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Abstract: This paper employs a calibrated model of the US economy to analyze the boom and bust in house prices as well as the shifts in the distribution of wealth during the years around the Great Recession. We replicate the dynamics of the housing market using shocks to aggregate income, the distribution of income, credit conditions, and expectations of future housing demand driven by irrational exuberance. We find that irrational exuberance was the primary driver behind the dynamics of house prices and that the relaxation and subsequent tightening of credit conditions are crucial to explain the behavior of mortgage debt, default rates, and housing holdings by households at the bottom of the wealth distribution. The boom in house prices led to a temporary decrease in wealth concentration, which was subsequently reversed during the bust.
Keywords: Credit Conditions, Expectations, Great Recession, Irrational Exuberance, House Prices
JEL Classification: E21, E32, G01, R31, D31, D84

Resumen: Este artículo utiliza un modelo calibrado a la economía de EUA para analizar el auge y caída de los precios de la vivienda, así como los cambios en la distribución de la riqueza durante los años alrededor de la Gran Recesión. Se replica la dinámica del mercado inmobiliario utilizando choques al ingreso agregado, la distribución del ingreso, las condiciones crediticias y las expectativas de demanda de vivienda futura impulsadas por exuberancia irracional. Encontramos que la exuberancia irracional explica la mayor parte de la dinámica de los precios de la vivienda y que la relajación y posterior endurecimiento de las condiciones crediticias son cruciales para explicar el comportamiento de la deuda hipotecaria, las tasas de incumplimiento y la tenencia de viviendas por parte de los hogares en la parte inferior de la distribución de la riqueza. El auge en los precios de la vivienda condujo a una disminución temporal en la concentración de la riqueza, que se revirtió durante la caída.
Palabras Clave: Condiciones Crediticias, Expectativas, Exuberancia Irracional, Gran Recesión, Precios de la Vivienda

1 Introduction

House prices and aggregate net wealth in the US rapidly increased between 1998 and 2007 and sharply decreased until 2013. During the same period there were also important movements in the distribution of wealth. For example, the drop in net wealth after 2007 was more considerable for households at the bottom of the net wealth distribution, partially because housing was the main asset in their portfolios (Figure 1).[1] The causes of the boom and bust in the housing market and its implications on the distribution of wealth are still debated to this day.
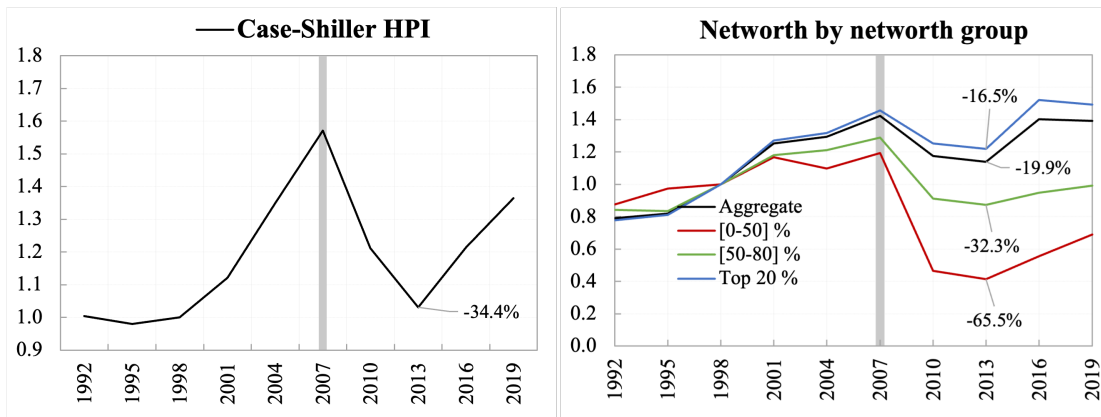
Figure 1: Case-Shiller National Home Price Index (left) and net worth by net worth group using data from the Survey of Consumer Finances (right)

In this paper, we study the causes behind the boom and bust in house prices around the Great Recession and quantify the importance of house prices and other relevant factors for the distribution of wealth during the same period. To this end, we use a general equilibrium model in which we replicate the boom-and-bust episode in both housing and mortgage markets by introducing shocks to credit conditions and expectations of future housing demand driven by irrational exuberance. We use our model as a tool to identify the relative importance of credit conditions and irrational exuberance by simultaneously calibrating the path for each shock

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[1]Using data from the Survey of Consumer Finances (SCF), we find that the average ratio of housing over net worth for the period 1998-2016 was 62% for households at the bottom 80% of the net worth distribution and 35% for the whole population.

to match as best as possible a set of variables that describe the housing market during the boom-and-bust episode. Then, we study the contribution of each shock on the net worth of different households across the net worth distribution.

We focus on credit conditions and irrational exuberance as potential drivers of the boom and bust in the housing market because there is plausible empirical evidence and theoretical mechanisms that support both channels. The credit view focuses on changes in housing demand driven by previously constrained households. In contrast, the irrational exuberance view emphasizes that changes in housing demand can be generated by what agents expect regardless of fundamentals. If enough families expect housing to be more valuable tomorrow, that will drive up prices today, becoming a self-fulfilling prophecy. Our contribution is to quantify the relative importance of each channel on the evolution of house prices and the distribution of wealth using a general equilibrium model.

Our model features two types of households that differ in their degree of impatience and access to financial markets in a framework without aggregate uncertainty. All households face idiosyncratic shocks to their income and the value of their housing, which is equal to the aggregate housing prices multiplied by a household-specific shock. Patient agents can fully insure against idiosyncratic income and house valuation shocks by pooling resources between them. This assumption simplifies the solution of the model, and it does not affect our conclusions, as the focus of this study is the difference between the top wealth holders as a group and the bottom wealth holders for which we do explicitly model heterogeneity. Impatient agents cannot insure against any source of idiosyncratic risk. This assumption is essential to replicate mortgage defaults in equilibrium as households that experience simultaneous declines in their income and the valuation of their homes will be the most likely to default on their mortgage payments. Both types of households value housing and consumption goods, and have access to either one-period mortgage contracts or risk-free deposits, offered by financial intermediaries. In addition, and following Guvenen (2009), there is also a productive asset in the form of a Lucas' tree that is only traded among patient households.

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In equilibrium, patient households save while the average impatient household borrows. Financial intermediaries collect resources from patient households (and some impatient households) to offer a menu of mortgage contracts consisting of combinations of mortgage size, interest rate, and value of the collateral (housing). The model also features lack of commitment which, along with the idiosyncratic house valuation shock, results in a fraction of households optimally defaulting on their mortgage every period, and therefore, losing their housing stock.

The assumption of two types of households with different levels of impatience is common in the literature to replicate the high concentration of wealth observed in the data. In reality, wealth concentration is a reflection of many factors, including unequal access to education and credit markets, the amount received as inheritance, preferences for leaving inheritances to descendants, and the success or failure of individuals' entrepreneurial ventures. Therefore, the difference in levels of impatience in the model can be seen as a reduced form way of capturing these complex factors.[2]

At the beginning of every period, households receive information about the current and future values for credit conditions, preferences for housing, and economic activity. We assume that agents do not have perfect foresight as new information can arrive unexpectedly every period. Deviating from the usual perfect foresight assumption is motivated by empirical evidence. Using survey data, Case, Shiller, and Thompson (2012) reported that at the bubble's peak in 2007, households expected, on average, an annual appreciation of 9% over the next ten years.[3] Cheng, Raina, and Xiong (2014) documented that most mid-level managers working in securitized finance did not exhibit awareness of problems in overall housing markets. These findings suggest that households and financial intermediaries made decisions based on expectations that turned out to be different from reality.

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[2]De Nardi and Fella (2017) summarize the different ways to replicate the high levels of wealth concentration observed in the data using heterogeneous agent models.

[3]Case, Shiller, and Thompson (2012) documented that surveyed households living in Alameda, Middlesex, Milwaukee, and Orange counties reported in 2007 that they expected an average yearly appreciation of 10.7%, 5.3%, 8.1%, and 12.2%, respectively, for the period 2007-2017.

The stationary equilibrium of the model is calibrated to match the distributions of net worth and income, as well as key properties of the housing market in the US during 1998. The mass of patient agents is set to 20% and they represent the top wealth holders in the economy.[4] Taking 1998 as the initial stationary equilibrium, we feed multiple shocks into the model to generate a boom and bust episode in the housing market: i. changes in credit conditions, captured by movements to both mortgage-to-income and loan-to-value limits, ii. expectations of future housing demand driven by irrational exuberance, modeled as expectations about the future value of preferences for housing, and iii. changes to aggregate income and its distribution, captured by the share of total income earned by impatient agents.

We discipline our replication of the boom and bust episode in the housing market by imposing the following restrictions. First, the path of aggregate income is assumed to be exogenous and matches the cyclical component of real mean family income during the period 2001-2016. Second, the fraction of aggregate income earned by the bottom 80% is also assumed to be exogenous, and matches that reported in the data. The loan-to-value limit is set at non-binding levels during the boom phase, and to binding levels after 2007. Lastly, the path of mortgage-to-income constraints and expectations of future preferences for housing, which represents the irrational exuberance component, are jointly calibrated to match the path of house prices, the ratio of average mortgage to average income for the bottom 80%, and the default rate observed in the data during the same period.

The calibrated model does a good job at replicating the behavior of house prices, net worth, default rate, and of the average mortgage-to-income ratio. In regard to the contributions of each shock to the good fitting of the model, we find that income shocks (level and distribution) and movements in both mortgage-to-income and loan-to-value limits are not enough to generate the large increases observed in house prices, default rates, and net worth. Nonetheless, in combination with the irrational exuberance shock, the relaxation and posterior tightening

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[4]According to the SCF, households in the top 20% of the net wealth distribution held between 87% and 93% of non-housing net worth during 1998-2016, which is in line with patient agents in our model owning most deposits.

of credit constraints is crucial to match the behavior of mortgage to income ratios, the default rate and the housing holdings of patient agents.

This leaves the irrational exuberance shock as the main driver of the boom and bust episode in the housing market. During the boom phase, an increase in demand for housing driven by economics agents expecting a higher preference for housing in the future results in an increase in the price of housing and hence, in aggregate net worth. Such an increase in the price of houses kept default rates at low levels, while the relaxation in mortgage-to-income constraints allowed borrowers to access an even larger set of mortgages, which amplified the effect of expectations. Starting on 2007, optimistic expectations reverted, and a tightening in credit conditions took place, which lowered demand for houses, pushed prices down, and increased the default rate.

Finally, we study the evolution of the net worth of households at the top 20% and the bottom 80% along the transition path. Our model can replicate the boom observed in the value of housing and net worth for both types of households and does a good job at quantitatively matching the fall in these two assets for both groups after 2007. Our counterfactual exercises indicate that a higher concentration of income and the loosening in credit conditions were forces that would have decreased the wealth holdings of patient households. A higher concentration of labor income implies a lower relative income and hence housing holdings for households at the bottom of the wealth distribution. On the other hand, loosening in credit conditions implies that impatient households could now borrow more against their housing holdings. Some of them were initially constrained in the sense of wanting to acquire more debt, and the relaxation in credit conditions allowed them to do so, which increased their present consumption but decreased their housing equity increasing wealth concentration.

We also find that the relaxation and subsequent tightening of credit conditions are crucial to explaining the behavior of mortgage debt, default rates, and housing holdings by households at the bottom of the wealth distribution. Movement in house prices explains most of the dynamics for these households, as housing represents the largest asset on their portfolio.

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The boom in house prices led to a temporary decrease in wealth concentration, which was subsequently reversed during the bust.

Related Literature

This paper is directly related to three strands of literature. First, to a literature that aims to replicate the distribution of wealth in heterogeneous agent models. Second, to a number of studies that build on these models to quantify the causes of changes in the distribution of wealth in the USA over time. Lastly, to an empirical and theoretical literature that explores the sources and consequences of the housing boom and bust around the Great Recession.

The Bewley model is the standard workhorse used in quantitative macroeconomics to model the distribution of wealth. Aiyagari (1994), and Huggett (1996) solved general equilibrium versions of this model and there has been a large body of literature that built on top of these models to generate a realistic distribution of wealth (see De Nardi and Fella (2017) for an excellent survey).

Our model closely follows Cóndor (2020), and it is based on an Aiyagari model in which households differ in terms of their patience to generate saving behavior that positively correlates with wealth and hence allow us to better match the distribution of wealth.[5] Unlike the basic Aiyagari model, we assume that patient agents are able to insure idiosyncratic income shocks by pooling their resources and hence all patient agents hold the same level of assets, which simplifies the solution of the model but at the cost of not being able to study heterogeneity at top of the distribution. We take this trade off given that we are interested in the inequality between the top 20% and the bottom 80% of the net worth distribution.

Our paper is also closely related to a literature that uses Bewley models to study and quantify the drivers of the changes in the wealth distribution of the USA. For instance, Kaymak and Poschke (2016) and Hubmer, Krusell, and Smith (2020), which follow similar strategies, study the effects of changes in both the concentration of labor income and the tax system, on

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[5]Krusell, Smith, and Jr. (1998) was the first paper that proposed this strategy as a reduced form way to generate a positive correlation between saving rates and levels of wealth.

the concentration of wealth between 1970 and 2012. We complement their work by explicitly introducing a detailed housing sector which allows us to quantify the portfolio effect, and by zooming in on the years around the Great Recession. More crucially, our framework is able to generate the boom-and-bust pattern in the levels of net worth of both the top 20% and bottom 80% of the net worth distribution, whereas this is not the case in models like theirs that do not include a housing sector.

Lastly, this paper is related to the literature that studies the causes and consequences of the housing boom and bust around the Great Recession. Kaplan, Mitman, and Violante (2020) is the closest paper to ours as it disentangles the relative contribution of movements to aggregate income, housing finance conditions, and beliefs about future housing demand around the Great Recession using an heterogeneous agent model with a detailed housing sector. Our paper differs from theirs in at least four aspects.

First, they feed expectations of housing demand from survey data into their model, and find that in fact they are the main driver of movements in house prices. On the other hand, we calibrate expectations on housing demand driven by irrational exuberance along with mortgage-to-income limits to match the path of house prices and other macro variables. Despite the difference in methodology, both our paper and theirs conclude that changes in credit conditions are not enough to rationalize the the observed increase in the price of houses (as it is the case in Favilukis, Ludvigson, and Van Nieuwerburgh (2017), Justiniano, Primiceri, and Tambalotti (2019) and Garriga, Manuelli, and Peralta-Alva (2019)).

Second, our paper's main focus is to study the contribution of house prices on the dynamics of net worth of different households, while theirs is to assess the effects of a hypothetical large-scale debt forgiveness program, and the transmission of house prices to consumption. Third, they explicitly model aggregate uncertainty on income and future housing demand. Instead, our model does not display aggregate uncertainty, which leads us to depart from the usual perfect-foresight transition path to generate the boom-and-bust episode in both housing and mortgage markets. Finally, while their model includes a rental market and a life cycle

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dimension, we abstract from those factors.

The rest of the document is organized as follows. The model is presented in Section 2, while details on the calibration are presented in Section 3. Section 4 describes how we generate the boom and bust episode, and Section 5 reports our main results. Lastly, section 6 concludes.

2 The Model

2.1 Environment

Endowments. The economy has two types of goods. First, there is an idiosyncratic endowment of a non-durable good $\mu_{y,t} y_t$, where y_t follows a Markov process with unconditional mean equal to one, and $\mu_{y,t}$ is a non-stochastic scale factor. The environment abstracts from aggregate uncertainty, which implies by the Law of Large Numbers that the aggregate endowment of the non-durable good is equal to $\mu_{y,t}$. This endowment can be interpreted as labor income when labor supply is fixed.

Second, there is a perfectly divisible durable good (which we call housing) in fixed supplied normalized to H_s.

Patient and Impatient Households. There are two types of households, a measure ψ of Impatient households with discount factor β; and a measure $(1 - \psi)$ of Patient households with discount factor $\widetilde{\beta}$, where $\beta < \widetilde{\beta}$.[6] Throughout the paper, for decision variables common to both types of households, x denotes Impatient choices while $\widetilde{x}$ represents Patient choices.

Impatient households get a fraction κ_t of the nondurable aggregate endowment $\mu_{y,t}$, while Patient ones get the remaining fraction $1 - \kappa_t$. Households derive period utility $u(c_t, h_t; \eta)$ and $\widetilde{u}(\widetilde{c}_t, \widetilde{h}_t; \widetilde{\eta})$ from nondurable consumption (c_t for Impatient, $\widetilde{c}_t$ for Patient) and housing

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[6]In equilibrium, the average Impatient household holds negative net financial assets, while the opposite applies for the average Patient household.

consumption which is proportional to the housing stock owned in that period (h_t and $\widetilde{h}_t$, respectively), where η and $\widetilde{\eta}$ are the relative weights assigned to housing consumption in each utility function.[7] The housing good can be purchased every period at price p_t (relative to the nondurable good).

Housing. Houses are risky assets subject to an idiosyncratic valuation shock ω_t. At the beginning of each period, each household faces a realization of ω_t so that the effective value of housing is given by $\omega_t p_t h_{t-1}$. The valuation shock ω_t is i.i.d. across households, has log-normal cumulative distribution $F(\omega_t)$, $E(\omega_t) = 1$, and $\sigma = var(\ln \omega_t)$.

Competitive bank. There is a competitive bank, owned by Patient households, whose role is to canalize resources from Patient to Impatient households. It issues one-period deposits, d_{t+1}, that pay a risk-free rate r_t^d, and also offers one-period fixed-rate mortgage contracts that are contingent on the characteristics of each household. Let Q_t denote the price schedule of such a contract.[8] If a household takes a new mortgage, it gets $Q_t m_{t+1}$ in the current period and agrees to make a payment m_{t+1} on the next period.

Every household has the option to default on its mortgage obligations after observing the realization of its valuation shock ω_t. When default is chosen, such a household loses its entire housing stock, which is seized by the bank. There are no other costs for the household after default.[9] The bank then sells the house incurring in a proportional cost μ.

Credit conditions. Mortgage contracts are subject to two constraints. The first one consists of a Mortgage Debt-to-Income constraint, governed by the parameter $\overline{MTI}_t$. The second one, a Loan-to-Value constraint, depends on the parameter $\overline{LTV}_t$.

Irrational exuberance. Expectations about future housing demand, and hence about the future price of housing, come from what we will call fundamental sources (expectations about economic activity and credit conditions) and non-fundamental sources (expected changes in

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[7]u and $\widetilde{u}$ must meet the minimum requirements for utility functions: nondecreasing and quasi-concave.

[8]The mortgage interest rate r_t^m is then given by $(1 + r_t^m) = 1/Q_t$

[9]No market exclusion and no recourse.

the future value of housing preferences). This second channel allows our model to generate changes in house prices driven exclusively by irrational exuberance or expectations unrelated to fundamentals. If households expect the future preference for houses to be larger in the next period, that increases the demand for houses today independently of what happens with the actual value of η during the next period.

Information structure. Each period t, households and banks receive information regarding the parameters that determine the present and future value of credit conditions, aggregate income, and preferences for housing. The information set common to all agents in the economy is defined as:

$$\aleph^t_{j\geq t} = \{ \ (\overline{MTI}^t_j), (\overline{LTV}^t_j), \ \ (\mu^t_{y,j}), (\kappa^t_j), \ \ (\eta^t_j), (\widetilde{\eta}^t_j)\}_{j\geq t}$$

Agents then make decisions in t based on this information. The key assumption that we make is that agents do not have perfect foresight as new information can arrive unexpectedly every period. In this setting, all agents are surprised every period t as long as $\aleph^t_{j\geq t+1} \neq \aleph^{t+1}_{j\geq t+1}$. This contrasts with a perfect-foresight transition path framework, in which agents in the model may initially be surprised ($t = 1$) but have complete information from then on.

Allowing the information to change every period allows us to replicate optimistic expectations for the preferences for housing (and hence for the future demand for housing) during the boom that then unexpectedly reverted during the bust.

Big Family of Patient Households. As Impatient households are the main focus, it is also assumed that Patient households belong to large representative family of patient households, so that they can diversify away any idiosyncratic risk. As a result, each household inside a patient family consumes exactly the same amount of the durable good $\widetilde{c}_t$ and housing services $\widetilde{h}_t$. Also, at the end of each period, such family pools all its assets among its members.

Aggregate state. The aggregate state is given by the beginning-of-period distribution of housing stock and deposit/mortgages among the two types of households. We choose the

asset distributions of Impatient households $(\Theta(h_{t-1}, m_t))$, where h_{t-1} denotes the initial housing stock of an Impatient household, and m_t accounts for the initial promised mortgage payments for the period. Let $X_t = \{\Theta(h_{t-1}, m_t)\}$ be the aggregate state of the economy.

2.2   Impatient Households' Problem

Each Impatient household starts a period with a portfolio $x_t = \{h_{t-1}, m_t\}$ of housing stock and promised mortgage payments for that period. Each household also gets a realization of the non-durable good endowment y_t and learns what its idiosyncratic valuation shock ω_t is, as well as the information set $\aleph^t_{j \geq t}$ containing current and future values of key parameters.

Then Impatient households make default/payment decisions regarding current period's mortgage payments m_t, choose consumption (c_t, h_t) along with next period's total mortgage obligations m_{t+1} taking as given the mortgage contract with price schedule Q_t. We guess and later verify that the default decision is characterized by a threshold $\overline{\omega}_t$. That is, an impatient household honors the promised payment when $\omega_t > \overline{\omega}_t$ and defaults otherwise. Let $D(\omega_t)$ be the default function associated with a threshold $\overline{\omega}_t$.

Given the mortgage contract with price schedule $Q(h_t, m_{t+1}, X_t, \aleph^t_{j \geq t})$, house price p_t, and future decision rules, the recursive problem of an Impatient household consists of choosing nondurable consumption c_t, housing stock h_t, total promised mortgage payments m_{t+1} and a default decision $D(\omega_t)$ to solve

$$V(h_{t-1}, m_t, y_t, \omega_t, X_t; \aleph^t_{j \geq t}) = \max_{c_t, h_t, m_{t+1}, D_t} u(c_t, h_t; \eta^t_t)$$
$$+ \beta E_{y_{t+1}, \omega_{t+1}} V(h_t, m_{t+1}, y_{t+1}, \omega_{t+1}, X_{t+1}; \aleph^t_{j \geq t+1})$$

$$c_t + p_t h_t + (1 - D(\omega_t))m_t = \frac{\kappa^t_t}{\psi} \mu^t_{y,t} y_t + (1 - D(\omega_t))\omega_t p_t h_{t-1} + Q_t m_{t+1}$$

$$m_{t+1} < \overline{LTV}^t_t \, p_t h_t$$

$$m_{t+1} < \overline{MTI}^t_t \frac{\kappa^t_t}{\psi} \mu^t_{y,t} y_t$$

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The left hand side of the budget constraint consists of nondurable consumption and housing consumption, as well as the promised mortgage payments m_t conditional on the default decision $(1 - D(\omega_t))$. The right hand side includes the endowment of the nondurable good y_t $(\frac{\kappa_t^t}{\psi}\mu_{y,t}^t y_t)$, the value of housing kept conditional on the default decision $(1 - D(\omega_t))\omega_t p_t h_{t-1}$, and the resources from additional mortgages taken in the current period, which are determined by tomorrow's additional coupon payments $Q_t m_{t+1}$.

Impatient households are also subject to two additional constraints. The first one consists in a Loan-to-Value constraint, given by the parameter $\overline{LTV}_t^t$. The second one, a Mortgage Debt-to-Income constraint, depends on the parameter $\overline{MTI}_t^t$, and the actual period endowment $\frac{\kappa_t^t}{\psi}\mu_{y,t} y_t$. Finally, recall that parameters $(\eta_t^t, \overline{LTV}_t^t, \overline{MTI}_t^t, \mu_{y,t}^t, \kappa_t^t)$ are the first elements of their corresponding sequences, all contained in the information set $\aleph_{j\geq t}^t$.

2.3   Patient Households' Problem

Inside the representative family of Patient households, each of them starts the period with the same portfolio $(\widetilde{h}_{t-1}, d_t)$ of housing stock and one-period deposits. The family collects its corresponding share $(\frac{1-\kappa_t^t}{1-\psi})$ of the non-durable good endowment from all members, $\mu_{y,t}^t$. It also collects the initial housing stock from all members, which is given by $\int \omega_t \widetilde{h}_{t-1} dF(\omega_t) = E(\omega_t)\widetilde{h}_{t-1} = \widetilde{h}_{t-1}$.[10] Given the house price p_t, the risk-free interest rate r_t^d, and the information set $\aleph_{j\geq t}^t$, the recursive problem of a representative family of Impatient households consists of choosing nondurable consumption $\widetilde{c}_t$, housing stock $\widetilde{h}_t$, and new deposits d_{t+1} to solve

$$\widetilde{V}(\widetilde{h}_{t-1}, d_t, X_t; \aleph_{j\geq t}^t) = \max_{\widetilde{c}_t, \widetilde{h}_t, d_{t+1}} \widetilde{u}(\widetilde{c}_t, \widetilde{h}_t; \widetilde{\eta}_t^t) + \widetilde{\beta}\widetilde{V}(\widetilde{h}, d', X'; \aleph_{j\geq t+1}^t)$$

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[10]Because $E(\omega_t) = 1$, the initial stock of housing, after all ω_t are realized, remains constant. Notice that, at this stage, there is heterogeneity at the member's level. However, the family pools its total housing stock among its members, and the heterogeneity disappears.

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$$\widetilde{c}_t + p_t(\widetilde{h}_t - \widetilde{h}_{t-1}) + \frac{d_{t+1}}{1 + r_t^d} = \frac{1 - \kappa_t^t}{1 - \psi}\mu_{y,t}^t + d_t$$

Notice that even though households in the representative family of Savers are also subject to idiosyncratic valuation shocks, they are completely unaffected from them because, in equilibrium, they do not take any debt.

2.4 Banks and the mortgage price schedule

The competitive bank is owned by Patient households, so when choosing a mortgage price schedule, they take into account Savers' stochastic discount factor (SDF). However, since there is no aggregate uncertainty, the SDF is always equal to one. Banks also take as given Impatient households' future decision rules, including the default decision. In equilibrium, given administrative costs θ, and the information set $\aleph_{j \geq t}^t$, the mortgage price schedule $Q(h_t, m_{t+1}, X_t; \aleph_{j \geq t}^t)$ satisfies:

$$Q(h_t, m_{t+1}, X_t; \aleph_{j \geq t}^t) = \frac{\Gamma(h_t, m_{t+1}, X_t; \aleph_{j \geq t}^t)}{(1 + r_t^d)(1 + \theta)}$$

where Γ satisfies

$$\Gamma(h_t, m_{t+1}, X_t; \aleph_{j \geq t}^t)m_{t+1} = \underbrace{\int_{\overline{\omega}_{t+1}}^{\infty} \omega dF(\omega)m_{t+1}}_{\text{non-defaulted coupon payments}} + \underbrace{(1 - \mu)\int_0^{\overline{\omega}_{t+1}} \omega dF(\omega)p_{t+1}h_t}_{\text{housing seized from defaulting members}}$$

The function Γ accounts for the resources the bank gets for every unit of next period's promised coupon payment, given the household's total collateral h_t and the total promised payment m_{t+1}. It consists of two parts. The first one accounts for the non-defaulted fraction $\int_{\overline{\omega}_{t+1}}^{\infty} \omega dF(\omega)$ of next period's payment m_{t+1}. The second part is the value of the houses

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associated with defaulted mortgages $\int_0^{\overline{\omega}_{t+1}} \omega dF(\omega)\, p_{t+1}h_t$, net of the foreclosure cost μ.[11]

Finally, because there is no aggregate uncertainty, dividends are equal to zero in the stationary equilibrium.

2.5   Stationary Equilibrium

Let $s = \mathbb{R}_+ \times \mathbb{R} \times \mathbb{R}_+$ denote the individual state space of Borrowers, $\widetilde{s} = \mathbb{R}_+ \times \mathbb{R}_+$ the individual state space for Savers, S be the aggregate state space, and Ω be the information set space.

For any given information set $\aleph^t_{j \geq t}$, a stationary recursive competitive equilibrium associated to the limit set $\aleph^t = \lim_{j \longrightarrow +\infty} \aleph^t_j$ is a collection of decision rules of Impatient households c, m', h, $\overline{\omega} : s \times S \times \Omega \to \mathbb{R}$; decision rules of Patient households $\widetilde{c}$, $\widetilde{h}$, $\widetilde{d} : \widetilde{s} \times S \times \Omega \to \mathbb{R}$; associated value functions $V : s \times S \times \Omega \to \mathbb{R}$ and $\widetilde{V} : \widetilde{s} \times S \times \Omega \to \mathbb{R}$, future decision rules g^c, g^m, g^h, $g^{\overline{\omega}} : s \times S \times \Omega \to \mathbb{R}$; prices p, $r^d : S \times \Omega \to \mathbb{R}$, mortgage price schedule $Q : s \times S \times \Omega \to \mathbb{R}$ and distribution Θ such that:

1. Decision rules and value functions solve both households' problems, taking future decision rules, p, r^d, Q, and $\aleph^t$ as given.

2. All markets clear.

$$\psi \left[\int \left(c + \mu \int D(\omega)\omega p h_{-1} dF(\omega) + \theta Q m' \right) d\Theta \right] + (1-\psi)\widetilde{c} = \mu_y^t$$

$$\psi \int h \, d\Theta + (1-\psi)\widetilde{h} = H_s$$

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[11]One way alternative way to interpret this payoff function is by assuming that banks live for two periods. In the first period, they get deposits from Impatient households to buy a diversified portfolio of mortgages. In the second period, banks meet their deposit obligations with funds collected from non-defaulted coupon payments and from selling the sized houses.

$$(1 + \theta)\psi \int Qm' \, d\Theta = (1 - \psi)\frac{d'}{(1 + r^d)}$$

3. Θ is a stationary probability measure.

4. Current and future decision rules coincide for all possible states.

2.6 Characterization of Equilibrium

This section develops the equilibrium conditions of some of the decision variables. In the case of Borrowers, the optimal default decision satisfies:

$$\overline{\omega}_t p_t h_{t-1} = m_t$$

This condition is just equating the current cost of defaulting, which is given by the loss of housing stock of value $\overline{\omega}_t p_t h_{t-1}$, with the of honoring the mortgage obligation, m. On the other hand, the FOCs for the family of Savers reads:

$$\widetilde{u}_{\widetilde{c},t} = \widetilde{\beta}(1 + r^d_t)\widetilde{u}_{\widetilde{c},t+1}$$
$$p_t\widetilde{u}_{\widetilde{c},t} = u_{\widetilde{h},t} + p_{t+1}\widetilde{\beta}\widetilde{u}_{\widetilde{c},t+1}$$

where, in the case of the stationary equilibrium asociated to the limit set $\aleph^t$, $p_t = p_{t+1}$ and $u_{\widetilde{c},t} = u_{\widetilde{c},t+1}$. From the first equation, the risk-free interest rate can be pinned down in the such stationary equilibrium as $1 + r^d = 1/\widetilde{\beta}$.

3 Calibration of Initial Equilibrium

A summary of the calibration for the initial year (1998) in a tri-annual frequency is shown in Table 1. Details are discussed below.

Income Process. The idiosyncratic non-durable good endowment y is assumed to be an AR(1) process of the form:

$$\log y = \rho \log y_{-1} + (1 - \rho^2)^{1/2} \varepsilon$$

where $E(\varepsilon) = 0$, $E(\varepsilon^2) = \sigma_\varepsilon^2$, and ρ is the one-period autocorrelation, whereas σ_ε is the unconditional standard deviation. Notice that with this functional form, the unconditional mean of y is equal to 1. Recent estimates[12] of the income process for heterogeneous-agent models report $\rho = 0.98$ and $\sigma_\varepsilon = 0.3$ on average, for an annual frequency. We choose $\rho = 0.96$ and $\sigma_\varepsilon = 0.3$ for our tri-annual frequency, and approximate this AR(1) process with a 5-state Markov chain using the algorithm by Tauchen and Hussey (1991).

Finally, μ_y is set to 1.0 in both initial and final stationary equilibria.

Productive Asset. The dividend from the Lucas' tree (div^{LT}) is set at 0.064 to match the share in housing in the total wealth of the top 20%, where net wealth for that group, in the model, consists of housing, deposits, and the value (price) of the Lucas' tree. Recall that this calibration choice does not change the total endowment received by patient households, given by $\frac{\kappa}{1-\psi} \mu_y y$. Thus, it does not affect any equilibrium allocation, except for the net worth of this wealth group, which includes the value of the tree.

Foreclosure Cost. A value a 0.22 is chosen for the foreclosure parameter μ, following the work of Pennington-Cross (2010) studying the liquidation sales revenue from foreclosed houses using national data.

Valuation Shock. The valuation shock ω follows a log-normal distribution with mean one and $\sigma = var(\ln \omega)$. Notice that, in the model, both default and foreclosure take place in the same period. In the real world, only a fraction of delinquent mortgages ends up being foreclosed two years after the initial date of default on average. In this paper, we focus on matching the foreclosure rate, on which data are available from 2005 onwards. We choose

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[12]See Storesletten, Telmer, and Yaron (2004).

a target of 0.36 percent for the default rate in the model for the initial equilibrium (level registered in 2019), which results in a value of 0.052 for σ. With this value, we consider ω as an AR(1) process with persitence parameter equal to zero, and approximate it as a 5-state Markov chain using the algorithm by Tauchen and Hussey (1991).

Demographics and Income Shares. The mass of Impatient Households (ψ) is set at 0.8, to represent the bottom 80 percent of households' net wealth distribution. This group accounts for 52.9 percent of total household income in 1998, which is the value assigned to κ in the initial equilibrium.

Preferences. The period utility functions have the form

$$u(c, h) = \frac{[(1 - \eta)c^\gamma + \eta h^\gamma]^{\frac{1-\sigma}{\gamma}}}{1 - \sigma}$$

$$\widetilde{u}(\widetilde{c}, \widetilde{h}) = \frac{[(1 - \widetilde{\eta})c^\gamma + \widetilde{\eta} h^\gamma]^{\frac{1-\widetilde{\sigma}}{\gamma}}}{1 - \widetilde{\sigma}}$$

Parameters η and $\widetilde{\eta}$ are chosen to match the average housing wealth over the average income of the Bottom 80 percent and Top 20 percent on the Survey of Consumer Finance in 1998. The average ratio for the Bottom 80 percent is 1.69, while that of Top 20 percent is 2.45, which imply values of η and $\widetilde{\eta}$ of 0.0250 and 0.0253 respectively.[13] The parameters σ and $\widetilde{\sigma}$ are set 2.0 and 1.0, following Guvenen (2002), so that the intertemporal elasticity of substitution (IES) for impatient and patient households is 0.5 and 1.0 respectively. The parameter related to the elasticity of substitution between housing and nondurables, γ, is set to 0.2 so that such elasticity is equal to 1.25, which is based on the estimates of Piazzesi et. al. (2007).

The discount factor of patient households, $\widetilde{\beta}$, is set at 0.972 to match a tri-annual equilibrium risk-free rate of 2.9%. On the other hand, the discount factor of impatient Households, β, is set at 0.925 to match the ratio of the average mortgage over average income of the Bottom 80

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[13]Alternatively, η and $\widetilde{\eta}$ could be equated and set to match the share of housing in total consumption expenditures from NIPA. The average share is 13.9% for the period 1998-2016. However, such value generates housing-wealth-to-income ratio 4 times as high as those in the Survey of Consumer Finance.

percent of 0.76 registered in 1998 from the Survey of Consumer Finance.

Mortgage. The administrative cost per unit of mortgage issued, θ, is set at 40 basis points per year, following Jeske, Krueger, and Mitman (2013).[14]

The Mortgage Debt-to-Income limit with respect to annual income, $\overline{MTI}$, is set at 1.55 to replicate the 85th percentile of mortgage-to-income ratios of the Bottom 80 percent, from the Survey of Consumer Finance in 1998. We choose to target such a percentile over 90th or 95th to avoid the effects of unusually low values of income reported in the survey that artificially inflate such ratios, which may imply more relaxed credit conditions than those actually observed during that year.

Finally, the Loan-to-Value limit, $\overline{LTV}$, is set at 0.70 to match an average loan-to-value ratio of 0.40 observed in 1998 in the Survey of Consumer Finance. Despite the fact that a value 0f 0.70 is smaller to the usual choice of 0.80, it is aligned with works in which agents are infinitely-lived and mortgage debt is one-period, like Campbell and Hercowitz (2009) and Justiniano et. al (2015). In both papers, the amount of housing that a household can use as collateral declines over time, which captures the notion that mortgage principals are gradually repaid, and is consistent with the observation that average loan-to-value ratios in the data are lower than those observed at origination. In practice, this modelling strategy reduces the effective loan-to-value limit with respect to the total amount of housing owned. Unlike those works, however, in which the Loan-to-Value limit converges to zero in the steady state, we choose to set it at 0.70 to allow for second mortgages and home equity lines of credits (HELOCs), which played an important role during the boom phase in the housing market.

Housing stock. A fixed housing stock H_s of 0.60 is chosen to match the median sales price of houses sold over the median family income in 1998, which was 3.2.

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[14]In their paper, banks have to pay 10 basis points for administrative fees and 30 basis points for insurance.

Table 1: Calibration for 1998

Exogenously Calibrated Parameters

Param	Description	Value	Source / Target
ρ	Income persistance	0.96	Storsletten et al. (2004)
σ_ε	Income volatility	0.30	Storsletten et al. (2004)
μ	Foreclosure cost	0.22	Pennington-Cross (2006)
θ	Mortgage administrative cost	40 BP	Jeske et al. (2013)
$\overline{MTI}$	Mortgage-to-Income limit	1.55	85th percentile MTI Bottom 80
ψ	Mass of Impatient HHs	0.80	Bottom 80 share Net Wealth
κ	Bottom 80's income share	0.529	Income Bottom 80 percent
σ	Inverse of IES Bottom 80	2.0	Guvenen (2002)
$\widetilde{\sigma}$	Inverse of IES Top 20	1.0	Guvenen (2002)
γ	Substitut param (house non-durable)	0.2	Piazzesi et. al. (2007)

Endogenously Calibrated Parameters

$\overline{LTV}$	Loan-to-Value limit	0.70	Average LTV 0.40 Bottom 80
σ_ω	Volatility of depreciation shock	0.52	Default rate 0.36%
$\widetilde{\eta}$	Top 20's house preference	0.0253	Housing to income 1.69
η	Bottom 80's house preference	0.025	Housing to income 2.45
$\widetilde{\beta}$	Discount Factor Top 20	0.972	Tri-annul risk-free rate 2.9%
β	Discount Factor Bottom 80	0.925	Mortgage / Income 0.76
H_s	Housing Stock	0.60	House price / Income 3.2

4 Boom-and-Bust Episode

Our calibration aims to replicate the boom-and-bust episode in the housing market. To this end, we introduce shocks to aggregate income, credit conditions, and expectations of future housing demand driven by irrational exuberance. The path of aggregate income is taken from the data while the paths for the shocks to credit conditions and irrational exuberance are si-

multaneously calibrated to match key moments of the data as best as possible. Our calibration strategy is agnostic about the importance of the credit and the irrational exuberance channels and a contribution of our paper is to quantify the importance of each according to our model.

The information structure is key to understand the definition of shocks in the model. At the beginning of each period, households receive information about the current and future values for the parameters that determine economic activity, credit conditions, and the expectations for future housing demand. Formally, $\aleph_t$ is the information set available to all agents in period t. Parameters not included in this set are assumed to remain constant (i.e., equal to theirs levels in the initial stationary equilibrium).

$$\aleph^t_{j \geq t} = \{ \, (\overline{MTI}^t_j), (\overline{LTV}^t_j), \;\; (\mu^t_{y,j}), (\kappa^t_j), \;\; (\eta^t_j), (\widetilde{\eta}^t_j) \}_{j \geq t}$$

Agents take decisions in t solving a complete transition path from period t onward assuming that parameters will behave according to the information set available at t. We deviate from the usual perfect foresight assumption as the information set in $t+1$ can differ from the one in t. Agents face a shock as long as $\aleph^t_{j \geq t+1} \neq \aleph^{t+1}_{j \geq t+1}$. [15] Our deviation from the perfect foresight assumption is in line with empirical evidence on both households and banks expecting house prices to keep appreciating even at the peak of the boom.

To calibrate the model we impose a simple structure for $\aleph_t$. Agents expect the current values for credit conditions and economic activity to remain constant at the current values. Furthermore, we allow the next period value for housing preferences to be different from the current

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[15]This means that, in period $t + 1$, agents get a new information set and solve for a new complete transition path from from period $t + 1$ on wards. In that sense, agents in the economy are constantly "surprised" by new information sets.

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one but constant from then on. Formally, we have that for $k \in \{1, 2, ...\}$:

$$
\begin{aligned}
\eta^t_{t+k+1} &= \eta^t_{t+1} \\
\widetilde{\eta}^t_{t+k+1} &= \widetilde{\eta}^t_{t+1} \\
\overline{MTI}_{t+k} &= \overline{MTI}_t \\
\overline{LTV}_{t+k} &= \overline{LTV}_t \\
\mu_{y,t+k} &= \mu_{y,t} \\
\kappa_{t+k} &= \kappa_t
\end{aligned}
$$

A shock to credit conditions an unexpected change in mortgage to income or loan to value limits. An irrational exuberance shock is an unexpected change in expectations for next period preferences for housing. If η^t_{t+1} is expected to be larger than η_t at the beginning of period t, then the expectations of future housing demand will have an irrational exuberance component as they will not depend exclusively on fundamentals (credit conditions and economic activity). In our exercise, we assume that the actual preferences do not move during the transition so all changes in demand for housing are purely driven by irrational exuberance or changes in credit conditions.

We discipline our calibration exercise by imposing three additional restrictions. First, $\mu_{y,t}$, κ_t, and $\overline{LTV}_t$ follow predetermined paths, based mainly on observed data. Specifically, $\mu_{y,t}$ follows the path of the cyclical component of real GDP using the Hodrick-Prescott filter. This cyclical component is additionally smoothed by taking a 2-period moving average, to avoid unnecessary noise during the transition path. κ_t follows the smoothed path of the share of total income earned by the Bottom 80 percent in the Survey of Consumer Finance. Finally, $\overline{LTV}_t$ is set at not-binding levels in the model during 2001-2007, and then set to 0.80 from 2010 onward.

Second, given the values of η and $\widetilde{\eta}$ in the initial equilibrium, the ratios η^t_{t+1}/η and $\widetilde{\eta}^t_{t+1}/\widetilde{\eta}$ are required to be equal. In other words, both parameters of housing-preference expectations

increase or decrease in the same proportion along the transition path. Third, the resulting path targets three variables in data: house prices P_t^h, the ratio of Bottom 80's mortgage debt to average income M_t^{B80}/Y_t^{B80}, and the default rate DEF_t. [16]

Thus, given the stationary equilibrium at the initial year 1998 ($t = 0$), the minimization problem to solve for the transition path between 2001 ($t = 1$) and 2016 ($t = 6$) can be expressed as:

$$\min_{\{\eta_{t+1}^t, \widetilde{\eta}_{t+1}^t, \overline{MTI}_t\}} \sum_{t=1}^{6} \frac{1}{6} \left\{ \alpha_1 \left(p_t - P_t^h\right)^2 + \alpha_2 \left(\frac{m_t'}{\mu_{y,t}^{B80}} - \frac{M_t^{B80}}{Y_t^{B80}}\right)^2 + \alpha_3 \left(def_t - DEF_t\right)^2 \right\} \text{ s.t.}$$

$$\frac{\eta_{t+1}^t}{\eta} = \frac{\widetilde{\eta}_{t+1}^t}{\widetilde{\eta}} \text{ for all } t$$

$$\mu_{y,t}, \ \kappa_t, \text{ and } \overline{LTV}_t \text{ are given}$$

Weights α_i add up to one and are proportional to the inverse of the standard deviation of each variable in the data.

5 Results

5.1 Aggregate Results

In this sub-section we assess how the transition path of macro variables in our model compares with the ones observed in the data, and deconstruct the relative importance of each shock to explain the dynamics.

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[16]In addition, the dividend of the Lucas' tree along the transition path, as a fraction of total income of the top 20%, is set such that the path of its price matches the dynamics of the asset categories "stocks", "businesses", and "corporate bonds" combined, in the Survey of Consumer Finance. Given that the dividend is not a choice variable and does not change total income, it does not affect any equilibrium allocation except for the level of net worth of the top 20%.

As it is shown in Figure 2, the model does a good job at replicating the behavior of house prices, the default rate, the ratio of average mortgage to average income, and aggregate net worth. Our calibration strategy generates an increase in house prices of 48% and a subsequent decrease of 26% (compared with 57% and 34% in the data) and matches almost exactly the peak of the default rate and the average mortgage over average income ratio. Lastly, the model generates an increase of 44% in net worth followed by a decrease of 24% compared with 42% and 20% in the data.

According to our counterfactual simulations, the increase and posterior decline in the demand for housing caused by the irrational exuberance shock was the main driver behind the boom and bust in both house prices and aggregate net wealth. If we abstract from it, the positive deviation of GDP with respect to its trend and the relaxation of credit conditions are only able to generate an increase of 7% in house prices and of 26% in net worth. This result is in line with Kaplan, Mitman, and Violante (2020).[17]

On the other hand, the relaxation, and posterior tightening, of credit conditions is crucial to match the behavior of the default rate and mortgage to income ratios. If we abstract from the credit channel, the stock of mortgages would have actually decreased because of the lower share of income going to impatient agents (κ shock), combined with fixed mortgage-to-income limits and loan-to-value limits. Instead, the loosening of credit limits led households that were previously constrained to optimally increase their mortgage debt. It is worth noting that the default rate does not increase if we abstract from the credit shock, which suggests that the presence of high levels of mortgage debt is key to generate an increase in default rates in the context of collapsing house prices.

When operating together, both shocks (irrational exuberance and credit conditions) paint a clear picture of what may have taken place during the boom-and-bust episode in the housing/mortgage market in the US. In the boom phase, an increase in demand for housing driven

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[17]Kaplan, Mitman, and Violante (2020) calibrate the expectation of house price appreciation during the boom from survey data (Case and Shiller (2003) and Case, Shiller, and Thompson (2012)) without directly targeting house prices while we explicitly use the Case-Shiller HPI as our target.

by expectations fueled by irrational exuberance resulted in an increase in house prices and, hence, in aggregate net worth. Such an increase in the cost of housing, along with the relaxation in credit constraints, allowed borrowers to access to an even larger set of mortgages, amplifying the effect of expectations, while keeping default rates low. Starting on 2007, however, optimistic expectations reverted which along with a tightening in credit conditions, contracted demand for houses and pushed both prices and net worth down. In such context, high levels of mortgage debt resulted in a sharp increase in the default rate in 2010, as heavily indebted households expected house prices to remain close to their 2007 level and instead faced a sharp decrease, which made default the optimal choice.

(a) House price

(b) Default rate

(c) Avrg mortgage to avrg income

(d) Net worth
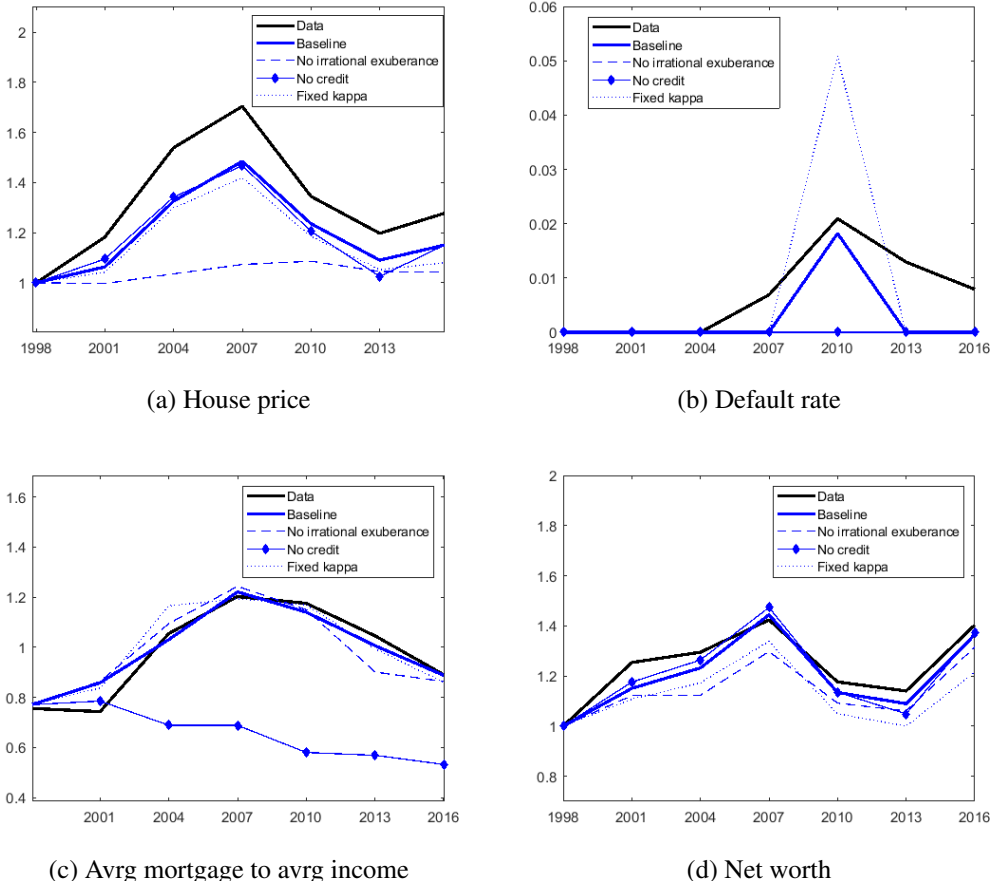
Figure 2: Aggregate variables

5.2 Distributional Results

In this subsection, we describe the wealth dynamics of patient and impatient households, following shocks to housing demand expectations (via irrational exuberance), credit conditions and to the level and distribution of aggregate income. Specifically, we assess how the evolution of housing and net worth for each type of household compares with the data, and discuss the main mechanisms behind these dynamics through the lens of our model.
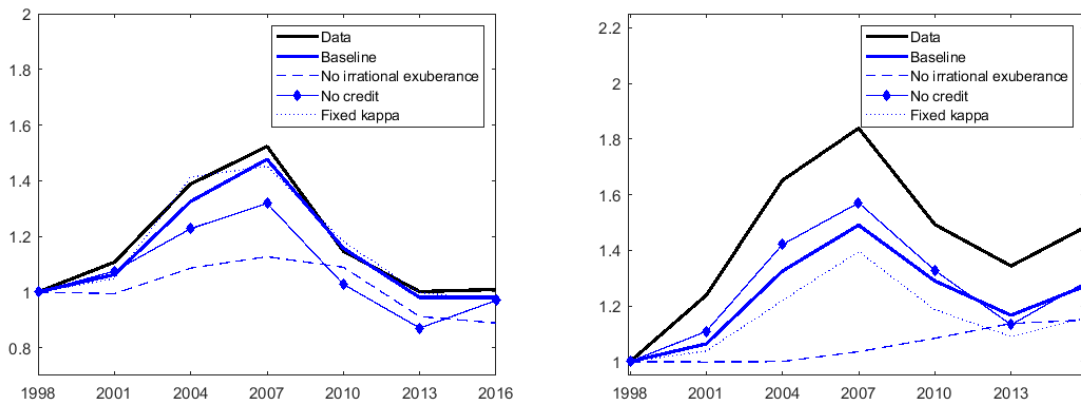

Figure 3: Housing of the bottom 80% and top 20% (model simulations and data from the SCF, 1998 =1).
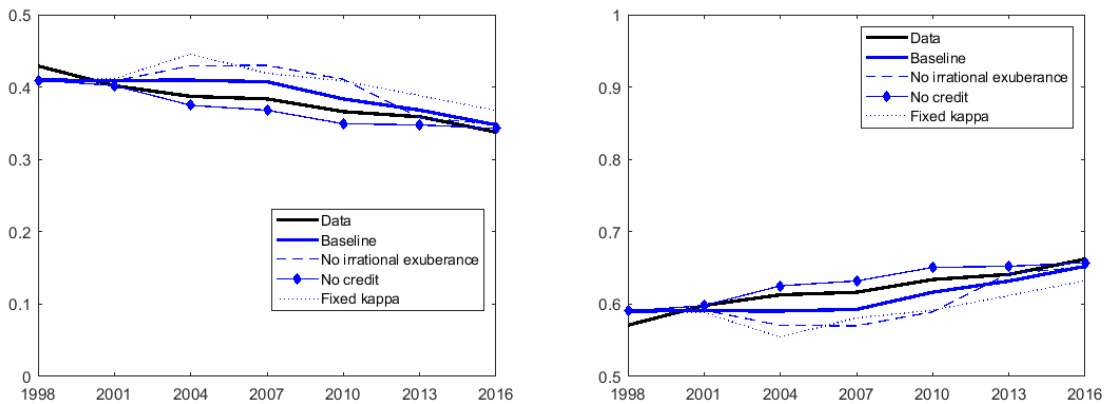
Figure 4: Share of Housing held by the bottom 80% and top 20% (model simulations and data from the SCF).

	Bottom 80%		Top 20%	
	Model (Baseline)	Data (SCF)	Model (Baseline)	Data (SCF)
1998-2007	47.68%	52.31%	49.05%	83.87%
2007-2013	-33.64%	-34.26%	-21.74%	-26.92%

Table 1: Housing of the bottom 80% and top 20% (model simulations and data from the SCF).

Our baseline calibration does a good job at quantitatively replicating the increase and posterior decrease in the value of housing holdings for impatient agents (Figure 3 and Table 1). The good fit of the model in this dimension is mainly driven by the irrational exuberance shock as abstracting from it would only generate a 13% increase in housing wealth of the Bottom 80%. Credit is also crucial to replicate the full increase in housing wealth for this group, as in the absence of loser credit conditions the value of their housing holdings would have increased only 32% rather than 48%. The relaxation of the mortgage-to-income and loan-to-value limits during the boom phase increased the demand for housing from the patient households as some households that were constrained increased the size of their mortgages and housing holdings.

The model also replicates the boom-and-bust pattern in the value of housing for patient households, closely matching its fall and generating a 49% increase during the boom in contrast with 84% in the data (Table 1). The reason for this is that our model features homogeneous housing, and our target is the aggregate Case-Shiller index while, in the data, counties with higher income experienced faster house price appreciation. [18]

The increase in aggregate income and a higher share of it going to the top 20% were forces increasing the housing holdings for this group, while the loosening in credit conditions operated in the opposite direction as they increased the return on deposits, making housing less attractive to patient agents. These two forces neutralized each other, resulting in a stable share

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[18]The nationwide inflation adjusted Case-Shiller index increased 72% between January 1998 and January 2007 and 175% for Los Angeles county during the same period. This highlights that the nationwide Case-Shiller index hides important heterogeneity in the behavior of house prices.

of total housing going to the top 20% before 2007 (Figure 4). The posterior fall in housing demand from the bottom 80% driven by the tightening of credit conditions eventually increased the relative holdings of the top 20% resulting in higher concentration of housing in line with what´s observed in the data.

Also, as shown in Figure 5 and Table 2, the model is able to qualitatively replicate the boom-and-bust pattern displayed by the net worth of both top 20% and bottom 80% groups. The rise in the price of housing increased the net worth of both groups between 1998 and 2007. Such increase was more pronounced for the bottom 80%, given that these households hold a larger fraction of their portfolio on housing and that this asset outperformed the rest during the boom. In the model, the net worth of the bottom 80% and top 20% increased 49% and 44% respectively, compared with 27% and 46% in the SCF data. So, even when our model does replicate an increase in the net worth of both groups, it generates a slight decrease in wealth concentration during the boom, while a slight increase was observed in the data (Figure 6). This is explained by three reasons.

First, all households in the model are homeowners and hence, benefited from the increase in house prices whereas, in the data, an important fraction of households in the bottom 80% are renters. With regard to this point, in appendix A.1, we contrast the model with the bottom 80% of the population of home owners and find that the increase in net worth in the data is closer to the one in the model. Second, the model does not include unsecured debt like credit cards or student loans, both of which increased considerably between 1998 and 2007, specially among the bottom 50%-80%. Lastly, as mentioned before, the model does not capture the full increase in the value of housing holdings for the top 20%.[19]

The increase in the net worth of the two groups reverted when the price of housing, aggregate income, and the value of productive assets collapsed after 2007. Given that households in the bottom 80% of the distribution hold most of its assets in housing and were leveraged, the

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[19]Households in the Top 20% have access to housing, claims on productive assets, and other assets. Other assets in the model are only represented by deposits while in the data include government bonds. This miss-match is an additional source of difference between our stylized model and the data.

unexpected and sharp drop in the price of housing affected their net worth more than it did the top 20%'s net worth. The model does a good job at qualitatively matching the decrease between 2007 and 2013 as the net worth of the bottom 80% dropped by 42% compared with 37% in the data; and the top 20% decreased by 23% compared with 16% in the data. This implies that our model does generate an increase in the share of wealth going to the top 20% as a consequence of the Great Recession in line with what is observed in the data. Housing prices below its 2007 level along with a higher concentration of total income and tighter credit conditions resulted in a higher concentration of net worth compared with 1998.
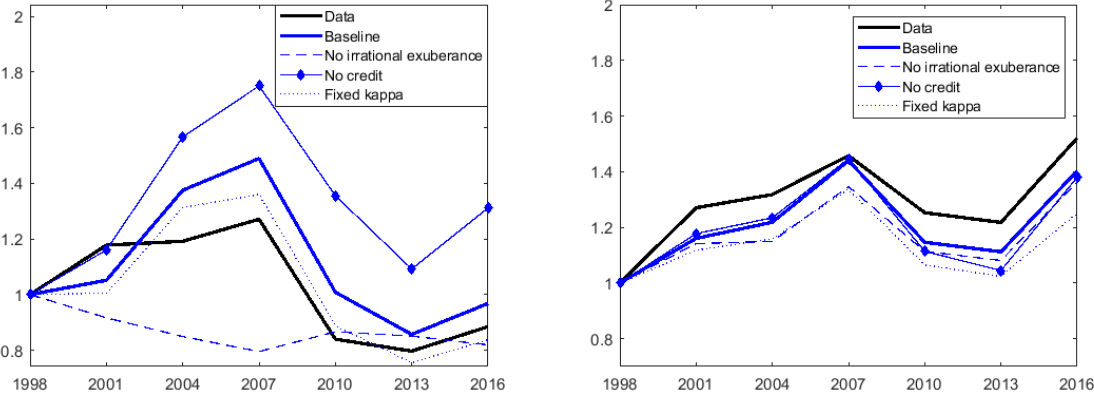

Figure 5: Net worth of the bottom 80% and top 20% (model simulations and data from the SCF, 1998 =1).

Finally, as it is shown in Figure 5, abstracting from the irrational exuberance shock would have generated a counterfactual decrease of 20% in the net worth of the Bottom 80%, as some of the previously constrained households optimally would have decided to increase the size of their mortgages in the presence of looser credit conditions and, therefore, reduced their home equity (which in the model is equal to net worth for the bottom 80%). Along the same lines, the net worth of the Bottom 80% would have been higher in the absence of loosening credit conditions, which suggests that a fraction of households would have used higher house prices and credit lines to finance present consumption, a strategy that would have increased their welfare but reduced their net worth.
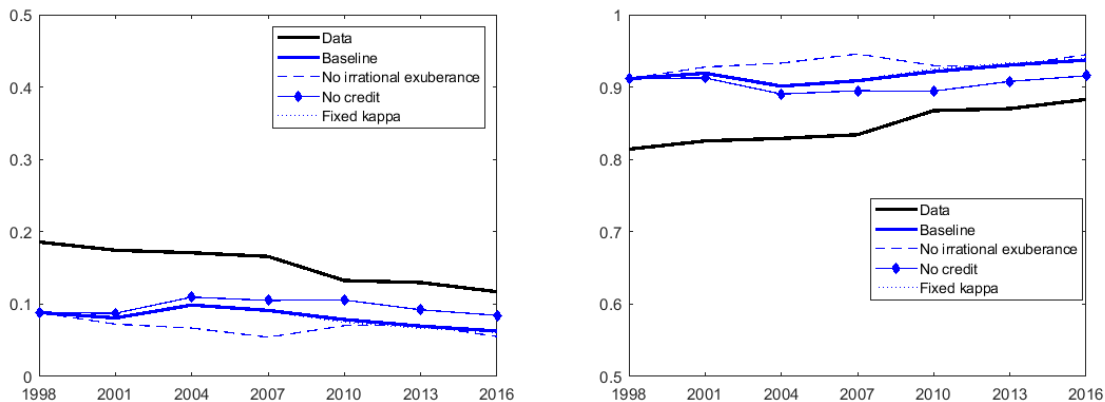
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Figure 6: Share of Net worth held by the bottom 80% and top 20% (model simulations and data from the SCF).

	Bottom 80%		Top 20%	
	Model (Baseline)	Data (SCF)	Model (Baseline)	Data (SCF)
1998-2007	48.92%	27.09%	43.98%	45.75%
2007-2013	-42.46%	-37.29%	-22.77%	-16.45%

Table 2: Net worth of the bottom 80% and top 20% (model simulations and data from the SCF).

In summary, the boom-and-bust pattern in house prices generated by the irrational exuberance shock was the most important factor at explaining the dynamics in housing wealth and net worth of both patient and impatient households. Loosening in credit conditions are crucial to match the observed increase in mortgages, and was also important to replicate the dynamics housing wealth of the Bottom 80%. The credit shock, by itself, was a force towards higher net worth concentration, as many households in the bottom 80% were initially constrained and optimally expanded present consumption. This shock, along with a higher concentration of labor income, were factors in favor of a higher concentration of net worth during the boom phase, that were counteracted by the increase in the value of houses. After the collapse in house prices, however, these factors ultimately took over and generated a higher net worth concentration.

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6 Conclusion

In this paper, we replicate the boom-and-bust episode in the housing market in the US using a calibrated model on which we introduced shocks to aggregate income, credit conditions and to expectations of future housing demand driven by irrational exuberance. Using this framework, we then analyze the effect of each one of these shocks on the net worth of different households across the net worth distribution.

We find that irrational exuberance was the main driver behind the fluctuations in house prices during the period 1998-2016, while changes to credit conditions are crucial to match the dynamics of the average mortgage-to-income ratio and the default rate. Swings in house prices explain most of the dynamics in net worth, particularly for households in the Bottom 80% of the net worth distribution. Thus, shocks to expected housing demand driven by irrational exuberance are essential in matching not only the fluctuations in house prices and aggregate variables but also the variations in the net worth of households across different wealth strata. The boom in house prices led to a temporary decrease in wealth concentration, which was reversed during the bust.

Several extensions could be studied in this framework. The ones that are more promising are introducing long-term contracts, as well as modeling the influx of foreign resources experienced before the Great Recession to match data more precisely. These extensions are left for future research.

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A   Appendix

A.1   Different definitions of net worth

In section 5.2 we compared the model with the data of net worth from the SCF where net worth is defined as the sum of all assets minus all liabilities. Given that our model abstracts from unsecured debt, in this section we contrast the transition path of our model with an alternative measure which subtracts unsecured debt (like credit card debt) from the definition of net worth. In addition to this, we also compute the evolution of this variable exclusively for home owners given that all households in the model own houses and hence this definition is conceptually closer to the one in the model. As expected, the increase in the net worth of the bottom 80% between 1998 and 2007 using these definitions is slightly closer to the increase generated by the model.
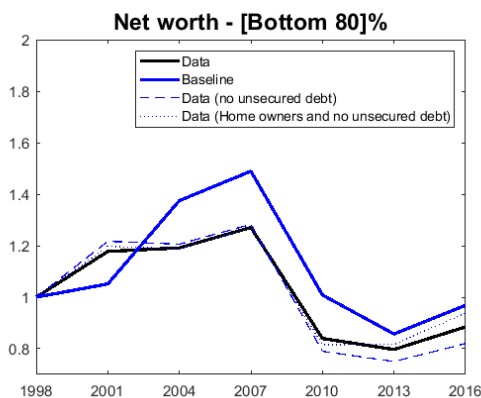

Figure 7: net worth of the bottom 80% and top 20% (model simulations and data from the SCF).

A.2 Decomposing the Bottom 80%
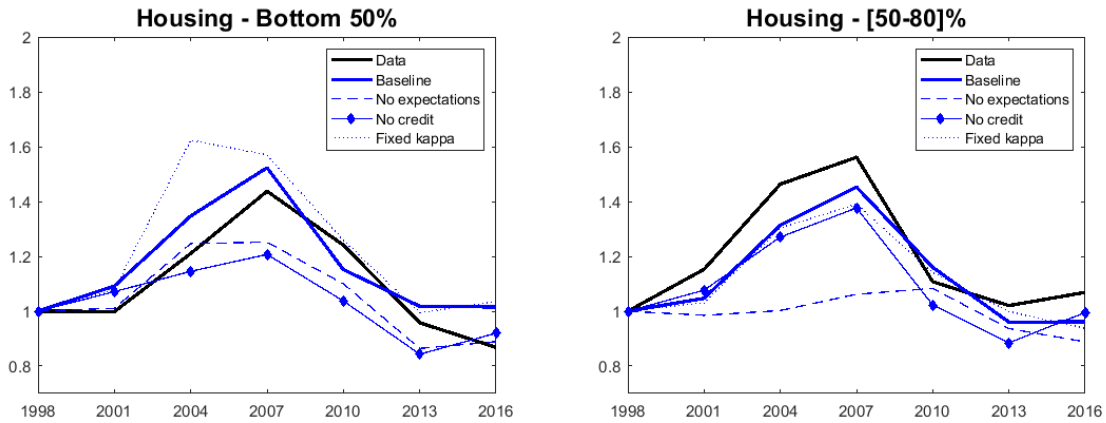
A.2.1 Housing

Figure 8: Housing of the bottom 50% and [50-80]% (model simulations and data from the SCF, 1998 =1).
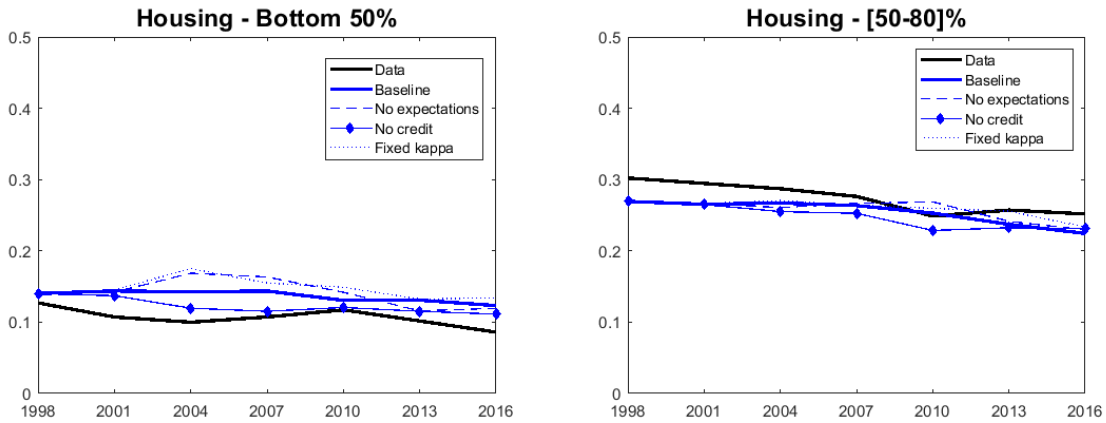

Figure 9: Share of Housing held by the bottom 50% and [50-80]% (model simulations and data from the SCF).
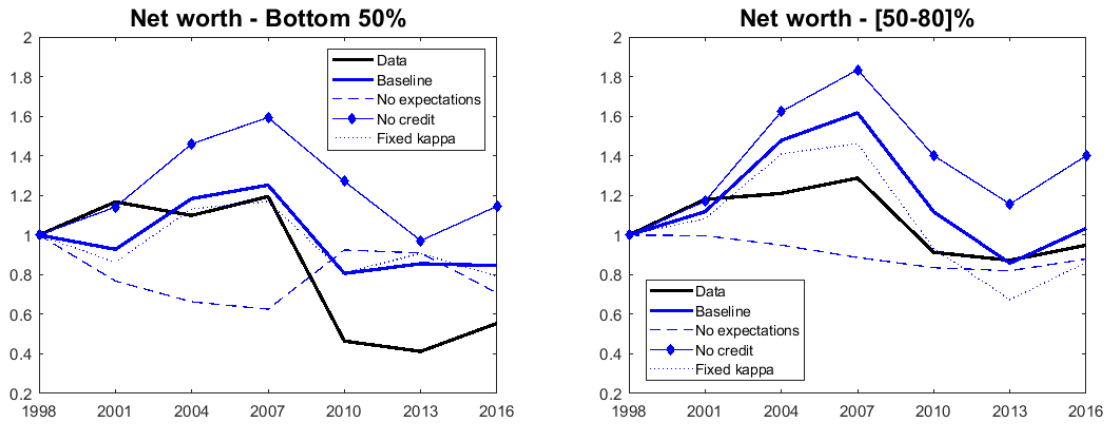
A.2.2 Net worth

Figure 10: Net worth of the bottom 50% and [50-80]% (model simulations and data from the SCF, 1998 =1).
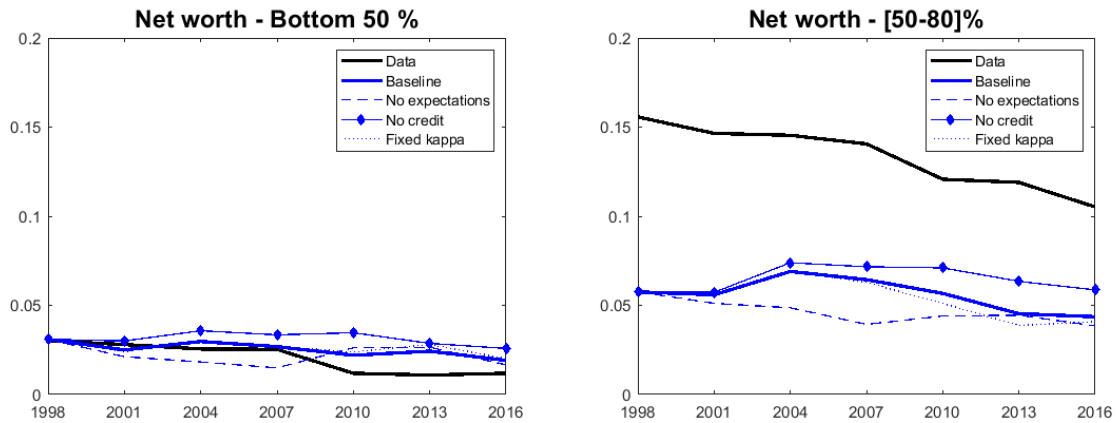

Figure 11: Share of Net worth held by the bottom 50% and [50-80]% (model simulations and data from the SCF).