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THE WEALTH DISTRIBUTION WITH DURABLE GOODS*

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In the United States, the distribution of houses is less egalitarian than that of earnings for the total population, but these two distributions are remarkably similar for homeowners. Additionally, housing as a fraction of total wealth decreases with the level of wealth. In order to understand the different factors that account for these wealth composition patterns, we introduce illiquid houses and collateral credit in a general equilibrium model of heterogeneous agents with idiosyncratic uncertainty. A combination of very persistent shocks to earnings, frictions in the housing market, and a rental market is necessary to obtain numbers in line with the evidence.

1. INTRODUCTION

In the United States, wealth is more unequally distributed than earnings, and models with uninsurable idiosyncratic labor risk have been used widely to try to account for this fact. In these models, wealth inequality arises because a perfect market to insure specific earnings risks does not exist, and households self-insure by accumulating a liquid asset that is used to smooth consumption over time.[2] Most of this literature abstracts from wealth composition issues that we address in this article. In particular, we focus on documenting and understanding the distribution of housing wealth and its importance on households' portfolios.

We begin by documenting some features of the wealth composition and the distribution of wealth using data from the 1998 *Survey of Consumer Finances*. We divide wealth (assets minus liabilities) into two components: housing wealth (the value of residential assets) and financial assets (net worth minus residential assets). We find that wealth is more concentrated than earnings (as documented extensively), financial assets are even more concentrated than net worth, and the distribution of houses is somewhat less egalitarian than that of earnings. Furthermore, the composition of households' portfolios changes with the level of wealth: Housing wealth

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[2] The first paper to address this issue within an infinite horizon framework is Aiyagari (1994). Huggett (1996) uses a life-cycle framework to address the same issue. Quadrini and Ríos-Rull (1997) review the literature up to that date. Krusell and Smith (1998) defend shocks to preferences to account for wealth inequality although Carroll (2000) argues that we should use models where consumers consider the accumulation of wealth as an end in itself or models where wealth yields a large unobservable flow of services. Quadrini (2000) is one of the first to study the link between entrepreneurial risk and wealth inequality. Castañeda et al. (2003) provide a theory to jointly understand the distribution of earnings and net worth. More recently, Cagetti and De Nardi (2006a) study the interaction between entrepreneurial risk and bequest motives to understand the high concentration of wealth. Cagetti and De Nardi (2006b) provide an excellent review of the literature.

represents 96.3% of total wealth for households in the bottom 80% of the wealth distribution, while this proportion goes down to 26.8% for households in the top 20%. The patterns are similar (with one exception) if we focus on homeowners, the main difference being that for this group the distributions of earnings and housing wealth are remarkably similar.

In order to understand the different factors that account for the wealth composition patterns just described, we construct a model in the tradition of the heterogeneous agents literature. Our framework, which builds upon Luengo-Prado (2006), is a general equilibrium model economy of ex ante identical households who face uninsurable idiosyncratic shocks to their labor earnings. Households value the consumption of a nondurable good and housing services that can be obtained in a rental market or through home ownership. They can save in the form of liquid financial assets and/or residential assets. Houses are illiquid (households must pay a commission when trading their homes), and housing equity above a minimum down payment can be used as collateral.

Our benchmark model economy, which is calibrated to reproduce selected aggregate statistics in the data and the Gini indices for earnings and total wealth (which requires using very persistent earnings shocks and a small fraction of individuals with very high earnings as in Castañeda et al., 2003), can reproduce the main patterns on wealth composition observed in the data reasonably well. Financial assets are more concentrated than total wealth, the housing distribution is less egalitarian than that of earnings for the total sample but not for homeowners, and the importance of housing on households' portfolios decreases with total wealth.

We focus on explaining why the distribution of houses is less egalitarian than that of earnings for the total population but not for homeowners and why houses represent a decreasing fraction of household's wealth. We first show that the decreasing importance of houses in household's net worth has to do with the fact that the return to housing is the marginal rate of substitution between nondurable consumption and housing services, which decreases with housing holdings, whereas the return to financial assets is constant. However, this factor alone cannot account for the large difference in wealth composition between the portfolios of the wealth rich and the wealth poor in the data. Through a series of carefully thought out experiments, we show that a combination of very persistent shocks to earnings, frictions in the housing market (in the form of adjustment costs and limited collateral credit), and a rental market is necessary to obtain numbers on portfolio composition in line with the evidence. The existence of a rental market is key to explaining the fact that the distribution of houses is less egalitarian than that of earnings for the total population. Persistent earnings shocks are required to produce similar distributions for housing and earnings for homeowners, and frictions in the housing market must exist for the poor not to have more housing in their portfolios than is evident in the data.

Our article also investigates how changes in the availability of collateral credit and transaction costs in the housing market affect the wealth composition and the distribution of wealth. We find the easing of credit has a significant effect on the portfolios of households in the bottom of the wealth distribution and the home ownership rate, but very little effect on the overall wealth distribution. The reason is that this friction affects mainly the wealth poor, who hold only a small fraction of total wealth. With a lower adjustment cost, all households increase their holdings of housing relative to financial assets, as liquid houses are more attractive for households of all wealth levels. However, the change particularly benefits the poor, and home ownership rates increase with lower transaction costs as well. The effect on the overall distribution of wealth is also rather small.

Our work is part of an emerging literature that incorporates durable goods in heterogeneous agents models. For instance, Díaz-Giménez et al. (1992) model durables explicitly to study the welfare effects of alternative monetary policies. Díaz-Giménez and Puch (1998) analyze the welfare consequences of imposing different levels of borrowing constraints. More recently, Luengo-Prado (2006) shows that the explicit consideration of durable goods and collateral credit is useful for understanding the "consumption excesses." Fernández-Villaverde and Krueger (2002) consider a model with liquid durables and replicate the hump-shaped evolution of durable and nondurable consumption expenditures over the life cycle. Chambers et al. (2008) focus on explaining changes in home ownership rates. Yao and Zhang (2005) and Cocco (2005) are examples of a growing literature that studies how the presence of housing affects the proportion of risky assets versus riskless assets on households' portfolios. Our work is closest to Gruber and Martin (2003), although our modeling strategy, calibration, and focus are quite different. Gruber and Martin analyze how transaction costs affect the volume of precautionary saving and the overall wealth distribution.

The remainder of the article is organized as follows. Section 2 documents some facts on wealth composition. Sections 3 and 4 present the model and our calibration strategy, and Section 5 contains the results. Brief concluding remarks are provided in Section 6.

2. SOME FACTS ON WEALTH COMPOSITION

We begin by documenting some features of the wealth composition and the distribution of wealth using data from the 1998 *Survey of Consumer Finances* (SCF-98).[3] We construct measures for (household-level) labor earnings and total wealth following Budría et al. (2002). Briefly, labor earnings are computed as labor income plus a fraction of capital income attributed to labor for business owners (both before taxes and transfers), whereas wealth is net worth or total assets minus total liabilities. Then, we divide wealth into two components: housing wealth (the value of residential assets) and financial assets (net worth minus residential assets). All debt, including mortgages and home equity loans, represent a negative position of financial assets. Since we will abstract from life-cycle features and business owners in our model, we focus on households with positive earnings in the survey. These households represent 77.7% of the sample and hold 78.9% of aggregate wealth.[4]

Table 1 shows the Gini coefficients and the distribution across quintiles of earnings, housing wealth, financial assets, and total wealth (E, H, A, W). Unless indicated, households are ordered by the variable presented in each row. For example, the quintiles for earnings represent the percentage of total earnings held by households in that particular earnings group, and similarly for wealth and its two components. Table 1 also contains a portfolio composition measure by wealth quintile: H/W, defined as total housing wealth over total wealth in the quintile times 100. Note that housing as a fraction of wealth can be more than 100% because housing wealth is the value of the stock, not just home equity. A number above 100% indicates that households in the quintile have a negative position in financial assets.

The Gini index for earnings is 0.49, whereas the Gini indices for houses, financial assets, and wealth are 0.64, 0.94, and 0.8, respectively. That is, wealth is more concentrated than earnings, financial assets are even more concentrated than net worth, and the distribution of houses is somewhat less egalitarian than that of earnings. Households in the top 20% of the wealth distribution hold 56.4% of all residential assets and 98.9% of all financial assets. Furthermore, the composition of households' portfolios changes with the level of wealth. Housing wealth represents 96.3% of total wealth for households in the bottom 80% of the wealth distribution, whereas this proportion goes down to 26.8% for households in the top 20%. The patterns are similar (with one exception) if we focus on homeowners with positive earnings, 68.7% of the sample. In this case, housing represents 95.4% of total wealth for households in the bottom 80% of the wealth distribution and just 24.3% for those in the top 20%. The earnings Gini index for homeowners is slightly lower, 0.47, and financial assets and wealth are still more concentrated than earnings with Gini indices of 0.94 and 0.75, respectively. The main difference is that for this group the distributions of earnings and housing wealth are remarkably similar (compare the earnings and housing quintiles in Table 1).

[3] The statistics we calculate using 1998 data are very similar to averages for several waves of the SCF. See Díaz and Luengo-Prado (2008) for more details.

[4] Households with zero earnings are mainly retirees, whereas households with negative earnings tend to be business owners. In a previous version of this article, we also reported distributional statistics for all households. Although the Gini index for earnings is higher if one includes nonpositive earnings, all other statistics are remarkably similar. See Díaz and Luengo-Prado (2006).

TABLE 1

INEQUALITY STATISTICS FROM THE 1998 SURVEY OF CONSUMER FINANCES

	Quintiles					Gini Coeff.
	1st	2nd	3rd	4th	5th	
			All Households			
Earnings, E	3.26	8.71	14.08	21.09	52.83	0.49
Houses, H	0.00	1.60	12.67	22.27	63.45	0.64
Financial assets, A	−8.52	−0.79	0.96	6.33	101.97	0.94
Wealth, W	−0.33	1.36	4.85	11.81	82.27	0.80
H/W	280.89		113.27	73.16	26.76	
Owners by W (%)	16.51	52.40	86.08	91.58	96.67	
Owners by E (%)	46.56	52.28	69.06	83.62	91.72	
			Homeowners: 68.65 % of Total Population			
Earnings, E	3.81	9.46	14.41	20.43	51.87	0.47
Houses, H	3.95	9.36	13.33	20.21	53.13	0.48
Financial assets, A	−7.71	−1.73	1.24	7.88	100.30	0.94
Wealth, W	0.69	3.15	6.21	12.58	77.35	0.75
H/W	194.00		91.81	67.05	24.33	

NOTES: Statistics for households with positive earnings in the survey. Households are ordered by the variable indicated in each row, except for the row labeled "H/W" in which households are ordered by total wealth. H/W is defined as total housing wealth in the quintile divided by total wealth in the quintile times 100. The first two quintiles are pooled together because wealth in the first quintile is zero. Housing wealth represents the total value of the homes, not just home equity. The quintiles for earnings (houses, financial assets, wealth) represent the percentage of total earnings (houses, financial assets, wealth) held by households in that particular group.

We now turn our attention to developing a model to better understand two patterns that have not been addressed in the previous literature: (1) the level of inequality in housing and the decreasing importance of housing wealth as households become richer, and (2) the remarkably similar distributions of housing and earnings for homeowners. In the process, we also shed some light on the reasons why financial assets (the other component of wealth) are more concentrated than total wealth.

3. THE MODEL ECONOMY

We consider a production economy populated by a continuum of households of measure one who live forever. We focus our analysis on steady states. Subsections 3.1, 3.2, and 3.3 describe the technology, the preferences and endowments, and the market arrangements. Subsections 3.4, 3.5, and 3.6 summarize the problems solved by the different agents in the economy, and Subsection 3.7 provides a formal definition of a steady state equilibrium.

3.1. *Technology.* Aggregate output, Y, is produced according to an aggregate Neoclassical production function that takes as inputs aggregate capital, K, and aggregate labor, L: $Y = F(K, L)$. The final good can be either consumed, invested in capital, or invested in housing on a one-to-one basis. Thus, the feasibility constraint is

$$C + I_k + I_h = F(K, L), \tag{1}$$

where C is nondurable consumption, I_k is investment in capital, and I_h is investment in housing stock.

3.2. *Preferences and Endowments.* Households derive utility from nondurable goods, c, and housing services, s, but not from leisure. Housing services can be obtained from either renting stock, f, or owning a home, h. One unit of housing stock (either rented or owned) provides one unit of housing services. Households cannot rent and be homeowners at the same time; z is an indicator for home ownership. The per period utility is $u(c, s)$, and lifetime utility is $\sum_{t=0}^{\infty} E_0 \beta^t u(c_t, s_t)$, where β is the time discount factor and $s_t = (1 - z_t) f_t + z_t h_{t+1}$, as homeowners buy the housing stock that renders services in period t at the end of the period. Each period, households receive a shock to their efficiency units of labor $e \in E = \{e_1, \ldots, e_{n_e}\}$. The shock is Markov with transition matrix $\pi_{e,e'}$.

3.3. *Market Arrangements.* There are no state contingent markets for the household-specific shock. Households hold residential assets $h \in [0, \infty)$ and financial assets $a \in [\underline{a}, \infty)$, $\underline{a} \in \mathbb{R}$. Financial assets pay a net interest rate r. There are no differences between borrowing and lending rates. Houses provide collateral for loans but households cannot borrow if they do not own residential assets. In particular,

$$a \geq -(1 - \theta) h. \tag{2}$$

This constraint implies that the maximum debt a household can incur is a fraction $(1 - \theta)$ of the household's residential stock, which determines the lower bound for a, $\underline{a}$. The constraint summarizes several aspects of collateral lending observed in reality. First, when purchasing a house, a household can only finance a fraction $(1 - \theta)$ of the house's value—i.e., the household must pay a *down payment*.[5] Second, when a household owns a house, the household can obtain a loan for up to a fraction $(1 - \theta)$ of the house value—i.e., there are *home equity loans*, and households pay no fees to obtain them. In summary, at any point in time, a homeowner is required to keep an accumulated home equity of θh.

When changing houses, homeowners must pay a nonconvex transaction cost, $\tau(h', h)$, which results in infrequent changes of the residential stock. The idea is that a household can buy a house of any desired size, but once it has been bought the stock is illiquid and a transaction cost must be paid to change it. Also, right after consuming housing services the stock depreciates at the rate δ^h and the household must do maintenance of the stock to avoid paying the transaction cost.[6] Specifically, the adjustment cost function is

$$\tau(h', h) = I\rho(1 - \delta^h) h, \tag{3}$$

where $I = 0$ if $h' = h$ and 1 otherwise. This cost can be seen as a loss in the selling price when changing the housing stock (e.g., a commission to a real estate broker) and is proportional to the inherited level of residential assets, $\rho(1 - \delta^h) h$.[7]

Housing services can also be purchased in a rental market, as there is a financial institution that buys housing stock and sells housing services in the market (we follow Gervais, 2002). The rental price is r^f. The financial institution is not subject to transaction costs when changing the housing stock of rental units. However, these units depreciate at the rate δ^f, which is higher than the rate of depreciation for owner-occupied houses due to moral hazard problems in the rental market (we follow Henderson and Ioannides, 1983).

[5] In practice, financial institutions require down payments for a number of reasons. Down payments reduce the moral hazard problem in the care that owners take in maintaining the value of their house and they also mitigate the effects of the adverse selection problem that results from asymmetric information in the credit market.

[6] The maintenance specification is convenient for computational reasons. Using a depreciation formulation instead of imposing maintenance did not change the results significantly. However, the pattern of durable purchases would be very different in both cases. Allowing for depreciation generates (S, s) dynamics for the household stock of houses, whereas the maintenance specification does not.

[7] With this specification, the transaction cost does not quickly diminish in importance as households become wealthier, as with a purely fixed cost.

3.4. *The Household's Problem.* The household's state variables are the earnings shock, capital holdings, and residential assets, $\{e, a, h\}$. The problem that a household solves is

$$v(e,a,h) = \max_{z,c,a',h',f} u(c,(1-z)f + zh') + \beta \sum_{e'} \pi_{e,e'}\, v(e',a',h') \tag{4}$$

$$\text{s.t.} \quad c \geq 0;\ z \in \{0,1\};\ h' = 0,\ f > 0 \quad \text{if} \quad z = 0;\ h' > 0,\ f = 0 \quad \text{if} \quad z = 1,$$

$$a' + (1-\theta)\,h' \geq 0,$$

$$c + r^f\, f + a' + h' + \tau(h',h) = w\,e + (1+r)\,a + (1-\delta^h)\,h.$$

3.5. *The Firm's Problem.* There is a representative firm that solves the following static problem:

$$\max_{K,L} F(K,L) - \left(r + \delta^k\right) K - wL, \tag{5}$$

where r is the rental price of capital net of depreciation, δ^k is the depreciation rate of capital, and w is the wage per efficiency unit of labor. In equilibrium, $r = F_1(K,L) - \delta^k$, and $w = F_2(K,L)$.

3.6. *The Financial Institution's Problem.* There is a risk-neutral financial institution that pools households' financial assets, A, and is able to transform them into either physical capital, K, or residential capital, F, on a one-to-one basis—it is not subject to adjustment costs. The financial institution rents physical capital to the firm and residential capital to households and earns zero profits in equilibrium. The financial institution solves the following problem:

$$\Psi(A) = \max_{A',K,F} \left\{ A' - (1+r)A + rK + (r^f - \delta^f)F + \frac{1}{1+r}\Psi(A') \right\} \tag{6}$$

$$\text{s.t. } K + F = A,$$

where F is the stock of rental units, r^f is the rental price and δ^f is the depreciation rate for rental units. The no-arbitrage condition $r = r^f - \delta^f$ must be satisfied in equilibrium for the problem to be well defined. In words, at the margin, the financial institution must be indifferent between renting physical capital to firms or residential capital to households, and the total interest paid on deposits, $r\,A$, must equal the interest received from renting physical capital and residential capital $r(K+F)$.

3.7. *Stationary Equilibrium.* For notational efficiency, we denote $x = \{e,a,h\}$ and $X = \{E \times [\underline{a},\overline{a}] \times [0,\overline{h}]\}$. A stationary equilibrium is given by an interest rate and a wage rate (r,w), a set of functions for the household problem $\{v(x), g^a(x), g^h(x), g^c(x), g^f(x)\}$, and a distribution of households over the state variables, μ, such that

1. Given μ, r, and w, the functions $\{v(x), g^a(x), g^h(x), g^c(x), g^f(x)\}$ solve the household's problem in (4).
2. Total labor services are obtained aggregating across households, $L = \int_X e\, d\mu$.
3. Total financial assets equal $A = \int_X a\, d\mu$.
4. The rental market for housing clears, $F = \int_X g^f(x)\, d\mu$.
5. The aggregate capital stock is $K = A - F$.
6. Factor rental prices equal factor marginal productivities: $r = F_1(K,L) - \delta^k$, and $w = F_2(K,L)$.
7. The rental price of housing satisfies the no-arbitrage condition $r^f = r + \delta^f$.
8. The markets for nondurable consumption, capital, and housing stock clear: $C = \int_X g^c(x)\, d\mu,\ I_k = \delta^k K,\ I_h = \delta^f F + \int_X [g^h(x) - (1-\delta^h)h + \tau(g^h(x),h)]\, d\mu$.
9. The feasibility constraint is satisfied: $C + I_k + I_h = F(K,L)$.

10. The distribution of households, μ, is stationary (i.e., given the prices implied by this distribution, households' actions reproduce the same measure μ in the following period).

4. CALIBRATION

We present the calibration of our benchmark economy in the following order: the earnings process, the technology, and the preferences and market arrangements.

4.1. *The Earnings Process.* We calibrate the earnings process so that the Gini index for earnings in our benchmark economy is that of the U.S. economy while also reproducing the U.S. Gini index for total wealth. There are two main data sources on household earnings and wealth data that we could use: The Panel Study of Income Dynamics (PSID) and the SCF. The PSID is a longitudinal data set and particularly useful for measuring the evolution of earnings over time but earnings are top coded. The SCF is specifically designed to measure household wealth. According to Juster et al. (1999), the PSID underestimates the value of home equity for all homeowners when compared to the SCF by about 10%, and the bias increases with household wealth. They also find that, although the PSID does a good job in representing household net worth for the bottom 99% of wealth distribution, it does a poor job for the top 1%. Although the purpose of this article is not to explain why earnings and wealth for the top 1% of the population are so large, we must acknowledge that the existence of these households may be important to understand the consumption and saving behavior of the rest of the population. Thus, for our calibration we rely mainly on the SCF-98. Given that our model is dynastic with no life-cycle features or business owners, we choose to match the wealth and earnings Gini coefficients for households with positive earnings presented in Section 2.

In order to jointly match the earnings and the wealth Gini coefficients (we do not attempt to match the Gini indices for the two wealth components separately), we follow an approach similar in spirit to Castañeda et al. (2003). We divide households with positive earnings into two groups: superstars (the top 1% of the distribution) and regular households (the rest). In turn, we split regular households in six groups of even size. For this group, we assume, as is standard in the literature, that log earnings follow an AR(1) process, $\log e_t = \rho \log e_{t-1} + \eta_t$, with $\rho = 0.9895$ and volatility $\sigma_\eta^2 = 0.0158$.[8] This combination delivers a Gini index for earnings of regular households equal to 0.43 (as in the SCF-98), and a coefficient of variation (CV) of 0.84, very similar to the one in the SCF-98 for households outside the top 1% of the earnings distribution.[9] We approximate the AR(1) process by a 6-point Markov chain using the procedures described in Tauchen (1986). The superstar earnings shock is 6 times the highest shock for regular households (in the SCF-98 the equivalent number is $e_7/e_6 = 6.26$). For simplicity, regular households have the same probability of becoming a superstar and the probability that a superstar becomes a regular household of type $i = 1, \ldots, 6$ is the same for all types. With these restrictions, we have two free parameters: the probability of becoming a superstar for a regular household and the probability of becoming a regular worker for a superstar. We chose these probabilities so that superstars represent 1% of the earnings distribution and the Gini index for wealth is that observed in the data, 0.8. The resulting Gini index for earnings for all households is also that of the data, 0.49. Table 2 summarizes the earnings process. Note that the probability of becoming a superstar is low, 0.05%, and the persistence of the shock is high—the probability of a superstar staying a superstar next period is 95.05%.

[8] The persistence and volatility of the AR(1) process we use are very similar to the numbers estimated by Storesletten et al. (2004) using data from the PSID for idiosyncratic earnings net of cohort effects ($\rho = 0.9989$ and $\sigma_\eta^2 = 0.0166$). Their earnings represent gross wage income plus transfers, slightly different from our definition. Moreover, they allow for transitory shocks and fixed effects (two types of households), which we do not model here.

[9] The CV for college graduates is 0.8 and for noncollege graduates is 0.81. When we combine them together, the CV is 0.88. Since in our model all households are ex ante identical, we choose the average of the combined sample and the individual samples.

TABLE 2
THE EARNINGS PROCESS

The Earnings Shocks, e						
1.00	1.90	2.82	4.05	6.05	13.11	78.65
The Transition Matrix, $\pi_{e,e'}$						
0.910833	0.088657	0.000010	0.000000	0.000000	0.000000	0.0005
0.088657	0.781730	0.128927	0.000186	0.000000	0.000000	0.0005
0.000010	0.128927	0.729050	0.141327	0.000186	0.000000	0.0005
0.000000	0.000186	0.141327	0.729050	0.128927	0.000010	0.0005
0.000000	0.000000	0.000186	0.128927	0.781730	0.088657	0.0005
0.000000	0.000000	0.000000	0.000010	0.088657	0.910833	0.0005
0.008250	0.008250	0.008250	0.008250	0.008250	0.008250	0.9505
Stationary Distribution, π^*						
0.165	0.165	0.165	0.165	0.165	0.165	0.010

4.2. *Technology.* We need to construct measures of output, capital, the stock of houses, and their investment counterparts ($Y,\ K,\ H+F,\ I_k,\ I_h$). We use data from the National Income and Product Accounts (henceforth NIPA) and the Fixed Assets Tables (henceforth FAT), both from the Bureau of Economic Analysis. We define capital as the sum of nonresidential private fixed assets plus the stock of inventories plus consumer durables. Investment in capital, I_k, is defined accordingly.[10] $H+F$ is private residential stock in the data and I_h is private residential investment. We define output as labor income plus income from nonresidential capital, $Y = F(K, L) = wL + rK = C + I_k + I_h$, or measured GDP minus imputed housing services.[11] We do not make any imputation to output for government-owned capital since our focus is on privately held wealth. We proceed as Cooley and Prescott (1995) did and calculate the implied share of capital in output, which is 0.26. The capital-output ratio is 1.64 and the housing-output ratio is 1.07.[12] We set the depreciation rate of capital, δ^k, so that it matches the investment to capital ratio in NIPA, $\delta^k = 0.12$. The implied steady-state interest rate is 3.91%.

The value of the implied capital share may seem low, but it is not very different from typical values in the literature when given as a function of GDP instead of output. GDP is output plus the imputed value of housing services: $GDP = Y + (r + \delta^h)\,H + r^f\,F$. The capital-$GDP$ ratio is 1.51, the housing-GDP ratio is 0.98, and the aggregate ratio $(K + H + F)/GDP$ is 2.49. The resulting share of capital income to GDP is 31.51%, just slightly lower than that estimated by Prescott (1986).

4.3. *Preferences and Market Arrangements.* For preferences over consumption of the nondurable good and housing services, we follow Luengo-Prado (2006) and use the separable utility function $u(c, s) = c^{1-\sigma}/(1-\sigma) + \gamma s^{1-\sigma}/(1-\sigma)$. σ, the risk aversion parameter is 2. The calibration of $\gamma,\ \delta^h$, and δ^f is not straightforward due to the presence of adjustment costs. In the steady state, I_h is $\delta^h\,H + \delta^f\,F$ plus the sum of the transaction costs paid by all households. We choose values for $\gamma,\ \delta^h$, and δ^f to jointly match the home ownership rate in the SCF-98, the ratio of housing to nondurable consumption, and the housing-output ratio in NIPA/FAT (roughly a 69% home ownership rate; $(H+F)/C = 1.40$ and $(H+F)/Y = 1.07$). This requires $\gamma = 0.177,\ \delta^h = 4.24\%$, and $\delta^f = 4.83\%$, which implies an additional depreciation of rental units of 0.59%. The discount factor, $\beta = 0.9015$, is such that the net interest rate in the steady state is 3.91%.

The down payment, θ, is 20%, slightly below the 25% average down payment for the period 1963–2001 reported by the Federal Housing Finance Board. Thus, individuals can borrow up to

[10] We include net exports in our measure of capital investment.
[11] C is output minus the sum of investment in physical capital and investment in residential capital.
[12] The figures we report are averages in NIPA/FAT for the sample period 1954–99.

80% of the value of the house. Although in reality households may be able to acquire houses with lower down payments, it is also the case that these households face higher marginal borrowing costs (including a higher interest rate and the purchase of mortgage insurance). In order to keep the model tractable, the down payment parameter is the same for all consumers, and the borrowing rate is not a function of θ. The adjustment cost parameter, ρ, is 5% (the typical fee charged by real estate brokers in the U.S. economy is around 6%).

All parameter values for the benchmark calibration are summarized in Table 3 (along with values for alternative calibrations that will be discussed later). Details on how to compute the model are given in the Appendix.

5. RESULTS

5.1. *The Benchmark Economy.* Table 4 presents several wealth distribution and wealth composition statistics for the benchmark economy that can be compared to their data

TABLE 3
MODEL PARAMETERS FOR ALTERNATIVE CALIBRATIONS

	Technology				Financial Arrangements		Utility		
	α	δ^k	δ^h	$\delta^f - \delta^h$	θ	ρ	β	σ	γ
Benchmark	0.255	0.117	0.042	0.006	0.2	0.05	0.902	2	0.177
No rental	0.255	0.117	0.037	–	0.2	0.05	0.901	2	0.168
$\rho = 0,\ \theta = 0$	0.255	0.117	0.043	–	0.0	0.00	0.904	2	0.156
$\rho = 0,\ \theta = 0$, vol. earnings	0.255	0.117	0.042	–	0.0	0.00	0.918	2	0.153
Vol. earnings	0.255	0.117	0.042	0.003	0.2	0.05	0.915	2	0.158
No rental, vol. earnings	0.255	0.117	0.039	–	0.2	0.05	0.913	2	0.156
No superstar	0.255	0.117	0.040	0.005	0.2	0.05	0.916	2	0.169

NOTES: α is the capital share, δ^k, δ^h, and δ^f are the depreciation rates for capital, owner-occupied houses, and rental units. θ and ρ are the down payment and the adjustment cost parameter. β is the discount factor, σ measures risk aversion, and γ is the parameter in the utility function that weights the importance of housing services relative to nondurable consumption.

TABLE 4
INEQUALITY STATISTICS IN THE BENCHMARK ECONOMY

	Quintiles					Gini
	1st	2nd	3rd	4th	5th	Coeff.
			All Households			
Earnings, E	4.19	7.99	12.57	19.67	55.57	0.49
Houses, H	0.00	3.90	14.50	25.18	56.43	0.58
Financial assets, A	−4.93	−1.17	0.34	8.51	97.25	0.91
Wealth, W	0.07	0.80	2.88	13.95	82.30	0.80
H/W	229.44		179.48	61.41	22.30	
Owners by W (%)	0.00	53.05	98.02	94.66	97.66	
Owners by E (%)	17.21	52.30	84.41	97.68	91.79	
			Homeowners: 68.68 % of Households			
Earnings, E	6.34	10.33	14.35	21.30	47.68	0.40
Houses, H	6.68	10.56	14.18	24.67	43.90	0.39
Financial assets, A	−4.16	−2.34	1.75	15.02	89.72	0.88
Wealth, W	0.88	2.01	6.45	17.87	72.79	0.72
H/W	233.18		82.42	47.66	21.47	

NOTES: Households are ordered by the variable indicated in each row, except for the row labeled "H/W" in which households are ordered by total wealth. H/W is defined as total housing wealth in the quintile divided by total wealth in the quintile times 100. Housing wealth represents the total value of the homes, not just home equity. The quintiles for earnings (houses, financial assets, wealth) represent the percentage of total earnings (houses, financial assets, wealth) held by households in that particular group.

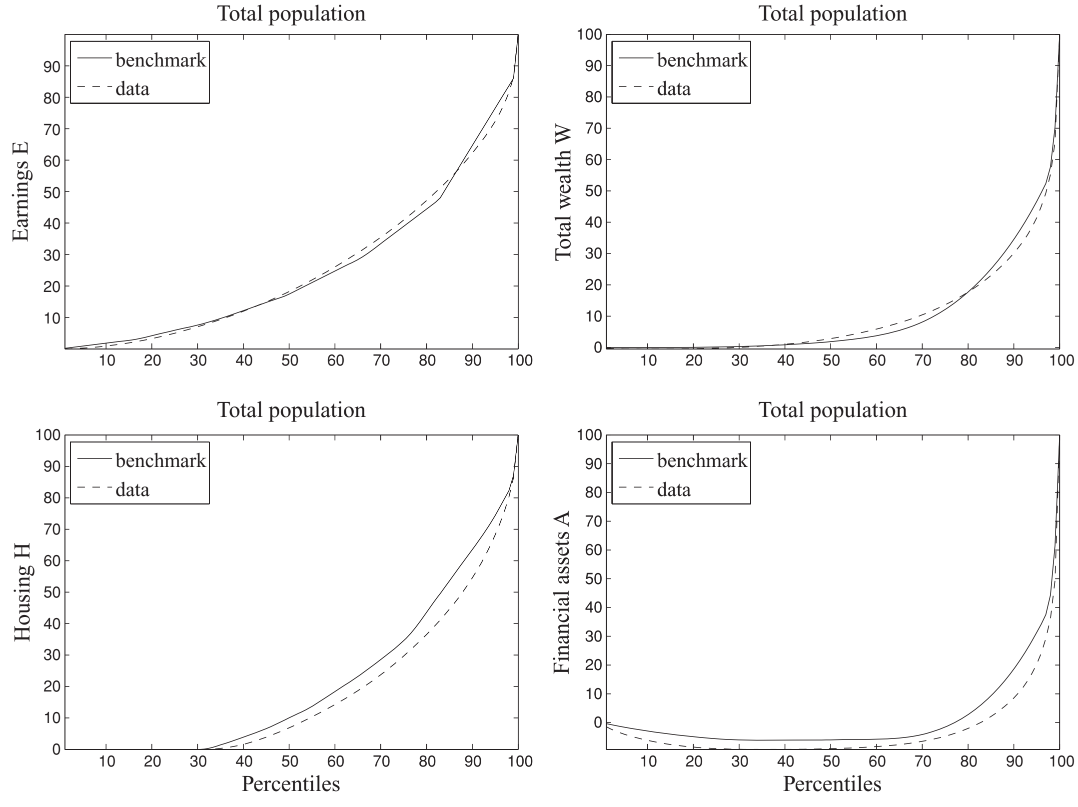

FIGURE 1

LORENZ CURVES (EARNINGS, TOTAL WEALTH, HOUSING, AND FINANCIAL ASSETS). TOTAL POPULATION

counterparts summarized in Table 1. Because of our calibration strategy, the Gini indices for earnings and wealth are the same as in the data (0.49 and 0.8, respectively). In terms of wealth composition, houses are more equally distributed than financial assets. The Gini coefficient for houses is 0.58 (vs. 0.64 in the data) and the Gini coefficient for financial assets is 0.91 (vs. 0.94 in the data).[13] The match of these statistics is not exact because we abstract from life-cycle effects, noncollateral credit, changes in house prices, taxation issues, and possible sources of heterogeneity other than earnings. Figure 1 depicts the Lorenz curves for earnings, wealth, houses, and financial assets and tells the same story: We match the Lorenz curves for earnings and wealth reasonably well, although we obtain slightly more egalitarian distributions of houses and financial assets than in the data.

We construct a portfolio composition measure by dividing housing wealth over total wealth by quintile or percentile (H/W). The pattern is clear: Houses comprise a smaller proportion of wealth for richer households. In the SCF-98, housing wealth represent 96.3% of total wealth for households in the bottom 80% of the wealth distribution, whereas this proportion goes down to 26.8% for households in the top 20%. We are able to reproduce this pattern. The equivalent numbers in our model are 88.9% and 22.3% (see the rows label "H/W" in Tables 1 and 4 for all wealth quintiles). To reiterate, the importance of housing wealth decreases rapidly with the level of wealth. Figure 2 (left panel) depicts our portfolio composition measure by wealth percentile for the top 80% of the wealth distribution (we exclude the first percentiles in the figure because these households have zero wealth in the data). Note that we overestimate somewhat

[13] Since financial assets may be negative, the reported Gini index is corrected following Chen et al. (1982) and is still between 0 and 1.

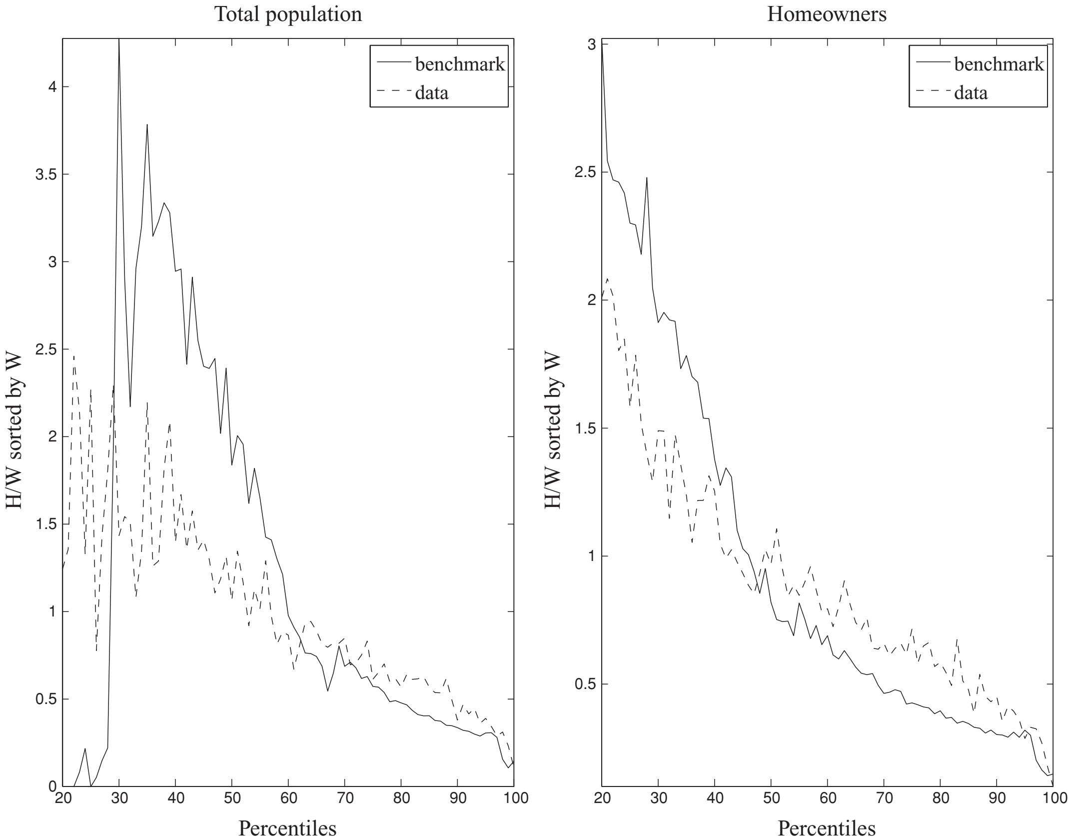

FIGURE 2

PORTFOLIO COMPOSITION BY WEALTH PERCENTILE (TOP 80%)

the importance of housing wealth from the 30th to the 60th percentile and underestimate it slightly for households over the 60th percentile.

Tables 1 and 4 (bottom panel), along with Figure 2 (right panel) and Figure 3, present the same statistics when restricting the sample to homeowners—not the target of our calibration. The Gini indices in the model for earnings, wealth, and its two components (houses and financial assets) are lower than those in the data. For example, the Gini indices of earnings and wealth for homeowners are 0.48 and 0.75 in the data vs. 0.4 and 0.72 in the model. This is because we underestimate the home ownership rates for the earnings poor (in spite of matching the overall home ownership rate, 69%), and there are less earnings differences among our simulated sample of homeowners. However, the finding we want to emphasize is the similarity in the distributions of houses and earnings for homeowners (in the model and in the data) with almost identical quintiles and Gini indices, also illustrated by the Lorenz curves depicted in Figure 4.

In Table 5, we report some additional statistics generated by our model compared to the data. The reported numbers are means of earnings, housing wealth, financial assets, and net worth (all normalized by mean earnings for the total population) for both renters and homeowners. We also show the percentages of earnings, wealth, and its two components held by owners vs. renters. Although the model is calibrated to reproduce the capital output–ratio and the housing–output ratio in aggregate data ($K/Y = 1.64$, $(H + F)/Y = 1.07$), we underestimate mean housing wealth and mean financial assets somewhat. In terms of the percentages of wealth and earnings held by owners and renters, the model fairs better. Homeowners hold 84% of

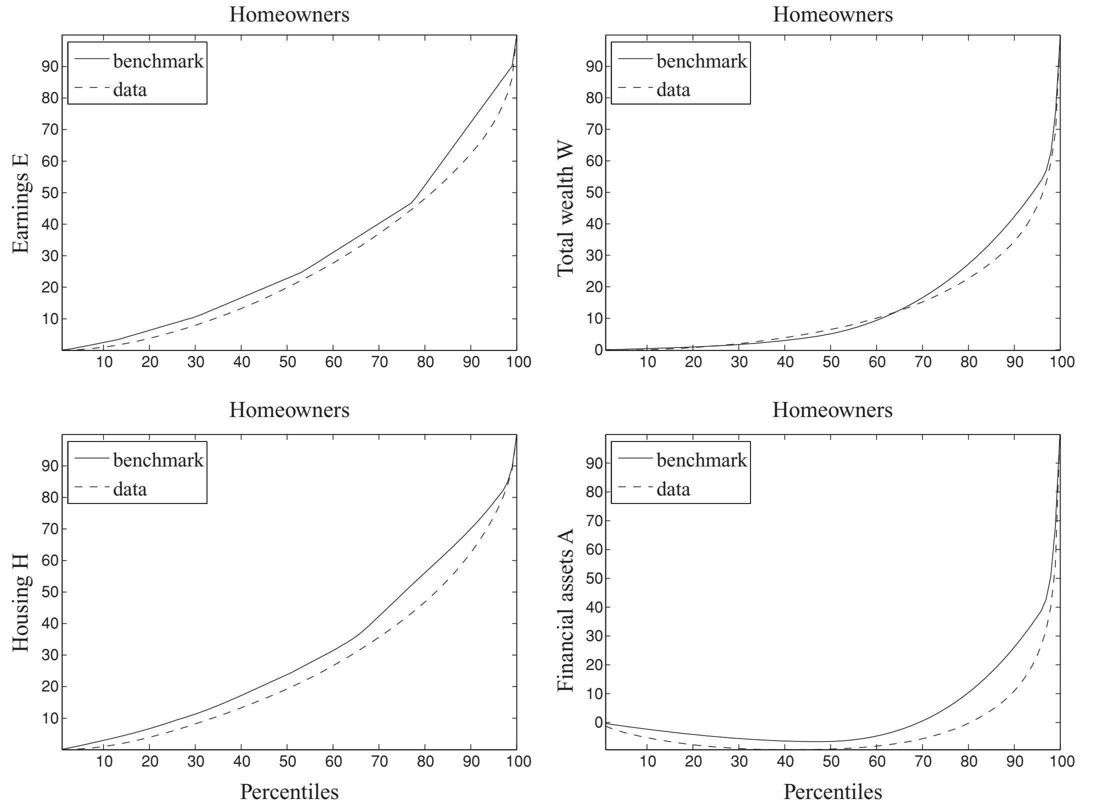

FIGURE 3

LORENZ CURVES (EARNINGS, TOTAL WEALTH, HOUSING, AND FINANCIAL ASSETS). HOMEOWNERS

earnings and 97% of all wealth in the SCF-98, whereas they hold just slightly less in our model, 82% and 94%, respectively.

To summarize, there are two patterns that we want to understand that have not been addressed in the previous literature: (1) the level of inequality in housing and the decreasing importance of housing wealth on portfolios as households become richer and (2) the remarkably similar distributions of housing and earnings for homeowners.

5.2. *The Interaction Between Earnings Risk and Illiquidity.* Our first goal is to jointly understand the determinants of the level of inequality in housing, as measured by the Gini index, and the magnitude of the decreasing importance of housing in household portfolios with the level of wealth. We argue that four ingredients in our model are relevant to understand these facts: the high level of persistence of the uninsurable idiosyncratic earnings shock, the adjustment cost in the housing market, the collateral constraint, and the rental market for houses. We analyze the contribution of each factor by studying a sequence of model economies where we gradually incorporate these elements. All the economies considered have been recalibrated to produce the same aggregate statistics as the benchmark economy (the interest rate, the housing–output ratio, and the housing to nondurable consumption ratio).

5.2.1. *Liquid houses, no down payment, and volatile earnings.* First, we consider an economy with no adjustment costs (i.e., houses are liquid), a zero down payment, and i.i.d. earnings shocks governed by the stationary probability of earnings in the benchmark economy to ensure that the earnings distribution remains unchanged. This economy is labeled "$\rho = 0,\ \theta = 0$, vol. earnings."

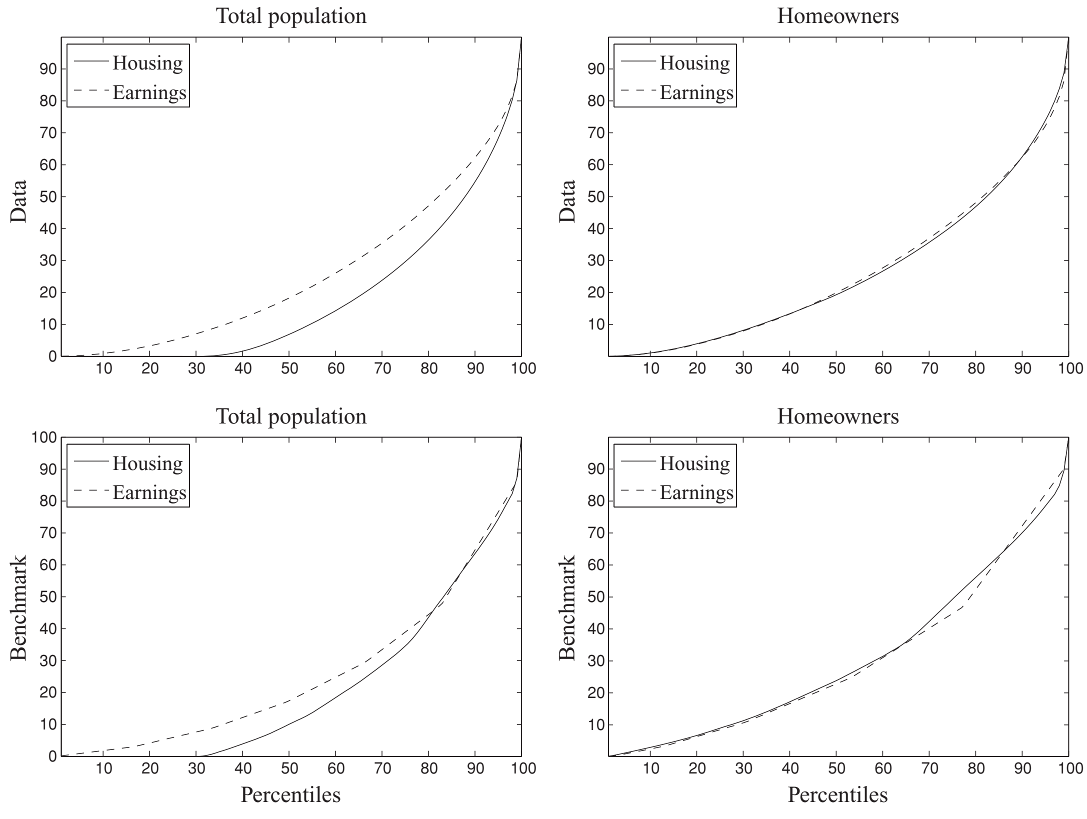

FIGURE 4

LORENZ CURVES FOR EARNINGS AND HOUSING. DATA AND BENCHMARK

TABLE 5

FURTHER STATISTICS: BENCHMARK CALIBRATION VS. DATA

	Earnings E	Houses H	Financial assets A	Wealth W
		1998 Survey of Consumer Finances		
All households	1.00	2.05	3.20	5.24
Homeowners	1.22	2.98	4.40	7.38
% of total	83.50	100.00	94.48	96.64
Renters	0.53	0.00	0.56	0.56
% of total	16.50	0.00	5.52	3.36
		Benchmark Calibration		
All households	1.00	1.24	2.39	3.63
Homeowners	1.19	1.80	3.17	4.97
% of total	81.96	100.00	91.08	94.12
Renters	0.58	0.00	0.68	0.68
% of total	18.04	0.00	8.92	5.88

NOTES: The numbers are averages normalized by mean earnings for the total population unless otherwise indicated.

As shown in Table 6 (first row), in this case all households are homeowners as houses are liquid and no initial down payment is required. Households who receive a negative shock can use home equity or liquidate the house at no cost if necessary, and households who receive good shocks can immediately adjust to the new desired level of housing stock. Compared to the benchmark economy, the Gini indices for wealth and its two components fall significantly—the Gini indices for houses, financial assets, and wealth are 0.2, 0.68, and 0.5, respectively. Figures 5

TABLE 6

THE ROLE OF EACH FRICTION

	H/W by Wealth Quintile					Gini Coefficients				Owners
	1st	2nd	3rd	4th	5th	E	H	A	W	%
				All households						
$\rho = 0,\ \theta = 0$, vol. earnings	99.59	55.14	41.20	23.21		0.49	0.20	0.68	0.50	100
$\rho = 0,\ \theta = 0$	551.86	213.24	63.90	23.92		0.49	0.49	0.93	0.81	100
No rental	344.23	184.48	68.20	24.02		0.49	0.48	0.93	0.79	100
Benchmark	229.44	179.48	61.41	22.30		0.49	0.58	0.91	0.80	68.80
Data	280.89	113.27	73.16	26.76		0.49	0.64	0.94	0.80	68.65

NOTES: E is earnings, H is house value, A is financial assets, and W is wealth. H/W is our portfolio composition measure by wealth quintile defined as total housing wealth in the quintile divided by total wealth in the quintile times 100. The different economies are calibrated to produce the same aggregates. Refer to Table 3 for the corresponding parameter values.

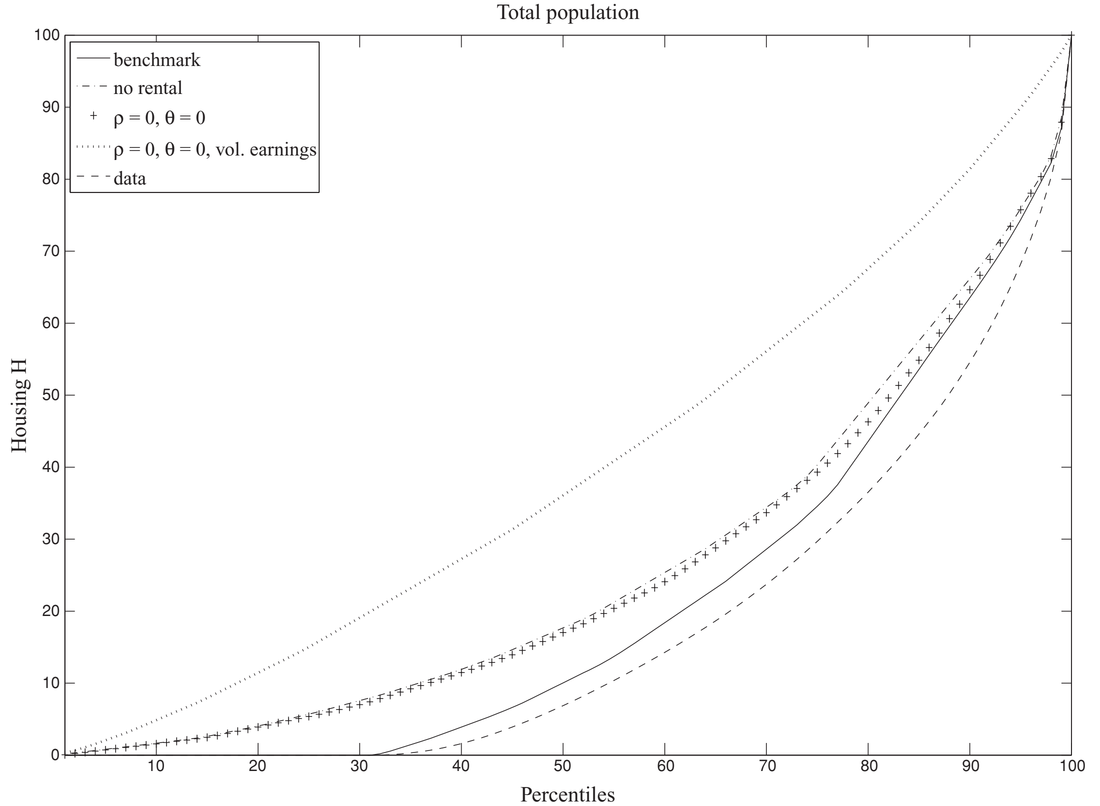

FIGURE 5

LORENZ CURVES FOR HOUSING. DIFFERENT FRICTIONS

and 6 show the Lorenz curves for the distribution of houses, financial assets, and total wealth, which depict a much more egalitarian distribution of wealth in both dimensions. Why does the Gini coefficient for housing decrease so much? Perhaps the best way to understand this change is to remember that housing is not only an asset but a consumption item and its distribution is linked to the distribution of permanent income. In our model, we can compute a "permanent" earnings shock, $\hat{e}$, as a function of the current earning shocks, e, as follows:

$$\hat{e} = e + \frac{1}{1+r} \sum_{e'} \pi_{e,e'} \hat{e}'. \tag{7}$$

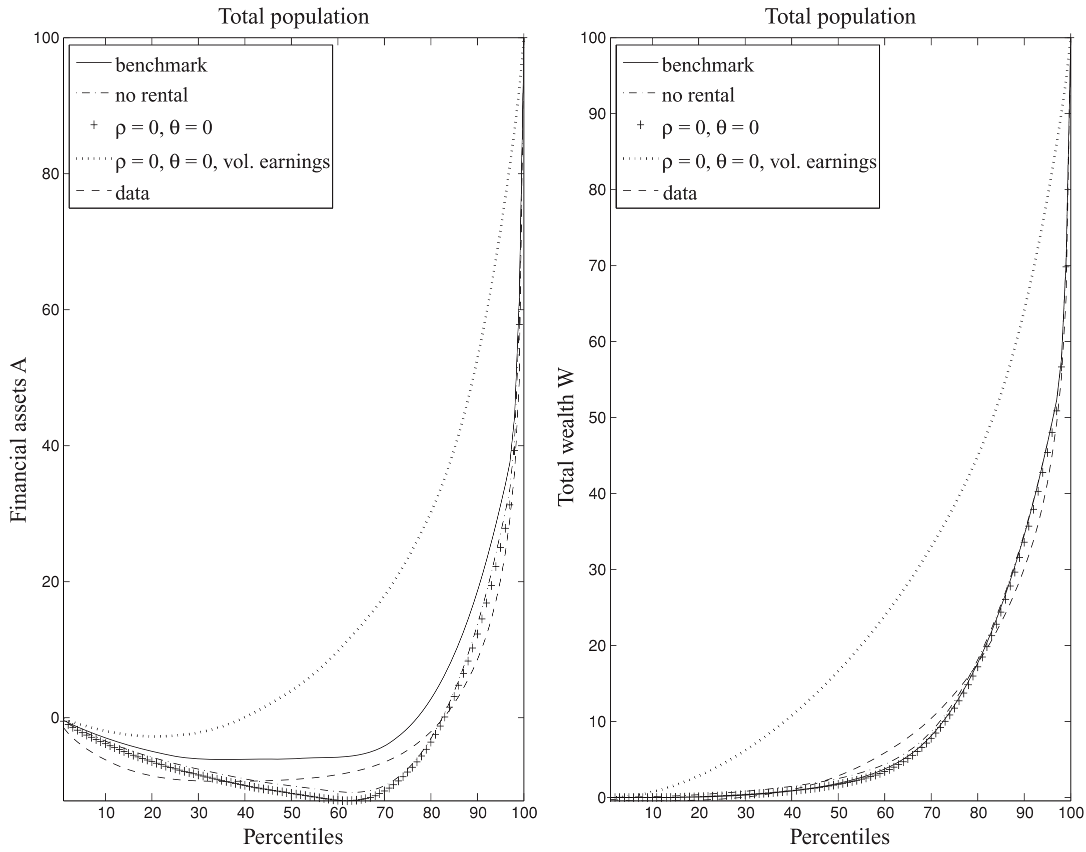

FIGURE 6

LORENZ CURVE FOR FINANCIAL ASSETS AND TOTAL WEALTH. DIFFERENT FRICTIONS

TABLE 7

CURRENT VS. PERMANENT EARNINGS SHOCKS

	Current Earnings Shocks, e							Gini Coefficient
Earnings	1.00	1.90	2.82	4.05	6.05	13.11	78.65	0.49
	Permanent Earnings Shocks, $\hat{e}$							
Benchmark economy	1.00	1.22	1.50	1.86	2.34	3.08	13.17	0.25
Volatile earnings	1.00	1.01	1.01	1.02	1.04	1.08	1.54	0.07

NOTES: Permanent earnings shocks are computed as $\hat{e} = e + 1/(1+r)\sum_{e'} \pi_{e,e'}\hat{e}'$. $\pi_{e,e'}$ for the benchmark economy is given in Table 2. With volatile earnings, $\pi_{e,e'}$ is a matrix with identical rows given by the stationary distribution, π^* in Table 2.

Permanent labor income is just $w\,\hat{e}$. Table 7 shows the value of the permanent earnings shocks and the Gini index for permanent labor income in both the benchmark economy and this economy. Permanent earnings shocks are less volatile with no persistence and the Gini index for permanent labor income is much lower (almost 0, 0.07, vs. 0.25 with persistent earnings) which results in a very egalitarian distribution of houses. The Gini coefficients for financial assets and total wealth are also lower because households do not need to accumulate as much wealth for precautionary reasons (there is less variation in permanent income from shock to shock, and houses are liquid). Importantly, the Gini index for financial assets is still higher than the Gini index for housing.

Figure 7 (left panel) depicts the portfolio composition by wealth percentile and compares this economy to the benchmark case and the data (and some alternative economies that are

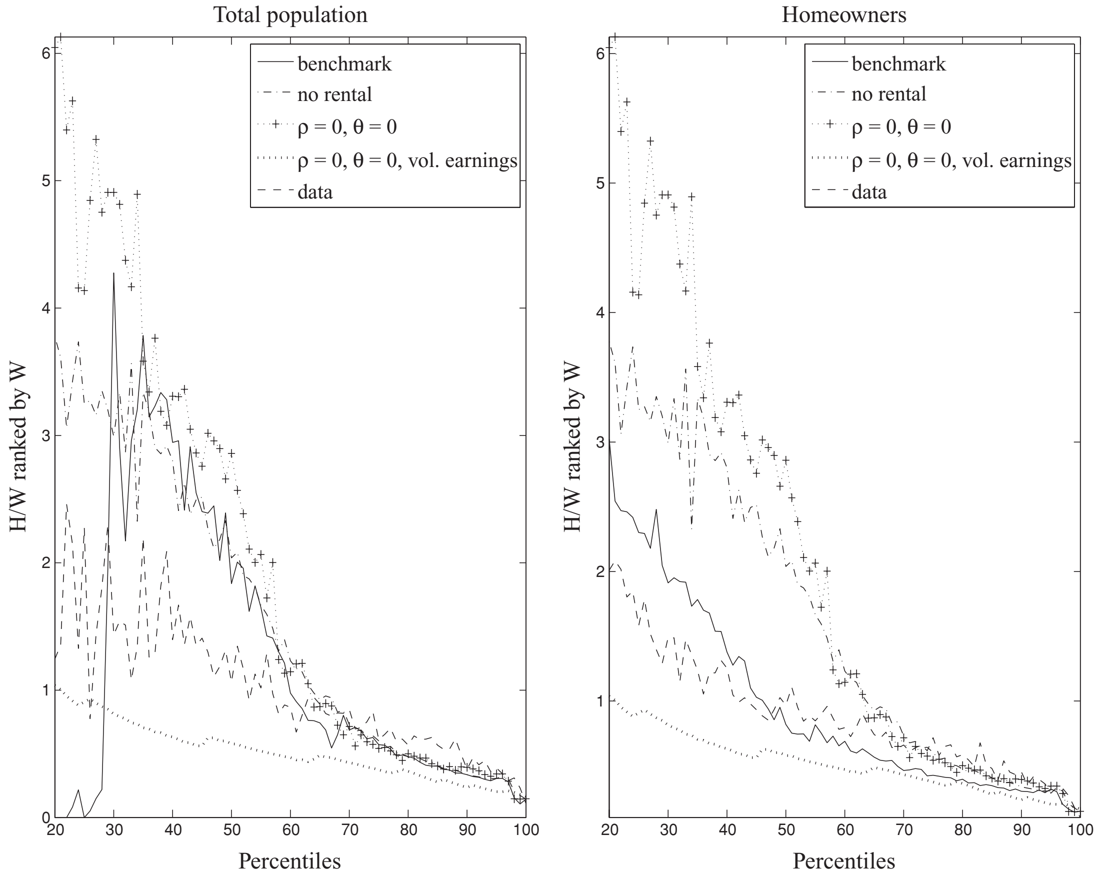

FIGURE 7

PORTFOLIO COMPOSITION BY WEALTH PERCENTILE (TOP 80%). DIFFERENT FRICTIONS

discussed next). Housing as a fraction of wealth falls with the level of wealth in all cases, but for this economy much less so. For example, for households in the bottom 40% of the wealth distribution houses represent 99.6% of total wealth, whereas this number is 229.44% in the benchmark economy and 280.89% in the data. For households in the top 20% of the wealth distribution, the fractions are not very different. Housing wealth represents 23.2% of all wealth in this economy, whereas the corresponding figures for the benchmark economy and the data are 22.3% and 26.8%. Thus, this model economy replicates the diminishing importance of housing in households' portfolios when wealth increases but not the magnitude of the decrease. For completeness, the right panel of Figure 7 focuses on homeowners. The portfolio composition for this group is also "flatter" than in the data.

The fact that housing wealth as a fraction of total wealth goes down with net worth and the fact that the Gini index for financial assets is higher than the Gini index for houses are connected. When a household receives a high earnings shock, the household increases holdings of financial assets proportionally more than the housing stock mainly because the return to housing as an investment good is linked to the marginal utility of housing (which decreases with the level of housing stock), whereas the return to financial assets is constant (it is the interest rate). As a result, housing wealth decreases with the level of wealth, in relative terms, and financial assets become more concentrated than residential assets. With volatile earnings, the differences between the rich and the poor are less extreme because permanent income varies much less by earnings shock. Housing choices for the different groups are more similar and there is less need to hold financial assets for precautionary motives.

From this exercise we learn that the decreasing importance of housing wealth on household portfolios as households become richer can be qualitatively explained in a world with just idiosyncratic earnings as long as the effective rate of return of housing (linked to marginal utility) is higher at low levels of holdings and the rate of return of financial assets is constant (or decreases more slowly). However, this economy cannot reproduce the observed Gini index for housing and produces a much flatter portfolio composition profile than that in the data.[14]

5.2.2. *Liquid houses, no down payment, and persistent earnings.* In order to understand the role of persistence, we bring the persistence level in earnings shocks back to the benchmark level while keeping adjustment costs and the down payment at zero. We labeled this economy "$\rho = 0,\ \theta = 0$" (second row in Table 6).

As before, all households are homeowners. The distribution of houses becomes more concentrated but is still far from being as skewed as in the data (the Gini index is 0.49 vs. 0.58 in the benchmark economy and 0.64 in the data). With persistent earnings, there is wide variation in housing holdings by earnings as there is more variation in permanent income. When a household receives a good shock, the household can upgrade to the new desired house level right away because of the zero down payment, which typically implies a large negative position in financial assets. Also, households who keep receiving the good shock prefer accumulating financial assets instead of increasing the housing stock because the return to houses falls with the stock. As a result, the Gini index for financial assets increases (from 0.68 in the previous economy to 0.93) and so does the Gini coefficient for total wealth (from 0.5 to 0.81). Importantly, the portfolio composition profile becomes significantly steeper (for the total population and for homeowners), as shown in Figure 7. For instance, households in the bottom 40% of the wealth distribution hold 551.9% of their wealth as houses, whereas this fraction was 99.6% in the previous economy and 229.4% in the benchmark economy. In summary, the persistence in earnings brings the Gini index for houses closer to the one observed in the data but implies that houses represent a too large fraction of wealth for poor households, compared to the data.

5.2.3. *Illiquid houses, positive down payments, persistent earnings, and no rental market.* Since adding persistence alone can account neither for the observed level of inequality in housing (it is still too low) nor the slope of the portfolio composition profile (it becomes too high for the wealth poor), we reintroduce the adjustment cost and the nonzero down payment (we disentangle the effects of these two factors in Subsection 5.5). With these frictions, some households prefer renting to owning. In order to facilitate the comparison with the previous economies, we force all households to be homeowners by not allowing for a rental market first. We labeled this economy "no rental" (third row in Table 6).

The distribution of houses depicted in Figure 5 is practically unaffected (the Gini coefficient falls from 0.49 in the previous economy to 0.48). The Lorenz curves for financial assets and total wealth change somewhat (see Figure 6) but the Gini coefficients do not vary much (the Gini coefficient for financial assets is the same, 0.93, and the Gini for wealth goes down from 0.81 to 0.79). However, there is a significant difference in the portfolio composition for households in the bottom of the wealth distribution (see Table 6 and Figure 7). For instance, households in the bottom 40% of the wealth distribution hold 344.2% of their wealth as houses, vs. 551.9% in the previous economy with no adjustment costs and a zero down payment. The fall is less significant for the other quintiles, indicating that poor households are most affected by these frictions.

In the previous economy, among the wealth poor were households that moved upwards in the earnings ranking and were adjusting the stock of housing right away. With a nonzero down

[14] This would also be the case with a Cobb–Douglas utility function. The main difference between our additively separable utility function and the Cobb–Douglas is that, in our case, the elasticity of the marginal rate of substitution between nondurables and durables depends on the risk aversion parameter, whereas this is not the case for a Cobb–Douglas utility function. The utility function specification would be important when analyzing the dynamic response of durables versus nodurables with respect to a change in relative prices.

payment and transaction costs, the adjustment will be sluggish, as households must provide a down payment (which may take a while to accumulate) and changing the stock is costly. Similarly, households who move downwards in the earnings ranking can no longer downsize at zero cost and may prefer to run down financial assets first. Summarizing, although the Gini index of financial assets does not change significantly, financial assets become more positively correlated with earnings. Importantly, households are forced to keep some equity in the form of the down payment, which lowers the H/W ratio for wealth poor households, closer to the observed ratio in the data.

5.2.4. *Adding the rental market.* We now add the rental market, which brings us back to the benchmark economy. In this case, wealth poor households rent instead of owning. Since renters hold zero housing wealth, the Gini index for houses increases from 0.49 to 0.58. The Gini index for financial assets goes down slightly (from 0.93 to 0.91) because renters hold their entire wealth as liquid assets but hold only a small fraction of the total. The Gini index for total wealth increases a bit, from 0.79 to 0.80. Figure 7 (right panel) shows that the portfolio composition for the total population in our benchmark economy is very similar to that of the no rental economy for households in the top 70% of the wealth distribution (the bottom 30% are almost all renters). Nevertheless, the benchmark economy matches the portfolio composition for homeowners better, as illustrated in the left panel of Figure 7. In summary, to reproduce the level of housing inequality and the slope of the wealth composition profile observed in the data, we need a combination of persistence in earnings, frictions in the housing market, and a rental market.

5.3. *The Distribution of Houses and Earnings.* When describing our benchmark economy, we emphasized the remarkable similarity in the distributions of houses and earnings for homeowners in the SCF-98 that our benchmark economy was able to replicate (refer back to Figure 4). We study in more detail these distributions to try to understand this fact.

We start by analyzing data from other waves of the SCF to make sure this pattern is not specific to 1998. Tables 8 and 9 show several statistics relating to the distributions of houses and earnings

TABLE 8
THE DISTRIBUTION OF HOUSES AND EARNINGS IN THE DATA (TOTAL POPULATION)

	Quintiles					Gini	Owners
	1st	2nd	3rd	4th	5th	Coeff.	%
			Survey of Consumer Finances 1989				
Earnings	3.09	8.89	14.60	21.79	51.63	0.48	
Houses	0.00	0.96	10.58	22.23	66.22	0.66	67.28
			Survey of Consumer Finances 1992				
Earnings	3.07	8.48	14.00	21.47	52.98	0.50	
Houses	0.00	0.99	11.26	22.92	64.81	0.66	66.24
			Survey of Consumer Finances 1995				
Earnings	3.12	8.68	14.03	21.24	52.91	0.49	
Houses	0.00	1.39	12.75	23.63	62.21	0.64	67.77
			Survey of Consumer Finances 1998				
Earnings	3.26	8.71	14.08	21.09	52.83	0.49	
Houses	0.00	1.60	12.67	22.27	63.45	0.64	68.65
			Survey of Consumer Finances 2001				
Earnings	3.07	7.99	12.91	20.33	55.69	0.52	
Houses	0.00	1.79	10.95	20.47	66.78	0.67	68.79
			Survey of Consumer Finances 2004				
Earnings	3.13	8.36	13.61	21.60	53.29	0.50	
Houses	0.00	2.13	10.84	20.01	67.01	0.67	70.64

NOTES: Statistics for households with positive earnings in the survey. Households are ordered by the variable indicated in each row. The quintiles for earnings (houses) represent the percentage of total earnings (houses) held by households in that particular group.

TABLE 9

THE DISTRIBUTION OF HOUSES AND EARNINGS IN THE DATA (HOMEOWNERS)

	Quintiles					Gini
	1st	2nd	3rd	4th	5th	Coeff.
			Survey of Consumer Finances 1989			
Earnings	3.89	10.01	15.02	21.12	49.94	0.45
Houses	3.15	8.12	12.94	21.66	54.10	0.50
			Survey of Consumer Finances 1992			
Earnings	3.44	9.11	14.52	20.92	52.00	0.48
Houses	3.76	8.71	13.61	20.72	53.19	0.49
			Survey of Consumer Finances 1995			
Earnings	3.65	9.26	14.53	20.63	51.90	0.48
Houses	3.93	9.64	14.24	20.99	51.19	0.46
			Survey of Consumer Finances 1998			
Earnings	3.81	9.46	14.41	20.43	51.87	0.47
Houses	3.95	9.36	13.33	20.21	53.13	0.48
			Survey of Consumer Finances 2001			
Earnings	3.48	8.70	13.44	19.83	54.55	0.51
Houses	3.85	7.97	12.13	19.28	56.77	0.52
			Survey of Consumer Finances 2004			
Earnings	3.67	9.21	14.23	21.53	51.33	0.47
Houses	3.46	7.84	11.78	19.19	57.70	0.53

NOTES: Statistics for households with positive earnings in the survey. Households are ordered by the variable indicated in each row. The quintiles for earnings (houses) represent the percentage of total earnings (houses) held by households in that particular group.

for six waves of the SCF (1989–2004). The Gini index for earnings (restricting the sample to households with positive earnings) ranges from 0.48 in 1989 to 0.52 in 2001, and the Gini index for houses ranges from 0.64 in 1998 to 0.67 in 2004. The home ownership rate increases steadily from 67.3% in 1989 to 70.6% in 2004. For homeowners, the Gini index for earnings varies from 0.45 in 1989 to 0.51 in 2001, and the Gini index for houses goes from 0.46 in 1995 to 0.52 in 2001. Although there is some variability over the years, the distributions of houses and earnings across quintiles are very similar for homeowners.

Why are these distributions so similar? The analysis of Subsection 5.2 suggests that the most important determinant of this pattern is the persistence of earnings. In order to make this point clearer, we construct Figure 8 depicting Lorenz curves that compare the distributions of houses and earnings in different scenarios. In particular, we show the benchmark economy, the no rental economy and two equivalent economies with i.i.d. earnings shocks recalibrated to produce the same aggregates ($\theta = 0.2$ and $\rho = 0.05$ in all cases). In the top-left panel, we show the distribution of houses for the benchmark economy and the no rental economy alongside the distribution of earnings (which is the same in both cases) for all households. With no rental market the Lorenz curves of earnings and houses for the total population are very similar, which is not what we see in the data because not all households are homeowners (refer to Figure 4, top panel). The top-right panel shows that the distribution of earnings and houses are almost identical for homeowners in the benchmark economy, as in the data. Thus, the rental market is necessary to obtain a Gini index of houses larger than the Gini index of earnings for the total population. With volatile earnings shocks (bottom panel of Figure 8), we cannot replicate the similarity of the distributions observed in the data because the distribution of houses becomes more egalitarian than that of earnings. With a rental market, the Gini index for houses is 0.41 for the total population and 0.13 for homeowners (vs. 0.58 and 0.39 with persistent earnings). With no rental market, the Gini index for houses is 0.20 (vs. 0.48 with persistent earnings). Thus, persistence is needed to explain the similarity of the distributions for homeowners.

Briefly, the distributions of earnings and houses for homeowners are alike with persistent earnings in our model because permanent income and current earnings are highly correlated

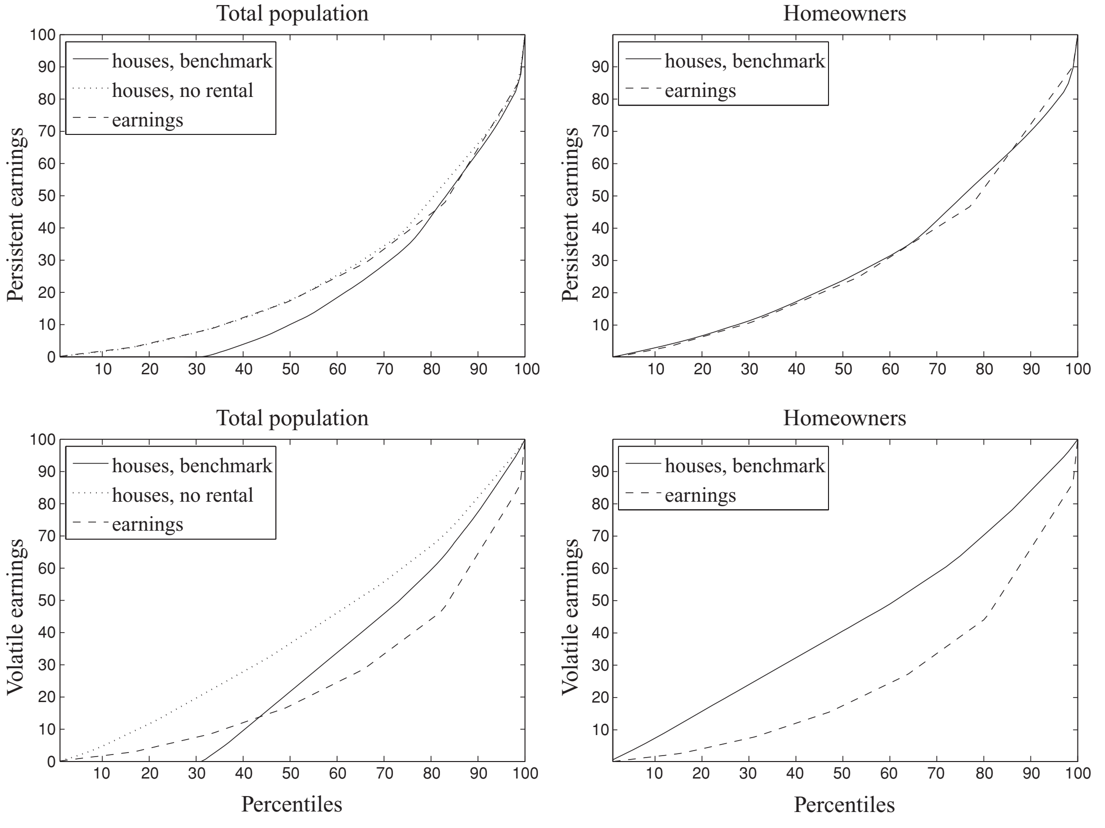

FIGURE 8

LORENZ CURVE FOR HOUSES AND EARNINGS. PERSISTENT VS. VOLATILE EARNINGS

and households acquire houses according to their permanent income. Although permanent income still guides house purchases with volatile earnings, current earnings in this case are not highly correlated with permanent income and the distributions of (current) earnings and housing are not alike.

5.4. *Changes in the Down Payment.* Over the last few decades, there has been a significant reduction in the down payments required by financial institutions as well as a proliferation of home equity loans. A decrease in the parameter θ captures these financial changes in our model, although we cannot disentangle one from the other. We analyze the effects of financial liberalization on the wealth distribution and composition by simulating our model economy for different values of the down payment requirement (keeping all other parameters constant).

A decrease in the down payment requirement relaxes the borrowing constraint for the wealth poor. Fewer households are constrained, home ownership increases, and inequality in houses decreases for the total population (see Table 10). For example, when moving from a 100% down payment to a 0% down payment, home ownership increases from 39% to 79%, and the Gini index for houses for the total population goes down from 0.74 to 0.57. The other side of the coin is that a decrease in θ implies more borrowing in the economy, so financial assets become more concentrated (the Gini index for financial assets goes up from 0.85 to 0.92 when decreasing θ from 100% to 0%). The overall effect on wealth inequality is negligible because the change in the down payment affects mainly constrained households. These households are concentrated at the bottom of the wealth distribution and hold only a small fraction of aggregate wealth (the change in the down payment has no effect on the wealth composition for the 5th wealth quintile).

TABLE 10

CHANGES IN THE DOWN PAYMENT AND THE ADJUSTMENT COST

	H/W by Wealth Quintile					Gini Coefficient				Owners
	1st	2nd	3rd	4th	5th	E	H	A	W	%
				All Households						
Data		280.89	113.27	73.16	26.76	0.49	0.64	0.94	0.80	68.65
$\theta = 1$		0.00	12.63	55.83	22.43	0.49	0.74	0.85	0.81	39.20
$\theta = 0.5$		0.00	98.50	60.49	22.17	0.49	0.68	0.88	0.81	49.14
Benchmark		229.44	179.48	61.41	22.30	0.49	0.58	0.91	0.80	68.68
$\theta = 0$		364.81	186.06	62.96	22.26	0.49	0.57	0.92	0.81	79.03
$\rho = 0$		339.01	201.35	66.15	26.16	0.49	0.52	0.93	0.80	89.27
				Homeowners						
Data		194.00	91.81	67.05	24.33	0.47	0.48	0.94	0.75	
$\theta = 1$		64.58	46.52	35.42	18.84	0.39	0.34	0.70	0.58	
$\theta = 0.5$		95.58	54.70	39.11	19.68	0.39	0.35	0.77	0.63	
Benchmark		233.18	82.42	47.66	21.47	0.40	0.39	0.88	0.72	
$\theta = 0$		357.15	110.84	54.26	22.21	0.47	0.45	0.90	0.76	
$\rho = 0$		327.24	148.42	59.35	25.35	0.46	0.46	0.92	0.77	

NOTES: E is earnings, H is house value, A is financial assets, and W is wealth. H/W is our portfolio composition measure by wealth quintile defined as total housing wealth in the quintile divided by total wealth in the quintile times 100. All parameters as in the benchmark case except the parameter being changed, which is indicated in each row.

A decrease in the down payment increases housing and wealth inequality among homeowners significantly (e.g., the Gini for total wealth goes up from 0.58 to 0.76 when decreasing θ from 100% to 0%), but this is simply the result of the group becoming more diverse as home ownership increases with lower down payments.

Summarizing, changes in the down payment result in changes in the composition of wealth but not in the distribution of total wealth. Moreover, changes in the down payment do not produce significant changes in the capital–output ratio—the interest rate goes up from 3.91% in the benchmark economy to 3.97% in the economy with a zero down payment.

5.5. *The Interaction Between Adjustment Costs and the Collateral Constraint.* In the discussion in Subsection 5.2, we compare our benchmark economy to an economy with no adjustment costs and a zero down payment but do not separate the two frictions. In principle, these frictions have different effects: Although adjustment costs affect both poor and wealthy households, the collateral constraint implied by the down payment affects mainly poor households. In order to disentangle the effects of each friction, we simulate an additional economy with no adjustment costs and a 20% down payment and compare it to the case with no down payment and adjustment costs (all other parameters are kept as in the benchmark case). The last two rows of Table 10 present some summary statistics of the distributions for these two scenarios.

With a zero down payment, the home ownership rate increases to 79% from 68.7% in the benchmark case. The housing Gini index for homeowners rises from 0.39 in the benchmark economy to 0.45 because homeowners become a more diverse group (note that the Gini index of earnings for homeowners rises to 0.47 from 0.4 in the benchmark economy). With further access to credit, the Gini index for financial assets also increases for this group, as seen in Table 10. Note that households in the bottom 40% of the wealth distribution hold more illiquid portfolios—houses represent 357.2% of household's wealth as opposed to 233.2% in the benchmark case—whereas households in the top wealth quintile are hardly affected. The effect of a zero adjustment cost is qualitatively similar. The home ownership rate rises to 89%, and the Gini indices of houses and financial assets increase significantly for the group of homeowners. In fact, the home ownership rate increase is so large that the Gini index of houses for the total population falls from 0.58 in the benchmark economy to 0.52. Since houses are liquid, the fraction of wealth held

TABLE 11
THE ROLE OF SUPERSTARS

	H/W by Wealth Quintile					Gini Coefficients				Owners
	1st	2nd	3rd	4th	5th	E	H	A	W	%
					Total Population					
No superstar		90.63	81.45	40.09	25.12	0.43	0.53	0.74	0.65	68.45
Benchmark		226.93	185.60	62.78	26.12	0.43	0.55	0.89	0.76	68.80
Data		290.25	114.29	74.70	30.77	0.43	0.63	0.94	0.77	68.65
					Homeowners					
No superstar		102.70	46.60	33.29	23.62	0.37	0.31	0.63	0.51	
Benchmark		235.10	83.51	48.34	23.33	0.35	0.34	0.85	0.67	
Data		196.04	93.36	68.10	28.21	0.40	0.46	0.93	0.70	

NOTES: E is earnings, H is house value, A is financial assets, and W is wealth. H/W is our portfolio composition measure by wealth quintile defined as total housing wealth in the quintile divided by total wealth in the quintile times 100. For the benchmark economy and the data, the numbers presented exclude households in the top 1% of the (positive) earnings distribution. The different economies are calibrated to produce the same aggregates. Refer to Table 3 for the different parameter values.

as houses increases for all wealth quintiles (although relatively more for the poor). The effect on the overall wealth distribution is minimal.

In summary, the effects of decreasing the down payment and the adjustment costs work in the same direction. With lower adjustment costs, houses are liquid and there is less need to accumulate financial assets for precautionary reasons. With a zero down payment, households accumulate less financial assets because they are not required to keep a down payment.

5.6. *The Role of Superstars.* As discussed in Section 4, when calibrating our earnings process we divide households into two groups: regular households and superstars. The first six earnings shocks—the regular shocks— are calibrated to reproduce the Gini index and the coefficient of variation for households with positive earnings outside of the top 1% of the earnings distribution. We add the superstar shock so that the Gini index for wealth in the benchmark economy matches its counterpart in the data. How does the presence of superstars affect our results? In order to answer this question, we construct an alternative economy assuming households can never become superstars while preserving the Markov process for the rest of the earnings shocks. We recalibrate the economy to produce the same aggregates as the benchmark economy and labeled it "no superstar." In Table 11, we compare selected distributional statistics for this economy to their counterparts in the data and in the benchmark economy, focusing on the sample of households outside the top 1% of the (positive) earnings distribution in the latter cases. Figure 9 shows the Lorenz curves for houses, financial assets, and total wealth in all three cases.

The first finding is that the distribution of housing for regular households is not affected much by the presence of superstars (the Lorenz curves for housing in Figure 9 are almost identical) but the distributions of financial assets and total wealth are. The Gini indices for housing, financial assets, and total wealth for the no superstar economy are 0.53, 0.74, and 0.65, vs. 0.55, 0.89, and 0.76 in the benchmark case (excluding the superstars). The corresponding numbers in the data are 0.63, 0.94, and 0.77. Thus, adding the superstars not only helps us bring the Gini coefficient of wealth for the total population closer to that of the data, but also helps us obtain the implied level of wealth inequality for households outside the top 1% of the earnings distribution. Note that the distributions of housing are similar in both scenarios because the probability of becoming a superstar is very low, so permanent labor income does not differ much between the two economies. When we restrict our attention to homeowners, we find a similar result: Having a positive probability of becoming a superstar does not affect the distribution of houses much, but brings the Gini indices of financial assets and total wealth (for regular households) closer to the values in the data.

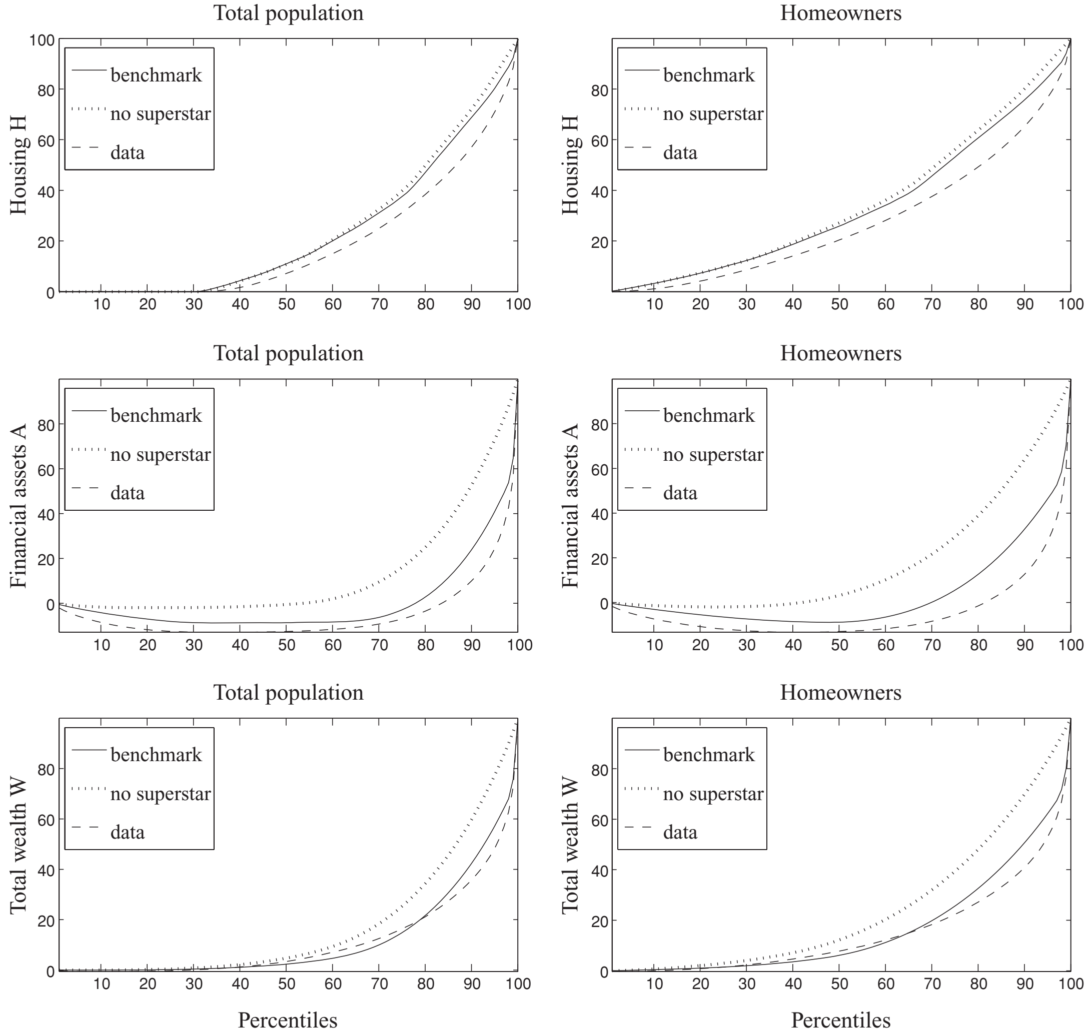

FIGURE 9

LORENZ CURVE (HOUSES, FINANCIAL ASSETS, AND TOTAL WEALTH). THE ROLE OF SUPERSTARS

The second and related finding is that in the no superstar economy households have much more liquid portfolios than in the benchmark economy and the data (see Figure 10). For instance, homeowners in the bottom 40% of the wealth distribution hold 102.7% of their wealth as houses, whereas the corresponding numbers in the benchmark economy and in the data are 235.1% and 190% (see Table 11 for other quintiles). In words, the portfolio composition profile is much flatter in the no superstar economy than in the benchmark economy. The reason is the following. In the benchmark economy, there are regular households who were superstars at some point in the past. When hit by a regular earnings shock, a fallen superstar will deplete the stock of financial assets or recur to home equity loans before readjusting the housing stock, which is costly (the larger the drop in earnings, the larger the adjustment in the portfolio that will be eventually necessary). Since superstars are equally likely to fall to any of the regular earnings states, the difference between the benchmark and the no superstar economy is larger for the lower percentiles of wealth. This observation also suggests one reason why the portfolio composition pattern in our benchmark economy is steeper than in the data. Perhaps in reality, superstars are less likely to fall to the lower regular earnings states than the higher ones.

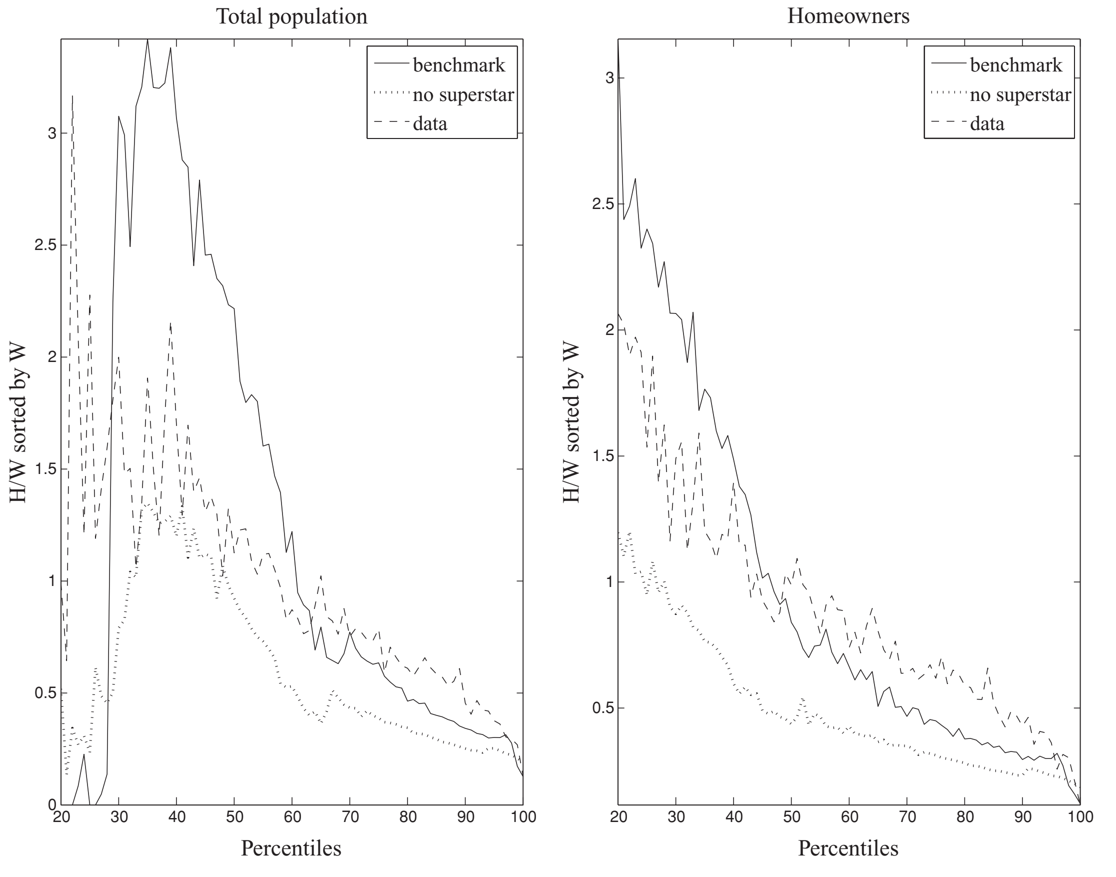

FIGURE 10

PORTFOLIO COMPOSITION BY WEALTH PERCENTILE (TOP 80%). THE ROLE OF SUPERSTARS

The question that arises at this point is who these superstars may be and how they differ from regular households. Table 12 summarizes some relevant information from several waves of the SCF focusing on households with positive earnings. Consistent with our model, we define superstars as households on the top 1% of the earnings distribution. Superstars are about 7 years older than regular households and more frequently married. In all SCF waves, the fraction of households with college degrees is significantly higher for the superstars and, although college education has increased over time for both groups, the difference has widened (the proportion of households with a college degree increased from 66% in 1989 to 93% in 2004 for superstars, and from 33% to 40% for regular households). Regular households and superstars also differ by occupation. Over 75% of regular households are employees—as opposed to self-employed or business owners—whereas this number is roughly 40% for superstars (with some variability over time). Thus, superstars tend to be college graduates and self-employed. Table 13 cross-tabulates occupation by education level for both groups of households. The pattern is clear: More than 75% of regular households are employees regardless of their level of education, whereas this fraction is about 45% for superstars. Since college graduates make the bulk of superstars, this is suggestive evidence that education is an important factor to become a superstar.

6. FINAL COMMENTS

In this article, we explicitly model the existence of illiquid houses that serve as collateral for loans in the context of a heterogeneous agents model with uninsurable earnings risk. Using

TABLE 12
CHARACTERISTICS OF THE TOP 1% OF EARNINGS RICH HOUSEHOLDS

	Age		% Population Married	% Population College Degree	Occupation		
	Mean	Median			Employee	Self/Business	Retired/Disabled/ Other
				Survey of Consumer Finances 1989			
Total population	42.4	40	65.7	33.1	73.9	14.2	11.9
Bottom 99%	42.3	40	65.5	32.8	74.3	13.7	12.0
Top 1 %	51.7	50	81.6	66.1	32.7	64.0	3.3
				Survey of Consumer Finances 1992			
Total population	42.9	41	65.8	37.4	71.4	13.7	14.9
Bottom 99%	42.8	41	65.5	36.9	71.7	13.4	15.0
Top 1 %	50.1	51	88.4	88.9	45.9	47.9	6.3
				Survey of Consumer Finances 1995			
Total population	43.0	42	66.0	35.0	75.0	12.6	12.4
Bottom 99%	42.9	42	65.8	34.6	75.4	12.1	12.5
Top 1 %	50.5	49	84.7	76.6	39.4	59.0	1.5
				Survey of Consumer Finances 1998			
Total population	43.5	42	65.4	37.5	74.8	13.7	11.6
Bottom 99%	43.5	42	65.1	37.1	75.2	13.1	11.6
Top 1 %	50.2	51	91.4	73.1	31.3	65.4	3.3
				Survey of Consumer Finances 2001			
Total population	44.0	43	65.0	38.2	75.7	14.3	10.2
Bottom 99%	43.9	43	64.7	37.8	76.0	13.8	10.2
Top 1 %	50.9	52	93.6	87.5	38.7	53.0	8.3
				Survey of Consumer Finances 2004			
Total population	44.5	44	64.4	40.3	75.1	14.2	10.67
Bottom 99%	44.4	44	64.1	39.8	75.4	13.9	10.7
Top 1 %	51.1	52	95.4	92.5	51.7	44.4	3.9

NOTES: Data restricted to households with positive earnings.

data from the Survey of Consumer Finances, we document that the distribution of houses is less egalitarian than that of earnings for the total population, whereas the distributions of houses and earnings are remarkably similar for homeowners. Furthermore, housing wealth as a fraction of net worth decreases with the household level of wealth. Armed with a two-asset model, we focus on understanding the distribution of housing wealth and the composition of households' portfolios.

We show that the decreasing importance of houses in households' net worth can only be partially understood by the fact that the return to housing decreases with one's holdings (because of decreasing marginal utility). In fact, a combination of very persistent shocks to earnings, adjustment costs, nonzero down payments, and a rental market is necessary to obtain portfolio composition numbers close to those in the data. The persistence of earnings shocks seems to be particularly important for understanding the similarity of the housing and earnings distributions for homeowners. This is because current earnings are a good indicator of permanent income (which guides housing purchases) with persistent earnings but not with volatile earnings. We also show that although changes in the frictions that affect the housing market (transaction costs and down payments) have limited impact on the overall wealth distribution, they have important effects on the portfolio composition and the home ownership rate.

In this study, we abstract from some important issues that remain topics for future research. The most obvious and potentially important one is the omission of life-cycle effects. In the data, a household's portfolio composition varies with age, and it would be interesting to analyze whether or not the model can account for the life-cycle patterns of wealth holding and wealth composition. A further extension could deal with the interaction between collateral credit and earnings ability.

TABLE 13

OCCUPATION BY EDUCATION LEVEL. REGULAR HOUSEHOLDS VS. SUPERSTARS

	No College Degree		College Degree	
	Employee	Self/Business	Employee	Self/Business
	Survey of Consumer Finances 1989			
Total population	72.5	12.8	76.8	16.9
Bottom 99%	72.7	12.5	77.7	16.0
Top 1%	27.7	69.9	35.3	60.9
	Survey of Consumer Finances 1992			
Total population	70.3	11.5	73.2	17.5
Bottom 99%	70.4	11.4	73.9	16.8
Top 1%	41.7	48.9	46.4	47.7
	Survey of Consumer Finances 1995			
Total population	73.5	11.4	77.9	14.9
Bottom 99%	73.5	11.2	78.9	13.8
Top 1%	54.9	41.5	34.7	64.4
	Survey of Consumer Finances 1998			
Total population	74.4	11.8	75.4	16.7
Bottom 99%	74.5	11.7	76.4	15.7
Top 1%	45.3	49.4	26.2	71.4
	Survey of Consumer Finances 2001			
Total population	76.3	12.1	74.6	17.5
Bottom 99%	76.5	12.0	75.3	16.7
Top 1%	2.6	75.5	43.9	49.8
	Survey of Consumer Finances 2004			
Total population	74.6	12.9	76.0	16.1
Bottom 99%	74.6	12.9	76.6	15.4
Top 1%	43.4	41.1	52.4	44.7

NOTES: Data for households with positive earnings.

For example, access to collateral credit could increase the probability of becoming a superstar (becoming a superstar may require some innate ability plus an initial investment).

APPENDIX

A. *Computational Procedures.* In order to compute the equilibrium of our benchmark model, it is convenient to reformulate the household problem. Define voluntary equity as the wealth held in excess of the required down payment, $q \equiv a + (1-\theta)h$. The state variables for the household problem are the earnings shock, voluntary equity, and the housing stock, $\{e, q, h\}$. With this reformulation, we deal with two states whose values are restricted to be nonnegative. This greatly simplifies the problem imposed by the endogenous liquidity constraint in the solution of the household problem, which can be rewritten as follows:

(A.1)

$$v(e,q,h) = \max_{z,c,q',h',f} u(c,(1-z)f + zh') + \beta \sum_{e'} \pi_{e,e'}\, v(e',q',h')$$

$$\text{s.t.} \quad c \geq 0;\ z \in \{0,1\};\ h' = 0,\ f > 0 \quad \text{if} \quad z = 0;\ h' > 0,\ f = 0 \quad \text{if} \quad z = 1;$$

$$q' \geq 0,$$

$$c + r^f f + q' + \theta h' + \tau(h',h) = w\,e + (1+r)\,q + \left[(1-\delta^h) - (1-\theta)(1+r)\right] h.$$

Because of the nonconvex adjustment cost, we use a finite state approximation approach to solve the household problem. The technique consists of specifying a finite-state (discrete)

TABLE A1
INEQUALITY STATISTICS FOR THE BENCHMARK ECONOMY (MORE GRID POINTS)

	Quintiles					Gini
	1st	2nd	3rd	4th	5th	Coeff.
			All Households			
Earnings, E	4.19	7.99	12.57	19.67	55.57	0.49
Houses, H	0.00	4.25	14.63	25.10	56.01	0.57
Financial assets, A	−5.12	−1.18	0.35	8.37	97.58	0.92
Wealth, W	0.07	0.83	2.91	13.83	82.34	0.80
H/W	241.69		180.29	61.01	22.09	
Owners by W (%)	0.00	55.80	98.19	94.18	97.66	
Owners by E (%)	17.14	51.36	87.61	99.44	90.29	
			Homeowners: 69.16% of Households			
Earnings, E	6.47	10.55	14.30	20.93	47.74	0.40
Houses, H	6.99	10.39	14.53	24.81	43.27	0.38
Financial assets, A	−4.37	−2.42	1.78	14.49	90.51	0.88
Wealth, W	0.91	2.01	6.36	17.69	73.01	0.72
H/W	239.21		80.61	49.51	21.31	

NOTES: Households are ordered by the variable indicated in each row, except for the row labeled "H/W," in which households are ordered by total wealth. H/W is defined as total housing wealth in the quintile divided by total wealth in the quintile times 100. Housing wealth represents the total value of the homes, not just home equity. The quintiles for earnings (houses, financial assets, wealth) represent the percentage of total earnings (houses, financial assets, wealth) held by households in that particular group. This table is equivalent to Table 4 with twice as many points for the discrete grids of houses and voluntary equity.

problem that approximates the continuous one we want to solve. With our reformulation, today's controls are next period's states and the grids for both assets start at zero. The upper values for the grids must be chosen with care by trial and error. We solve the problem by value function iteration. We guess an initial value function and make agents choose next period's values of q' and h' in the grid. Choosing values of the policy function in a two-dimensional grid can be computationally very costly. We use a policy function accelerator described in Judd (1998) to speed up convergence. In order to compute the steady state of the model, we use standard procedures.

For the results reported in this article, we use 300 hundred grid points for voluntary equity and 100 points for the housing stock (the grid points are not equally spaced to maximize efficiency). With seven exogenous earnings shocks, this implies solving the household's problem for 210,000 points at each iteration. In order to verify that our results are robust to the density of the grids, we solve the benchmark specification with twice as many points for each asset. Table A1 presents wealth distribution statistics equivalent to those in Table 4 for the benchmark case. The Gini coefficients and quintiles are extremely similar in both cases. Of course, parameter values have to be adjusted to obtain the same aggregates with more points. The changes, however, are minimal, with differences at the fourth or fifth decimal point. β is the parameter most affected and is equal to 0.9013 with more points vs. 0.9015 in the benchmark case. Since the differences are not very significant, we proceeded with fewer grid points to save on computational time.

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