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WP 11-05

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Abstract

We incorporate house price risk and mortgages into a standard incomplete market (SIM) model. We calibrate the model to match U.S. data, and we show that the model also accounts for non-targeted features of the data such as the distribution of down payments, the life-cycle profile of homeownership, and the mortgage default rate. In addition, we show that the average coefficients that measure the agents' ability to self-insure against income shocks are similar to those of a SIM model without housing (as presented by Kaplan and Violante, 2010). However, incorporating housing increases the values of these coefficients for younger agents, which narrows the gap between the SIM model's implications and the data. The response of consumption to house price shocks is minimal. We also study the effects of default prevention policies. Introducing a minimum down payment requirement of 15 percent reduces defaults on mortgages by 30 percent, reduces the homeownership rate up to only 0.2 percentage points (if the aggregate house price level does not adjust), and may cause house prices to decline up to 0.7 percent (if homeownership does not adjust). Garnishing defaulters' income in excess of 43 percent of median consumption for one year produces a similar decline in defaults; but, since it reduces the median equilibrium down payment from 19 percent to 9 percent, it boosts homeownership up to 4.3 percentage points (if the aggregate house price level does not adjust) and may increase house prices up to 16.1 percent (if homeownership does not adjust). The introduction of minimum down payments or income garnishment benefit a majority of the population.

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Keywords: mortgage, default, life cycle, down payment, garnishment.

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1 Introduction

This paper proposes a model that accounts for the observed behavior of mortgage borrowing and default in the U.S. and then uses the model to study the effects of introducing minimum down payment requirements and allowing lenders to garnish defaulters' income. Mortgage defaults are widely seen as costly, which has led to both academic and policy discussions about the reduction of default rates. For instance, in the U.S., Qualified Residential Mortgage rules proposed by regulators make higher down payments necessary to obtain more favorable interest rates. Critics argue that these rules could have significant negative effects on the homeownership rate (see, for example, MBA, 2011). Others have proposed to allow mortgage creditors to take defaulters' assets or income (see, for example, Feldstein, 2008). The findings in this paper shed light on the possible effects of such mortgage default prevention policies (IMF, 2011, describes the utilization of these policies accross countries).

We propose an extension of a standard incomplete market (SIM) model.[1] In particular, we follow closely the model studied by Kaplan and Violante (2010), but we introduce housing, house price risk, and mortgages. We model mortgages as long-term loans that can be refinanced or enter into default in any period and are collateralized by a house. There are no restrictions on the initial down payment other than the requirement that it be non-negative. Interest rates are set endogenously and depend on the default probability.

We calibrate our model to match income and house price shocks, the median net-worth, the mean house price-to-income ratio, and the home ownership rate in the U.S. Since the home equity position is the key determinant of mortgage default decisions, plugging into the model a realistic process for house price shocks seems crucial for our objective of accounting for defaults and studying implications of default prevention policies.

We find that the model fits non-targeted features of the data. In particular, the endogenous distribution of down payments generated by the model is similar to its empirical counterpart. Again, since the home equity position is the key determinant of mortgage default decisions,

[1] See Carroll (1997), Huggett (1993, 1996), Kaplan and Violante (2010), Krusell and Smith (2006), and Ríos-Rull (1995).

the fact that the model generates a plausible distribution of down payments seems crucial for accounting for default behavior. Furthermore, since the policy exercises we study affect the equilibrium through borrowing constraints, it seems important that the model generates a plausible endogenous borrowing behavior. The model also predicts a life-cycle profile of homeownership and a mortgage default rate similar to their empirical counterparts.

We also study the model's predictions about agents' ability to self-insure. This is important because agents' welfare is determined by their ability to borrow and insure against shocks. We find that consumption inequality increases substantially over the life cycle but less than earnings inequality, and its increase is approximately linear. This is consistent with the findings in previous studies (see, for example, Storesletten et al., 2004; Kaplan and Violante, 2010). Furthermore, in our benchmark, average insurance coefficients for income shocks (see Blundell et al., 2008) are very close to the coefficients we obtain in our model without housing and very close to the ones reported by Kaplan and Violante (2010) from their SIM model without housing. While incorporating housing does not have a significant effect on the average value of insurance coefficients, it increases the values of these coefficients for younger agents. Kaplan and Violante (2010) argue that the life-cycle profiles of insurance coefficients in the data are flatter than the ones predicted by a SIM model. Thus, our findings indicate that housing narrows the gap between the SIM model's implications and the data.

We also find that, as in Li and Yao (2007), house price shocks are not an important source of consumption inequality. On the one hand, since housing is a major component of agents' portfolios, one could expect house price shocks to be an important source of risk and cross-sectional heterogeneity. On the other hand, one could expect this role to be less important because a house is not only an investment vehicle but also a consumption good. Using the insurance coefficients proposed by Blundell et al. (2008), we find that 98 percent of the variance of house price shocks does not translate into changes in consumption. Estimating the marginal propensity to consume housing wealth is a difficult task, and therefore there is a wide range of estimated values (see Carroll et al., 2011, and references therein). Our findings support the expectation of a low marginal propensity to consume housing wealth that results from agents' need to consume housing services (see Benito et al., 2006).

We use the model to perform two policy experiments that shed light on recent discussions about mortgage default prevention policies. First, we study the effects of requiring a minimum down payment. Recall that in our benchmark there is only a non-negative down payment restriction. We find that requiring a minimum down payment of 15 percent of the house value reduces defaults on mortgages by 30 percent, reduces the homeownership rate up to only 0.2 percentage points (if the aggregate house price level does not adjust), and may cause house prices to decline up to 0.7 percent (if homeownership does not adjust). On the one hand, most homeowners (and thus a majority of the population) benefit from improved credit conditions. The minimum down payment requirement increases the cost of defaulting because it implies that it would be more difficult for a defaulter to buy a house in the future. Thus, when the minimum down payment requirement is imposed, homeowners can refinance their mortgage at lower interest rates. On the other hand, prospective home buyers are typically worse off with minimum down payment requirements because the requirements make buying a house more difficult.

Second, we study the effects of allowing for garnishment of a defaulter's income. Our benchmark calibration does not allow for garnishment. In most U.S. states, legislation (such as bankruptcy, foreclosure, deficiency, and non-recourse laws) limits the defaulter's responsibility for the difference between the value of the collateral and his debt. We find that garnishing defaulters' income in excess of 43 percent of median consumption for one year reduces defaults on mortgages by 30 percent.

Because income garnishment increases the cost of defaulting, under garnishment agents can borrow with a low interest rate even with a low down payment. In our experiment, the potential for garnishment reduces the median down payment from 19 percent of the house value to 9 percent. Consequently, it boosts homeownership by up to 4.3 percentage points (if the aggregate house price level does not adjust) and may increase house prices up to 16.1 percent (if home ownership does not adjust). The improved credit conditions implied by the potential for garnishment benefit most agents. But, since we impose garnishment on existing debt contracts, agents who are very likely to default are worse off with this policy.

2 The model

We study a life-cycle SIM model close to the one presented by Kaplan and Violante (2010). As they do, we model the choices of an agent who lives up to T periods and works until age $W \leq T$. In contrast with their study, we assume that (i) in addition to consuming non-durable goods, the agent consumes housing; (ii) in addition to earning shocks, the agent faces house price shocks; and (iii) borrowing options are endogenously given by lenders' zero-profit conditions on mortgages contracts.

2.1 Housing

We present a stylized model of housing that follows closely the one presented by Campbell and Cocco (2003).[2] As in Campbell and Cocco (2003), we assume that the agent must live in a house and that, in any given period, the agent may own up to one house. For simplicity, we assume all houses the agent could own deliver the same housing services and have the same price, p_t. This price changes stochastically over time. If the agent owns a house, he must live in the house he owns. The cost of buying a house is $\xi_B p_t$, and the cost of selling a house is $\xi_S p_t$.

We depart from Campbell and Cocco (2003) by allowing the agent to choose whether to own or rent his house. For simplicity, we assume a constant renting cost r that the agent must pay each period in which he chooses to rent. Assuming a constant renting cost facilitates the assurance that the agent can always afford housing. There is a disutility from renting denoted by θ. Thus, the agent maximizes

$$E_t \left[\sum_{s=0}^{T-t} \beta^s \zeta_{t,t+s} \left(\frac{c_{t+s}^{1-\gamma}}{1-\gamma} - I_{t+s}\theta \right) \right],$$

where β denotes the subjective discount factor, $\zeta_{t,t+s}$ denotes the probability on being alive at age $t+s$ conditional of being alive at age t, c_t denotes consumption at age t, γ denotes the curvature parameter, and $I_t = 1$ ($I_t = 0$) if the agent is renting (owns a house). All agents alive at the beginning of age T die with certainty at the end of that period.

[2] Campbell and Cocco (2003) study the optimal choice between fixed-rate mortgages and adjustable-rate mortgages in an environment with inflation and interest rate risk.

2.2 Earning and house price stochastic processes

We allow for correlation between earnings and house prices. As it is standard in the housing literature, we explicitly allow for predictability in house prices (see Corradin et al., 2010; Nagaraja et al., 2009, and references therein). In particular, following Nagaraja et al. (2009), the log of the house price is assumed to follow an AR(1) process:

$$\log(p_{t+1}) = (1-\rho_p)\log(\bar{p}) + \rho_p \log(p_t) + \nu_t, \tag{1}$$

where $\bar{p}$ is the mean price.

Each period, the agent receives an endowment of income y_t. Before retirement, income has a persistent component, a life-cycle component, and an i.i.d component:

$$\log(y_t) = z_t + f_t + \varepsilon_t,$$

where

$$z_t = \rho_z z_{t-1} + e_t,$$

ε is normally distributed with variance σ_ε^2, and e and ν are jointly normally distributed with correlation $\rho_{e,\nu}$ and variances σ_e^2 and σ_ν^2.

Note that we abstract from the fixed component in the agent's earning process used in the literature to capture differences such as education (see, for example, Krueger and Perri, 2006). This abstraction is convenient because we assume the agent can only choose from two possible levels of housing services (as he chooses whether to own or rent).[3]

It is well understood that social security may play an important role in terms of risk-sharing. We model social security using a concave schedule as in Storesletten et al. (2004) but, in order to economize one state variable, we use the last realization of the persistent component of working-age income as a proxy for the lifetime average income. Benefits are equal to 90 percent of average past earnings up to a first bend point, 32 percent from this first bend point to a second bend point, and 15 percent from this second bend point to a third bend point, and fixed at the level

[3] Alternatively, for each level of the fixed component in the agent's earning process, we could compute one economy with two levels of housing services. Because the income elasticity of housing consumption is close to 1 (see Aguiar and Bils, 2011), we expect each of these economies would be very similar to the one we study.

of the third bend point beyond that. The three bend points are set at, respectively, 0.18, 1.10, and 2.30 times cross-sectional average gross earnings.

2.3 Mortgage contracts and savings

Mortgage loans are the only loans available to the agent and he can have up to one mortgage. A mortgage for an agent of age t is a promise to make constant payments of $b > 0$ for next $n = T - t$ years or to cancel his debt in any period before T by paying the value of the remaining payment obligations discounted at the risk-free rate, $q^*(n)$, where

$$q^*(n) = \begin{cases} \sum_{j=1}^{n} \left(\frac{1}{1+\bar{r}}\right)^j, & \text{if } b > 0 \\ 1, & \text{otherwise.} \end{cases}$$

The agent can default on his mortgage. If the agent chooses to default he hands in his house to his lender who sells it with a discount at $p_t(1 - \overline{\xi}_S)$, with $0 \leq \overline{\xi}_S \leq 1$. The lender also may garnish part of the defaulter's income,

$$\pi(b, y, p, n) = \min\left\{\max\left\{y - \phi, 0\right\}, q^*(n)b - p\right\},$$

where ϕ denotes the minimum subsistence consumption that the agent is legally entitled to and $q^*(n)b - p$ denotes the deficiency balance after the foreclosed property is sold. The agent must rent in the period in which he defaults.

Each period, a homeowner with positive expected home equity receives a transfer $\epsilon(b', p, n)$ equal to his discounted expected next-period home equity position (net of the cost of selling the house) multiplied by the probability of his death,

$$\epsilon(b', p, n) = \max\left\{0, \frac{1 - \chi_n}{1 + \bar{r}}\left[\mathbb{E}[p'|p](1 - \xi_S) - q^*(n-1)\max\left\{b', 0\right\}\right]\right\},$$

where χ_n denotes the probability of being alive next period at age $T - n$. If the homeowner dies, the financial intermediary who contracted with the homeowner receives the house. After paying the selling cost, the financial intermediary sells the house and uses the proceeds to pay to the mortgage holder the minimum between the mortgage prepayment amount and the proceeds from the house sale. Mortgages are priced by risk-neutral lenders who make zero expected profits and have an opportunity cost of lending given by the interest rate $\overline{r}$.[4]

We denote by b_0 the agent's initial asset position. If the agent does not have a mortgage, he can save using one-period annuities. If the agent has a mortgage, he can save only by accumulating home equity.

2.4 Timing

The timing of events is as follows. At the beginning of the period, the agent observes the realization of his earning and house price shocks. After observing his shocks, the agent makes his housing and borrowing decisions. If the agent enters the period as a renter, he chooses to either become a homeowner or to stay as a renter. If the agent enters the period as a homeowner with a mortgage, he can: (i) make his current-period mortgage payment; (ii) default; (iii) sell the house, prepay his mortgage, rent, and save; and (iv) prepay and change his financial position. If the agent enters the period as a homeowner without a mortgage, he chooses whether to stay in his house or sell his house, as well as his next-period financial position.

2.5 Recursive formulation

The lifetime utility of an agent who enters the period as a renter and can live up to n periods is given by

$$R(b, z, \varepsilon, p, n) = \max\{G(\cdot), B(\cdot)\}, \tag{2}$$

where $b \leq 0$ denotes the renter's saving level at the beginning of the period, G denotes the lifetime utility of an agent who decides to stay as a renter during the period and B denotes the lifetime utility of an agent who buys a house in the period.

If the agent continues renting, he can choose his next-period savings $b' \leq 0$. Since the agent saves using one-period annuities, in order to have an asset level of $b' \leq 0$ next period, he needs

[4] In a model with asymmetric information about the borrower's type, Guler (2008) study the effects of improvements in the lenders' ability to assess mortgage credit risk.

to save $\frac{\chi_n}{1+\overline{r}}b'$ in the current period. The value of $G(b,z,\varepsilon,p,n)$ is determined as follows:

$$G(b,z,\varepsilon,p,n)=\max_{b'\leq 0}\left\{u\left(y-b+\frac{\chi_n}{1+\overline{r}}b'-r\right)-\theta+\beta\chi_n\mathbb{E}[R(b',z',\varepsilon',p',n-1)|z,p]\right\}. \quad (3)$$

Let $b'q(b',z,p,n)$ denote the resources the agent obtains with a mortgage that promises to pay $b'>0$ per period, or the resources the agent has to save if he wants to have $-b'>0$ of financial assets next period. Then,

$$q(b',z,p,n)=\begin{cases}\frac{\chi_n(q_{\text{pay}}+q_{\text{prepay}}+q_{\text{default}})+(1-\chi_n)q_{\text{die}}}{1+\overline{r}} \text{ if } b'>0\\ \frac{\chi_n}{1+\overline{r}} \text{ if } b'\leq 0,\end{cases}$$

where

$$\begin{aligned}
q_{\text{pay}} &= \mathbb{E}\left[I_{\text{pay}}(b',z',\varepsilon',p',n-1)\left(1+q\left(b',z',p',n-1\right)\right)|z,p\right],\\
q_{\text{prepay}} &= \mathbb{E}\left[I_{\text{prepay}}(b',z',\varepsilon',p',n-1)q^*(n-1)|z,p\right],\\
q_{\text{default}} &= \mathbb{E}\left[\frac{I_{\text{default}}\left(b',z',\varepsilon',p',n-1\right)(p'(1-\overline{\xi}_S)+\pi(b',z',\varepsilon',p',n-1))}{b'}|z,p\right],\\
q_{\text{die}} &= \mathbb{E}\left[\frac{min\left\{q^*(n-1)b',p'(1-\xi_S)\right\}}{b'}|p\right].
\end{aligned}$$

In the expressions above, $I_{\text{pay}}(b',z',\varepsilon',p',n-1)$ is an indicator function that is equal to one (zero) if the optimal choice of an agent with states $(b',z',\varepsilon',p',n-1)$ is to make (to not make) his current-period mortgage payment; $I_{\text{prepay}}(b',z',\varepsilon',p',n-1)$ is equal to one (zero) if his optimal choice is (is not) to prepay his mortgage; $I_{\text{default}}(b',z',\varepsilon',p',n-1)$ is equal to one (zero) if his optimal choice is (is not) to default.

The expected discounted lifetime utility of an agent who decides to buy a house satisfies

$$\begin{aligned}
B(b,z,\varepsilon,p,n) &= \max_{b'}\left\{u\left(y-b+b'q(b',z,p,n)-(1+\xi_B)p+\epsilon(b',p,n)\right)\right.\\
&\quad \left.+\beta\chi_n\mathbb{E}\left[H(b',z',\varepsilon',p',n-1)|z,p\right]\right\} \quad (4)\\
&\quad s.t.\\
&\quad b'q(b',z,p,n)\leq p, \quad (5)
\end{aligned}$$

where H denotes the expected discounted lifetime utility of an agent who enters the period as a homeowner; i.e,

$$H(b,z,\varepsilon,p,n)=\begin{cases}\max\{P(\cdot),D(\cdot),S(\cdot),F(\cdot)\}\text{if } b>0\\ \max\{M(\cdot),S(\cdot)\} \text{ otherwise.}\end{cases} \quad (6)$$

If $b > 0$, H is the maximum among four options. The value of the first option is given by P, the expected discounted lifetime utility of making the current-period mortgage payment, in which case the agent cannot further adjust his financial asset position and $b' = b$,

$$P(b, z, \varepsilon, p, n) = u\left(y - b + \epsilon(b, p, n)\right) + \beta \chi_n \mathbb{E}[H(b, z', \varepsilon', p', n-1)|z, p]. \tag{7}$$

The second value is given by D, the expected discounted lifetime utility of defaulting, in which case the agent cannot save or borrow and $b' = 0$,

$$D(b, z, \varepsilon, p, n) = u(y - \pi(b, z, \varepsilon, p, n) - r) - \theta + \beta \chi_n \mathbb{E}[R(0, z', \varepsilon', p', n-1)|z, p]. \tag{8}$$

The value of the third option is given by S, the expected discounted lifetime utility of selling the house and then becoming a renter and saving $b' \leq 0$,

$$S(b, z, \varepsilon, p, n) = \max_{b' \leq 0} \left\{ u\left(y - q^*(n)b + p\left(1 - \xi_S\right) - r + \frac{\chi_n b'}{1 + \overline{r}} \right) - \theta + \beta \chi_n \mathbb{E}[R(b', z', \varepsilon', p', n-1)|z, p] \right\}. \tag{9}$$

The fourth and last value is given by F, the expected discounted lifetime utility of prepaying the mortgage and then asking for a new mortgage or saving,

$$\begin{aligned} F(b, z, \varepsilon, p, n) &= \max_{b'} \left\{ u\left(y - q^*(n)b + q(b', z, p, n)b' + \epsilon(b', p, n)\right) + \beta \chi_n \mathbb{E}[H(b'', \varepsilon', p', n-1)|z, p] \right\} \\ & s.t. \qquad (10) \\ & b' q(b', z, p, n) \leq p. \qquad (11) \end{aligned}$$

If $b \leq 0$, there are only two options. The first option is selling the house and then becoming a renter. The value of this option is S. The second option is to continue as an owner. The value of this option is given by M,

$$\begin{aligned} M(b, z, \varepsilon, p, n) &= \max_{b'} \left\{ u(y - b + q(b', z, p, n)b' + \epsilon(b', p, n)) + \beta \chi_n \mathbb{E}[H(b', z', \varepsilon', p', n-1)|z, p] \right\} \\ & s.t. \qquad (12) \\ & b' q(b', z, p, n) \leq p. \qquad (13) \end{aligned}$$

Borrowing constraints in equations (5), (11), and (13) imply that the agent cannot ask for a mortgage with a loan-to-value ratio higher that 100 percent. With these constraints, a version of our model with $p_t = 0\ \forall t$ is a SIM model without housing and with a zero borrowing limit. This facilitates the comparison of our findings with those of previous studies.

2.6 Discussion of main assumptions

There are several characteristics of our framework that are important in accounting for our results and in differentiating our work from other studies. We assume the agent chooses his debt level.[5] This contrasts with the approach in other studies where the borrower's choice is restricted to a small predetermined set of down payment levels. Since home equity is a key determinant of mortgage default decisions, having a realistic distribution of down payments seems crucial for accounting for mortgage defaults. More importantly, a clear advantage of our approach is that it allows for endogenous changes in down payment levels (that we find are significant) when we perform policy experiments that change the mortgage contracts available to the agent.

We assume that home equity is affected by shocks to house prices that do not affect the services the agent obtains from the house. Thus, our house price shocks affect both the agent's wealth and the price of housing services. Our approach contrasts with the one in previous studies that model shocks to the house value as depreciation shocks that affect the agent's wealth but do not affect the price of housing. Allowing for house price shocks that affect both wealth and housing prices could be important for accounting for the effects of these shocks on non-housing consumption and mortgage default decisions. Additionally, our modeling allows us to calibrate the stochastic process for house prices using estimations obtained with micro data. Previous studies often calibrate depreciation shocks to match the default rate.

We assume the agent borrows using flexible long-term debt contracts. This contrasts with previous studies that assume one-period debt. Long-term debt helps the model generate mortgage defaults given realistic house price changes, as these changes accumulate over time. In addition, each period we allow the agent to refinance by prepaying his mortgage and asking for a new mortgage. In most previous studies, refinancing is not possible or is expensive. Allowing for refinancing makes it possible to study how changes in the mortgage contracts available to the agent may affect homeowners who may want to refinance in the future. As most studies of mortgage debt, we do not allow mortgage debtors to hold multiple mortgages (or home-equity

[5] Our modeling of mortgages extends the equilibrium default model à la Eaton and Gersovitz (1981) that has been used in quantitative studies of credit card debt (see, for example, Athreya, 2005, 2006; Chatterjee et al., 2007).

lines of credit). However, since we allow for prepayment, the agent can change his home equity position. Since home equity is a key determinant of default decisions, the agent must be able to adjust his equity position to be able to choose his exposure to default risk. Importantly, we allow the interest rate on mortgage contracts to be a function of the borrower's characteristics. This eliminates profitable deviations for lenders. Previous studies pool borrowers with different characteristics into the same mortgage contract.[6]

There are two key simplifying assumptions in our framework. First, we assume mortgage payments are constant and the mortgage duration is fixed. However, because we allow borrowers to modify their debt level every period, they can choose a decreasing or increasing pattern of mortgage payments and change the effective duration of their mortgage. Second, as it is standard in models of bankruptcy (Chatterjee et al. (2007)), to save computation time we do not allow agents to hold debt and assets at the same time. However, since we allow borrowers to modify the equity they have in their house, they can change their savings every period. We show in section 4.2 that the agent's ability to self-insure in our framework is comparable to the one in the SIM model without housing where the agent saves using financial assets.

Finally, in order to facilitate the comparison of our findings with those of previous studies of household risk and cross-sectional heterogeneity, we incorporate the features discussed above in a life-cycle SIM model. When we assume that house prices are equal to zero, our model is very similar to the model without housing studied by Kaplan and Violante (2010).

3 Calibration

We calibrate the model using data for the U.S. A period in the model refers to a year; agents enter the model at age 22, retire at age 62, and die no later than at age 82. Survival rates are obtained from the Centers for Disease Control and Prevention. We assume that the initial asset position matches the mean net asset position at age 22 in the 2004 Survey of Consumer Finances.

Our strategy is to feed into the model stochastic processes for income and prices estimated

[6] Corbae and Quintin (2010) show that pooling borrowers into the same contract could affect their results significantly. They discuss how much of the recent rise in foreclosures can be explained by the introduction of mortgage contracts with low down payments and delayed amortization.

using micro data. We pin down the variance of house price innovations σ_ν^2 and the correlation of income and house price innovations ($\rho_{e,\nu}$) by seeking to match the standard deviation of house price growth and the correlation between house price growth and income growth estimated by Campbell and Cocco (2003), $\sigma_{\Delta_p} = 0.115$ and $\rho_{\Delta_p,\Delta_y} = 0.027$, where

$$\begin{aligned}\Delta_p &= \log(p_{t+1}) - \log(p_t),\\ \Delta_y &= \log(y_{t+1}) - \log(y_t),\end{aligned}$$

and σ_{Δ_p} and ρ_{Δ_p,Δ_y} are, respectively, the standard deviation of Δ_p and the correlation coefficient of Δ_p and Δ_y. We use the estimate of the persistence of house prices (ρ_p) by Nagaraja et al. (2009).

The life-cycle component of the income process is calibrated following Kaplan and Violante (2010). The estimated profile peaks after 21 years of labor market experience at twice the initial value, and then it slowly declines to 80 percent of the peak value. The parameters $\sigma_e, \sigma_\varepsilon$ and ρ_z are set according to Storesletten et al. (2004).

For our benchmark, we assume that there is no income garnishment after default; i.e., we assume that ϕ is higher than the maximum possible income level. In Section 5.4 we solve the model for different values of ϕ. We assume rent is zero ($r = 0$) to ensure that agents are always able to afford renting. Therefore, the only cost of renting is determined by the disutility parameter θ.[7]

The disutility from renting, the discount factor, and the mean house price are calibrated to match the homeownership rate, the mean house price-to-income ratio, and median home equity. The mean house price is the key parameter that allows us to match the mean house price-to-income ratio. The discount factor is the key parameter that allows us to match the median home equity, while the disutility associated with renting is the key parameter to determine home ownership in our simulations.

We use estimations presented in previous studies to set the remaining parameter values. We

[7]Chambers et al. (2009a) present a richer model of the homeownership decision and account for the boom in homeownership from 1994 to 2005 by examining the roles of demographic changes and mortgage innovations. Chambers et al. (2009b) study different policies to foster owner-occupied housing and how housing impacts the effects of income tax reforms.

set $\gamma = 2$, which is within the range of accepted values in studies of real business cycles. Following Kocherlakota and Pistaferri (2009), we set $\bar{r} = 2 percent$. We set the cost of buying and selling a house using estimates in Gruber and Martin (2003) and Pennington-Cross (2006). Table 1 presents the value of all parameters used.

4 Results

We solve the model using the discrete state space method. For b, we use 300 evenly spaced grid points between -20 and 20, and 200 evenly spaced grid points between -120 and -20.[8] The grid for income and house price shocks are obtained according to Terry and Knotek II (2008). In all cases we center points around the mean and we use a radius of 3 standard deviations. For the permanent income shock we use 15 grid points, for the transitory income shock we use 5, and for the house price shock we use 11. We simulate the behavior of 20,000 agents during their lifetime. Statistics are computed using Census data to assign population weights to each cohort.

The rest of this section is organized as follows. First, we discuss the ability of our benchmark model to match basic features of the housing and mortgage markets. Second, we discuss the agent's ability to self-insure. Third, we study the effect of imposing minimum down payment restrictions. Fourth, we discuss the effects of introducing income garnishment.

4.1 Housing and mortgages

Table 2 reports moments in the data and in our simulations. Statistics are computed using agents younger than 62 years of age. The data are taken from the 2004 SCF (Survey of Consumer Finances).[9]

Table 2 shows that we approximate well the three targeted moments: homeownership, mean price-to-income ratio, and median net worth-to-income ratio. This table also illustrates a tension between approximating home equity and net worth in the data. This tension is not surprising

[8]Hatchondo et al. (2010) discuss the computation cost of obtaining accurate solutions in equilibrium default models.

[9]We consider agents between 22 and 62 years of age that are not in the top 5 percentile of wealth for comparability with the data generated using the model.

Table 1: Parameter values.

Parameter	Value	Definition	Basis
σ_ν^2	0.302	Variance of ν	Campbell and Cocco (2003)
$\rho_{e,\nu}$	0.115	Correlation e and ν	Campbell and Cocco (2003)
ρ_p	0.970	Persistence in p	Nagaraja et al. (2009)
$f(a)$	–	Life-cycle component	Kaplan and Violante (2010)
σ_ε^2	0.0630	Variance of ε	Storesletten et al. (2004)
σ_e^2	0.0166	Variance of e	Storesletten et al. (2004)
ρ_z	0.990	Persistence in z	Storesletten et al. (2004)
ϕ	∞	Income not subject to garnishing	No garnishment
r	0	Rent	Positive consumption
$\overline{r}$	0.020	Risk-free rate	Kocherlakota and Pistaferri (2009)
b_0	0.250	Initial wealth	SCF
γ	2.000	Risk aversion	Standard RBC
ξ_B	0.025	Cost of buying, hhds	Gruber and Martin (2003)
ξ_S	0.070	Cost of selling, hhds	Gruber and Martin (2003)
$\overline{\xi}_S$	0.220	Cost of selling, bank	Pennington-Cross (2006)
θ	0.105	Renting disutility	Calibrated to match targets
$\overline{p}$	5.699	Mean price	Calibrated to match targets
β	0.945	Discount factor	Calibrated to match targets

Table 2: Benchmark simulations

	Data 2004	Model
Home ownership rate (%)	64.5	63.1
Mean price-to-income ratio	2.6	2.6
Median net-worth-to-income ratio	1.4	1.4
Mean equity-to-price ratio (%)	50.0	65.7

since in our model borrowers can save only by increasing their home equity. In spite of generating mean equity that is too high, our model can generate poor agents with negative equity who are willing to default. The default rate generated by the model is 0.6 percent, which is close to the default rate of 0.5 percent used by Jeske et al. (2010).[10]

In addition, our model matches other measures of indebtedness in the data. Figure 1 shows that the endogenous distribution of down payments generated by the model matches closely its empirical counterpart. We constructed the empirical distribution using data on combined loan-to-value ratios at origination for the 2000-2009 period presented by Paniza Bontas (2010).[11]

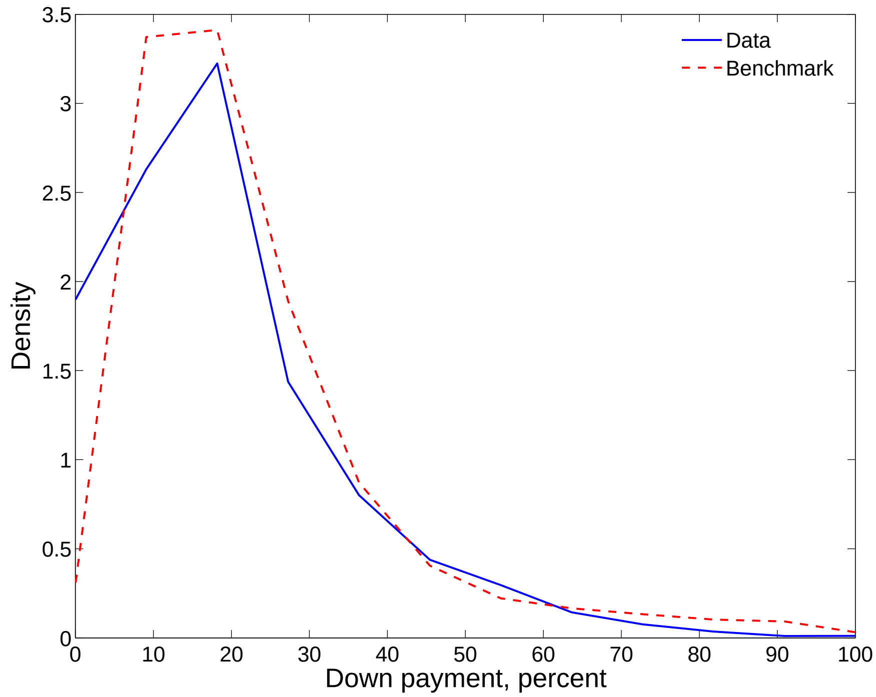
Figure 2 shows that the model also generates an increasing life-cycle profile of homeownership, similar to the one observed in the data. Note that this occurs even though our calibration targets only the average homeownership rate.

In order to illustrate the importance of assuming long-term debt for generating defaults, we computed the share of mortgages in default by age (or tenure) of the contract using our simulations. The results are depicted in Figure 3. Most defaults result from the accumulation

[10] Jeske et al. (2010) study the macroeconomic effects of a mortgage interest rate subsidy. They explain that the quarterly foreclosure rate was 0.4 percent between 2000 and 2006 and that the ratio of mortgages in foreclosure that eventually end in liquidation was 25 percent in 2005 (as reported by the Mortgage Bankers Association). They argue that since a default in their model implies that the agent hands in his house to the bank, the default rate in the model should be closer to the liquidation rate in the data. They also argue that since the default rate in the data is for a period of strong house price appreciation, they should target a higher default rate.

[11] Paniza Bontas (2010) presents a detailed description of the data. We thank Jennifer Paniza Bontas for sharing her data with us. That the model generates a share of mortgages with zero down payments lower than the one in the data could be explained by the lack of growth of the aggregate house price level in the model (which contrasts with the high growth of the aggregate house price level observed between 2000 and 2009).

Figure 1: Down payment distribution



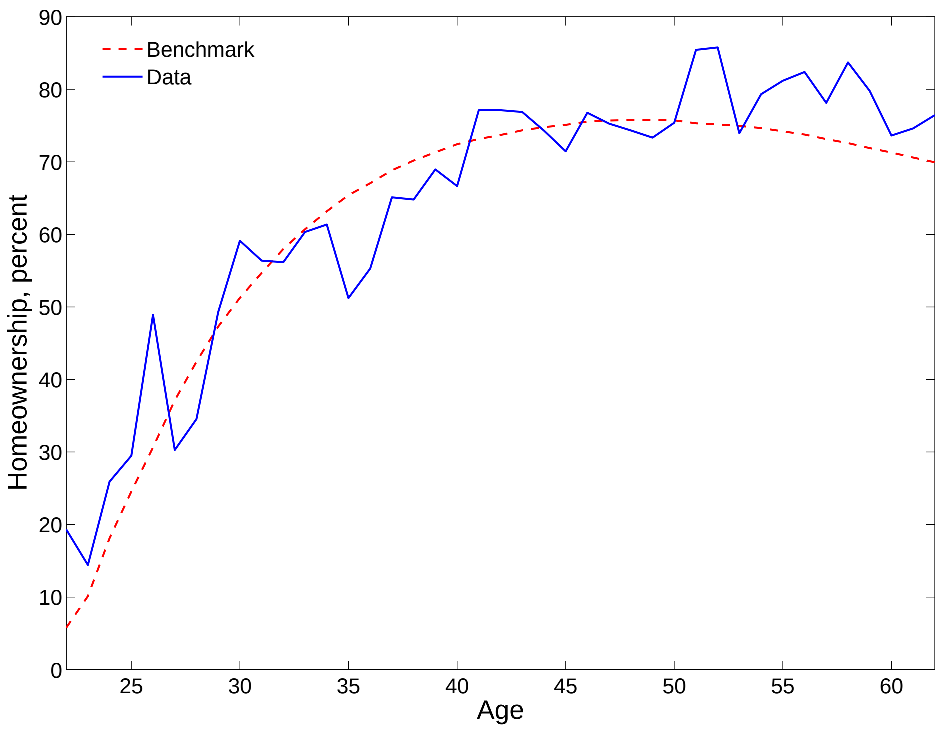
of house price declines over several periods. Only 6 percent of the mortgages in default were acquired in the previous period.

Another central aspect of mortgage contracts in our model is that, every period, the agent can modify his contract. Consequently, in spite of our assumption of a unique mortgage with constant payments and a given nominal duration, the agent can choose a decreasing or increasing pattern of payments and the effective duration of his debt. Figure 4 shows that agents use the prepayment option often: 51 percent of mortgages are less than five years old.[12]

The prepayment option also implies that, even though we assume debtors cannot hold financial assets, they can choose to adjust their saving level by adjusting their home equity. In the next subsection we show that the saving flexibility we give to agents seems to be enough for the

[12] It should be mentioned that, since our model does not allow for multiple mortgages and home equity lines of credit, the agent can adjust his home equity only by pre-paying his mortgage. Thus, one should not attempt to match the mortgage tenure distribution in the data with the one predicted by the model.

Figure 2: Home ownership over the life cycle



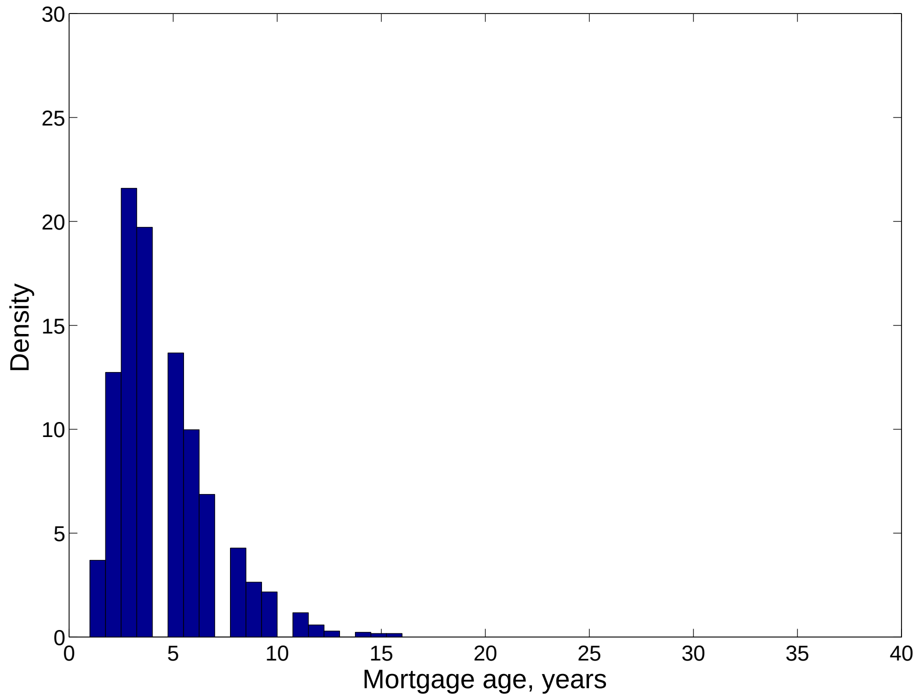
model to produce reasonable consumption smoothing predictions.

4.2 Self-insurance

In this section, we assess the agent's ability to self-insure against each of the three shocks in our benchmark. Recall that, for tractability, we assume that debtors cannot hold financial assets. Thus, debtors can adjust their savings only by changing their home equity (which they can do by prepaying their mortgage and obtaining a new mortgage with no transaction cost).[13] We show that our simplifying assumption does not seem to impair debtors' ability to self-insure against adverse shocks: The response of consumption to income shocks implied by our model is

[13]Even though there are no transaction costs for refinancing, when the agent prepays his mortgage future payments are discounted at the risk-free rate, which, because of the default premia, may be lower than the interest rate at which he borrows. This difference is not quantitatively important.

Figure 3: Mortgages in default by tenure (in the simulations)



comparable with the response implied by a SIM model without housing in which the agent saves using financial assets.

As in Blundell et al. (2008) and Kaplan and Violante (2010), we define the insurance coefficient for shock x_{it} as

$$\mu^x = 1 - \frac{cov(\Delta c_{it}, x_{it})}{var(x_{it})},$$

where the variance and covariance are taken cross-sectionally over the entire population.[14] Similarly, the insurance coefficient at age t, μ_t^x, is computed using the variance and covariance calculated for all agents of age t. The insurance coefficient is interpreted as the share of the variance of the x shock that does not translate into consumption growth.

Table 3 presents the value of insurance coefficients in the simulations of our benchmark. This

[14] Also as in Blundell et al. (2008) and Kaplan and Violante (2010), when computing insurance coefficients, log consumption and log after-tax earnings are defined as residuals from an age profile.

Figure 4: Mortgages not in default by tenure (in the simulations)

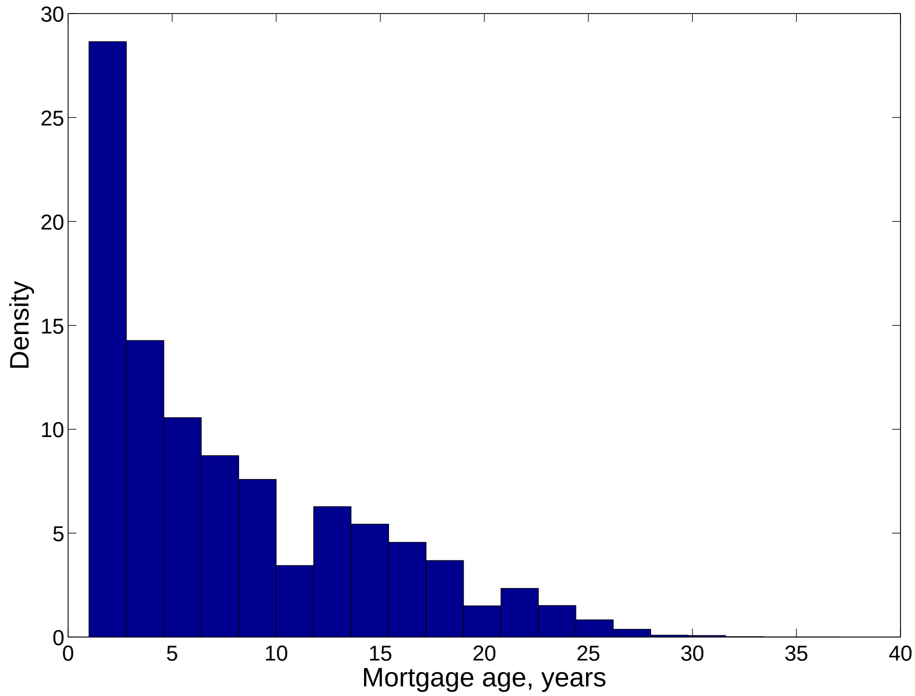


table also presents these coefficients for a version of our model without housing ($p_t = 0\ \forall t$) and with an adjusted discount factor ($\beta = 0.96$) that implies the median net worth to income ratio in the benchmark. Comparing coefficients for that version of the model with the ones for our benchmark helps us to tease out how introducing housing affects the predictions of a SIM model about the agent's ability to self-insure against income shocks. In addition, this table presents the data coefficients estimated by Blundell et al. (2008) (standard errors in parenthesis) and the coefficients obtained by Kaplan and Violante (2010) using a SIM model without housing. Kaplan and Violante (2010) report the insurance coefficients implied by a SIM with a zero borrowing limit, with a natural borrowing limit, and for different degrees of persistence of the permanent earning shock. We present the coefficients that Kaplan and Violante (2010) obtained for the same persistence in permanent earning shocks that we assume in our calibration.

Table 3 shows that insurance coefficients for earnings shocks in our benchmark are similar to

Table 3: Insurance coefficients

Shock	Benchmark	No housing	Kaplan and Violante	Blundell et al.
Persistent shock (%)	25.7	25.3	27.0, 30.0	36.0 (9.0)
Transitory shock (%)	81.9	82.9	82.0, 93.0	95.0 (4.0)
House price shock (%)	98.4	na	na	na

The first (second) term in the fourth column correspond to an economy with a zero (natural) borrowing limit.

the ones for the economy without housing and to the ones Kaplan and Violante (2010) report for the case with a zero borrowing limit. Note that our model without housing is a zero-borrowing-limit model very similar to the one presented by Kaplan and Violante (2010) and our calibration is also close to theirs.[15] Thus, our findings indicate that on average the introduction of housing does not seem to have significant effects on the agent's ability to self-insure against income shocks predicted by the SIM model. In particular, our simplifying assumption on the debtors' inability to hold financial assets does not have major consequences on the SIM model's predictions about their ability to self-insure. Like the coefficients obtained by Kaplan and Violante (2010), our coefficients are lower than the point estimates in Blundell et al. (2008).[16]

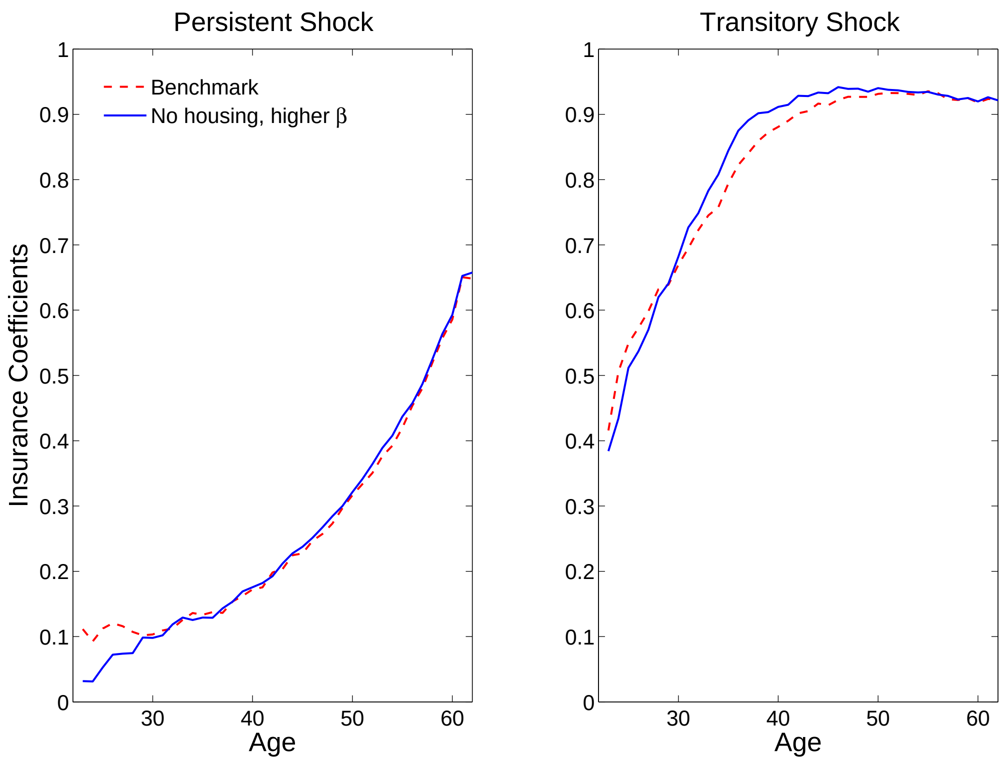
Even though we do not find a significant effect of housing on the average insurance coefficients, Figure 5 shows that incorporating housing increases the coefficients for younger agents. Kaplan and Violante (2010) explain that the "misalignment between the age-profile of insurance coefficients in the model and the data is particularly acute for young individuals." Figure 5 indicates that introducing housing narrows the gap between the implications of the SIM model and the data. This was conjectured by Kaplan and Violante (2010).

Table 3 also reports our benchmark's insurance coefficients for the house price shock—Kaplan and Violante (2010) and Blundell et al. (2008) do not study this shock. In our benchmark calibration, 98 percent of the variance of the house price shock does not translate into changes in consumption. This is consistent with the mild response of consumption to house price shocks

[15]The main difference being our simplified social security system.

[16]Kaplan and Violante (2010) discuss how the coefficients estimated by Blundell et al. (2008) may be biased.

Figure 5: Insurance Coefficients



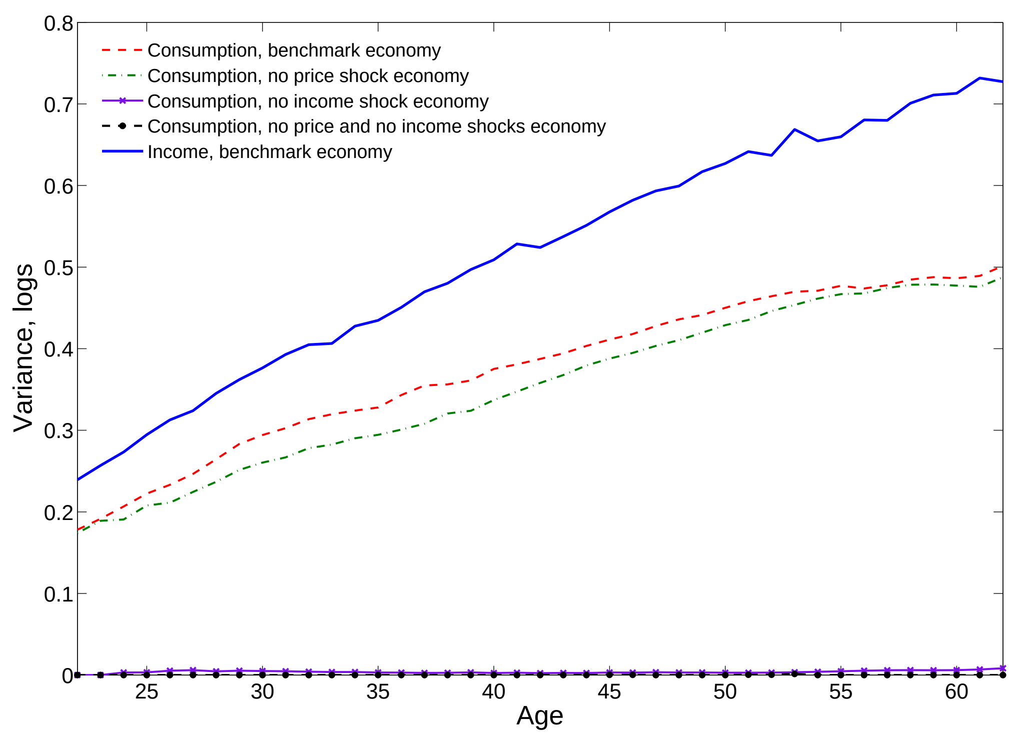
found by Li and Yao (2007).[17] Obtaining empirical estimates of the effects of changes in house prices on consumption is challenging, and, therefore, the range of estimates is large (see Carroll et al., 2011, and the references therein). The mild response of consumption to house price shocks in our model is consistent with the lower end of empirical estimates. One could expect this response to be mild because a house is not only an investment vehicle but also a consumption good.

To further test the extent of risk sharing in our benchmark and the effects of the house price shock on consumption inequality, Figure 6 presents the growth in consumption dispersion over the life cycle in the benchmark and in economies where the shocks' variances are assumed to be equal

[17]The framework presented by Li and Yao (2007) differs from ours in that they assume an exogenous collateral constraint to both newly initiated mortgages and ongoing loans and that they assume i.i.d. permanent house price shocks that are not correlated with earning shocks.

to zero. In our model, as in the data and previous SIM models, the cross-sectional variance of log consumption increases linearly over the life cycle and is lower and increases more slowly than the cross-sectional variance of log income. Furthermore, the growth in the cross-sectional variance of log consumption in our benchmark is between the range of empirical estimates.[18] Figure 6 also shows that most of the consumption inequality is explained by earning shocks: When we assume these variances are zero, consumption inequality almost disappears. In contrast, when we assume that the variance of the house price shock is equal to zero, there is only a modest shift in consumption inequality.

Figure 6: Inequality over the life cycle



[18]See Storesletten et al. (2004).

Table 4: Default and ownership under different down payment requirements

	Benchmark	$\geq$ 15 %	$\geq$ 20 %	$\geq$ 25 %
Default rate (%)	0.6	0.4	0.3	0.2
Home ownership (%)	63.1	62.9	62.5	61.8

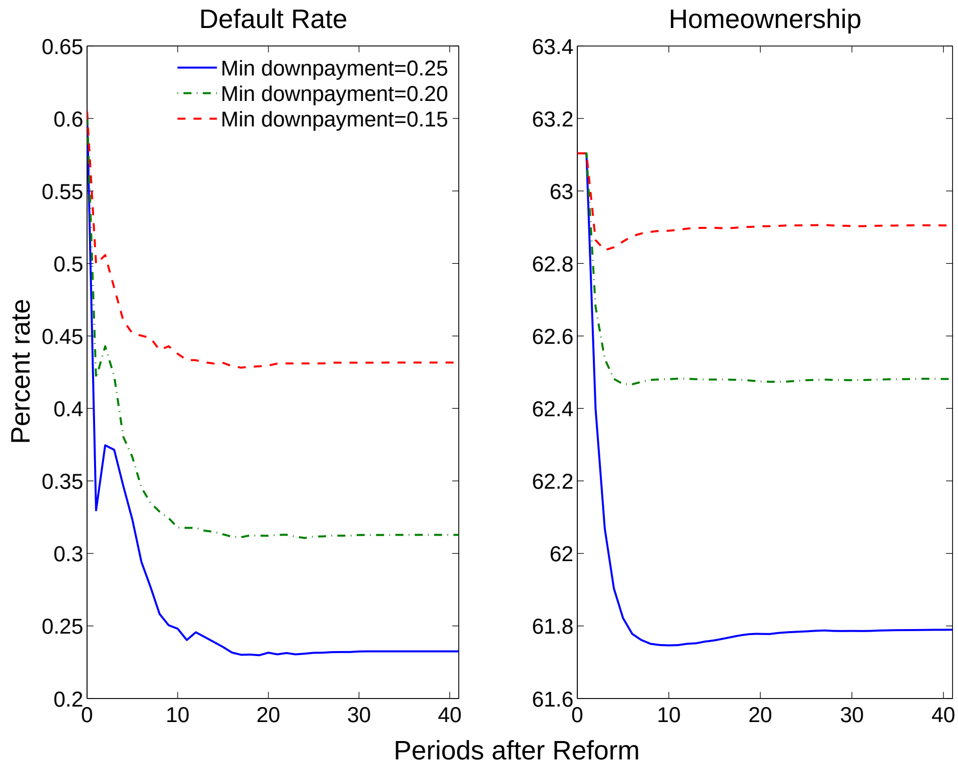
4.3 Down payment requirements

In this section, we study the effects of imposing down payment requirements. Table 4 reports the default and home ownership rate in economies with minimum down payments of 15 percent, 20 percent, and 25 percent. This table shows that economies with a higher minimum down payment feature a significantly lower default rate at the cost of a mild decline in the home ownership rate. Furthermore, as the down payment requirement increases, a given decline in the default rate seems to imply a larger decline in homeownership.

Figure 7 presents the evolution of the default and homeownership rates after the minimum down payment requirement is imposed in the benchmark economy. The figure shows that about half of the long-run decline in the default rate is observed in the year when the requirement is implemented, and most of the remaining decline in the default rate occurs over the next 10 years. For the highest down payment requirement we imposed, which results in the most significant decline in homeownership, it takes six years for the homeownership rate to decline 1.3 percentage points to its new long-run level.

Figure 8 shows that a majority of agents in our benchmark economy would benefit from the imposition of a minimum down payment requirement. The figure presents the distribution of welfare gains from minimum down payment requirements using the distribution of agents observed in our simulations. We measure welfare gains as consumption compensations (in percentage terms) that make agents indifferent between the benchmark economy with a non-negative down payment requirement and economies with higher minimum down payment requirements. A positive compensation means that agents prefer the alternative economy over the benchmark

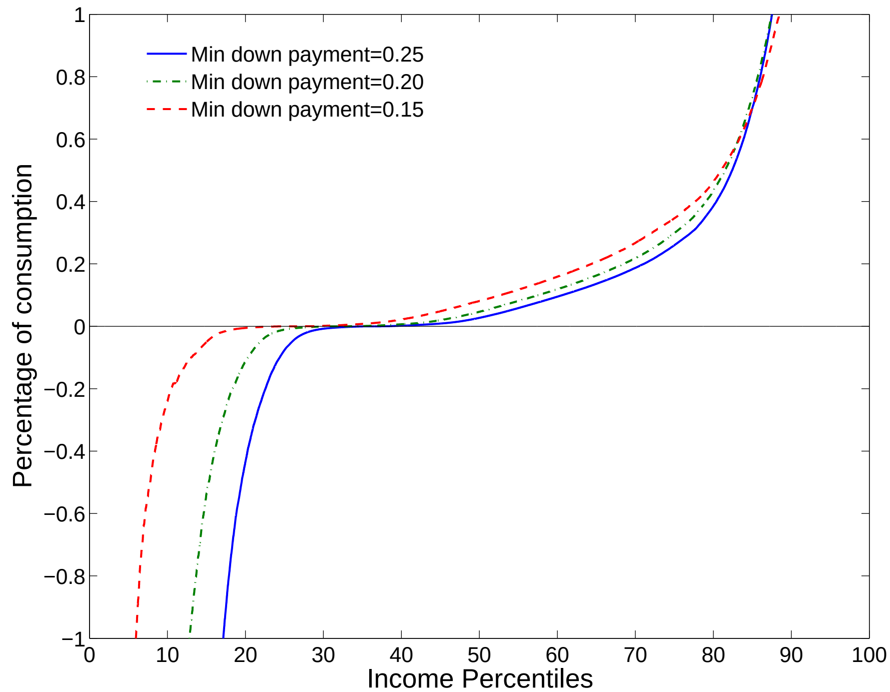
Figure 7: Transitions after the imposition of down payments requirements



economy. Down payment requirements make it more difficult for renters to buy a house; they are forced to save more before buying it. The increased difficulty of buying a house benefits most homeowners (a thus a majority of the population). This occurs because as it becomes more difficult to buy a house, the cost of defaulting on a mortgage and then losing the house is higher. A higher defaulting cost decreases the default probability, and thus reduces the cost of borrowing and allows homeowners to refinance their mortgage at a lower rate.

Figure 9 illustrates how the introduction of a minimum down payment requirement decreases the cost of borrowing. This figure presents the interest rate spread (the yield the borrower has to pay on top of the risk-free rate) as a function of the down payment. The figure is constructed for an agent who would choose to buy a house both with or without the down payment restriction. Dots in Figure 9 represent the optimal choice of this agent for each case. This shows that while the minimum down payment restriction forces the agent to buy a house with a higher down

Figure 8: Distribution of welfare gains from minimum down payment requirements

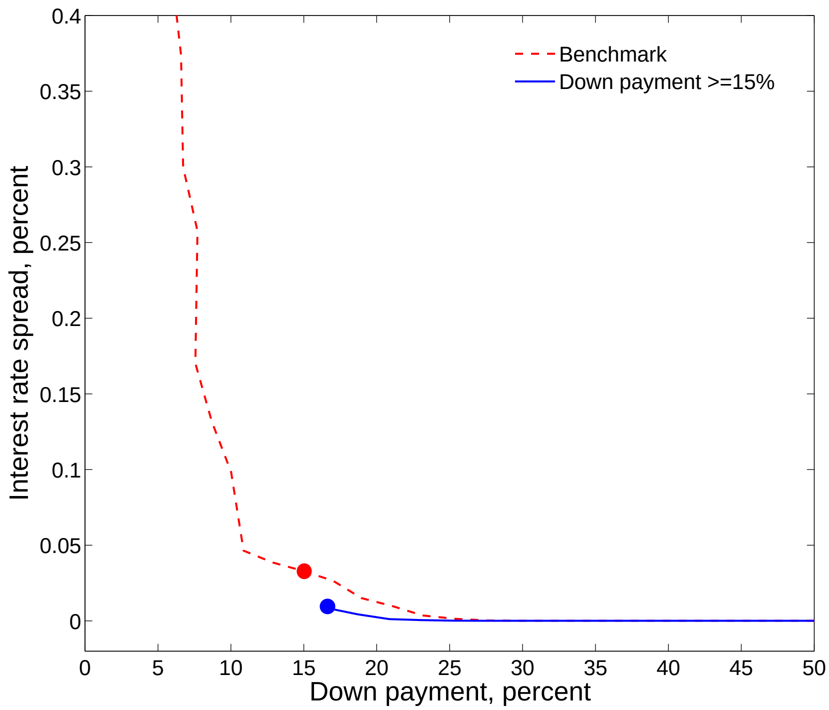


payment, it also allows him to finance it with a lower interest rate.

The analysis presented up to here assumes that house prices are not affected by shifts in the demand for (owner-occupied) housing implied by the imposition of down payment requirements (i.e., it assumes the supply of housing is perfectly elastic). The extreme assumption of a perfectly elastic housing supply is commonly used in the literature and provides a useful benchmark, especially for studying long-run effects. However, analyzing cases with a less elastic supply of housing may also be informative.[19] Thus, we next study the other extreme case in which, after the imposition of down payment requirements, the mean house price level, $\bar{p}$, declines so that homeownership (i.e., the quantity of owner-occupied housing) does not change. This case is a useful benchmark because it gives us an upper bound on the model's prediction for the house

[19]Chatterjee and Eyigungor (2009) study the effect on mortgage defaults of an unanticipated increase in the supply of housing that affects the endogenous house price. They assume that house prices are constant in the steady state in which agents cannot modify their mortgage contract and can terminate this contract only if they choose to sell the house.

Figure 9: Borrowing opportunities and minimum down payment requirement



price decline implied by down payment requirements. We also present results for intermediate cases in which both $\bar{p}$ and ownership adjust.

Table 5 presents the effects of minimum down payment requirements under different responses of the aggregate house price level $\bar{p}$. The table shows that on average, if $\bar{p}$ declines 1 percent, homeownership increases by 0.3 percentage points. This relationship is remarkably stable across the different cases considered in the table. It also indicates that 0.7 percent, 2.0 percent, and 4.9 percent are upper bounds for the long-run decline in the mean house price implied by the introduction of minimum down payments of 15 percent, 20 percent, and 25 percent, respectively (starting from an economy with a nonnegative down payment restriction). This table also shows that changes in the aggregate house price level do not translate into significant changes in the long-run default rate predicted by the model. Furthermore, ex-ante welfare losses implied by minimum down payment requirements are smaller when the aggregate house price level declines.

Since agents enter the economy without houses and most of them buy houses at some point, they benefit from more affordable housing. On average, a decline in the aggregate house price level of 1 percent implies an ex-ante welfare gain of 0.03 percent, in terms of consumption equivalent units. This relationship is also remarkably stable across the different cases considered in the table.

4.4 Income Garnishment

In this section, we study the effects of allowing for income garnishment by decreasing the maximum income a defaulting agent can keep (denoted by ϕ). Table 6 shows that when ϕ is lower (i.e., when lenders can garnish more income from defaulters), the default probability is lower even though down payments are lower. The model's predictions are consistent with the effects of augmenting garnishment that one would expect. Ghent and Kudlyak (2011) exploit law differences across U.S. states and find that defaulter-friendly laws have a positive effect on the default probability. Pence (2006) finds that the average loan size is smaller in states where foreclosure laws are more defaulter friendly.

To give more economic content to the experiments presented in Table 6, one can think about the income that defaulters are allowed to keep after garnishment as a percentage of median consumption. For $\phi = 1.45$, $\phi = 0.63$, and $\phi = 0.25$, these percentages are 100 percent, 43 percent, and 17 percent, respectively. Thus, Table 6 indicates that relatively low levels of post-garnishment consumption are necessary for garnishment to have significant effects on the default rate. However, this is in part because for simplicity, we assume that all garnishment occurs in one year. Similar results could be obtained by garnishing less over a longer period.

A long literature (in law, history, and economics) has emphasized that facilitating defaults can be welfare enhancing because the ability to repudiate debts can play an important role in helping agents fend against adverse shocks (see Athreya et al., 2009; Bolton and Jeanne, 2005; Grochulski, 2010, and references therein). Table 7 shows that the effects of strengthening garnishment (and thus increasing the cost of defaulting) on the agents' ability to self-insure are minimal. The variance of log consumption and the insurance coefficients are almost identical

Table 5: Minimum down payment requirements under different housing supply elasticities

	Perfectly elastic supply	Intermediate case	Perfectly inelastic supply
	Min down payment = 15 %		
$\bar{p}$ decline, %	0.0	0.3	0.7
Home ownership, %	62.9	63.0	63.1
Default rate, %	0.4	0.4	0.4
Ex-ante welfare gain, %	-0.02	-0.02	-0.01
	Min down payment = 20 %		
$\bar{p}$ decline, %	0.0	1.0	2.0
Home ownership, %	62.5	62.8	63.1
Default rate, %	0.3	0.3	0.3
Ex-ante welfare gain, %	-0.09	-0.06	-0.04
	Min down payment = 25 %		
$\bar{p}$ decline, %	0.0	3.0	4.9
Home ownership, %	61.8	62.5	63.1
Default rate, %	0.2	0.2	0.2
Ex-ante welfare gain, %	-0.20	-0.11	-0.06

Table 6: Summary statistics under different garnishment rules

	Benchmark	$\phi = 1.45$	$\phi = 0.63$	$\phi = 0.25$
Default rate (%)	0.6	0.6	0.4	0.1
Home ownership (%)	63.1	63.7	67.4	69.8
Median down payment (%)	19.0	16.8	9.0	6.6

Table 7: Insurance under different garnishment rules

	Benchmark	$\phi = 1.45$	$\phi = 0.63$	$\phi = 0.25$
Var(log C)	0.4	0.4	0.4	0.4
Persistent-income-shock insurance coefficient (%)	25.7	24.9	23.6	23.2
Transitory-income-shock insurance coefficient (%)	81.9	81.6	80.3	80.3
Price-shock insurance coefficient (%)	98.4	98.4	98.3	98.1

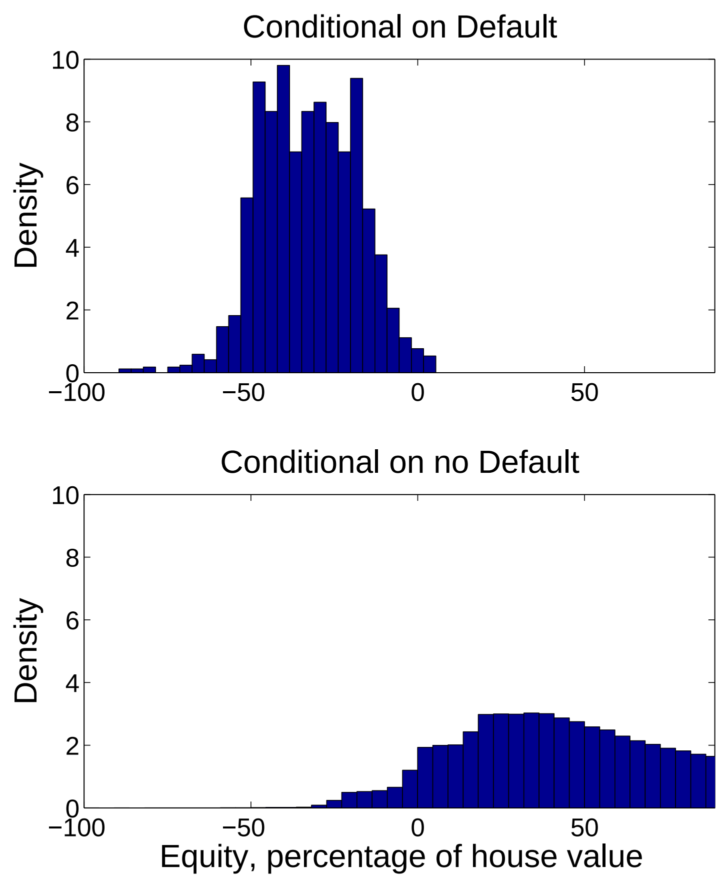
across economies with different degrees of garnishment.

The findings presented in the previous paragraph imply that legislation that protects defaulters would be difficult to justify for its effects on consumption smoothing. There are three forces behind these findings. First, the share of agents who benefit from debt forgiveness after defaulting is small. Even without garnishment, mortgage defaults are triggered by unlikely declines in house prices. Figure 10 indicates the strong correlation between mortgage defaults and equity (and thus house price shocks).[20] Second, benefits from debt forgiveness are not well targeted to low-income agents. In our benchmark economy (without garnishment), the mean income of defaulting agents is lower than the mean income of non-defaulters, but defaults by agents with

[20]It should be mentioned that, in the figure, equity is calculated using the house price and not the price minus the selling cost, which is relevant for the agents' default decision. This is why there are defaults with positive equity in the figure. Empirical studies document the importance of home equity for default decisions. See, for example, Bajari et al. (2008), Campbell and Dietrich (1983), Deng et al. (2000), Mayer et al. (2009), and Schwartz and Torous (2003).

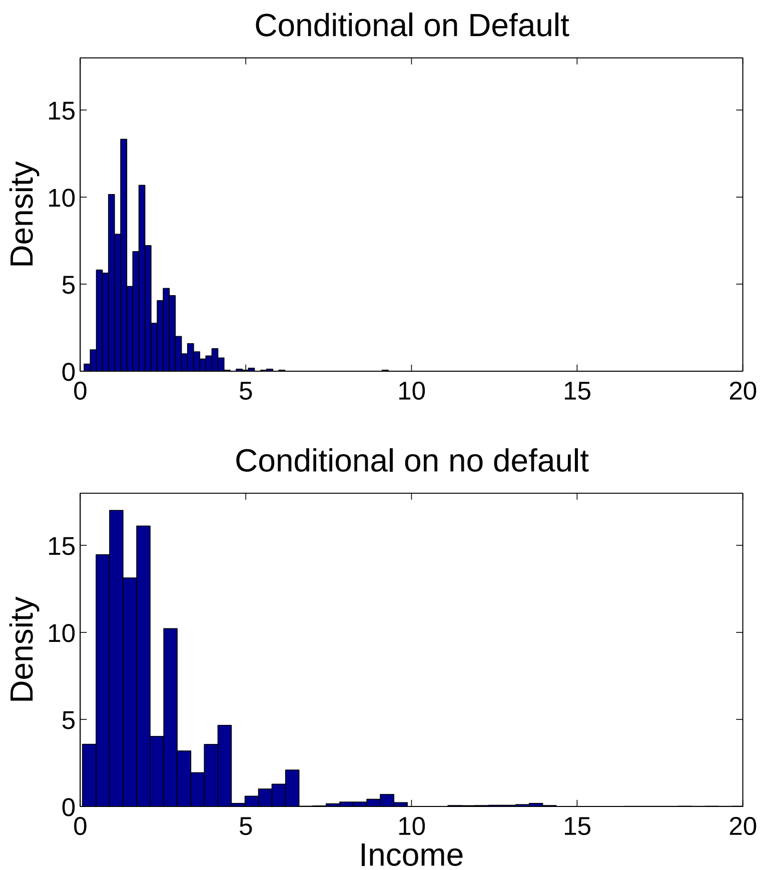
relatively high income are frequent. This is illustrated in Figure 11, which shows the income distribution of defaulters (top panel) and non-defaulters (bottom panel). Third, as illustrated by the insurance coefficients presented in Table 7, the average effects of changes in house prices on consumption is small and is not significantly affected by the degree of garnishment in the economy.

Figure 10: Equity distributions in the benchmark economy



The minimal effects of garnishment on the agents' ability to self-insure contrasts with the significant effects of this policy on the agents' ability to borrow (illustrated by the changes in down payment levels presented in Table 6). Figure 12 further illustrates how garnishment relaxes borrowing constraints. This figure presents the interest rate spread as a function of the

Figure 11: Income distributions in the benchmark economy



down payment for an agent who would choose to buy a house both with or without garnishment, with the dots representing the optimal choice of this agent for each case. It shows that garnishment allows the agent to have a mortgage with both a lower down payment and a lower interest rate. The relaxation of the agents' borrowing constraints implied by garnishment has significant effects on homeownership. The results presented in Table 6 show that when we allow for enough garnishment to almost eliminate defaults, homeownership increases by more than 6 percentage points. Figure 13 indicates that the increase in the level of homeownership implied by garnishment is generated by precipitating the decision of becoming a homeowner. That the effect of garnishment is stronger for young agents is not surprising because these agents typically are borrowing constrained and find it more difficult to pay down payments.

Figure 12: Borrowing opportunities and income garnishment

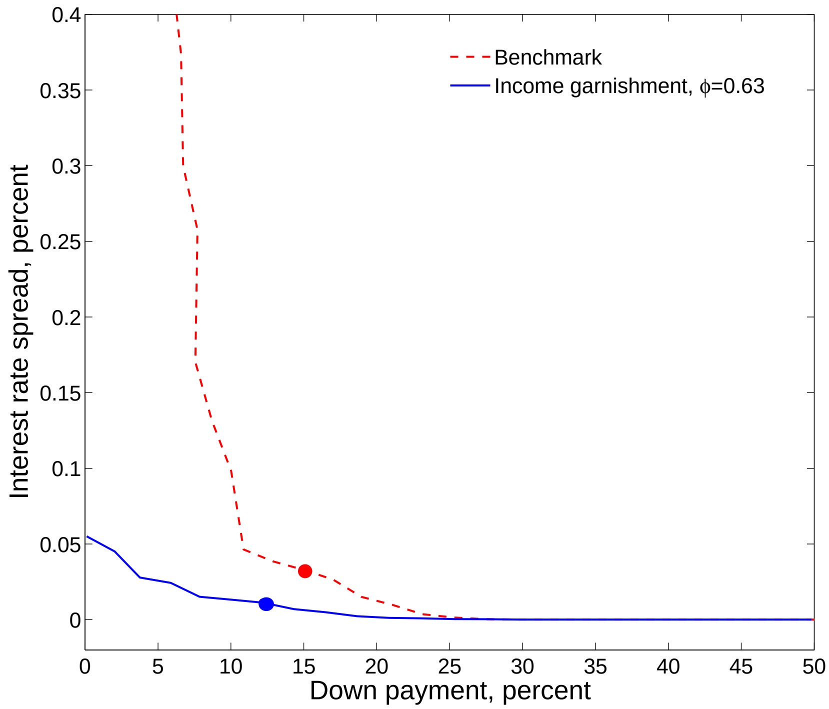
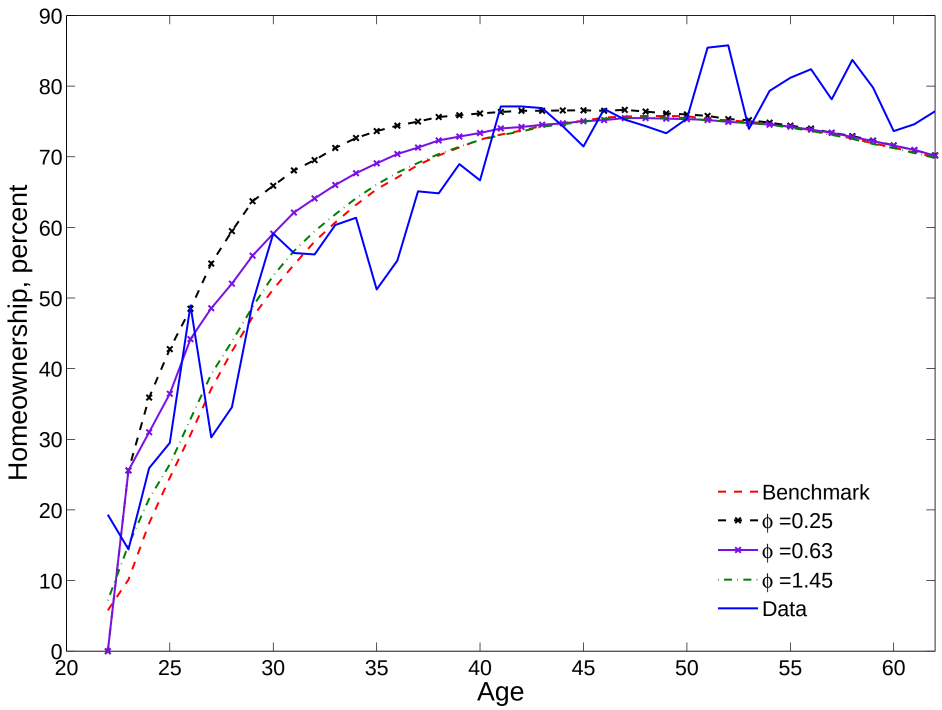


Figure 14 presents the evolution of the default and homeownership rates after garnishment is imposed. We assume that the garnishment rule becomes effective one period after its announcement and it applies to both new and existing loans. This is the way in which the 2005 reform in the bankruptcy legislation—that made filing for bankruptcy harder—was introduced. The possibility of defaulting in the announcement period before the imposition of garnishment reduces the negative effect of imposing garnishment on existing loans. Figure 14 shows that this creates a spike in defaults in the announcement period, which is consistent with the spike in bankruptcy fillings observed before the implementation of the 2005 reform. Agents who are likely to default in the future prefer to default before garnishment is introduced. This figure also shows that after the initial spike, the default rate falls drastically (to zero in the case of $\phi = 0.25$) because agents who were likely to default did so before the imposition of garnishment. After that sharp decline

Figure 13: Home ownership over the life cycle, different garnishments

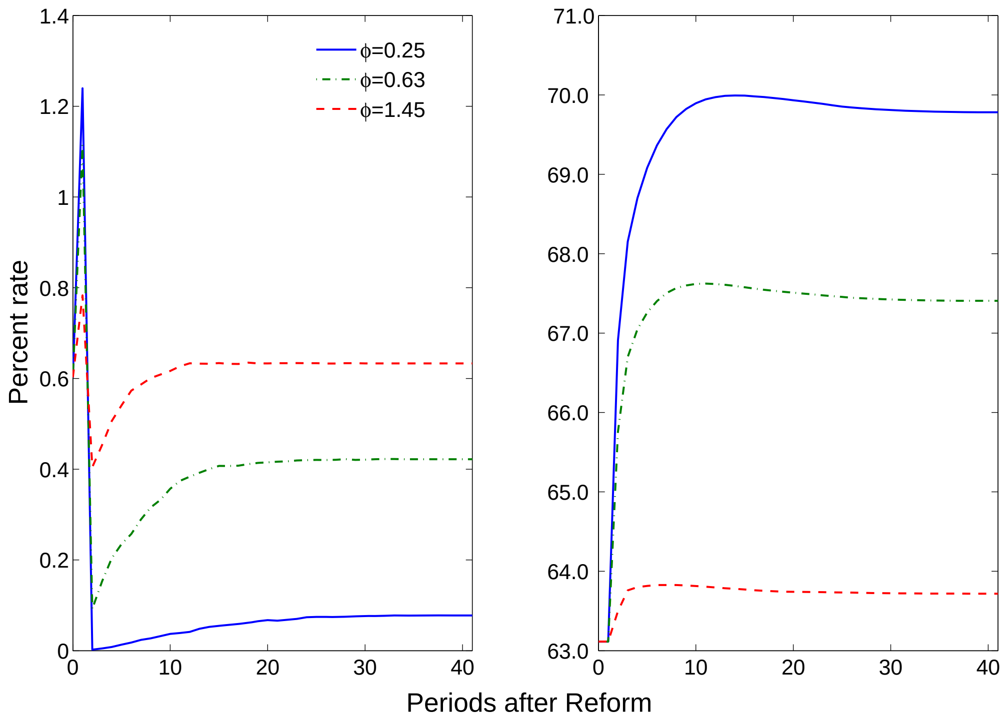


the default rate increases to its long-run value. In addition, Figure 14 shows that for the harsher garnishment policy we consider, it takes up to 10 years for the homeownership rate to increase 6.6 percentage points to its new long-run level.

Figure 15 shows that almost all agents in our benchmark economy would benefit from the imposition of income garnishment. Since an increase in income garnishment does not have a significant negative effect on the agents' ability to self-insure but it has a significant positive effect on their ability to borrow, for most agents welfare increases with the level of garnishment in the economy. However, as explained above, since we impose garnishment also on existing loans, debtors who are very likely to default are harmed by this policy.

As we did when we studied down payment requirements, we now consider cases with changes in the aggregate house price level $\bar{p}$. Table 8 presents the effects of income garnishment under different responses of $\bar{p}$. This table shows that on average, if $\bar{p}$ increases 1 percent, homeownership

Figure 14: Transitions after the imposition of income garnishment

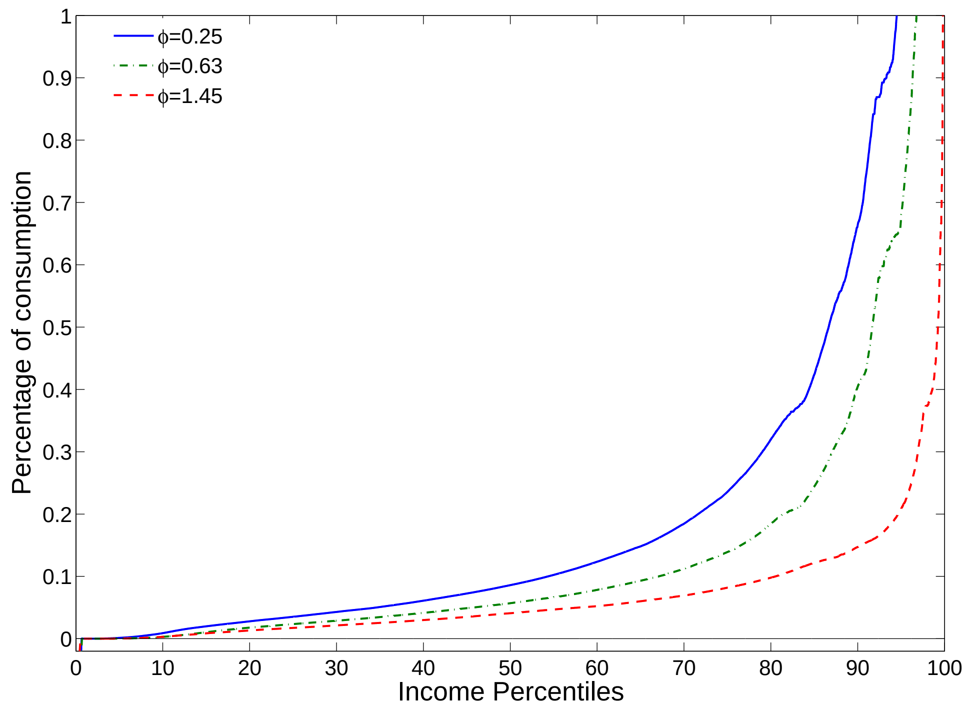


declines by 0.3 percentage points and ex-ante welfare declines 0.03 percent, in terms of consumption equivalent units. Additionally, Table 8 shows that garnishment could imply increases in house prices of up to 27 percent if the housing supply does not adjust. These price increases imply a deterioration of housing affordability that washes out most of the ex-ante welfare gains from introducing garnishment.

Table 8: Income garnishment under different housing supply elasticities

	Perfectly elastic supply	Intermediate case	Perfectly inelastic supply
		$\phi = 1.45$	
$\bar{p}$ increase, %	0.0	1.0	2.0
Home ownership, %	63.7	63.4	63.1
Default rate, %	0.6	0.6	0.6
Ex-ante welfare gain, %	0.16	0.13	0.10
		$\phi = 0.63$	
$\bar{p}$ increase, %	0.0	9.4	15.8
Home ownership, %	67.4	65.0	63.1
Default rate, %	0.4	0.4	0.4
Ex-ante welfare gain, %	0.64	0.34	0.15
		$\phi = 0.25$	
$\bar{p}$ increase, %	0.0	13.9	27.4
Home ownership, %	69.8	66.3	63.1
Default rate, %	0.1	0.1	0.1
Ex-ante welfare gain, %	0.85	0.41	0.04

Figure 15: Distribution of welfare gains from income garnishment



5 Conclusions

We incorporated house price risk and mortgages into a SIM model and showed that the model produces plausible implications for mortgage borrowing and default behavior. We also showed that incorporating housing does not have a significant effect on the average income insurance coefficients obtained with the SIM model but it increases the values of the coefficients for young agents. Furthermore, we found that the response of consumption to house price shocks in the model is minimal. We studied two policies intended to mitigate mortgage default risk: Imposing minimum down payment requirements and imposing garnishment of defaulters' income. We showed that both policies would reduce the mortgage default rate and would benefit a majority of agents. While down payment requirements reduce the default rate because there are fewer agents with low equity, in the case of garnishment there are more agents with low equity, but there are fewer defaults because the cost of defaulting is higher.

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