1-\varepsilon) = 1.25$. The effect of varying ε does not seem to interact with the choice of the comparison network.

5 Conclusion

This paper develops a tractable framework to study the effects of general social comparisons among heterogeneous agents on aggregate consumption and borrowing behavior. Using this framework we can rigorously analyze the idea that income inequality drives up household debt due to upward-looking social comparisons (e.g. Rajan, 2010; Stiglitz, 2009; Frank, 2013). In fact, the model suggests that this link can rationalize up to a quarter of the US debt boom prior to the Great Recession.

Our mechanism works on the demand for housing and, hence, the *demand for credit*. This complements the multitude of studies that provide explanations for a surge in the *supply of credit*. Two of which even show that inequality can be drive the supply of credit due to an increased appetite for savings (Kumhof et al., 2015; Mian et al., 2021). To the extent that social comparisons have a strong spatial dimension, this channel also helps rationalize the link between rising top incomes and non-rich debt-to-income ratios at the state level as the local rich exert a social externality on non-rich households in the same area. In contrast, rising top incomes arguably have only small effects on local credit supply if financial markets are integrated across US states.

We show that the nature of social comparisons critically determines the link between inequality and debt. Whenever income is redistributed from less popular to a more popular agent, demand for housing and debt rise. This link only breaks down when all agents have the same popularity. This knife-edge occurs when agents compare themselves with the population average—which is the standard specification in previous studies of social comparisons in a macro-finance context.

In order to seriously quantify the effect of rising inequality on macro-financial outcomes it is essential to have a good estimate popularities across the income distribution, or even better, to have an estimate of the comparison network. Future research should thus investigate who households compare themselves to. The exact asymmetries in the network of comparisons shapes the degree to which agents differ in their popularity and hence in how much their choices affect others (social externality) and thereby macro-financial aggregates.

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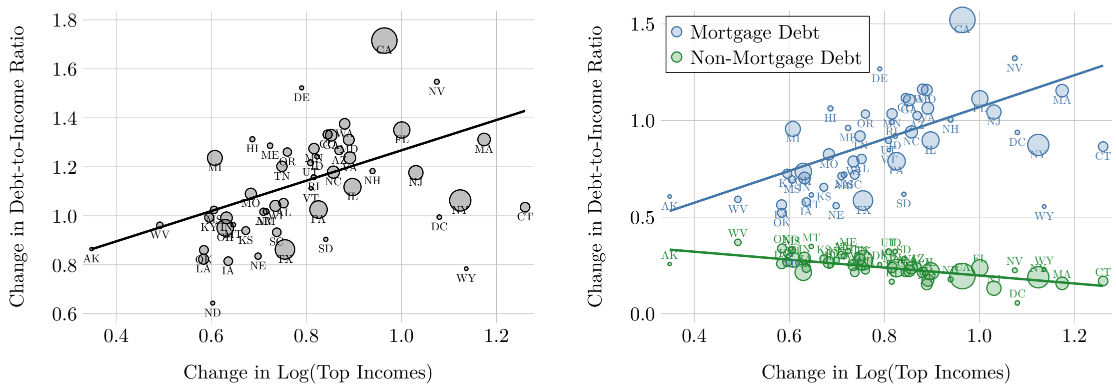
A Empirical Analysis: Top Incomes and Household Debt

In this Appendix, we use state-level DINA data to document that the key prediction of the *Keeping up with the rich(er) Joneses* (KURJ) mechanism is borne out in state-level US data between 1980 and 2007: Rising top incomes are associatated with rising mortgage-to-income ratios, but constant or falling non-mortgage-debt-to-income ratios of non-rich households. Figure 8 visualizes the positive (bivariate) relationships between the long-run change in debt-to-income ratios of the bottom 90% and the corresponding change in average log top incomes between the years 1980-1982 and 2005-2007. Panel A shows that states that experienced a stronger increase in average top incomes also experienced a stronger increase in the debt-to-income ratio of non-rich households. Panel B shows that this overall positive

Figure 8: Non-Rich Debt and Top Incomes: 1980 – 2007

(a) Total Debt

(b) Mortgage vs. Non-Mortgage Debt



Notes: Panel A plots the change in the debt-to-income ratio of the bottom 90 against the change in the log of average top 10 incomes for each state between 1980-1982 and 2005-2007. Panel B shows the change in the ratio of mortgage debt to income and non-mortgage debt to income. The size of the markers corresponds to the state's population size in the base period.

relationship is entirely driven by mortgage debt whereas non-mortgage debt is, if anything, negatively related to top incomes.[18]

We now investigate this relationship using two-way fixed effects regressions. The relationship holds conditional on time-invariant state-level heterogeneity, aggregate shocks, state-specific time trends, and time-varying demographic controls. In addition, the relationship is particularly strong *before* the house price boom (1997–2007) and not driven by states with a low price-elasticity of housing supply (Saiz, 2010).

However, let us emphasize at the outset that we do not have an explicit source of quasi-experimental variation in top incomes.[19] Hence, we do not claim that the relationships documented below can be interpreted causally. Nevertheless, we find that the link between top income inequality and non-rich indebtedness is a robust feature of the data and consistent with the large literature on social comparisons which motivates our theoretical and quantitative analysis (Kuchler and Stroebel, 2021).

Our approach follows closely the work of Bertrand and Morse (2016) who show that top incomes drive up consumption expenditures of the non-rich, in particular

[18] We take three-year averages to limit the importance of temporary shocks in 1980 and 2007. However, the relationship is virtually unchanged without the averaging.

[19] We follow Mian et al. (2020) and argue that plenty of evidence in the literature supports the view that the rise in top inequality was triggered by shifts in technology and globalization that took place at the outset of the rise in inequality around 1980 (e.g. Katz and Murphy, 1992; Autor, Katz, and Kearney, 2008; Smith, Yagan, Zidar, and Zwick, 2019).

for housing. That is, we exploit state-year variation in top incomes across states and time. A key assumption for this state-level analysis is that social comparison have some spatial bias. Even in the presence of modern communication technology, the local rich are arguable more visible and thus impose a greater status externality on households in the same state compared to other households across the country.[20]

A.1 Data & Approach

We use state-level data on incomes and debt between 1980 and 2007 adapted from the data provided by Mian et al. (2020). These data are based on DINA data from Piketty et al. (2018). As state-level identifiers in the DINA data are suppressed for incomes above 200,000 US dollars, state identifiers are imputed using state-level data from the Internal Revenue Service (IRS) which include information on how many tax returns above 200,000 dollars come from each state.[21]

Our main data set is a state-year panel for the period 1980–2007 covering income, outstanding mortgage, and non-mortgage debt and key demographics for different income groups such as the rich (top 10% of the income distribution) and the non-rich (bottom 90%, middle 40%, bottom 50%). Demographic variables are the average age of the household head, the share of female and married household heads and the average number of children per household.

We estimate regression equations of the following form:

$$\begin{aligned} \log(\text{debt}_{s,t}^{bot90}) = \beta \log(\text{income}_{s,t-k}^{top10}) &+ \gamma \log(\text{income}_{s,t}^{bot90}) + \delta \log(\text{income}_{s,t-k}^{bot90}) \\ &+ \text{income-bin}_{s,t-k}^{bot90} + \text{income-bin}_{s,t}^{bot90} + \text{demographics}_{s,t}^{bot90} \\ &+ \text{state}_s + \text{year}_t + \text{state}_s \times \text{trend}_t + \varepsilon_{s,t}. \end{aligned}$$

where s indexes states and t indexes years. The dependent variable is the log of total, mortgage and non-mortgage debt of non-rich households, i.e. the bottom 90 percent of the income distribution. The main explanatory variable is the log of lagged top incomes measured as the average income in the top 10 percent.[22] If β is positive,

[20]This conjecture is consistent with the findings in Bellet (2019) who shows that the sensitivity of non-rich housing satisfaction with respect to changes in top housing declines in the distance between the non-rich and the rich.

[21]The imputation is based on the assumption that incomes above 200 thousand dollars follow a state-specific Pareto distribution with density $f_s(y) = \frac{\alpha_s 200{,}000^{\alpha_s}}{y^{\alpha_s+1}}$ where α_s can be computed from the state-level mean income of units with gross income above 200,000 dollars. The ratio of the state-specific and aggregate income density gives the relative likelihood that an observation comes from that state. This is then used to weight all observations when computing state averages.

[22]The results hold up when using debt-to-income ratios as dependent variables (see Table **??**

higher top income levels are associated with higher future (non-rich) debt-to-income ratios as we flexibly control for in non-rich incomes using fixed effects for income bins of $2000 in addition to the log of non-rich income.

As in Bertrand and Morse (2016), the lagging of top incomes is motivated by the fact that any causal relationship due to the KURJ-motive would realistically occur with a delay and builds up over time. In our baseline regressions, we use the fifth lag of top income, but show the dynamic response of non-rich debt to a change in top incomes over an eight year period below. We choose the fifth lag to balance the need for a time delay with the cost of losing observations.

In order to eliminate the confounding impact of time-invariant heterogeneity across states and nation-wide shocks, we include state and year fixed effects. To rule out that lagged top incomes pick up the effects of lagged own incomes, we also control for lagged non-rich income. In our preferred specification, we also condition on time-varying demographics and state-specific linear time trends. When estimating equation A.1, we weight observations by population size to obtain nationally representative coefficients and cluster standard errors at the state level.

A.2 Results

Table 8 shows the estimation results for equation A.1 for different types of non-rich debt on the left hand side. Conditional on state and year fixed effects, state-specific trends, demographics and current and lagged own incomes, an increase in top incomes by one percent is associated with an increase in the non-rich debt by about 0.22 percent. While the same increase in top incomes translates into a 0.32 percent increase in non-rich mortgage debt, non-mortgage debt decreases by 0.08 percent. The effects are statistically significant and economically sizable. Increasing top incomes by one standard deviation increase in non-rich mortgage debt by 0.22 standard deviations and decreases non-mortgage debt by 0.09 standard deviations.

Why do we not see a positive relationship between top incomes and non-mortgage debt? Our theoretical analysis shows that we only expect top incomes to increase non-rich debt for goods that are both (more) status relevant (relative to other goods) and durable such that higher expenditures today do not prevent higher expenditures in the future. The findings are thus in line with our assumption that housing is more

in the appendix). We opt for log debt on the left-hand side hold non-rich incomes fixed to make transparent that debt-to-income ratios do not simply rise because higher top incomes lead to lower non-rich incomes. Holding own incomes fixed, a positive relationship between top incomes and non-rich debt implies rising debt-to-income ratios.

Table 8: Top Incomes and Non-Rich Debt

	Total Debt			Mortgage Debt			Non-Mortgage Debt		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\log(\text{income}^{top10}_{s,t-5})$	0.198***	0.194***	0.216***	0.300***	0.295***	0.319***	-0.071*	-0.096**	-0.078*
	(0.052)	(0.067)	(0.065)	(0.071)	(0.096)	(0.095)	(0.041)	(0.045)	(0.039)
$\log(\text{income}^{bot90}_{s,t})$	0.458***	0.603***	0.378***	0.475**	0.708***	0.473**	0.428***	0.420***	0.201***
	(0.154)	(0.143)	(0.138)	(0.221)	(0.203)	(0.204)	(0.070)	(0.059)	(0.060)
$\log(\text{income}^{bot90}_{s,t-5})$	0.291***	0.313***	0.261**	0.452***	0.460**	0.406**	-0.037	0.014	-0.038
	(0.105)	(0.117)	(0.116)	(0.145)	(0.172)	(0.175)	(0.060)	(0.068)	(0.056)
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income Bins	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lagged Income Bins	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Time Trends	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Demographic Controls	No	No	Yes	No	No	Yes	No	No	Yes
N	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172
R^2	0.983	0.987	0.988	0.976	0.982	0.983	0.985	0.988	0.990

Notes: This table shows the estimation results corresponding to equation A.1 for $k = 5$. The dependent variable is the log of either total, mortgage or non-mortgage debt of the bottom 90%. Robust standard errors, clustered at the state level, are in parentheses. The stars indicate the range of the p value: $^{***} \leq 0.01 \leq {}^{**} \leq 0.05 \leq {}^{*} \leq 0.1$.

status-relevant than non-housing consumption inducing households to substitute towards housing. Bertrand and Morse (2016) also find that expenditures on more visible consumption goods and in particular housing increase in lagged top incomes while households spend less on utilities or health and education. While it would be worthwhile to study non-rich debt on other status-relevant durables such as cars, we cannot distinguish between different types of non-mortgage debt. Hence, we only capture the net effect on all types of non-mortgage debt – many of them are either less status relevant and/or non-durable.[23]

Table 9 confirms that it takes time for rising top incomes to translate into higher non-rich debt. We see significant effects only four years after the increase in top incomes and the effect levels out after five to seven years.[24] This delay is to be expected if the results are driven by the KURJ improving housing takes time. Both the rich and the non-rich take time to react to higher top incomes and improved top housing respectively. Interestingly, while the effect of top incomes increases in the lag order until $k = 7$, the effect of own income peaks at $k = 4$ and diminishes earlier. Again, this is in line with a trickle-down type pattern where top incomes impact a non-rich household's housing and mortgage decisions with a greater delay

[23] Moreover, the evidence on cars is surprisingly mixed. On the one hand, Kuhn et al. (2011) find significant conspicuous consumption patterns for cars among neighbors of lottery winners. On the other hand, Bertrand and Morse (2016) do not find that non-rich expenditures on cars respond to top incomes.

[24] When using an unbalanced sample, the results are very similar.

Table 9: Top Incomes and Non-Rich Household Mortgage Debt: Dynamic Effects

	Log Non-Rich Mortgage Debt							
	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$	$k=7$	$k=8$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\log(\text{income}^{top10}_{s,t-k})$	0.062	0.146*	0.209**	0.212**	0.319***	0.375***	0.473***	0.429***
	(0.103)	(0.078)	(0.092)	(0.090)	(0.095)	(0.100)	(0.096)	(0.079)
$\log(\text{income}^{bot90}_{s,t})$	0.281	0.367	0.483**	0.506**	0.473**	0.525**	0.296	0.106
	(0.254)	(0.248)	(0.225)	(0.227)	(0.204)	(0.213)	(0.195)	(0.230)
$\log(\text{income}^{bot90}_{s,t-k})$	0.416*	0.461**	0.627***	0.669***	0.406**	0.392*	0.346*	0.229
	(0.207)	(0.191)	(0.197)	(0.166)	(0.175)	(0.195)	(0.181)	(0.150)
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income Bins	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lagged Income Bins	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Time Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,375	1,324	1,273	1,223	1,172	1,120	1,069	1,016
R^2	0.980	0.981	0.982	0.982	0.983	0.983	0.984	0.985

Notes: This table shows the estimation results corresponding to equation A.1 for $k = 1, \ldots, 8$. The dependent variable is the log of mortgage debt of the bottom 90%. Robust standard errors, clustered at the state level, are in parentheses. The stars indicate the range of the p value: $^{***} \leq 0.01 \leq {}^{**} \leq 0.05 \leq {}^{*} \leq 0.1$.

than own incomes.

B The consequences of uneven income growth

Between 1980 and 2007 real pre-tax incomes of the Top 10 doubled, while the those of the Bottom 50 stagnated, according to DINA data by Piketty et al. (2018). This is shown in Figure 9. The Bottom 50 did not participate in the growth of aggregate income.

In this Appendix we analyse the aggregate consequences of this *uneven income growth*. Under what circumstances will aggregate housing demand and aggregate debt rise if only one type experiences income growth?

We show that the aggregate housing-to-income ratio and the aggregate debt-to-income ratio increase whenever j's popularity is higher than the average popularity of the other types (weighted by income and corrected for population weights). In absolute terms, aggregate housing and aggregate debt always increase in this case.

Proposition 4 (Uneven growth)**.** *Compare two steady states that differ only in*

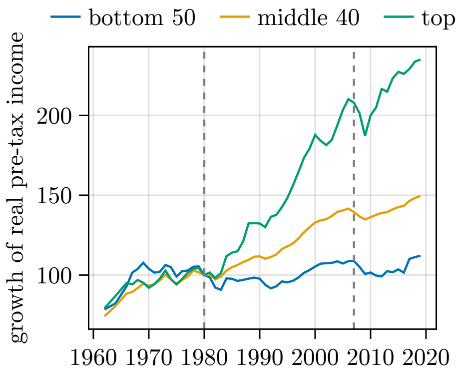


Figure 9: Growth of pre-tax real incomes by income groups in the US. The base year is 1980. Source: DINA data (Piketty et al., 2018)

disposable incomes. Let the difference in disposable incomes be $\Delta \boldsymbol{y} = \boldsymbol{y}' - \boldsymbol{y}$*, where*

$$\Delta y_j > 0, \quad \textit{and } \Delta y_i = 0 \textit{ for all } i \neq j.$$

The aggregate housing-to-income ratio is increases if and only if if and only if type j*'s popularity is higher than the average popularity of the other types (weighted by incomes, corrected by population share):*

$$\Delta \frac{\boldsymbol{\omega}^T \boldsymbol{h}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}} > 0 \iff \frac{b_j}{\omega_j} > \sum_{i \neq j} \lambda_i \frac{b_i}{\omega_i},$$

with weights given by $\lambda_i = \frac{\omega_i \mathcal{Y}_i}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}} - \omega_j \mathcal{Y}_j}$*, and* $\sum_{i \neq j} \lambda_i = 1$*. The same condition holds for the debt-to-income ratio if aggregate initial wealth is zero,* $\omega^T a_0 = 0$*.* ω *If aggregate initial wealth is positive, this condition is sufficient, but not necessary.*

Proof. See Appendix D.2. □

Let us consider the impact of *uneven growth* of top incomes y_R on aggregate debt-to-income or aggregate housing-to-income. In cases (a) and (b) the ω-corrected popularity $\frac{b_i}{\omega_i}$ is the same for all types. That is, there will be no effect on aggregate housing-to-income or aggregate debt-to-income. In case of *Rich Joneses* (d) there will be a positive effect if the rich R gain because the rich are more popular than the other types. In the case of *Richer Joneses* (c), one cannot generally say if the rich are sufficiently popular for a positive effect on aggregate housing-to-income and debt-to-income. Figure 10 shows the parameter regions in which the rich R are more

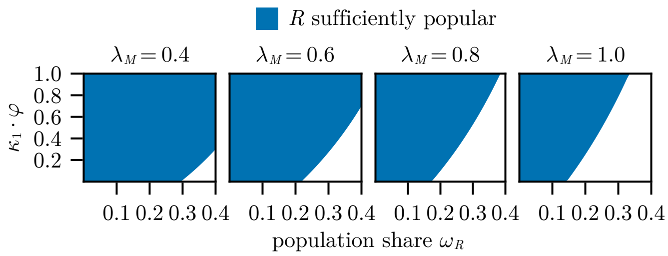


Figure 10: Are the rich sufficiently popular in scenario (c)?

popular than the income weighted average of types P and M,

$$\lambda_P \underbrace{\frac{b_P}{\omega_P}}_{=0} + \lambda_M \frac{b_M}{\omega_M} > \frac{b_R}{\omega_R}.$$

Only if the population share of the rich ω_R gets very large the popularity of the rich R will get low enough so that uneven income growth of the rich will not drive up aggregate debt-to-income. The region where redistribution from M to R will drive up aggregate debt levels,

$$\frac{b_M}{\omega_M} > \frac{b_R}{\omega_R}.$$

is the same as in the right-most panel of Figure 10 ($\lambda_M = 1$).

The lessons of this example hold more generally. According to the classic macroeconomic interpretation of *Keeping up with the Joneses*, rising top income inequality will have no effect on aggregate housing-to-income and aggregate debt-to-income. This is because all types have the same corrected popularity. Under upward comparisons, however, rising top income inequality will drive up aggregate housing-to-income and debt-to-income as long as the rich are sufficiently popular.

C Summary of Analytical Example

	no Joneses	mean Joneses	richer Joneses	rich Joneses
G	$\begin{pmatrix}0&0&0\\0&0&0\\0&0&0\end{pmatrix}$	$\begin{pmatrix}\omega_P&\omega_M&\omega_R\\\omega_P&\omega_M&\omega_R\\\omega_P&\omega_M&\omega_R\end{pmatrix}$	$\begin{pmatrix}0&1&0\\0&0&1\\0&0&0\end{pmatrix}$	$\begin{pmatrix}0&0&1\\0&0&1\\0&0&1\end{pmatrix}$
$L(G,\tilde{\varphi})$	$\begin{pmatrix}0&0&0\\0&0&0\\0&0&0\end{pmatrix}$	$\frac{\tilde{\varphi}}{1-\tilde{\varphi}}\begin{pmatrix}\omega_P&\omega_M&\omega_R\\\omega_P&\omega_M&\omega_R\\\omega_P&\omega_M&\omega_R\end{pmatrix}$	$\begin{pmatrix}0&\tilde{\varphi}&\tilde{\varphi}^2\\0&0&\tilde{\varphi}\\0&0&0\end{pmatrix}$	$\frac{\tilde{\varphi}}{1-\tilde{\varphi}}\begin{pmatrix}0&0&1\\0&0&1\\0&0&1\end{pmatrix}$
$b(G,\boldsymbol{\omega},\tilde{\varphi})$	$\begin{pmatrix}0\\0\\0\end{pmatrix}$	$\frac{\tilde{\varphi}}{1-\tilde{\varphi}}\cdot\begin{pmatrix}\omega_P\\\omega_M\\\omega_R\end{pmatrix}$	$\begin{pmatrix}0\\\omega_P\tilde{\varphi}\\\omega_P\tilde{\varphi}^2+\omega_M\tilde{\varphi}\end{pmatrix}$	$\frac{\tilde{\varphi}}{1-\tilde{\varphi}}\cdot\begin{pmatrix}0\\0\\1\end{pmatrix}$

where for clarity $\tilde{\varphi} := \kappa_1\varphi$.

D Proofs

D.1 Proof of Proposition 1

Lemma 2. *The necessary conditions for an optimum of the households' problem are*

$$\beta^t u_c\big(c_t, s(h_t,\tilde{h}_t)\big) = \lambda_t \tag{5}$$

$$\beta^t u_s\big(c_t, s(h_t,\tilde{h}_t)\big) s_h(h_t,\tilde{h}_t) = \lambda_t p\frac{\delta+r}{1+r} \tag{6}$$

$$\lambda_{t+1}(1+r) = \lambda_t \tag{7}$$

where λ_t are the Lagrange multipliers of the constraint optimization problem.

Proof. The Lagrangian is

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t u(c_t, s(h_t,\tilde{h}_t)) \\ + \lambda_t\Big(y_t + (1+r)a_t - c_t - p\big(h_t - (1-\delta)h_{t-1}\big) - a_{t+1}\Big)$$

First and second conditions are the first order conditions for c_t and a_t. The first order conditions with respect to h_t is

$$\beta^t u_{s_t} s_{h_t} = p(\lambda_t - \lambda_{t+1}(1-\delta)).$$

Using (7)

$$\beta^t u_{s_t} s_{h_t} = \lambda_t p\Big(1 - \frac{1-\delta}{1+r}\Big).$$

Rearranging delivers (6). $\square$

Lemma 3. *Under our assumption of CRRA-CES preferences, the optimal relation of c_t and h_t is given by*

$$\frac{\xi}{1-\xi}\Big(\frac{s(h_t,\tilde{h}_t)}{c_t}\Big)^{\varepsilon-1} s_h(h_t,\tilde{h}_t) = (r+\delta)p.$$

Further, Assumption 2 yields

$$c_t = \kappa_0(h_t - \varphi\tilde{h}_t), \quad \text{where } \kappa_0 := \Big(p\frac{\delta+r}{1+r}\frac{1-\xi}{\xi}\Big)^{\frac{1}{1-\varepsilon}}. \tag{8}$$

Proof. Combining conditions (5) and (6) yields

$$\frac{u_s(c_t,s_t)}{u_c(c_t,s_t)} s_h(h_t,\tilde{h}_t) \stackrel{!}{=} p\frac{\delta+r}{1+r}.$$

For the given CRRA-CES preferences the marginal utilites are given by

$$\begin{aligned} u_c(c_t,s_t) &= ((1-\xi)c_t^\varepsilon + \xi s_t^\varepsilon)^{\frac{1-\gamma}{\varepsilon}-1}(1-\xi)c_t^{\varepsilon-1} \\ u_s(c_t,s_t) &= ((1-\xi)c_t^\varepsilon + \xi s_t^\varepsilon)^{\frac{1-\gamma}{\varepsilon}-1}\xi s_t^{\varepsilon-1}. \end{aligned}$$

Thus,

$$\frac{u_s(c_t,s_t)}{u_c(c_t,s_t)} = \frac{\xi}{1-\xi}\Big(\frac{s_t}{c_t}\Big)^{\varepsilon-1}.$$

Plugging in above yields the first statement. Using Assumption 2 we get

$$
\begin{aligned}
\frac{\xi}{1-\xi}\Big(\frac{h_t-\varphi\tilde{h}}{c_t}\Big)^{\varepsilon-1} &= p\frac{\delta+r}{1+r}.\\
\Big(\frac{c_t}{h_t-\varphi\tilde{h}}\Big) &= \Big(p\frac{\delta+r}{1+r}\frac{1-\xi}{\xi}\Big)^{\frac{1}{1-\varepsilon}} =: \kappa_0\\
c_t &= \kappa_0 h_t - \kappa_0\varphi\tilde{h}_t
\end{aligned}
$$

□

Lemma 4. *Under the assumption of time-constant house prices p, and all previous assumptions of this section, individual choices c_t, h_t are constant over time.*

Proof. The costate λ is constant over time. This follows from using Assumption 1 in condition (7), which gives $\dot{\lambda}_t = 0$.

Plugging (8) in condition (6) one gets that an decreasing function of h is constant over time, thus h_t is constant over time. Knowing that h_t constant over time, and a similar argument for condition (5) it follows that c_t is constant over time. □

From the lemmas above we get that

$$
c = \kappa_0 s(h,\tilde{h}) = \kappa_0 h - \kappa_0\varphi\tilde{h}. \tag{9}
$$

The lifetime budget constraint is

$$
\begin{aligned}
(1+r)a_0 + \frac{1+r}{r}y &= \frac{1+r}{r}(c+\delta ph) + (1-\delta)ph\\
\implies \mathcal{Y} := ra_0 + y &= c + \delta ph + \frac{r}{1+r}(1-\delta)ph\\
&= c + ph\frac{\delta+r}{1+r}
\end{aligned}
$$

Using (8)

$$
\begin{aligned}
&= h\Big(p\frac{\delta+r}{1+r}+\kappa_0\Big) - \kappa_0\varphi\tilde{h}\\
\implies h &= \frac{\mathcal{Y}+\kappa_0\varphi\tilde{h}}{p\frac{\delta+r}{1+r}+\kappa_0} = \underbrace{\frac{1}{p\frac{\delta+r}{1+r}+\kappa_0}}_{\kappa_2}\mathcal{Y} + \underbrace{\frac{\kappa_0}{p\frac{\delta+r}{1+r}+\kappa_0}}_{\kappa_1}\varphi\tilde{h} = \kappa_2\mathcal{Y} + \kappa_1\varphi\tilde{h}
\end{aligned} \tag{10}
$$

where $\kappa_1 \in (0,1)$ since $\kappa_0 > 0$ and $p\frac{\delta+r}{1+r} > 0$. Stacking equations (10) for and using $\tilde{\boldsymbol{h}} = G\boldsymbol{h}$

$$\begin{aligned}
\boldsymbol{h} &= \kappa_2 \boldsymbol{\mathcal{Y}} + \kappa_1 \varphi G \boldsymbol{h} \\
\boldsymbol{h} &= (I - \kappa_1 \varphi G)^{-1} \kappa_2 \boldsymbol{\mathcal{Y}}
\end{aligned}$$

$(I - \kappa_1\varphi G)^{-1}$ is a Leontief inverse. It exists if the matrix power series $\sum_{i=0}^{\infty}(\kappa_1\varphi G)^i$ converges[25]. In that case

$$(I - \kappa_1\varphi G)^{-1} = \sum_{i=0}^{\infty}(\kappa_1\varphi G)^i = \underbrace{(\kappa_1\varphi G)^0}_{I} + \underbrace{\sum_{i=1}^{\infty}(\kappa_1\varphi G)^i}_{=:L}.$$

Thus,

$$\boldsymbol{h} = \kappa_2 (I + L) \boldsymbol{\mathcal{Y}}$$

Moreover,

$$\begin{aligned}
\tilde{\boldsymbol{h}} = G\boldsymbol{h} &= \frac{\kappa_1\varphi}{\kappa_1\varphi} G \Big(\sum_{i=0}^{\infty}(\kappa_1\varphi G)^i\Big)\kappa_2 \boldsymbol{\mathcal{Y}} \\
&= \frac{1}{\kappa_1\varphi}\Big(\sum_{i=1}^{\infty}(\kappa_1\varphi G)^i\Big)\kappa_2 \boldsymbol{\mathcal{Y}} \\
&= \frac{1}{\kappa_0\varphi}\Big(\sum_{i=1}^{\infty}(\kappa_1\varphi G)^i\Big)\boldsymbol{\mathcal{Y}} \\
&= \frac{1}{\kappa_0\varphi} L \boldsymbol{\mathcal{Y}}
\end{aligned}$$

Now, we calculate debt.

$$-ra = y - \delta p h - c$$

[25] This is the case for all nilpotent matrices (there exists a power p such that $G^p = 0I$) (there are no infinitely-long paths in the network) or if all eigenvalues of $\kappa_1\varphi G$ are between 0 and 1. This holds whenever G can be interpreted as a Markov Chain.

using (9),

$$
\begin{aligned}
&= y - \delta p h - \kappa_0 h + \kappa_0 \varphi \tilde{h} \\
&= y - (\delta p + \kappa_0) h + \kappa_0 \varphi \tilde{h} \\
-r\boldsymbol{a} &= \boldsymbol{y} - \underbrace{(\delta p + \kappa_0)\kappa_2}_{=:\kappa_6}(I + L)\boldsymbol{\mathcal{Y}} + L\boldsymbol{\mathcal{Y}} \\
&= (\boldsymbol{\mathcal{Y}} - r\boldsymbol{a}_0) - \kappa_6 (I + L)\boldsymbol{\mathcal{Y}} + L\boldsymbol{\mathcal{Y}} \\
&= (1 - \kappa_6)(I + L)\boldsymbol{\mathcal{Y}} - r\boldsymbol{a}_0 \\
\implies \quad -\boldsymbol{a} &= \underbrace{\frac{1 - \kappa_6}{r}}_{=:\kappa_3}(I + L)\boldsymbol{\mathcal{Y}} - \boldsymbol{a}_0
\end{aligned}
$$

Note that

$$
\begin{aligned}
1 - \kappa_6 &= 1 - \frac{\delta p + \kappa_0}{p\frac{\delta + r}{1 + r} + \kappa_0} \\
&= \frac{p\frac{\delta + r}{1 + r} + \kappa_0}{p\frac{\delta + r}{1 + r} + \kappa_0} - \frac{\delta p + \kappa_0}{p\frac{\delta + r}{1 + r} + \kappa_0} \\
&= \left(p\frac{\delta + r}{1 + r} - \delta p\right)\kappa_2 \\
&= p\frac{r(1 - \delta)}{1 + r}\kappa_2 \\
\implies \quad \kappa_3 &= \frac{p(1 - \delta)}{1 + r}\kappa_2.
\end{aligned}
$$

D.2 Proof of Propositions 2 and 4

The expressions for aggregate housing and debt as a function of population weights and popularities are given in Corollary 2.

$$
\boldsymbol{\omega}^T \boldsymbol{h} = \kappa_2 (\boldsymbol{\omega} + \boldsymbol{b})^T \boldsymbol{\mathcal{Y}} \tag{11}
$$

$$
-\boldsymbol{\omega}^T \boldsymbol{a} = \kappa_3 (\boldsymbol{\omega} + \boldsymbol{b})^T \boldsymbol{\mathcal{Y}} - \boldsymbol{\omega}^T \boldsymbol{a}_0. \tag{12}
$$

The difference of aggregate housing and aggregate debt across two steady states depends on differences in permanent incomes $\Delta \boldsymbol{\mathcal{Y}} = \Delta \boldsymbol{y} = \boldsymbol{y}' - \boldsymbol{y}$:

$$
\begin{aligned}
\Delta \boldsymbol{\omega}^T \boldsymbol{h} &= \boldsymbol{\omega}^T (\boldsymbol{h}' - \boldsymbol{h}) = \kappa_2 (\boldsymbol{\omega} + \boldsymbol{b})^T \Delta \boldsymbol{y} \\
\Delta(-\boldsymbol{\omega}^T \boldsymbol{a}) &= \boldsymbol{\omega}^T (-\boldsymbol{a}' - (-\boldsymbol{a})) = \kappa_3 (\boldsymbol{\omega} + \boldsymbol{b})^T \Delta \boldsymbol{y}.
\end{aligned}
$$

Hence, a change in the income distribution $\Delta \boldsymbol{y}$ increases steady state aggregate housing and debt, if and only if $(\boldsymbol{\omega} + \boldsymbol{b})^T \Delta \boldsymbol{y} > 0$.

Concerning the case of mean-preserving *redistribution*, we get

$$\begin{aligned}(\boldsymbol{\omega} + \boldsymbol{b})^T \Delta \boldsymbol{y} &= (\omega_i + b_i)\Delta y_i + (\omega_j + b_j)\Delta y_j \\ &= b_i \Delta y_i + b_j \Delta y_j \\ &= \big(b_j - \frac{\omega_j}{\omega_i} b_i\big)\Delta y_j.\end{aligned}$$

Since $\Delta y_j > 0$ by assumption, the expression is positive whenever $\big(b_j - \frac{\omega_j}{\omega_i} b_i\big) > 0$ which is equivalent to $\frac{b_j}{\omega_j} > \frac{b_i}{\omega_i}$. As aggregate income is constant, the housing-to-income and debt-to-income ratios increase if and only if aggregate housing and debt increase, respectively. This completes the proof of Proposition 2.

For the case of *unequal growth*, we get

$$(\boldsymbol{\omega} + \boldsymbol{b})^T \Delta \boldsymbol{y} = (\omega_j + b_j)\Delta y_j > 0,$$

independent of the distribution of population weights or popularities because $\Delta y_i = 0$ for all $i \neq j$. This proves that aggregate housing and debt increase in the case of uneven growth.

We are left to show that the housing-to-income and debt-to-income ratios increase if and only if

$$\frac{b_j}{\omega_j} > \sum_{i \neq j} \lambda_i \frac{b_i}{\omega_i},$$

with weights given by $\lambda_i = \frac{\omega_i \mathcal{Y}_i}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}} - \omega_j \mathcal{Y}_j}$. Note that $\sum_{i \neq j} \lambda_i = 1$.

Dividing (11) and (12) by $\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}$ gives the aggregate housing-to-income and debt-to-income ratios:

$$\begin{aligned}\frac{\boldsymbol{\omega}^T \boldsymbol{h}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}} &= \kappa_2 \Big(1 + \frac{\boldsymbol{b}^T \boldsymbol{\mathcal{Y}}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}}\Big) \\ -\frac{\boldsymbol{\omega}^T \boldsymbol{a}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}} &= \kappa_3 \Big(1 + \frac{\boldsymbol{b}^T \boldsymbol{\mathcal{Y}}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}}\Big) - \frac{\boldsymbol{\omega}^T \boldsymbol{a}_0}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}}\end{aligned}$$

The housing-to-income ratio is increasing if and only if $\frac{\boldsymbol{b}^T \boldsymbol{\mathcal{Y}}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}}$ increases in y_j. Hence, Lemma 5 completes this part of the proof. For the debt-to-income ratio, this is a sufficient, but not a necessary condition as the increase in aggregate income leads to an increase in the debt-to-income ratio because initial wealth is constant. Hence a larger share of lifetime permanent income is received in the future, which induces agents to take on more debt, $\frac{\partial}{\partial y_j} \frac{\boldsymbol{\omega}^T \boldsymbol{a}_0}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}} < 0$.

Lemma 5. *Let $b_i, \omega_i, \mathcal{Y}_i \geq 0$ and $\frac{\partial \mathcal{Y}_i}{\partial y_i} = 1$ for all i. Then*

$$\frac{\partial}{\partial y_j} \frac{\boldsymbol{b}^T \boldsymbol{\mathcal{Y}}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}} > 0 \iff \frac{b_j}{\omega_j} > \sum_{i \neq j} \lambda_i \frac{b_i}{\omega_i},$$

with $\sum_{i \neq j} \lambda_i = 1$. The weights given by $\lambda_i = \frac{\omega_i \mathcal{Y}_i}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}} - \omega_j \mathcal{Y}_j}$, that is the income share of type i of the incomes not earned by j.

Proof. Using the the quotient rule and rearranging gives

$$\begin{aligned}
\frac{\partial}{\partial y_j} \frac{\boldsymbol{b}^T \boldsymbol{\mathcal{Y}}}{\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}}} &= \frac{b_j \boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}} - \omega_j \boldsymbol{b}^T \boldsymbol{\mathcal{Y}}}{(\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}})^2} \frac{\partial \mathcal{Y}_j}{\partial y_j} > 0 \\
\iff \boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}} b_j &> \omega_j \boldsymbol{b}^T \boldsymbol{\mathcal{Y}} \\
&= \omega_j \sum_{i=1}^{n} b_i \mathcal{Y}_i = \omega_j b_j \mathcal{Y}_j + \omega_j \sum_{i \neq j} b_i \mathcal{Y}_i \\
\iff b_j (\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}} - \omega_j \mathcal{Y}_j) &> \omega_j \sum_{i \neq j} b_i \mathcal{Y}_i \\
\iff \frac{b_j}{\omega_j} (\boldsymbol{\omega}^T \boldsymbol{\mathcal{Y}} - \omega_j \mathcal{Y}_j) &> \sum_{i \neq j} \frac{b_i}{\omega_i} \omega_i \mathcal{Y}_i.
\end{aligned}$$

Rearranging completes the proof. □

D.3 Proof of Proposition 3

Define the implicit function

$$F(p; y_1, \ldots, y_N) = \delta \kappa_2(p)(\boldsymbol{\omega} + \boldsymbol{b}(p))^T \mathcal{Y} - (\alpha p)^{\frac{\alpha}{1-\alpha}} \bar{L}$$

which in equilibrium equals zero, $F(p, y) = 0$. Now consider the total differential of the house price function $p(y)$:

$$\mathrm{d}p = \sum_{k=1}^{N} \frac{\partial p}{\partial y_k} \mathrm{d}y_k$$

By the implicit function theorem, we have

$$\mathrm{d}p = \sum_{k=1}^{N} -\frac{\frac{\partial F}{\partial y_k}\Big|_y}{\frac{\partial F}{\partial p}\Big|_y}\mathrm{d}y_k = -\frac{\frac{\partial F}{\partial y_i}\Big|_y}{\frac{\partial F}{\partial p}\Big|_y}\mathrm{d}y_i - \frac{\frac{\partial F}{\partial y_j}\Big|_y}{\frac{\partial F}{\partial p}\Big|_y}\mathrm{d}y_j = \frac{\frac{\partial F}{\partial y_j}\Big|_y}{\frac{\partial F}{\partial p}\Big|_y}\frac{\omega_j}{\omega_i}\mathrm{d}y_j - \frac{\frac{\partial F}{\partial y_j}\Big|_y}{\frac{\partial F}{\partial p}\Big|_y}\mathrm{d}y_j$$

where the second equality follows from $\mathrm{d}y_k = 0$ for all $k \notin \{i, j\}$ and the last equality uses $\mathrm{d}y_j = -\frac{\omega_i}{\omega_j}\mathrm{d}y_i$. Lemma 6 shows that there exists a $\bar{e} > 1$ such that $\frac{\partial F}{\partial p}\Big|_y < 0$ whenever $e \equiv 1/(1-\varepsilon) < \bar{e}$. Hence, for all $e < \bar{e}$, we have

$$\begin{aligned}
\mathrm{d}p > 0 &\iff \frac{\frac{\partial F}{\partial y_j}\Big|_y}{\frac{\partial F}{\partial p}\Big|_y}\frac{\omega_j}{\omega_i}\mathrm{d}y_j - \frac{\frac{\partial F}{\partial y_j}\Big|_y}{\frac{\partial F}{\partial p}\Big|_y}\mathrm{d}y_j > 0 \\
&\iff \frac{\partial F}{\partial y_i}\Big|_y \frac{\omega_j}{\omega_i}\mathrm{d}y_j - \frac{\partial F}{\partial y_j}\Big|_y \mathrm{d}y_j < 0 \\
&\iff \delta\kappa_2(p(y))\big(\omega_i + b_i(p(y))\big)\frac{\omega_j}{\omega_i} - \delta\kappa_2(p(y))\big(\omega_j + b_j(p(y))\big) < 0 \\
&\iff \big(\omega_i + b_i(p(y))\big)\frac{\omega_j}{\omega_i} - \big(\omega_j + b_j(p(y))\big) < 0 \\
&\iff \omega_j + \frac{\omega_j}{\omega_i}b_i < \omega_j + b_j \\
&\iff 1 + \frac{b_i(p(y))}{\omega_i} < 1 + \frac{b_j(p(y))}{\omega_j} \\
&\iff \frac{b_i(p(y))}{\omega_i} < \frac{b_j(p(y))}{\omega_j}
\end{aligned}$$

Lemma 6. *Consider the function*

$$F(p; y_1, \dots, y_N) = \delta\kappa_2(p)\left(\boldsymbol{\omega} + \boldsymbol{b}\big(\kappa_1(p)\big)\right)^T \mathcal{Y} - (\alpha p)^{\frac{\alpha}{1-\alpha}}\bar{L}$$

where $\kappa_1(p)$ is defined as in Proposition 1:

$$\kappa_1(p) = \frac{p^e x^e}{p^{\frac{\delta+r}{1+r}} + p^e x^e} \quad \textit{with} \quad x = \frac{\delta + r}{1+r}\frac{(1-\xi)}{\xi} > 0, \ \textit{and} \quad e = \frac{1}{1-\varepsilon} > 0.$$

Then, there exists $\bar{e} > 1$ such that $\partial F/\partial p$ is negative for all $e < \bar{e}$.

Proof. The partial derivative of F with respect to p is given by:

$$\frac{\partial F(p,y)}{\partial p} = \underbrace{\delta \frac{\partial \kappa_2(p)}{\partial p} \left(\boldsymbol{\omega} + \boldsymbol{b}\big(\kappa_1(p)\big)\right)^T \boldsymbol{\mathcal{Y}}}_{\equiv A<0}$$
$$+ \frac{\partial \kappa_1}{\partial p} \underbrace{\delta \kappa_2(p) \sum_{i=1}^{N} \frac{\partial b_i}{\partial \kappa_1} \mathcal{Y}_i}_{\equiv B>0}$$
$$\underbrace{-\alpha^{\frac{\alpha}{1-\alpha}} \bar{L} \frac{\alpha}{1-\alpha} p^{\frac{2\alpha-1}{1-\alpha}}}_{\equiv C<0}$$

As $\partial \kappa_2/\partial p < 0$, the first term is negative, $A < 0$. Moreover, note that the last term is also negative, $C < 0$. Finally, $B > 0$ because $b_i(\kappa_1) = \sum_{k=1}^{\infty} (\kappa_1 \varphi G)^k$, $\varphi > 0$, and all entries of G are non-negative such that $\partial b_i/\partial \kappa_1 > 0$.

Hence, for $\partial F/\partial p$ to be negative, we need to show that:

$$\frac{\partial \kappa_1}{\partial p} \leq \underbrace{-\frac{(A+C)}{B}}_{>0}$$

The partial derivative of κ_1 with respect to p is given by:

$$\frac{\partial \kappa_1}{\partial p} = \frac{e p^{e-1} x^e \left(p \frac{\delta+r}{1+r} + p^e x^e\right) - p^e x^e \left(\frac{\delta+r}{1+r} + e p^{e-1} x^e\right)}{\left(p \frac{\delta+r}{1+r} + p^e x^e\right)^2} = \frac{(e-1) p^e x^e \frac{\delta+r}{1+r}}{\left(p \frac{\delta+r}{1+r} + p^e x^e\right)^2}$$

From here, we first find that

$$\frac{\partial \kappa_1}{\partial p} < 0 \iff e \leq 1$$

which is a sufficient condition for $\partial F/\partial p < 0$ because $0 < -\frac{(A+C)}{B}$. Note that $\partial \kappa_1/\partial p$ is continuously differentiable in e. The partial derivative with respect to e evaluated at $e = 1$ is positive:

$$\frac{\partial}{\partial e}\left(\frac{\partial \kappa_1}{\partial p}\right) = \frac{\frac{\delta+r}{1+r}(xp)^e(\frac{\delta+r}{1+r}p + (xp)^e - ((xp)^e - \frac{\delta+r}{1+r}p)(e-1)\log(xp))}{(\frac{\delta+r}{1+r}p + (xp)^e)^3}$$
$$\frac{\partial}{\partial e}\left(\frac{\partial \kappa_1}{\partial p}\right)\Big|_{e=1} = \frac{\frac{\delta+r}{1+r}xp(\frac{\delta+r}{1+r}p + xp)}{(\frac{\delta+r}{1+r}p + xp)^3} > 0$$

Hence, there exists a $\bar{e} > 1$ such that $\frac{\partial F}{\partial p} < 0$ for all $e < \bar{e}$. $\square$

E Calibration tables for sensitivity analysis

Table 10: Calibration table for appendix

	internally calibrated				targeted moment (model)				
$\frac{1}{1-\varepsilon}$	ξ	φ	ρ	δ	d2y	avg sensitivity	hx share	N	loss
no Joneses									
0.25	0.384	0.0	0.147	0.134	0.462	0.0	0.162	0.05	0.0
0.5	0.222	0.0	0.147	0.134	0.462	0.0	0.162	0.05	0.0
0.75	0.18	0.0	0.147	0.134	0.462	0.0	0.162	0.05	0.0
1.0	0.162	0.0	0.147	0.134	0.462	0.0	0.162	0.05	0.0
1.25	0.151	0.0	0.147	0.134	0.462	0.0	0.162	0.05	0.0
richer Joneses									
0.25	0.000446	1.13	0.147	0.134	0.462	0.8	0.162	0.05	0.0
0.5	0.00757	1.13	0.147	0.134	0.462	0.8	0.162	0.05	0.0
0.75	0.0193	1.13	0.147	0.134	0.462	0.8	0.162	0.05	0.0
1.0	0.0306	1.13	0.147	0.134	0.462	0.8	0.162	0.05	0.0
1.25	0.0402	1.13	0.147	0.134	0.462	0.8	0.162	0.05	0.0
rich Joneses									
0.25	0.00191	0.457	0.147	0.134	0.462	0.8	0.162	0.05	0.0
0.5	0.0156	0.457	0.147	0.134	0.462	0.8	0.162	0.05	0.0
0.75	0.0309	0.457	0.147	0.134	0.462	0.8	0.162	0.05	0.0
1.0	0.0434	0.457	0.147	0.134	0.462	0.8	0.162	0.05	0.0
1.25	0.0531	0.457	0.147	0.134	0.462	0.8	0.162	0.05	0.0
mean Joneses									
0.25	0.00191	0.765	0.147	0.134	0.462	0.8	0.162	0.05	0.0
0.5	0.0156	0.765	0.147	0.134	0.462	0.8	0.162	0.05	0.0
0.75	0.0309	0.765	0.147	0.134	0.462	0.8	0.162	0.05	0.0
1.0	0.0434	0.765	0.147	0.134	0.462	0.8	0.162	0.05	0.0
1.25	0.0531	0.765	0.147	0.134	0.462	0.8	0.162	0.05	0.0

Table 11: Calibration table for appendix

	internally calibrated				targeted moment (model)				
sens	ξ	φ	ρ	δ	d2y	avg sensitivity	hx share	N	loss
no Joneses									
0.0	0.162	0.0	0.147	0.134	0.462	0.0	0.162	0.05	0.0
richer Joneses									
0.2	0.142	0.0774	0.147	0.134	0.462	0.2	0.162	0.05	0.0
0.4	0.118	0.183	0.147	0.134	0.462	0.4	0.162	0.05	0.0
0.6	0.0861	0.371	0.147	0.134	0.462	0.6	0.162	0.05	0.0
0.8	0.0306	1.13	0.147	0.134	0.462	0.8	0.162	0.05	0.0
rich Joneses									
0.2	0.144	0.0397	0.147	0.134	0.462	0.2	0.162	0.05	0.0
0.4	0.119	0.104	0.147	0.134	0.462	0.4	0.162	0.05	0.0
0.6	0.0859	0.22	0.147	0.134	0.462	0.6	0.162	0.05	0.0
0.8	0.0434	0.457	0.147	0.134	0.462	0.8	0.162	0.05	0.0
mean Joneses									
0.2	0.144	0.128	0.147	0.134	0.462	0.2	0.162	0.05	0.0
0.4	0.119	0.297	0.147	0.134	0.462	0.4	0.162	0.05	0.0
0.6	0.0859	0.513	0.147	0.134	0.462	0.6	0.162	0.05	0.0
0.8	0.0434	0.765	0.147	0.134	0.462	0.8	0.162	0.05	0.0