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DECISIONS: A STRUCTURAL ESTIMATION

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Interactions Between Job Search and Housing Decisions: A Structural Estimation*

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Abstract

In this paper, we investigate to what extent shocks in housing and financial markets account for wage and employment variations in a frictional labor market. To explain these interactions, we use a model of job search with accumulation of wealth as liquid funds and residential real estate, in which house prices are randomly persistent. First, we show that reservation wages and unemployment are increasing in total wealth. And, second, we show that reservation wages and unemployment are also responsive to the composition of wealth. Specifically, when house prices are expected to rise, holding a larger share of wealth as residential real estate tends to increase reservation wages, which deteriorates employment transitions and increases unemployment. We estimate our model structurally using National Longitudinal Survey of Youth data from 1978 to 2005, and we find that more relaxed house financing conditions, in particular lower down payment requirements, decrease employment rates by 5 percentage points in the short run and by 2 percentage points in the long run. We also find that worse labor market conditions immediately increase homeownership rates by up to 5 percent points, whereas in the long run homeownership decreases by 8 percentage points.

Keywords: job search, housing, savings, structural estimation

JEL Classifications: J64, E21, E24, R21

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1 Introduction

The effects of deteriorating labor market conditions on wealth accumulation have been sufficiently studied and are well understood. The same cannot be said for the impact of changes in home financing conditions and the composition of wealth on job search dynamics, which are relatively less understood. This paper aims to contribute to the understanding of interactions between the housing and labor markets when there are frictions in both, and individuals also face financial constraints. To this purpose, we develop a model of job search, extended to allow for accumulation of wealth as liquid funds and residential real estate, where individuals decide whether to own or rent a house, and where house prices are stochastic. This allows us to evaluate the dynamics of homeownership, wealth, unemployment, employment transitions, and wages under varying home lending conditions.

In our economy, the underlying mechanism by which easier access to home credit causes higher unemployment rates is a change in reservation wages. While the labor literature has already established that wealth matters in the process of job search, we go on to affirm that, in the presence of frictions in the housing market, it is also the *composition* of wealth that matters. Thus, house price fluctuations have an effect on the labor market via changes in wealth. We show that when house prices are low, and are therefore expected to increase, reservation wages increase in the share of residential wealth. This, in turn, deteriorates employment transitions and decreases employment. And so, we are able to explain the robust empirical finding that homeownership is positively associated with unemployment.

We perform the structural estimation of our model using data from the National Longitudinal Survey of Youth (NLSY) and show that it accurately replicates the main observed trends of homeownership rates, residential and liquid wealth, as well as wages, employment status, and employment transitions. With the recovered structural parameters, we evaluate the effect of unexpected counterfactual regime variations in the housing market on the labor market and the reciprocal effect of regime variations in the labor market on the housing market. We find that more relaxed home lending conditions increase workers' reservation wages, making them more selective in their job search. This, in turn, causes their employment transitions to deteriorate: Job finding and job-to-job transition rates decline, while job loss rates increase, so that the overall employment rate decreases by 5 percentage points in the short run and 2 percentage points in the long run. We also find that worsening labor

market conditions decrease homeownership rates by 8 percentage points in the long run, though they briefly increase by 5 percentage points in the very short run.

In the last decade, the economic literature has paid increased attention to housing as the household's main investment and, consequently, to its important macroeconomic effects. Several dynamic models consider housing in their analysis of business cycles and taxation, notably Gervais (2002); Sanchez (2007); Yang (2009); Díaz and Luengo-Prado (2010); Chambers, Garriga, and Schlagenhauf (2011); Fisher and Gervais (2011); Bajari et al. (2013); Iacoviello and Pavan (2013); Sommer, Sullivan, and Verbrugge (2013); Head, Lloyd-Ellis, and Sun (2014); and Hedlund (2014a, 2014b). However, in all these models the individual's income process is assumed to be exogenous, so that the housing market has no direct effect on the labor market. Rather, it is deteriorating labor market conditions (and lending to those who lose their jobs) that have a negative impact on the housing market.¹

A very recent and growing strand of literature does establish a connection between housing and job search via the “lock in” effect, whereby declining home prices put homeowners with home loans “under water.”² These homeowners then have less home equity to use as a down payment for a new mortgage loan in a new geographical location. They, therefore, are forced to reject job offers that would require them to move. See, for example, Laufer (2008), Sterk (2010), Head and Lloyd-Ellis (2012), Rupert and Wasmer (2012), Davis et al. (2013), Karahan and Rhee (2013), and Nenov (2013). This mechanism appears to provide strong support for the positive association between homeownership and unemployment rates first shown by Oswald³ (1997), then later by Bover, Muellbauer, and Murphy (1989), Chan (2001), Engelhardt (2003), Mian and Sufi (2011), Ferreira, Gyourko, and Tracy (2010, 2012), and Blanchflower and Oswald (2013). Thus, the lock in effect temporarily gained traction as one of the main explanatory mechanisms of the Great Recession. However, more recently,

¹Haurin, Hendershott, and Wachter (1997) find ownership to be quite sensitive to potential earnings, the cost of owning relative to renting, and especially borrowing constraints. Chambers, Garriga, and Schlagenhauf (2009) show in a quantitative exercise that innovations resulting in a lowering of the downpayment requirement can help explain the rise—and fall—in homeownership since 1994.

²Homeowners are “under water” when they owe more on their mortgage than their home is worth on the market.

³Oswald's finding was based upon analysis of time series and cross-section data for Organisation of Economic Co-operation and Development (OECD) countries and for regions within selected OECD countries. Green and Hendershott (2001) replicated Oswald's results for the U.S. states and by age group within states. Flatau, Forbes, Hendershott and Wood (2003) provided a summary of the empirical results on the relationship between unemployment and homeownership, with some empirical tests supporting this finding and some refuting it.

Aaronson and Davis (2011), Mumford and Schultz (2013), and Valletta (2013) find evidence that homeowners are not less likely to move from their current location than renters, which challenges the existence of a housing lock in effect.

This article’s approach stems from the literature on how wealth accumulation influences job search.⁴ Our explanation for this interaction, however, is not based on geographical mobility, but rather, it is based on the effect of homeownership and wealth on reservation wages. We show that individuals are more selective in their job search the larger the share of residential wealth in their total wealth and the more relaxed their credit conditions.⁵ Thus, our mechanism also provides an explanation for the positive relation between homeownership and unemployment rates found in the earlier empirical studies. But, contrary to the lock in mechanism, we find a positive association between house prices and unemployment. When house prices are low, agents expect prices to rise and their wealth to increase, so they are more selective in their job search and unemployment increases, the more so the larger the percentage of wealth held in the form of residential real estate. This does not happen because agents with relatively more residential wealth are locked in and have thus less geographical mobility, but rather, because they are more selective in their job search.

Beyond affecting labor supply decisions, the housing crisis deteriorated labor demand by putting financial institutions in distress, which tightened liquidity constraints for employers who, in turn, reduced labor demand.⁶ We address this declining labor demand by simulating displacements of the wage offer distribution and increases in the layoff rate.

To estimate our model, we input its policy rules in a simulated method of moments (SMM). The NLSY provides us with a detailed work history of individuals in the U.S. from 1978 until 2010, including their employment transitions, wages, and several types of wealth, including residential wealth. The model fits reasonably well with the data on the evolution of homeownership rates, the composition of wealth as residential real

⁴The job search model in this paper is set up along the lines of Mortensen (1977) and Burdett and Mortensen (1998) and includes wealth accumulation as in Danforth (1979), Acemoglu and Shimer (1999), Costain (1999), Rendon (2006), Lentz (2009), and Lise (2013).

⁵A mechanism similar to ours is provided by Herkenhoff and Ohanian (2013) who emphasize the effect of foreclosure delays on unemployment with a detailed characterization of the reservation wage. Delayed foreclosures alleviate liquidity constraints in housing with the effect of increasing reservation wages and unemployment.

⁶According to our model, falling house prices imply lower reservation wages, which should have offset, at least partly, the increase in unemployment due to a falling labor demand. Testing for this mechanism during the Great Recession is, however, beyond the purpose of this paper.

estate and liquid funds, as well as wages, employment, and employment transitions.

Once the behavioral parameters are recovered, we evaluate the dynamics of employment, employment transitions, wealth accumulation, and homeownership under two counterfactual scenarios: (i) more relaxed conditions for housing credit and (ii) deterioration of labor market demand. We accomplish these scenarios by modifying the underlying parameters that we estimated previously. The first regime change aims to assess the evolution of lending conditions for housing in the early 2000s, whereas the second regime change endeavors to evaluate the decline in hiring by firms once the crisis broke up in the late 2000s.

The first regime change reveals that more lenient home loan conditions, in particular a reduction of 15 percentage points in down payment requirements, decrease employment substantially, by up to 2 percentage points. The second regime change shows that falling labor market demand, in particular a reduction in the wage offer of 20 percentage points, decreases homeownership rates by up to 8 percentage points. Furthermore, we also evaluate the impact of fiscal policies that extend unemployment benefits,⁷ and we find that there is an *additional* impact of 3 percentage points on the employment rate. On the other hand, this policy is able to reduce the drop in homeownership rates by 2 percentage points.

The remainder of the article is organized as follows. The next section explains the model and characterizes the optimal solution. Section 3 describes the data used in the estimation and documents their basic trends. Section 4 details the estimation procedure, namely the criterion function of the SMM estimation and the target statistics. Section 5 presents the results of the estimation, the behavioral parameters and an assessment of how well the model fits the data. Section 6 performs the policy experiments mentioned previously. The main conclusions of this article are summarized in Section 7. A sensitivity analysis, proofs, details on the solution of the model, and further explanation of the data used in the estimation are contained in the appendices.

2 Model

In our model, individuals maximize their expected lifetime utility by choosing their home size and home tenure status (owning versus renting the house in which they

⁷This has been discussed, among others, by Rothstein (2011), Hagedorn et al. (2013), and Mitman and Rabinovich (2014).

live), the level of consumption of nondurables, and acceptable wage offers.

Agents finish their schooling and immediately enter the labor market in quarter 1. That is, agents are active, employed, or unemployed, during $t \in \{1, \dots, T\}$ quarters, then retire and live for $t \in \{T + 1, \dots, T_F\}$ additional quarters. There are no bequests, so agents die in period T_F without assets.

Specifically, in quarter 1, agents are age 18, then stay in the labor market for a total of 47 years until age 65, when they retire; that is, agents are active for $T = 188$ quarters. Once agents retire, they live an additional 16 years (or 64 quarters) until the age of 81; that is, agents live for a maximum of $T_F = 252$ quarters.

In each period t , individuals derive utility from consumption of nondurables, C_t , and from consuming the services of a house of size $H_t \in [\underline{H}, \overline{H}]$, which they can own or rent, so that their period-by-period utility function is $U(C, H)$. Renters can adjust the level of housing services they consume without cost as long as they remain renters. But first-time buyers and owners who change the size of their house must bear a price-dependent adjustment cost of the form

$$c(H_{t-1}, H_t, p_t) = p_t(H_t - H_{t-1}) + a_b p_t \max(H_t - H_{t-1}, 0) - a_s p_t \min(H_t - H_{t-1}, 0),$$

where p_t is the price per house unit in period t , so that house value is $p_t H_{t-1}$; a_b is equivalent to a fee per unit of increase in house size, and a_s is a similar fee per unit of decrease in house size.⁸ When there is no variation in house size, $c(\cdot) = 0$. There is no house depreciation and no house maintenance spending. The house price follows a Markov process $P(p_{t+1} | p_t)$, parameterized as an AR(1) process: $\ln p_{t+1} \sim N(\rho \ln p_t, \sigma_p^2)$, where $p_t \in [\underline{p}, \overline{p}]$, $0 < \underline{p} < \overline{p} < +\infty$.

Rental payments are $r_h H_t$, where r_h is the rent per house unit. Renting does not give the same utility as owning; so a renter of a house of size H_t only enjoys a fraction g of that house size: gH_t .

Homeowners can rent part of their house and live in the remaining space, denoted by $s_t \in [0, 1]$. If they do, they receive an extra income equal to $(1 - s_t)r_h H_t$, but they only derive utility from the part of the house that is not rented $s_t H_t$.

Agents can buy or sell a house throughout their lifetime, but they can only experience employment transitions during their active period, that is, when $t \leq T$. Unemployed agents receive transfers b , which include nonlabor income (such as family transfers), plus unemployment compensation net of out-of-pocket search costs.

⁸This cost is equivalent to requiring the house be sold each time there is a variation in house size, as in Flavin and Nakagawa (2008).

Retired agents receive a pension b_R for $t > T$. These transfers allow agents to rent at least the smallest house, so that they are never homeless. This constitutes the *no-homelessness condition*:

$$b, b_R \geq r_h \underline{H}.$$

All agents enter active life as unemployed and with an initial stock of *liquid* wealth A_0 . Agents have a subjective discount factor $\beta \in (0, 1)$, can save at a rate of return r , and can borrow up to a limit B_{t+1} at that same rate. This borrowing limit is determined by the liquidation value of a house owned in property that is used as collateral:⁹

$$B_{t+1}(H_t) \equiv -k_t(1-d)\underline{p}(1-a_s)H_t,$$

where d is the down payment rate; \underline{p} is the lowest possible price per house unit and constitutes a “natural borrowing limit” for banks, that will not lend more than what they can recover with probability one; a_s is the adjustment fee when a house is sold, and it must be deducted from the house value, as it will not be available to the owner in the event of a sale. And the time adjustment factor $k_t = \frac{(1+r)^T - (1+r)^t}{(1+r)^T - 1}$ is a stylized way of capturing a house mortgage loan in a finite horizon environment without an extra state variable.¹⁰ Because this constraint becomes tighter every subsequent period, the indebted homeowner will want to pay this home loan. Thus, this borrowing limit ensures that home loans are always repaid and there is no bankruptcy.

Unemployed agents receive a wage offer x with probability λ_t^u , drawn from a wage offer distribution $F(\cdot)$, ($x \in (\underline{w}, \bar{w}), 0 < \underline{w} < \bar{w} < \infty$). They become employed if they receive and accept a wage offer; otherwise, they remain unemployed. Employed agents are laid off with probability θ_t , and with probability π_t , they receive a wage offer drawn from the same distribution $F(\cdot)$. They change employer when they receive an offer and accept it. They continue to work for the same employer when they are not laid off, when they receive an offer that they do not accept or when they do not

⁹Banks do not lend to retirees, not on account of their pension, nor on account of their home, if they own it.

¹⁰The idea here is that if at period 0 the agent borrows $(1-d)\underline{p}(1-a_s)H_t$, then from period 0 until period T the agent must make a fixed payment m per period, as if it were a mortgage, so that $(1-d)\underline{p}(1-a_s)H_t = \sum_{s=0}^T \frac{m}{(1+r)^s}$. Consequently, the lower bound on liquid wealth at period t is $B_t = -\sum_{s=t}^T \frac{m}{(1+r)^{s-t}}$, that is, $B_t = -(1-d)k_t\underline{p}(1-a_s)H_t$, where $k_t = \frac{\sum_{s=t}^T \frac{1}{(1+r)^{s-t}}}{\sum_{s=0}^T \frac{1}{(1+r)^s}} = \frac{1 - (\frac{1}{1+r})^{T-t}}{1 - (\frac{1}{1+r})^T} = \frac{(1+r)^T - (1+r)^t}{(1+r)^T - 1}$. A fraction s of future secure income could also be included in the borrowing limit: $B_{t+1} = -s \sum_{j=t}^T \frac{b - r_h \underline{H}}{(1+r)^j} - k_t(1-d)\underline{p}(1-a_s)H_t$. We previously conducted estimations of this specification and found s was very close to zero.

receive an offer at all and the current job is preferable to unemployment. Employed individuals can always quit to become unemployed. Arrival rates λ_t , layoff rates θ_t , and wages $w_t(\omega)$ are age-specific. The evolution by age of these labor market parameters captures the accumulation of human capital over time.

The present discounted utility V_t^r for an individual who decides to rent, has liquid wealth holdings A_t , income y , for a house of size H_{t-1} and unit house price p_t , is

$$V_t^r(A_t, y, H_{t-1}, p_t) = \max_{A_{t+1} \geq B_{t+1}, H_t^r} \left\{ U \left(A_t + w(y) - c(H_{t-1}, 0, p_t) - r_h H_t^r - \frac{A_{t+1}}{1+r}, g H_t^r \right) + \beta E_t V_{t+1}(A_{t+1}, y, 0, p_t) \right\}.$$

As explained previously, a renter only derives utility from a fraction of the total rented house, $g H_t^r$. A renter who owned a house in the past period must have sold it, so $c(H_{t-1}, 0, p_t)$. When the individual is indebted, liquid assets are negative.

If the agent decides to own a house, the present discounted utility V_t^o for the same state variables is

$$V_t^o(A_t, y, H_{t-1}, p_t) = \max_{A_{t+1} \geq B_{t+1}, H_t, s_t} \left\{ U \left(A_t + w(y) - c(H_{t-1}, H_t, p_t) + (1 - s_t) r_h H_t - \frac{A_{t+1}}{1+r}, s_t H_t \right) + \beta E_t V_{t+1}(A_{t+1}, y, H_t, p_t) \right\}.$$

This owner may decide to rent a fraction of his property and earn additional income $(1 - s_t) r_h H_t$, which implies that the remaining fraction of the house yields some satisfaction, $s_t H_t$.

Then, the value function is the maximum between the value of renting and the value of owning:

$$V_t(A_t, y, H_{t-1}, p_t) = \max [V_t^r(A_t, y, H_{t-1}, p_t), V_t^o(A_t, y, H_{t-1}, p_t)],$$

When the agent is retired, $t = T + 1, \dots, T_F$, $y = 0$, $w(0) = b_R$, and the agent only expects fluctuations in future house prices:

$$E_t V_{t+1}(A_{t+1}, 0, H_t, p_t) = \int V_{t+1}(A_{t+1}, 0, H_t, p_{t+1}) dP(p_{t+1} | p_t).$$

When the agent is active, $t = 1, \dots, T$. If the agent is unemployed, then $y = 0$, $w(0) = b$, and

$$\begin{aligned}
E_t V_{t+1}(A_{t+1}, 0, H_t, p_t) = & \\
& \lambda_{t+1} \iint \max [V_{t+1}(A_{t+1}, x, H_t, p_{t+1}), V_{t+1}(A_{t+1}, 0, H_t, p_{t+1})] dF(x) dP(p_{t+1}|p_t) \\
& + (1 - \lambda_{t+1}) \int V_{t+1}(A_{t+1}, 0, H_t, p_{t+1}) dP(p_{t+1}|p_t).
\end{aligned}$$

And if the agent is employed, $y = \omega$, and

$$\begin{aligned}
E_t V_{t+1}(A_{t+1}, \omega, H_t, p_t) = & \{(1 - \theta_{t+1}) \\
& \left[\pi_{t+1} \iint \max [V_{t+1}^e(A_{t+1}, \max(x, \omega), 0, p_{t+1}), V_{t+1}^u(A_{t+1}, 0, p_{t+1})] dF(x) dP(p_{t+1}|p_t) \right. \\
& + (1 - \pi_{t+1}) \int \max [V_{t+1}^e(A_{t+1}, \omega, 0, p_{t+1}), V_{t+1}^u(A_{t+1}, 0, p_{t+1})] dP(p_{t+1}|p_t) \left. \right\} \\
& + \left\{ \theta_{t+1} \left[\pi_{t+1} \iint \max [V_{t+1}^e(A_{t+1}, x, 0, p_{t+1}), V_{t+1}^u(A_{t+1}, 0, p_{t+1})] dF(x) dP(p_{t+1}|p_t) \right. \right. \\
& \left. \left. + (1 - \pi_{t+1}) \int V_{t+1}^u(A_{t+1}, 0, p_{t+1}) dP(p_{t+1}|p_t) \right] \right\}.
\end{aligned}$$

In the absence of bequest motives, $A_{T_F+1} = 0$ and $H_{T_F} = 0$. Active agents solve a dynamic problem with a finite horizon T and a “salvage value,” which is the present discounted utility at retirement: $V_t(A_t, \omega, H_{t-1}, p_t) = V_t(A_t, 0, H_{t-1}, p_t)$, at $t = T + 1$. At all times, the solution to this problem is contained in the liquid wealth accumulation rule and the housing decision rule: $A_{t+1}(A_t, \omega, H_{t-1}, p_t)$ and $H_t(A_t, \omega, H_{t-1}, p_t)$, respectively. That is, wealth accumulation and house consumption depend on liquid wealth, employment status, wages if employed, and on homeownership status and house prices. See Appendix A1 for details on the solution. When agents are active, there exists a reservation wage that indicates the lowest acceptable wage offer:

$$\omega_t^*(A_t, H_{t-1}, p_t) \equiv \{\omega \mid V_t(A_t, 0, H_{t-1}, p_t) = V_t(A_t, \omega, \chi_{t-1} H_{t-1}, p_t)\}.$$

The reservation wage depends on holdings of liquid wealth, residential wealth, and house prices. Thus, this model creates an explicit connection between wealth accumulation, homeownership, house prices, and job transitions.

Proposition 1 *If adjustment fees are zero ($a_b = a_s = 0$), lifetime value functions will be unaffected by the liquidity composition of wealth and will only be determined*

by the amount of total wealth $Z_t = A_t + p_t H_{t-1}$:

$$V_t(A_t, \omega, H_{t-1}, p_t) = V_t\left(\alpha Z_t, \omega, (1 - \alpha) \frac{Z_t}{p_t}, p_t\right),$$

for all $\alpha \in [0, 1]$, A_t, ω, H_{t-1} , and p_t .

Proof: In Appendix A2.

If there are no adjustment fees, objective functions are unaffected by the composition of wealth in liquid funds and illiquid property, and owning a house of size H_{t-1} has the same effect on lifetime utility as holding its value $p_t H_{t-1}$ in liquid funds. In other words, in the absence of adjustment fees, the composition of wealth is irrelevant for an agent wishing to maximize lifetime utility; only the total amount of wealth is relevant. This property is reflected in the reservation wage.

Corollary 1 *As value functions are determined only by total wealth, so are reservation wages. If adjustment fees are zero ($a_b = a_s = 0$), the reservation wage will be the same whether the individual owns a house of size H_{t-1} or whether she holds $p_t H_{t-1}$ in liquid funds:*

$$\omega^*(A_t, H_{t-1}, p_t) = \omega^*\left(\alpha Z_t, (1 - \alpha) \frac{Z_t}{p_t}, p_t\right),$$

for all $\alpha \in [0, 1]$, A_t, ω, H_{t-1} , and p_t .

If the housing market is frictionless and there are no adjustment costs, an individual's reservation wage depends only on the total size of his wealth, and the liquidity structure of this individual's wealth is irrelevant. The “neutrality” of reservation wages to a worker's asset liquidity can be viewed as equivalent to the neutrality of a firm's investment to its asset structure in the Modigliani-Miller Theorem. If unemployment allows workers to reject low wage offers and attain better job matches, then it is beneficial for the whole economy, similarly to firms' investment and increased production.

Because there are no closed-form solutions to this model, we assume specific functional forms. Our utility function is a Cobb-Douglas function embedded into a constant relative risk aversion (CRRA) utility function:

$$U(C, H) = \frac{(C^\gamma H^{1-\gamma})^{1-\sigma} - 1}{1 - \sigma},$$

where σ is the coefficient of relative risk aversion, and γ represents the share of consumption of nondurables.

The base wage offer distribution is a truncated lognormal $F(x)$: $\ln \omega \sim N(\mu, \sigma^2 | \underline{\omega}, \bar{\omega})$; $0 < \underline{\omega} < \bar{\omega} < \infty$. Age-dependent arrival and layoff rates are logistic: $q_t^k = \frac{\exp(\alpha_q^0 + \alpha_q t)}{1 + \exp(\alpha_q^0 + \alpha_q t)}$, where $q = \{\lambda, \pi, \theta\}$. Finally, the wage growth function has the form $w_t(\omega) = \omega \exp(\alpha_1 t + \alpha_2 t^2)$.

Approximation to the policy rules and value functions is done numerically. We allow wealth and wages to be continuous while we discretize house size and house prices. Accordingly, we use the Euler equation and an interpolation algorithm to solve for wealth next period and a numerical maximization to solve for housing. We integrate the value functions for wages exploiting an interpolation technique while we integrate over prices by using a weighted summation. The dynamic problem is solved backward, starting with retirement and ending in period one. See Appendix A3 for a detailed explanation of the numerical solution to the model.

[Figure 1 here]

The policy rules are illustrated in Figure 1, which shows the reservation wage and the value of the house owned as a function of liquid wealth.¹¹ Both are increasing in wealth, that is, wealthier workers are more selective in their job search and buy larger houses. The house value increases monotonically in liquid wealth until it reaches its largest possible level. The reservation wage is lowest when the agent is most indebted, grows rapidly as debt levels decrease, and it stabilizes when the agent buys the largest possible house and saves.

[Figure 2 here]

Figure 2 shows the reservation wage and house size as a function of liquid wealth for two different current house values and two different price levels. In Figures 2a and 2b, we can see that for all levels of liquid wealth, both owning a more valuable house and facing a higher price per house unit imply higher reservation wages. Figure 2c shows that increasing the value of the house currently owned by the individual (from \$67,000 to \$121,000) implies owning a larger house also in the next period for any

¹¹We use the estimated parameters in Table 4 to characterize the model in these policy rules and for the sensitivity analysis that follows. The benchmark house value is \$67,000 at the lowest price, 0.825. We then increase the current house value to \$121,000, and the price to 1.212 (see the price vector on page 19).

level of liquid wealth. And, for any given level of liquid wealth Figure 2d shows a higher house price implies owning a smaller house in the next period, in accordance with the law of demand. After this price increase, a house initially worth \$67,000 increases in value to \$80,000, as indicated by the horizontal dotted lines. The agent then switches ownership to a smaller house and increases his liquid wealth.

[Figure 3 here]

Figures 3 and 4 show the effect of homeownership on the reservation wage when *total* wealth is held constant at four different levels. In Figure 3, the price level is low, whereas in Figure 4 the price level is held high. As per Proposition 1, when adjustment fees are zero, the reservation wage is unaffected by the composition of wealth. In our simulation adjustment fees are positive, so the composition of wealth does affect the reservation wage at all levels of total wealth. Note that when the value of the house owned by the individual surpasses the total wealth level, the individual is in debt, the more so the higher the value of the house. In Figure 3, we can see that for individuals with the lowest level of total wealth (\$48,000), the reservation wage is unresponsive to low house values. However, when house values are high, the individual is in debt and cannot afford to be selective in his job search, as a relatively low reservation wage indicates. Thus, the reservation wage of low-wealth individuals is decreasing in house value only for higher levels of residential wealth.¹² For a medium-to-low level of total wealth (\$62,000), reservation wages are clearly increasing in residential values. The agent expects current home prices to rise and, therefore his total future wealth to increase, the more so the larger the proportion of total wealth held as real estate. Accordingly, his reservation wage goes up. For medium-to-high and high levels of total wealth (\$76,000 and \$99,000, respectively), the reservation wage profile is unresponsive to residential value.

[Figure 4 here]

Figure 4 shows how the reservation wage responds to high house prices when *total* wealth is held constant at four different levels. When house prices are high, the reservation wage is markedly unresponsive to residential wealth for high and low levels

¹²The agent with the lowest level of total wealth can only own a home worth more than \$48,000 if he borrows. Buying a house worth \$148,000 means this individual has a debt of \$100,000, which eventually will make him less selective in accepting job offers.

of total wealth (\$71,000 and \$145,000, respectively). Only for medium levels of total wealth is the reservation wage decreasing slightly in residential wealth. When house prices are high, individuals expect them to fall; consequently, replacing residential wealth with liquid wealth makes the agent slightly less selective in a job search.

In sum, this model exhibits an explicit mechanism whereby the housing market and the individual’s finances crucially affect the job search. In this frictional labor market, an individual’s amount of total wealth, the composition of this wealth, and price fluctuations in the housing market are very important determinants of an individual’s wages and employment status.

Most analyses on the connection between the financial and real estate sectors focus on firms and on how a firm’s collateral constrains how much the firm can borrow. When the Modigliani-Miller assumptions are not fulfilled, a firm’s ability to expand its scale of production depends on how much capital is available to the firm. Hereby, we show an additional connection centered on the worker and on job search. The amount a worker can borrow is constrained by the value of the collateral available to him. The single most important collateral of an individual is his house, so that his ability to reject low-wage offers in his job search throughout his active life will be determined by the value of his house. Therefore, more collateral and easier housing credit conditions allow an individual to be more selective in the job search and obtain higher wages, but they also lengthen the duration of unemployment spells and, thus, increase overall unemployment rates.

We also perform a sensitivity analysis of all the parameters of the model, which we detail in Appendix A4. This analysis establishes the connection between parameter variations and the response of several observed statistics. We are particularly attentive to “cross-effects,” that is, effects of housing market parameters on labor market observables, and of labor market parameters on housing market observables. Both types of effects are fairly important in the model and in our analysis of possible regime changes. In the next sections, we examine how our model stands up to the actual data.

3 Data

We use data from the National Longitudinal Survey of Labor Market Experience - Youth Cohort (NLSY), a national stratified sample of 12,686 individuals who were between 14 and 21 years of age in January 1979 and who have been interviewed annually

from 1979 until 2010. This data set contains information on personal characteristics of the individual, household composition, educational status and attainment, military experience, labor market activity and transitions, detailed week-by-week work history, income and several forms of wealth, including residential property.

Total wealth is the net market value of the sum of residential wealth and liquid wealth. Residential wealth is the market value of the house owned by the individual if it were sold at the time of the interview. Liquid wealth consists of business assets, financial assets, vehicles, and other assets (such as jewelry or furniture), all net of debts, *minus all debts on residential property*. Annual data on residential wealth and the various forms of liquid wealth are available from year 1985 onward; this information is assigned to the calendar quarter in which the interview took place.

Out of the total number of respondents, we select only those individuals who are most likely to conform to our theoretical model: white males born after December 31, 1960, without military experience, who finished high school and attended college for a maximum of one year,¹³ and for whom wealth and housing data are available. We are left with a sample of 268 individuals. However, our theoretical model does not include out-of-the-labor force as an employment status, nor does it consider search intensity. Therefore, to avoid further reducing the sample, we *also* classify as unemployed those individuals who are not working and not looking for a job, those who work less than 20 hours a week, and those for whom information on wages is missing.¹⁴ For each individual in the sample, we have up to 132 quarterly observations on wealth, housing, wages, employment status, and employer. Appendix A5 provides further explanations on these variables.

[Table 1 here]

Table 1 presents summary statistics for the variables used in the model. On average 37% of the individuals in the sample are homeowners, with the mean house value around \$60,000 of 1982-1984. However, the standard deviation on this value is also around \$60,000. These individuals hold, on average, around 12,000 constant

¹³A sample exclusively composed of high school graduates would be too small. Therefore, our sample also includes individuals who have attended college for a maximum of one year.

¹⁴It is for this reason that our “unemployment” rates are higher than those reported in employment surveys. To avoid confusion, we will use the term “nonemployment rate” to denote the percentage of people who are not working (either because they are not searching or because they do not find employment), are underemployed, and for whom we do not have enough observations on wages. We will use “employment rate” for the reciprocal concept.

dollars worth of liquid assets. About 33% of the individuals have negative liquid wealth, that is, they are in debt for this amount. However, total wealth (net liquid wealth plus the market value of the house) amounts to about \$40,000, and only 8% of individuals exhibit negative total wealth. Clearly, owning a home is the reason for these debts. As for labor market statistics, around 72% of individuals are employed, while the average wage is \$4,726 per quarter, or 8.26 in log wages.

[Table 2 here]

Table 2 shows summary statistics by homeownership and employment status. The average house value is about \$59,500, and 43% of individuals own a house that is worth less than \$40,000. Only 21% of homeowners own houses that are worth \$80,000 or more. Renters hold slightly more liquid wealth than owners: \$12,300 and \$11,300, respectively. About 60% of homeowners and 12% of renters are in debt, that is, they have negative liquid wealth. However, the totality of renters wealth is liquid, whereas on average, only about 16% of the total wealth of homeowners is held in liquid assets. Specifically, homeowners' total wealth is around \$71,000, and only 3% of them have a negative total wealth position. Out of all renters, 48% are not employed, compared with only 22% of homeowners. Average wage for renters is \$3,400 (7.92 in log wages), whereas it is \$5,100 (8.35 in log wages) for homeowners.

If we look at statistics by employment status, we can see that employed individuals are more than twice as likely to be homeowners: 47% of the employed are owners compared with only 21% of the nonemployed. Moreover, the average value of the houses owned is also higher for the employed: \$63,000 compared with \$47,000 for the nonemployed. And 58% of the owners who are not employed own a house that is worth less than \$40,000; this percentage is 38% for employed individuals. Similarly, liquid and total wealth are both greater for the employed. While the employed have around \$15,000 worth in liquid wealth and around \$49,000 of total wealth, these values for individuals who are not employed are, respectively, around \$6,700 and \$19,000. However, among the employed the proportion of those with negative liquid wealth is higher: 38% compared with 25% among those who are not employed. Because the employed are more likely to be homeowners, they also are more likely to have home loans.

[Table 3 here]

Table 3 shows the main variables of our model 4, 12, and 20 years after the individual left high school. Homeownership increases from 5% in year four to 66% in year 20, while the value of the house owned increases from around \$31,000 to \$64,000 for these same years. Similarly, liquid wealth also increases for both renters and homeowners. Log wages increase 60% from year four to year 20, from 7.9 to 8.5. The dispersion of log wages is relatively stable over time at 0.5. Meanwhile, the nonemployment rate declines from 43% in year four to 10% in year 20. This is the result of increasing rates for job taking and job-to-job transitions and decreasing rates for job separations.

These trends are informative of the evolution of the main variables of the model and of their interconnections. They suggest that better labor market outcomes are associated with homeownership, which involves borrowing and, hence, negative holdings of liquid wealth. Accordingly, homeowners typically have more total wealth but less liquid wealth than renters. Our next step is an estimation of the behavioral parameters of the model.

4 Estimation

The estimation strategy aims to recover the behavioral parameters of the theoretical model. The estimation procedure is an SMM in which the parameter estimates of the theoretical model are the minimizers of this function. We build a set of simulated data and use it to compute some selected moments that are then matched to the actual moments. For each individual in the sample, we generate 100 simulations. Because wealth and housing are observed only since 1985, there are several periods for which we can only observe employment and wage data but not wealth and housing data. For these periods, data for simulations are assumed to be the same as the actual data. From the quarter that we first observe wealth onward, we use the policy rules that solve the dynamic programming problem and random numbers for the stochastic components (job offers, layoffs, wage offers, and house price fluctuations) to generate simulated career paths. That is, simulated data are based on observed liquid wealth and observed employment status and wages, assuming no homeownership and a medium housing unit price. At each iteration of the parameter computation, we construct a measure of distance between the observed and the simulated moments. Since for many quarters there are very few actual observations, we compute biannual periods both in the actual and the simulated moments.

In the estimation, we only use data for the first 26 years of labor market experience, which approximately contain observations from 1978 until 2005 for most people. That is, we are trimming the sample to cover the period just before the Great Recession.

We fix the down payment rate at 20% to reinforce identification of other parameters, in particular the coefficient of risk aversion. The rate of discount fixed at 0.9872 and the interest rate at 0.012272 are the quarterly values that match the annual values of 0.95 and 0.05, respectively.

The parameters to estimate are then $\Theta = \{a_b, a_s, \rho, \sigma_p, r_h, \sigma, \gamma, g, b, \lambda, \alpha_\lambda, \theta, \alpha_\theta, \mu, \alpha_1, \alpha_2, \sigma_w\}$. The moments used in this estimation are the following:

1. percentage of owners by year after graduation,
2. value of the house by year after graduation,
3. liquid wealth holdings by year after graduation and homeownership status,
4. log-wage means and standard deviations by year after graduation,
5. employment rates and employment transitions by year after graduation,
6. liquid wealth variation when buying and selling a house,
7. residential wealth variation when buying and selling a house,
8. percentage of people ever buying and ever selling a house, and
9. duration of the period to buy a house for the first time and average house tenure period.

The SMM procedure relates a parameter set to a weighted measure of distance between sample and simulated moments:

$$S(\Theta) = \Delta m' W^{-1} \Delta m,$$

where $\Delta m = (m_a - m_p)$ is the distance between each sample and simulated moment and W is a weight matrix. The estimated behavioral parameters are thus $\hat{\Theta} = \arg \min S(\Theta)$. We minimize this function by means of the Powell algorithm, as in Press et al. (1992), which uses direction set methods to find the minimum and relies on function evaluations, not gradient methods.

5 Results

The estimates and their corresponding asymptotic standard errors are reported in Table 4. As we show, these estimates reproduce the observed trends in the evolution of homeownership status, house value, liquid wealth by homeownership, wages, nonemployment rate, and employment transitions.

The share of nondurable consumption is identified by the relative evolution of observed liquid wealth with respect to residential wealth. The coefficient of risk aversion is pinned down by the speed of wealth accumulation and homeownership over time. The subjective value of a rented house is pinned down by variations in homeownership that happen without large variations in wealth, while the rent parameter is identified by variations in homeownership that happen together with relatively large variations in wealth. The adjustment fee parameters are identified mainly by variations in liquid and residential wealth when buying and selling a house, as well as the time before buying a house for the first time. Since the available data set does not contain data on house prices, these prices are treated as an unobserved random variable required to estimate the model.¹⁵ Labor market parameters are identified mainly by observed wages and transitions per quarter, as it is well established in prior estimations.¹⁶

[Table 4 here]

Adjustment fees both for buying and selling are around 9% of the variation in house size: 9.15% for buying and 9.50% for selling. The stochastic process for the housing price has an autocorrelation coefficient of 0.87, which reveals a moderate persistence over time. The volatility for this process is 0.11, which is also moderate. Given that we work with seven house prices, these parameters generate the following

¹⁵This has to be solved numerically because the model does not admit a closed-form solution. Similarly, the analysis on the identification of the model's parameters by observables is also numerical. The sensitivity analysis in Appendix A4 discusses the effects of each parameter on the main observables.

¹⁶The identification of behavioral labor market parameters from data on wages and employment transitions is discussed by Flinn and Heckmann (1982a, 1982b) and Wolpin (1992). The identification in models of wealth accumulation and job search is discussed by Blundell, Magnac, and Meghir (1997) and Rendon (2006).

price vector and transition matrix:

$$p = \begin{bmatrix} 0.825 \\ 0.880 \\ 0.938 \\ 1.000 \\ 1.066 \\ 1.137 \\ 1.212 \end{bmatrix}, \quad P(p_{t+1} | p_t) = \begin{bmatrix} 0.526 & 0.215 & 0.149 & 0.074 & 0.027 & 0.007 & 0.001 \\ 0.330 & 0.227 & 0.209 & 0.139 & 0.066 & 0.023 & 0.007 \\ 0.171 & 0.186 & 0.228 & 0.202 & 0.129 & 0.059 & 0.025 \\ 0.073 & 0.118 & 0.194 & 0.229 & 0.194 & 0.118 & 0.073 \\ 0.025 & 0.059 & 0.129 & 0.202 & 0.228 & 0.186 & 0.171 \\ 0.007 & 0.023 & 0.066 & 0.139 & 0.209 & 0.227 & 0.330 \\ 0.001 & 0.007 & 0.027 & 0.074 & 0.149 & 0.215 & 0.526 \end{bmatrix}.$$

Annual rent is around 2.034% of the average house value, which is in line with observed rent-to-value ratios. The coefficient of risk aversion is 0.73, which is lower than in prior estimations. This is not unrealistic considering in our model a house is both a consumption good and residential wealth and that, moreover, it determines the individual's borrowing constraint. Models in which these aspects are absent do require higher coefficients of risk aversion to account for observed savings. The share of nondurable consumption is 83.8%, in line with descriptive data. The subjective valuation of a rented house is 72%, similar to values used in other models.

The estimated amount of net transfers while not employed is about \$432 per quarter. At the beginning of active life, when the agent has no work experience, the probability of receiving an offer λ is 28%. A growth parameter α_λ of 0.004576271 implies that 20 quarters (6 years) after graduation, this probability becomes 30%, and it is 32% and 37% 40 quarters (10 years) and 80 quarters (20 years) after graduation, respectively. The probability of receiving an offer while employed π with no experience is 1.28%. A parameter α_π of 0.000884202 implies that 20 quarters after graduation this arrival rate becomes 1.31% and is 1.33% and 1.38% after 40 and 80 quarters, respectively. The base layoff rate θ is 13.9%. A parameter α_θ of -0.009323368 implies that at quarters 20, 40, and 80 after graduation this rate becomes 11.8%, 10.0%, and 7.1%, respectively. The estimated base mean of the underlying distribution of log wages is 6.75, and the corresponding variance is 0.99. The values of parameters α_1 and α_2 imply that, at quarter 20 after graduation, the base mean log-wage offer becomes 6.80, an increase in mean wages of 6.10%; and at quarters 40 and 80 after graduation, the base log-wage values are, respectively, 6.83 and 6.89, implying increases in mean wages of 7.8% first and then 13%. These parameters imply that wages peak at quarter 135, when the individual is around 51, out of the sample used in the estimation. As seen in Table 3, the implied increase of wages from year 4 to year 20 is around 60%,

while these parameters imply an increase of wages of only 10% for the same period. These parameters exhibit, thus, a slow variation of arrival rates and of the wage offer distribution, which suggests that they are not the main drivers of the observed variations in wages and employment transitions. Rather, the increase in reservation wages is a product of the life-cycle accumulation of wealth, both in the form of liquid assets and residential real estate.

Asymptotic standard errors are calculated using the outer-product gradient estimator; they are, in general, small. To assess whether these parameter estimates capture the essential features of the observed data, we compare the observed and the predicted trajectories of homeownership, house value, wealth by homeownership status, wages, employment status, and employment transitions.

[Table 5 here]

[Figures 5 and 6 here]

Table 5 provides a summary of the actual and predicted distribution of all variables for years 4, 12, 20, and 28 after graduation.¹⁷ It also shows goodness of fit tests: χ^2 for discrete variables and R^2 for continuous variables.¹⁸ In addition, Figures 5 and 6 present a graphical comparison of actual and predicted variables by year after graduation. Figures 5a and 5b show that the predicted path of the homeownership rate and the house value are relatively close to the actual path, which can be confirmed by looking at the χ^2 and R^2 statistics in Table 5. Figures 5c and 5d compare the actual and predicted liquid wealth of renters and owners. Both show some overprediction in the later years. In spite of some noise in the liquid wealth data, the model reproduces quite well the observed trend in wealth accumulation, as the R^2 statistics in Table 5 confirm.

Figures 6a and 6b show that the model reproduces well the wage distribution, especially in the later periods, as is confirmed by their respective R^2 statistics in Table

¹⁷This last year is not used in the estimation, but it is reported as an out-of-sample prediction, as a means to perform a cross-validation of the model.

¹⁸For discrete variables $\chi^2 = \sum_{t=1}^T \frac{(n_t - \hat{n}_t)^2}{\hat{n}_t}$, where n_t is the actual number of observations at time t , \hat{n}_t is the model predicted counterpart, and T is the number of periods. This statistic has an asymptotic χ^2 distribution with $T - 1$ degrees of freedom. For continuous variables $R^2 = \frac{\sum \hat{Y}^2}{\sum \hat{Y}^2 + \sum e^2}$, where \hat{Y} is the predicted continuous variable and $e = Y_{obs} - \hat{Y}$ is the predicted error. Squaring and summing across observations, we obtain $\sum Y_{obs}^2 = \sum \hat{Y}^2 + 2 \sum \hat{Y}e + \sum e^2$, and it is not necessarily true that $\sum \hat{Y}e = 0$, as in the linear regression framework.

5. Figure 6c shows that the model captures well the overall trend of the nonemployment rate in spite of some underprediction in the early years and some overprediction in the later years. Similarly, in Figures 6e and 6f, we can see the model replicates fairly well the overall trend of actual job loss rates and job-to-job transitions.

[Table 6 here]

Finally, Table 6 shows actual and predicted variations of liquid and residential wealth when buying a house for the first time and then selling it, as well as the percentage of agents involved in these transactions and the duration of time for buying and selling. In the data, wealth is only observed every four quarters, that is, annually, and only for some years, whereas the model always exhibits quarterly variations. This precludes an exact comparison between observables and their predictions. However, these moments are important for identifying some parameters, particularly the adjustment fees.

As shown in Table 6, variations of liquid wealth are larger in the model, but residential wealth variations are larger in the data. The model also exhibits more turnover in the housing market: More people buy and more people sell their houses, so that they are homeowners for eight and a half years, one and a half years less than in the data. The model, however, replicates well the duration to sell a house, at about five years.

In short, both graphically and formally, the model is fairly successful in replicating the main features of the data.

6 Regime Changes

After recovering the underlying parameters of the model and assessing their success in replicating the data, we perform two regime changes: relaxing housing credit conditions and deteriorating labor market demand. We assess these changes in two different ways, when agents start their career with the new regime and when agents start their careers with the benchmark regime and the new regime is introduced without anticipation in different periods. In Table 7, we report the effects on several observables on three selected years, when agents start their careers with the new regime. In Figures 7 and 8, we report the effects on just one relevant outcome variable, when these same regime changes are introduced unanticipatedly in different years once agents have entered the labor market.

[Table 7]

In the first experiment we decrease the down payment required to buy a house, d , by 15 percentage points, and decrease the persistence of the housing price process, ρ , by 10 percentage points. We are interested in evaluating how these regime changes, one at a time and combined, influence the labor market.

A reduction in the down payment increases homeownership rates and the wealth of renters, who now have an incentive to save more, and decreases liquid wealth held by homeowners, who can now buy larger houses. This variation also increases both wages and nonemployment rates, while it deteriorates employment transitions, which is consistent with an increase in the reservation wage. Nonemployment rates increase 1.2 percentage points 20 years after graduation. That is, easier access to housing credit generates higher nonemployment rates.

A fall in the persistence of the housing price process means currently low prices are more likely to increase and currently high prices are more likely to fall. This fall increases the rate of homeownership, while it decreases wealth of any type for both renters and owners. In the labor market, this fall is reflected in an increase in wages and the nonemployment rate, which is consistent with increasing reservation wages. Employment transitions also worsen in that transitions from nonemployment to employment fall, while transitions from employment to nonemployment increase.

The combined effect of these regime changes is shown in Table 7, where both kinds of wealth for renters and owners decrease, while homeownership increases. In terms of the labor market, this change generates an increase of nonemployment of up to 2 percentage points, while wages increase by a maximum of 4 percentage points.

[Figure 7 here]

In Figure 7, we can see the immediate jump in nonemployment once housing market conditions are loosened. This jump is higher (5%) for relatively older individuals and lower for individuals who have recently entered the labor market. Over time, this increase fades, but then it increases again, reaching almost 2 percentage points, which is the common long-run variation for the years in which the regime change is introduced.

The second experiment consists of deteriorating labor demand; that is, decreasing the base mean wage offer and increasing layoff rates and nonemployment transfers. A decrease in the mean wage offer reduces homeownership rates and the wealth of

both renters and owners, and it also pushes wages down. However, nonemployment rates decline. It is the decrease in reservation wages that makes it possible for wages and nonemployment to both fall. Accordingly, job finding rates increase while job separations and job-to-job transitions do not change much.

An increase in the layoff rate decreases homeownership by 5 percentage points, while it decreases liquid wealth for renters and residential wealth for owners. The lay-off rate is crucial in determining savings for precautionary reasons. Thus, its increase deteriorates labor market conditions, but it also boosts savings for homeowners. As a result of this change, wages fall and nonemployment rates increase, while job findings and job separations both rise, and job-to-job transitions fall.

When the previous regime changes happen simultaneously, there is a larger fall in homeownership of up to 8 percentage points. Liquid wealth holdings of both renters and owners fall by larger amounts than in any single change (except in initial years for owners), which suggests that, because of this labor market deterioration, only the initially wealthy buy houses. Over time, fewer and fewer of the initially wealthy buy houses while their liquid wealth falls further. This combined change implies an increase in the nonemployment rate and a large fall in wages, particularly in the later years (23 percentage points). There is also lower job finding and fewer job-to-job transitions but more job separations.

We also consider the additional impact of an increase in nonemployment transfers, which captures the government's attempt to counteract deterioration of labor market conditions, as in Rothstein (2011) and Hagedorn et al. (2013). Under this combined regime, the decline in homeownership rates is also large (6 percentage points) but below what it would be without an increase in nonemployment transfers, 8 percentage points. Wealth of renters also falls by less, but the liquid holdings of owners in the later years decrease by a bit more. Wages fall by 6 percentage points, substantially less than the 12 percentage point decrease without transfers. Nonemployment increases by larger amounts, up to 6 percentage points instead of the previous 3 percent increase, mostly due to slower transitions from nonemployment to employment. In sum, a government intervention that increases nonemployment transfers is effective in alleviating the substantial fall in homeownership rates and liquid wealth that follow the decrease in labor demand. This policy also impedes wages to fall further while it generates larger nonemployment rates.

[Figure 8 here]

In Figure 8, we can see the effect of labor market deterioration on homeownership. After an initial jump of 5 percentage points, homeownership systematically falls by almost 8 percentage points, especially for individuals who are hit by this shock early in their careers and are, hence, exposed longer to this regime change.

Thus, housing and labor markets are closely connected, and their respective shocks affect one another. These reciprocal effects are understandably larger the longer the exposure to the specific regime change. For both kinds of shocks, there are relatively large short-term effects that work in opposite directions to the long-term effects, which are important.

7 Conclusions

In this paper, we have developed a framework that allows us to analyze interactions between the housing, financial, and labor markets when there are frictions. We propose an extended model of job search that allows for savings and for choice of homeownership status and house size under random house prices. Contrary to most other dynamic models of housing where the income process is exogenous, in our search-theoretic framework, workers decide to accept or reject wage offers. Individuals have, therefore, some control over their income, which produces a feedback effect between collateralized financing and house price fluctuations on the one side and between wages and unemployment on the other. In this environment, reservation wages, and thereby unemployment, are not only increasing in total wealth but, under costly housing adjustment, are also responsive to the composition of this wealth as liquid funds and residential real state. In particular, when house prices are low and expected to increase, holding a larger share of residential wealth tends to increase reservation wages, which deteriorates employment transitions and increases unemployment. In this manner, we are able to explain how higher homeownership rates are associated with higher nonemployment rates without relying on the mechanism of homeowners' geographical lock in.

Moreover, our finding that wealth composition and access to credit affect the individual's reservation wage and, hence, unemployment is consequential in that it suggests an additional mechanism through which finance affects real economic activity. Liquidity constraints and internal finance are thus not only relevant for the firm but also for the worker.

We have fit this model to data from the NLSY and recovered the behavioral

parameters, which are realistic for both the housing and the labor market. The model exhibits a fairly good capability to replicate the main observables, namely, the evolution of homeownership rates, house value, liquid wealth, wages, employment status, and employment transitions over time.

We have shown that more relaxed conditions for home loans decrease employment rates by around 2 percentage points. We have also evaluated the effects of deteriorating labor demand on the housing market and found that less job creation by employers, captured by lower arrival rates, higher layoff rates and lower wage offers, reduces homeownership by 8 percentage points.

Future research can extend our framework to explore other important dimensions of the connection between housing markets and job search. In our model, lenders do not share risk with borrowers, so that they recover their loans with probability one. One could explore how the model's predictions change when a borrower has the option to default on his loan.¹⁹ One could also model the mortgage structure, allow for foreclosures in case of default, consider underwater mortgages, or relax the no-homelessness condition and have some agents become homeless.

As for the labor market, an obvious concern is to allow for an equilibrium framework with matching. This would enable the model to assess firms' reactions to relevant regime changes, such as those discussed in this article. For instance, if workers are more selective in their search, firms will have a harder time finding a worker. Once firms realize this, the value of a vacancy will decrease: Firms will open fewer vacancies and the unemployment rate will increase, potentially more so than in a partial analysis. On the other hand, an equilibrium framework will also enrich the analysis on the effect of finance on the real activity, as liquidity constraints will act on both sides of the frictional labor market. Firms' investment and vacancy creation as well as workers' acceptable wages will be limited by assets used as collateral on loans, in one case by the amount of a firm's capital and in the other by the size of an individual's home.

¹⁹A possibility is to declare bankruptcy, which will prevent the individual from borrowing at all in the future.

Appendix

A1. Solution of the Model

As in the main text, $y_t = b_R$ if $t > T$, and if $t \leq T$, $y_t = b$ when the agent is unemployed, and $y_t = w_t(\omega)$ when the agent is employed. Then, the solution for renting, $H_t = 0$ is:

$$V_t(A_t, y, H_{t-1}, p_t) = \max_{A_{t+1}, H_t^r} \left\{ U \left(A_t + y_t - c(H_{t-1}, 0, p_t) - r_h H_t^r - \frac{A_{t+1}}{1+r}, gH_t^r \right) + \beta EV_{t+1}(A_{t+1}, y, 0, p_t) \right\}$$

$$\text{where } U(C_t, gH_t^r) = \frac{(C_t^\gamma (gH_t^r)^{1-\gamma})^{1-\sigma} - 1}{1-\sigma}.$$

Then, we have the following FOC for A_{t+1} :

$$\gamma \frac{(C_t^\gamma (gH_t^r)^{1-\gamma})^{1-\sigma}}{C_t} = \beta(1+r) EV_A(A_{t+1}, y, 0, p_t),$$

which is inverted in the following way:

$$C_t = \left(\frac{\beta(1+r) EV_A(A_{t+1}, y, 0, p_t)}{\gamma (gH_t^r)^{(1-\gamma)(1-\sigma)}} \right)^{\frac{1}{(1-\sigma)\gamma-1}}. \quad (1)$$

If the borrowing constraint is binding, $A_{t+1} = B_{t+1}(0)$, and thus, the Euler equation does not hold, we have the following equation for consumption:

$$C_t = A_t + b - c(H_{t-1}, 0, p_t) - r_h H_t^r - \frac{B_{t+1}(0)}{1+r}. \quad (2)$$

The corresponding FOC for H_t^r is

$$(C_t^\gamma (gH_t^r)^{1-\gamma})^{1-\sigma} \left[-\frac{\gamma}{C_t} r_h + \frac{(1-\gamma)}{H_t^r} \right] = 0,$$

which implies $\frac{\gamma}{C_t} r_h = \frac{(1-\gamma)}{H_t^r}$ and can be expressed in the following way:

$$H_t^r = \frac{1-\gamma}{r_h \gamma} C_t. \quad (3)$$

From (1) and (3), we obtain

$$H_t^{ri} = \frac{1-\gamma}{r_h \gamma} \left[\frac{\beta(1+r) EV_A(A_{t+1}, y, 0, p_t)}{\gamma \left(g \frac{(1-\gamma)}{\gamma r_h} \right)^{(1-\gamma)(1-\sigma)}} \right]^{-\frac{1}{\sigma}}.$$

If the borrowing constraint (2) is binding, then

$$H_t^{ri} = \frac{1-\gamma}{r_h} \left(A_t + y_t + p_t(1-a_s) H_{t-1} - \frac{B_{t+1}(0)}{1+r} \right),$$

which holds if the rented house size lies between the house size bounds. Since there is a minimum and a maximum house size, $H_t^r \in [\underline{H}, \overline{H}]$, in general this expression has to be bounded:

$$H_t^r = \min \left[\max \left[H_t^r, \underline{H} \right], \overline{H} \right].$$

In any case, conditional on A_{t+1} , once H_t^r consumption C_t is simply

$$C_t = A_t + b - c(H_{t-1}, 0, p_t) - r_h H_t^r - \frac{A_{t+1}}{1+r}.$$

Solution for owning, $H_t > 0$:

$$V(A_t, y, H_{t-1}, p_t) = \max_{A_{t+1}, H_t, s_t} \left\{ U \left(A_t + y_t - c(H_{t-1}, H_t, p_t) + r_h (1 - s_t) H_t - \frac{A_{t+1}}{1+r}, s_t H_t \right) + \beta EV_{t+1}(A_{t+1}, y, H_t, p_t) \right\},$$

$$\text{where } U(C_t, s_t H_t) = \frac{\left(C_t^\gamma (s_t H_t)^{1-\gamma} \right)^{1-\sigma} - 1}{1-\sigma}.$$

Optimal house size is determined by discrete choice of the house size that maximizes the value function. Consumption (or wealth next period) and the fraction of the owned house that is rented are determined by the first-order conditions for A_{t+1} and s_t below.

For A_{t+1} :

$$\gamma \frac{\left(C_t^\gamma (s_t H_t)^{1-\gamma} \right)^{1-\sigma}}{C_t} = \beta (1+r) EV_A(A_{t+1}, y, H_t, p_t),$$

which is inverted in the following way:

$$C_t = \left(\frac{\beta (1+r) EV_A(A_{t+1}, y, H_t, p_t)}{\gamma (s_t H_t)^{(1-\gamma)(1-\sigma)}} \right)^{\frac{1}{(1-\sigma)\gamma-1}}. \quad (4)$$

If the borrowing constraint is binding $A_{t+1} = B_{t+1}(0)$, and the Euler equation does not hold, we have the following:

$$C_t = A_t + y_t - c(H_{t-1}, H_t, p_t) + r_h (1 - s_t) H_t - \frac{B_{t+1}(0)}{1+r}. \quad (5)$$

For s_t :

$$s_t^{(1-\gamma)(1-\sigma)} \left(C_t^\gamma H_t^{1-\gamma} \right)^{1-\sigma} \left[-\frac{\gamma}{C_t} r_h H_t + \frac{(1-\gamma)}{s_t} \right] = 0, \quad (6)$$

which can be expressed as follows:

$$s_t^i = \frac{C_t (1-\gamma)}{H_t \gamma r_h}.$$

From (4) and (6) we obtain

$$C_t = \left[\frac{\beta (1+r) EV_A(A_{t+1}, y, H_t, p_t)}{\gamma \left(\frac{1-\gamma}{\gamma r_h} \right)^{(1-\gamma)(1-\sigma)}} \right]^{-\frac{1}{\sigma}}.$$

And when the borrowing constraint binds, (5) and (6), consumption is given by

$$C_t = \gamma \left[A_t + b - c(H_{t-1}, H_t, p_t) + r_h H_t - \frac{B_{t+1}(0)}{1+r} \right].$$

These expressions, however, apply only when $s_t < 1$. If C_t is high enough, then $s_t = 1$ and (4) and (5) directly provide an expression for consumption. A general expression for s_t is then

$$s_t = \min \left[\frac{C_t (1-\gamma)}{H_t \gamma r_h}, 1 \right].$$

There is no scenario under which $s_t = 0$, as $C_t > 0$ and $\underline{H} > 0$.

A2. Proof of Proposition 1

Proof of Proposition 1 *If $a_b = a_s = 0$, then $A_t - c(H_{t-1}, H_t, p_t) = A_t + p_t H_{t-1} - p_t H_t = Z_t - p_t H_t$.*

At time T_F , $V_{T_F} \left(\alpha Z_t, 0, (1-\alpha) \frac{Z_t}{p_t}, p_t \right) = \max_{H_t^r} U \left(Z_t + b_R - r_h H_t^r \right)$, so that only total wealth matters, that is, $V_{T_F} \left(\alpha Z_t, 0, (1-\alpha) \frac{Z_t}{p_t}, p_t \right) = V_{T_F} (Z_t, 0, 0, p_t)$ for any $\alpha \in [0, 1]$. Then we proceed backward and define the value function for renting

$$\begin{aligned} V_t^r \left(\alpha Z_t, 0, (1-\alpha) \frac{Z_t}{p_t}, p_t \right) &= \max_{A_{t+1} \geq 0, H_t^r} \left\{ U \left(Z_t + b_R - r_h H_t^r - \frac{A_{t+1}}{1+r}, g H_t^r \right) \right. \\ &\quad \left. + \beta \int V_{t+1} (Z_{t+1}, 0, 0, p_{t+1}) dP(p_{t+1} | p_t) \right\}, \end{aligned}$$

and for owning a house

$$\begin{aligned} V_t^o \left(\alpha Z_t, 0, (1-\alpha) \frac{Z_t}{p_t}, p_t \right) &= \max_{A_{t+1} \geq 0, H_t, s_t} \left\{ U \left(Z_t + b_R - p_t H_t + (1-s_t) r_h H_t - \frac{A_{t+1}}{1+r}, s_t H_t \right) \right. \\ &\quad \left. + \beta \int V_{t+1} (Z_{t+1}, 0, 0, p_{t+1}) dP(p_{t+1} | p_t) \right\}. \end{aligned}$$

In none of these functions, the value of α , the share of liquid wealth in total wealth, makes a difference. At every time, the composition of wealth is irrelevant, that is, $V_t \left(\alpha Z_t, 0, (1-\alpha) \frac{Z_t}{p_t}, p_t \right) = V_t (Z_t, 0, 0, p_t)$ for any $\alpha \in [0, 1]$. The process is repeated backward until the first period of retirement. Then the process is repeated backward throughout the agent's active life, only paying attention to the particular employment status and its associated expected value function, until the first period of active life is reached. ■

A3. Numerical Solution of the Model

Continuous and discrete variables

As mentioned in the main body of the paper, the model is solved by means of gridpoints. Liquid wealth and wages are continuous variables, only discretized to support the computation of any value on their domains, whereas house sizes and house prices are discretized. Table A1 gives further details of this discretization.

Table A1. Discretization of Variables

	Liquid Wealth	Base Wages	House Size	House Price
Original variable	A	ω	H	p
Discretized variable	$A(i, h_{-1}, t)$	$\omega(j)$	$H(h)$	$p(l)$
Gridpoints	$i = 1, \dots, N_A$	$j = 1, \dots, N_\omega$	$h = 1, \dots, N_h$	$l = 1, \dots, N_p$
Gridpoint location	Left	Left	Middle	Middle
Number of gridpoints	$N_A = 51$	$N_\omega = 31$	$N_h = 7$	$N_p = 7$
Number of intervals	$N_A - 1$	$N_\omega - 1$	N_h	N_p
Lower bound	$\underline{A} = B(h_{-1}, t)$	$\underline{\omega} = \max(1, 500, r_h H(1))$	$\underline{H} = 20,000$	$\ln \underline{p} = -\frac{\sigma_p}{\sqrt{1-\rho^2}}$
Upper bound	$\bar{A} = p(N_p) H(N_h) (1 - a_s)$	$\bar{\omega} = 10,000$	$\bar{H} = 180,000$	$\ln \bar{p} = \frac{\sigma_p}{\sqrt{1-\rho^2}}$
Gridsize	$\Delta_A = \frac{\bar{A} - \underline{A}}{N_A - 1}$	$\Delta_\omega = \frac{\ln \bar{\omega} - \ln \underline{\omega}}{N_\omega - 1}$	$\Delta_H = \frac{\bar{H} - \underline{H}}{N_h}$	$\Delta_p = \frac{\ln \bar{p} - \ln \underline{p}}{N_p}$

The lower bound on liquid wealth is set so that an agent can borrow up to some fraction of the lowest possible value of the house owned, net of value of rent of the smallest possible house. The fraction is determined by the down payment coefficient and the remaining active lifetime. Accordingly, the wealth array depends on the size of the house owned and on time. A retired agent cannot borrow.

$$\begin{aligned} B(h_{-1}, t) &= -(1-d) k_t p(1) H(h_{-1}) (1 - a_s) + r_h H(1), \text{ if } t \leq T_F, \\ B(h_{-1}, t) &= 0, \text{ if } t > T_F. \end{aligned}$$

The lowest possible base wage allows an individual to rent the smallest possible house (no homelessness condition).

Wage as a function of base wage and time $w(\omega, t)$ becomes $w(j, t) = \omega(j) \exp(\alpha_1 t + \alpha_2 t^2)$.

Wage and house price distributions

Wages: For each wage interval $j = 1, N_\omega - 1$, we compute three truncated moments of the log-normal base wage distribution (see Jawitz, 2004):

$$\begin{aligned} F(\omega_{j+1}) - F(\omega_j) &= \frac{\Phi\left(\frac{\ln \omega_{j+1} - \mu}{\sigma_\omega}\right) - \Phi\left(\frac{\ln \omega_j - \mu}{\sigma_\omega}\right)}{\Phi\left(\frac{\ln \bar{\omega} - \mu}{\sigma_\omega}\right) - \Phi\left(\frac{\ln \underline{\omega} - \mu}{\sigma_\omega}\right)}, \\ E[\omega | \omega_j \leq \omega \leq \omega_{j+1}] &= \exp\left(\mu + \frac{\sigma_\omega^2}{2}\right) \frac{\Phi\left(\frac{\ln \omega_{j+1} - \mu}{\sigma_\omega} - \sigma_\omega\right) - \Phi\left(\frac{\ln \omega_j - \mu}{\sigma_\omega} - \sigma_\omega\right)}{\Phi\left(\frac{\ln \bar{\omega} - \mu}{\sigma_\omega}\right) - \Phi\left(\frac{\ln \underline{\omega} - \mu}{\sigma_\omega}\right)}, \\ E[\omega^2 | \omega_j \leq \omega \leq \omega_{j+1}] &= \exp(2\mu + 2\sigma_\omega^2) \frac{\Phi\left(\frac{\ln \omega_{j+1} - \mu}{\sigma_\omega} - 2\sigma_\omega\right) - \Phi\left(\frac{\ln \omega_j - \mu}{\sigma_\omega} - 2\sigma_\omega\right)}{\Phi\left(\frac{\ln \bar{\omega} - \mu}{\sigma_\omega}\right) - \Phi\left(\frac{\ln \underline{\omega} - \mu}{\sigma_\omega}\right)}. \end{aligned}$$

House prices: Following Tauchen (1986), the discrete conditional probability for a price $p(i)$ is

$$p_{l'|l} = \begin{cases} \Phi\left(\frac{\ln p(l') + \Delta_p/2 - \rho \ln p(l)}{\sigma_p}\right) & \text{for } l' = 1, \\ \Phi\left(\frac{\ln p(l') + \Delta_p/2 - \rho \ln p(l)}{\sigma_p}\right) - \Phi\left(\frac{\ln p(j) - \Delta_p/2 - \rho \ln p(i)}{\sigma_p}\right) & 1 < l' < N_p, \\ 1 - \Phi\left(\frac{\ln p(l') - \Delta_p/2 - \rho \ln p(l)}{\sigma_p}\right) & l' = N_p. \end{cases} .$$

Value function, policy rules, and expected value function

These are approximated by

$$\begin{aligned} V_t(A_t, \omega, H_{t-1}, p_t) &= V[i, j, h_{-1}, l, t] \\ A'(A_t, \omega, H_{t-1}, p_t) &= A'(i, h_{-1}, t) \\ H(A_t, \omega, H_{t-1}, p_t) &= H(h)(i, h_{-1}, t) \\ EV_t^e(A_t, \omega, H_{t-1}, p_t) &= EV[i', j, h, l]. \end{aligned}$$

Only value functions and policy rules are stored. Expected value functions are over-written at each iteration.

Numerical solution

The numerical solution starts at period $t = T_F = 252$ and proceeds backward. In reaching period $T = 188$, the agent becomes active, then the solution keeps going backward until reaching period $t = 1$. Table A2 illustrates how current income differs in both stages:

Agent	Retired	Active	
		Unemployed	Employed
$t =$	$T_F, \dots, T + 1$	$T, \dots, 1$	
$j =$	0	0	$1, \dots, N_\omega$
$y(j, t) =$	b_R	b	$w(j, t)$

The following steps are done for each i, j, h_{-1} , and l :

1. Initialization. In the last period, $t = T_F$, the agent is retired and does not bequest any liquid or illiquid wealth, so $A_{T_F+1} = 0$ and $H_{T_F} = 0$. The agent just rents to maximize his current utility.

Define the discretized value function for each i, h_{-1}, l :

$$\begin{aligned} V[i, j, h_{-1}, l, t] &= U(A(i) + y(j, t) - c(H(h_{-1}), 0, p(l)) - r_h H^r(h), gH^r(h)), \\ H^r(h) &= \min \left[\max \left[\frac{1-\gamma}{r_h} (A(i) + y(j, t) + p_t(1-a_s)H(h_{-1})), \underline{H} \right], \bar{H} \right]. \end{aligned}$$

To improve legibility, arguments h_{-1} and t are omitted in $A(i, h_{-1}, t)$, that becomes $A(i)$.

2. Integration. Go backward one period, to $t - 1$. The function previously computed, $V [i, 0, h_{-1}, l, t]$, becomes $V [i', 0, h, l', t + 1]$.

For the retired agent,²⁰ and for each i' , j , h , and l , define

$$EV [i', j, h, l] = \sum_{l'=1}^{N_l} V [i', j, h, l', t + 1] P(l' | l).$$

3. Differentiation. Compute the derivative of this object over liquid wealth using a cubic interpolation.

$$\begin{aligned} EV_A [i', j, h, l] &= \frac{-EV [i' + 2, j, h, l] + 4EV [i' + 1, j, h, l] - 3EV [i', j, h, l]}{A (i' + 2) - A (i')}, \text{ if } i' = 1; \\ &= \frac{EV [i' + 1, j, h, l] - EV [i' - 1, j, h, l]}{A (i' + 1) - A (i' - 1)}, \text{ if } N_A > i' > 1; \\ &= \frac{3EV [i', j, h, l] - 4EV [i' - 1, j, h, l] + EV [i' - 2, j, h, l]}{A (i') - A (i' - 2)}, \text{ if } i' = N_A. \end{aligned}$$

To improve legibility, arguments h and $t + 1$ are omitted in $A(i', h, t + 1)$, that becomes $A(i')$.

4. Policy rule inversion. We use the endogenous gridpoints methods as in Carroll (2006). For each i' and h , and renting of the house owned I_s ($= 0$, if the owner does not rent; $= 1$, if the owner does rent), optimal consumption $C (i', h, I_s)$ is found.

Renting, $h = 0$:

$$\begin{aligned} H_t^r (h^r) &= \frac{1 - \gamma}{r_h \gamma} \left[\frac{\beta (1 + r) EV_A [i', j, 0, l]}{\gamma \left(g \frac{(1-\gamma)}{\gamma r_h} \right)^{(1-\gamma)(1-\sigma)}} \right]^{-\frac{1}{\sigma}}, \\ C (i', 0, 1) &= \left(\frac{\beta (1 + r) EV_A [i', j, 0, l]}{\gamma (g H_t^r (h))^{(1-\gamma)(1-\sigma)}} \right)^{\frac{1}{(1-\gamma)\rho-1}}. \end{aligned}$$

Owning, $h > 0$:

No renting, $I_s = 1$, that is, if $s = 1$, then

$$C (i', h, 1) = \left(\frac{\beta (1 + r) EV_A [i', j, h, l]}{\gamma H (h)^{(1-\gamma)(1-\sigma)}} \right)^{\frac{1}{(1-\gamma)\rho-1}}.$$

²⁰To improve legibility of this pseudo-code, the integration of the value function for the active agent is explained in step 2.

Renting, $I_2 = 2$, that is, if $s < 1$, then

$$C(i', h, 2) = \left[\frac{\beta(1+r)EV_A[i', j, h, l]}{\gamma \left(\frac{(1-\gamma)}{\gamma r_h} \right)^{(1-\gamma)(1-\sigma)}} \right]^{-\frac{1}{\sigma}}.$$

5. Smoothing. Conditional on h and $I_s = 1, 2$, regress $C(i', h, I_s)$ on $A(i')$. Whenever there are nonmonotonicities (see below) in $C(i', h, I_s)$ over $A(i')$, use predicted consumption instead of actual consumption:

$$\widehat{C}(i', h, I_s) = \widehat{b}_0 + \widehat{b}_1 A(i') + \widehat{b}_2 [A(i')]^2.$$

6. Inverse solution. Find liquid wealth at time t as a function of i' and h , denoted by \widetilde{A} , for each l, j , and h_{-1}, j , and l :

Renting, $h = 0$:

$$\begin{aligned} H^r(h) &= \frac{1-\gamma}{r_h \gamma} \widehat{C}(i', 0, 1), \\ \widetilde{A}(i', 0) &= \widehat{C}(i', 0, 1) - y(j, t) - c(h_{-1}, 0, l) - r_h H^r(h) - \frac{A(i')}{1+r}. \end{aligned}$$

Owning, $h > 0$:

Define

$$s = \min \left[\frac{1-\gamma}{r_h \gamma} \frac{\widehat{C}(i', h, 2)}{H(h)}, 1 \right].$$

If $s = 1$, then $\widetilde{A}(i', h) = \widehat{C}(i', 0, 1) - b_R - c(h_{-1}, h, l) - \frac{A(i')}{1+r}$;

if $s < 1$, then $\widetilde{A}(i', h) = \widehat{C}(i', 0, 2) - y(j, t) - c(h_{-1}, h, l) + (1-s)r_h H(h) - \frac{A(i')}{1+r}$.

In both cases, store $s(i', h) = s$.

7. Conditional solution. Reposition current liquid wealth \widetilde{A} to find the solution conditional on housing h .

Interior solution. For each i , locate i' such that $\widetilde{A}(i', h) < A(i', h) < \widetilde{A}(i'+1, h)$, then compute the linear interpolations

$$\begin{aligned} A^*(i, h_{-1}, h) &= aA(i', h) + (1-a)A(i'+1, h), \\ s^* &= as(i', h) + (1-a)s(i'+1, h), \\ EV^* &= aEV(i', h) + (1-a)EV(i'+1, h), \end{aligned}$$

where $a = \frac{A(i, h) - \widetilde{A}(i', h)}{\widetilde{A}(i'+1, h) - \widetilde{A}(i', h)}$, and we drop price and time arguments to improve legibility.

Corner solutions. If $A(i, h) < \tilde{A}(i', h)$, then $i^* = 1$; if $A(i, h) > \tilde{A}(N_A, h)$, then $i^* = N_A$:

$$\begin{aligned} A^*(i, h_{-1}, h) &= A(i^*, h) \\ s^* &= s(i^*, h) \\ EV^* &= EV(i^*, h). \end{aligned}$$

Then,

$$\begin{aligned} C^*(i, h_{-1}, h) &= A(i, h) + y(j, t) - c(h_{-1}, h, l) + (1 - s^*)r_h H(h) - \frac{A^*(i, h_{-1}, h)}{1 + r}, \\ \tilde{V}(i, h_{-1}, h) &= U(C^*(i, h_{-1}, h), s^*H(h)) + \beta EV^*. \end{aligned}$$

8. Solution. Find the optimal choice of housing.

Choose $h \in [0, N_h]$ that maximizes the value function:

$$\begin{aligned} V(i, h_{-1}, t) &= \max_h \tilde{V}(i, h_{-1}, h), \\ h(i, h_{-1}, t) &= \arg \max_h \tilde{V}(i, h_{-1}, h), \\ A'(i, h_{-1}, t) &= A^*(i, h_{-1}, h(i, h_{-1}, t)), \\ C'(i, h_{-1}, t) &= C^*(i, h_{-1}, h(i, h_{-1}, t)). \end{aligned}$$

Choice variables with static solutions, such as H^r and s , are not stored, as i) they can always be recovered from h and C , and ii) they do not have observable counterparts in the available data set.

9. Go back to step 2. and repeat the process until reaching period $t = 1$.

2' Integration. Active agent.

For all three consecutive wage gridpoints, the value function while employed (for simplicity expressed dropping all arguments except wages) is interpolated using a quadratic function:

$$V_j(w) = a_j + b_j w + c_j w^2.$$

For $j = 2, \dots, N_w - 1$, these three points are $j - 1$, j , and $j + 1$. For $j = 1$, these three points are j , $j + 1$, and $j + 2$, that is, the calculated coefficients are the same as those of $j = 2$.²¹ Then $c_j = \frac{V_{j+1} - V_{j-1} - d}{(\omega_{j+1} - \omega_{j-1})^2}$, $b_j = \frac{d}{\omega_{j+1} - \omega_{j-1}} - 2\omega_{j-1}c_j$, and $a_j = V_{j-1} - b_j\omega_{j-1} - \omega_{j-1}^2c_j$, where $d = \frac{V_j - V_{j-1} - x^2(V_{j+1} - V_{j-1})}{x - x^2}$ and $x = \frac{\omega_j - \omega_{j-1}}{\omega_{j+1} - \omega_{j-1}}$.²²

²¹Notice that i) wage intervals are not of equal size, because the discretization of this variable is done over log wages, and ii) this interpolation is done over wage levels; it cannot be done in the unit interval as other interpolations, because the purpose is not just to interpolate some value but to integrate a function.

²²To determine these coefficients, we first interpolate V over x : $V(x) = V_{j-1} + dx + ex^2$, where

With this quadratic function the expected value function for each wage interval is computed exploiting the previously defined truncated moments:

$$\begin{aligned} E[V_j(\omega) | \omega_j \leq \omega \leq \omega_{j+1}] &= \int_{\omega_j}^{\omega_{j+1}} [a_j + b_j\omega + c_j\omega^2] dF(\omega) \\ &= a_j [F(\omega_{j+1}) - F(\omega_j)] + b_j E[\omega | \omega_j \leq \omega \leq \omega_{j+1}] \\ &\quad + c_j E[\omega^2 | \omega_j \leq \omega \leq \omega_{j+1}]. \end{aligned}$$

The computation of the reservation wage is also facilitated by this interpolation. It proceeds then in two steps:

1. Find j^* such that $V(\omega_{j^*}) \leq V(0) \leq V(\omega_{j^*+1})$.
2. Then find $\omega^* = \{w | V(0) = V_j(\omega) = a_j + b_j\omega + c_j\omega^2\}$, that is, $\omega^* = \frac{-b_j + \sqrt{b_j^2 - 4(a_j - V(0))c_j}}{2c_j}$.

We compute the expected value for an interval conditional on wages exceeding the reservation wage, $E[V_{j^*}(\omega) | \omega^* \leq \omega \leq \omega_{j+1}]$ in a similar manner. Then we compute the expected value conditional on wages being above any current wage or the reservation wage:

$$\begin{aligned} E[V(\omega) | \omega \geq \omega_j] &= \sum_{s=j}^{N_w-1} E[V(\omega_s) | \omega_s \leq \omega \leq \omega_{s+1}] \\ E[V(\omega) | \omega \geq \omega^*] &= E[V_{j^*}(\omega) | \omega^* \leq \omega \leq \omega_{j^*+1}] + E[V(\omega) | \omega \geq \omega_{j^*+1}]. \end{aligned}$$

Once the integration over wages is done, we form the complete expressions for the expected value functions and integrate them over house prices:

$$\begin{aligned} EV[i, 0, h, l] &= \sum_{l'=1}^{N_l} [\lambda_t^u E[V(\omega) | \omega \geq \omega^*] + (1 - \lambda_t^u [1 - F(\omega^*)]) V[i, 0, h, t]] P(l' | l) \\ EV^e[i, j, h, l] &= \sum_{l'=1}^{N_l} [(1 - \theta_t) (\lambda_t^e E[V(\omega) | \omega \geq \max[\omega^*, \omega_j]]) \\ &\quad + (1 - \lambda_t^e [1 - F(\max[\omega^*, \omega_j])]) \max[V[i, j, h, t], V[i, 0, h, t]] \\ &\quad + \theta_t (\lambda_t^e E[V(\omega) | \omega \geq \omega^*]) + (1 - \lambda_t^e [1 - F(\omega^*)]) V[i, 0, h, t]] P(l' | l). \end{aligned}$$

Addressing nonmonotonicities. Nonmonotonicities over $A(i')$ actually arise in the expected marginal value function $EV_A[i']$, because of the discreteness of house size h . This function is decreasing in $A(i')$, but exhibits upward “jumps,” produced by discrete increases in the optimal house size h that do not go away with the integration (actually summation) over discrete house prices $p(l)$.²³ These nonmonotonicities are

x is defined as above and lies on the unit interval. The solution for this interpolation is d , also as defined above and $e = V_{j+1} - V_{j-1} - d$. Then, using the definition of x , we find the corresponding coefficients for V as a function of ω .

²³See Fella (2014) for a formal and computational treatment of these nonmonotonicities.

inherited by optimal consumption, calculated by inversion of the policy rule. It is, however, very convenient to perform this smoothing in the consumption space, as opposed to smoothing in the space of the expected marginal value. The principle of this smoothing is to use an envelope of the kinked value function, so that its marginal value is monotonically decreasing, as we can see in Figure A1.

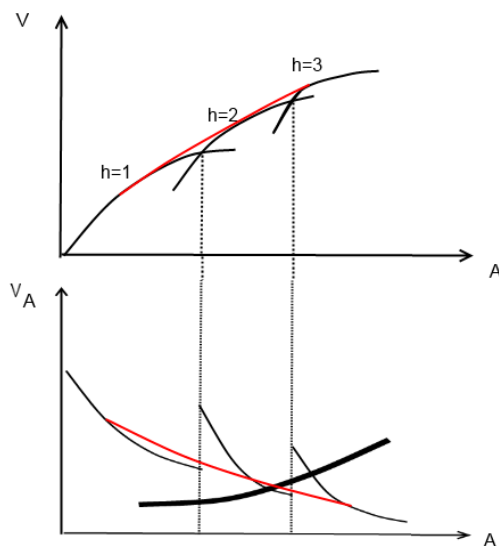


Figure A1: Discontinuity and smoothing of the marginal value function

A4. Sensitivity Analysis

We perform a sensitivity analysis in which we change the baseline value of each parameter in the model, one at a time, and measure the resulting effects on selected statistics such as the homeownership rate, holdings of liquid wealth by homeownership status, wages, the unemployment rate, and employment transitions (from unemployment to being employed, from employment to becoming unemployed, and from one job to another one). We report these results in Table A3.

[Table A3 here]

Our baseline scenario refers to variable values 20 years (or 80 quarters) after individuals started their careers, assuming that all of them started off unemployed with no house and zero liquid wealth. The baseline homeownership rate is 62%, the average home value is \$69,000, and homeowners' average debt is \$10,000. Renters hold \$14,000 in liquid wealth. The overall unemployment rate is almost 31%, and the percentage of unemployed individuals that find a job is about 21%. Around 9% of the employed lose their job, and only 4% transition directly to a new job.

Increases in a first group of housing and savings parameters, the down payment rate d , the persistence parameter ρ , the variability of housing price σ_p , rent r_h , the

coefficient of risk aversion σ , and the subjective valuation of a rented house g , all prompt a decrease in homeownership rates, associated with decreasing average accepted wages. They, however, differ in their effect on wealth accumulation and unemployment in three different ways.

First, increases in the down payment rate d and in the coefficient of risk aversion σ decrease both the incentive to save to buy a house, thereby eliciting a decrease in wealth of renters and a decrease in residential wealth of owners, who end up holding more liquid wealth. The coincidence of these effects suggests that allowing for housing in an estimated utility-maximizing job search model, for a given set of observables, will decrease the estimated coefficient of risk aversion, thereby creating problems of separate identification of these parameters, as we will discuss here. These two variations also reduce the unemployment rate and improve employment transitions.

Second, increases in the persistence parameter ρ and in variability of a housing price σ_p , as well as in the subjective value of renting g in decreasing home ownership, ensure that only the wealthiest agents remain homeowners. Accordingly, average residential wealth increases and liquid wealth of homeowners decreases (or stays almost unchanged, as with the increase of house price persistence), while the liquid wealth of renters increases, as they save more before buying a house. These variations also increase unemployment and deteriorate employment transitions.

Third, a higher rent r_h discourages any kind of wealth accumulation. Renters reduce savings earmarked for future home purchases; owners stop considering a potential move to a larger house and also reduce savings. Wages go down, but unemployment declines and employment transitions improve.

On the other hand, increases in adjustment fees a_b and a_s increase homeownership, increase liquid wealth holdings of owners, decrease residential wealth, and decrease liquid wealth holdings of renters, while increasing wages and unemployment rates (except when a_b increases). Increased adjustment fees disincentivize renters' savings, while they displace homeowners' savings from residential wealth toward liquid wealth. A larger share of income spent in housing makes more people homeowners, which decreases the average value of home property while increasing average homeowners' liquid wealth and decreasing renters' savings. An increase in the share of income spent on nondurables γ increases liquid wealth holdings both for renters and owners while it decreases residential wealth. Agents spend less on their homes, but more people become homeowners. This change is associated with an increase in reservation wages that increases accepted wages and unemployment.

In the lower half of Table A3 we can see the impact on the same model variables of changes of labor market parameters: unemployment transfers, the arrival rates when unemployed and employed (and their respective growth rates), the layoff rate (and its growth rate), the mean log wage (and its linear growth rate), and the log wage standard deviation. All of these variations impact labor market variables in a similar fashion as usual models of job search.

An increase in unemployment transfers b decreases the percentage of homeowners, but it increases residential wealth, while decreasing liquid wealth both of renters and owners, because it increases the reservation wage. Accordingly, it increases wages, the unemployment rate, and decreases transitions from unemployment to employment.

If the arrival rate when unemployed λ increases, wages increase and the unemployment rate decreases. Accordingly, homeownership and savings of homeowners in both

forms of wealth increase, while savings of renters decrease. Increases in the growth rate of this arrival rate α_λ have exactly the same effect, except for the decrease in residential wealth.

If the arrival rate when employed π increases, homeownership and residential wealth also increase, but liquid wealth of both renters and owners goes down, as workers' wages go down and they are more likely to be employed. Increasing the growth rate α_π , however, depresses wages and with them all types of savings and homeownership, while it increases unemployment. When the layoff rate θ and its growth rate α_θ increase, wages decline and unemployment increases, and so do homeownership and owners' wealth. This change, however, increases wealth holdings of renters, who have to save more to buy a house and hedge against future unemployment spells.

An increase in the mean wage μ and in the dispersion of wage offers σ_ω increases wages and the unemployment rate, while it increases homeownership and residential wealth and liquid wealth of owners, while decreasing wealth of renters. An increase in the growth rate of wages α_1 increases wages, decreases unemployment, and it decreases savings of renters and residential wealth, while increasing homeownership and homeowners' wealth.

A5. Definition of the Variables

For all variables, we use quarters of working experience as our time unit. The very first quarter is the one in which the individual starts his employment history, right after the last quarter in which he reports being enrolled in school or in college. Because of attrition and missing data, or because of individuals later resuming their college education, not all individuals are observed through 2010.

We consider an individual has a job in a particular quarter if the NLSY reports a job for him for the first week of this quarter. The NLSY provides information on multiple jobs held by a person in the same period, however we only consider the job with the most hours of work. We also ignore any other job held during the rest of the quarter. Consequently, the wage for the quarter is the wage for the job reported in the first week of the quarter in 1982-1984 dollars times 13. We use the Consumer Price Index reported by the Bureau of Labor Statistics (BLS)²⁴ to convert nominal values into real amounts.

We define someone as employed if the individual works 20 or more hours per week and is unemployed in any other instance. That is, a person is given the status of unemployed if the weekly labor status array of the NLSY does not report a job for him,²⁵ if the individual works fewer than 20 hours per week, or if there is missing information on wage rates or hours worked.

The NLSY also contains annual data on the financial characteristics of the household for years 1985 onward. Respondents report the market value of their assets at the

²⁴See <http://www.bls.gov/cpi/cpifiles/cpiat.txt>.

²⁵The weekly labor status array of the NLSY distinguishes between several status for an individual who is not working: "associated with an employer but periods not working with employer are missing;" unemployed; OLF [out of the labor force]; "not working but OLF vs unemployed status is unknown;" "activemilitary service;" and "no information is reported to account for the week."

moment of the interview;²⁶ this information is then assigned to its particular calendar quarter, leaving blank all other quarters. There are five types of assets: residential property, financial assets, business assets, vehicles, and other. Residential property is the market value of the house or apartment owned or being bought by the respondent. We define liquid wealth as the sum of all other assets net of liabilities. That is, the net value reported for liquid wealth is the sum of financial assets, business assets, vehicles, and other assets net of any liability on residential property, such as mortgages, back taxes, home improvement loans, or debts such as assessments, unpaid amounts of home improvement loans, or home repair bills. Since the NLSY reports a variable named “total assets,” to construct “liquid wealth,” we just subtract the market value of residential property from this total.

²⁶The NLSY defines market value as the amount the respondent would reasonably expect someone else to pay if the particular asset were sold today in its present condition.

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Table 1. Summary Statistics
Money Amounts Are in 1982-1984 Dollars

Variable	Obs	Mean	St Dev	Min	Max
Owners	4,228	0.3697	0.4828	0	1
Residential Wealth	1,563	59,484	59,800	640	780,950
Liquid Wealth	3,582	11,888	84,944	-402,691	1,526,997
% Liquid Wealth <0	1,189	33.19			
Total Wealth	3,603	37,927	106,262	-151,286	1,633,592
% Total Wealth <0	295	8.19			
Employed	29,443	0.7155	0.4511	0	1
Wages	21,238	4,726	3,663	25	140,225
Log Wages	21,238	8.260	0.688	3.219	11.851

Table 2. Summary Statistics by Homeownership and Employment Status
Money Amounts Are in 1982-1984 Dollars

Variable	Homeownership		Employment Status	
	Renter	Owner	Non-employed	Employed
Owners %			21.24	46.64
Residential Wealth		59,484	46,968	62,990
Residential Wealth Distribution (%)				
0-40,000		42.54	58.19	38.15
40,001-60,000		22.17	19.59	22.89
60,001-80,000		13.77	7.60	15.50
>80,000		21.52	14.62	23.46
Liquid Wealth	12,331	11,315	6,738	14,872
Liquid Wealth Distribution (%)				
<0	12.09	60.46	24.89	38.01
=0	8.32	0.26	8.83	2.47
>0	79.59	39.28	66.29	59.52
	100.00	100.00	100.00	100.00
Total Wealth	12,332	70,799	18,833	48,981
Total Wealth Distribution (%)				
<0	12.09	3.13	10.67	6.75
=0	8.32	2.11	9.69	3.59
>0	79.59	94.75	79.64	89.66
	100.00	100.00	100.00	100.00
Employed %	52.42	78.12		
Wages	3,393	5,067		4,857
Log Wages	7.920	8.351		8.324

Table 3. Summary Statistics by Selected Years of Experience
 Money Amounts Are in 1982-84 Dollars

	Year 4	Year 12	Year 20
Percentage Owners	4.9	44.7	65.8
Value of the House	30,888	41,351	63,743
Liquid Wealth Owners	-11,584	-3,372	5,969
Liquid Wealth Renters	3,352	9,668	17,155
Log wages	7.9	8.2	8.5
St. Dev. Wages	0.5	0.5	0.5
Nonemployment Rate	43.0	36.6	10.3
Employment Transitions			
Job Finding	17.2	18.4	24.3
Job Separations	13.4	6.8	3.2
Job-to-Job	0.6	2.2	2.0

Table 4. Parameter Values and Asymptotic Standard Errors (ASE)

Parameter	$\hat{\Theta}$	Estimate	ASE
Down payment	d	0.200000000	0.000000000
Adjustment fee, buying	a_b	0.091479041	0.004907915
Adjustment fee, selling	a_s	0.094953740	0.007532628
Housing price autocorrelation	ρ	0.871330909	0.013948936
St. dev. of housing price	σ_p	0.109919398	0.003662866
Rent as a percentage of house price	r_h	0.020343353	0.000959350
Coefficient of relative risk aversion:	σ	0.734941022	0.016490091
Share of nondurable consumption	γ	0.837871017	0.008221805
Utility of renting	g	0.721856013	0.016631338
Unemployment transfers	b	431.706509597	26.512249931
Arrival rate unemployed: base	λ_0	0.285119383	0.028264290
growth	α_λ	0.004576271	0.001777756
Arrival rate employed: base	π_0	0.012829060	0.001124295
growth	α_π	0.000884202	0.000355822
Layoff rate: base	θ_0	0.139052984	0.008751022
growth	α_θ	-0.009323368	0.001232146
Mean of base log wages:	μ	6.754128610	0.242220967
growth linear	α_1	0.002351331	0.000263365
growth quadratic	α_2	-0.000008687	0.000001415
Standard deviation of log wages	σ_ω	0.991080850	0.009962110

Table 5. Summary of Actual and Predicted Choice Distribution (in Percentage)

Observable	Years of Experience								Fit	
	Year 4		Year 12		Year 20		Year 28		R^2	χ^2
	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.		
Percentage Owners	4.9	17.7	44.7	53.7	65.8	62.0	76.4	69.2		13.8
Residential Wealth	30,888	26,928	41,351	45,627	63,743	68,629	83,026	79,867	0.99	
Liquid Wealth Renters	3,352	3,573	9,668	11,107	17,155	13,868	25,271	12,568	0.88	
Liquid Wealth Owners	-11,584	-12,194	-3,372	-14,511	5,969	-9,706	9,786	6,849	0.29	
Log wages	7.9	8.0	8.2	8.2	8.5	8.3	8.5	8.5	0.99	
St. Dev. Log wages	0.4	0.4	0.5	0.4	0.5	0.4	0.5	0.4	0.97	
Nonemployment Rate	43.0	34.1	36.6	33.0	10.3	30.8	15.8	29.0		45.6
Employment Transitions										
Job Finding	17.2	26.1	18.4	22.6	24.3	20.7	15.9	18.5		14.1
Job Separations	13.4	13.4	6.8	11.1	3.2	9.3	3.1	7.6		17.0
Job-to-Job	0.6	0.9	2.2	3.4	2.0	4.0	1.5	4.5		4.3

Critical value at .5% significance: $\chi^2_{(12)} = 28.3$.

Table 6. Actual and Predicted Variables when Buying and Selling a House for the First Time

Variable	Buying a House		Selling a House	
	Actual	Predicted	Actual	Predicted
Liquid wealth variation	-25,522	-33,822	21,322	28,294
Residential wealth variation	46,829	30,559	-46,022	-30,114
Percentage ever	85.8	98.6	47.4	82.5
Time before	42.1	34.0	19.4	19.5

Table 7. Summary of Regime Changes: Effects of Housing Market Loosening and Labor Market Tightening on Home Ownership and Employment Statistics

Statistics	Year	Benchmark in Levels	Regime Changes						
			Looser Housing Market			Tighter Labor Market			
			Lower down payment	Less persistent home prices	Both	Lower wage offers	Higher layoff rate	Both	Both and +UI
Percent Owners	4	22.2	10.4	3.6	16.1	-0.6	-0.0	-0.9	-1.0
	12	49.1	17.7	27.6	40.6	0.3	-0.2	-1.3	-0.9
	20	61.9	11.7	31.0	36.7	-2.0	-4.8	-7.5	-5.6
Residential Wealth	4	30,590	2,534	-782	1,626	188	-17	88	2,914
	12	51,877	2,285	-11,268	-3,332	-3,388	-6,072	-7,803	-3,176
	20	68,405	8,145	-19,591	-7,623	-2,327	-3,322	-5,556	-20
Liquid Wealth Owners	4	2,789	84	-235	-9	-129	36	-83	-139
	12	10,656	2,640	-5,531	-4,418	-113	0	-253	-437
	20	12,543	2,888	-6,211	-2,255	674	512	454	-139
Liquid Wealth Renters	4	-8,338	-5,660	688	-5,287	266	102	363	-1,181
	12	-5,969	-8,678	-2,142	-9,337	-3,115	-2,847	-2,970	-3,938
	20	1,204	-9,267	-4,020	-9,849	-3,102	-3,919	-4,251	-4,800
Log Wages	4	8.03	-0.5	-0.5	-0.3	-2.8	-1.5	-4.0	0.8
	12	8.25	1.9	1.2	3.3	-6.3	-5.3	-11.3	-4.2
	20	8.39	2.5	3.2	4.4	-6.3	-6.3	-12.1	-5.4
Nonemployment Rate	4	35.8	-0.1	-0.2	0.2	-0.3	1.4	1.1	4.4
	12	30.7	1.4	0.6	1.9	-0.7	3.2	2.7	6.1
	20	29.4	1.2	1.8	2.0	-0.3	3.1	2.5	5.8
Employment Transitions									
Job Finding	4	25.5	0.0	0.1	-0.4	0.3	0.7	0.9	-3.0
	12	22.6	-1.1	-0.6	-1.3	0.7	2.8	3.2	-1.0
	20	19.9	-1.5	-1.8	-2.5	0.2	2.7	3.4	-0.7
Job Separations	4	12.1	0.2	0.0	0.1	0.2	2.0	1.9	1.8
	12	10.0	0.2	-0.2	0.2	0.0	3.0	2.9	2.5
	20	8.4	-0.0	-0.1	-0.3	0.0	2.6	2.5	2.1
Job-to-Job	4	0.3	0.1	0.0	0.2	0.0	-0.1	-0.1	-0.1
	12	3.3	0.9	0.2	1.2	0.4	-0.3	-0.4	-0.6
	20	3.7	0.3	0.3	0.3	0.2	-0.0	0.0	-0.6

Note: Log wage variations are multiplied by 100, so they are read as percent variations. Regime changes are contained in the following parameter variations: $\Delta d = -0.15$, $\Delta \rho = -0.1$, $\Delta \mu = -0.2$, $\Delta \theta = 0.05$, and $\Delta b = 200$. Year refers to Year of Experience. UI: Unemployment Insurance

Table A3. Sensitivity Analysis. Effect of Parameter Variations on Selected Statistics
Variation of Statistics Resulting from Variations of One Parameter at a Time

Parameter Variation	Percent Owners	Resid. Wealth	Liquid W Owners	Liquid W Renters	Log Wages	U. Rate%	Transitions in %			
							U→E	E→U	E→E'	
Statistics Levels										
Baseline	62.01	68,629	-9,706	13,868	8.35	30.76	20.67	9.28	3.99	
Statistics Variations:										
Housing and Savings Parameters										
d	0.1	-9.9	-8,517	4,719	-2,165	-2.03	-0.95	1.13	0.15	-0.14
a_b	0.01	1.19	-4,271	849	-1,229	-0.09	0.15	-0.35	-0.04	0.03
a_s	0.01	8.91	-10,138	2,498	-2,239	0.73	0.37	-0.82	-0.19	0.09
ρ	0.01	-1.17	814	4	1,292	-0.22	0.25	-0.34	-0.04	0.20
σ_p	0.01	-4.71	5,599	-3,016	7,336	-0.07	0.13	-0.33	-0.08	0.05
r_h	0.01	-1.4	-13,538	-9,601	-12,555	-7.28	-2.33	1.13	-0.59	-0.13
σ	0.1	-3.47	-3,102	253	-1,757	-3.41	-1.3	1.05	-0.06	0.31
γ	0.1	34.29	-6,686	5,267	13,961	4.23	2.16	-2.84	-0.4	-0.23
g	0.01	-1.11	1,121	-776	852	-0.06	0.05	-0.01	0.02	0.06
Labor Market Parameters										
b	100	-0.02	917	-136	-61	2.74	1.44	-1.82	-0.26	-0.48
λ	0.1	4.06	1,071	907	-448	7.1	-1.11	1.39	0.2	-0.84
α_λ	0.01	2.57	-2,412	343	-1,620	9.39	-2.17	3.21	0.49	-0.89
π	0.1	1.3	1,176	-1,436	-1,521	-4.92	-2.63	5.44	0.94	25.69
α_π	0.01	-0.3	-817	-388	-374	-1.18	0.3	0.6	0.41	4.07
θ	0.1	-6.77	-10,089	-2,766	1,190	-11.87	6.24	4.11	5.23	-0.92
α_θ	0.01	-2.29	-5,631	-1,472	3,548	-12.48	6.75	4.6	5.85	-1.08
μ	0.1	1.1	1,409	330	-110	3.12	0.36	-0.34	0.03	-0.01
α_1	0.01	8.85	-1,268	829	-2,806	51.61	-3.49	4.92	0.33	1.22
σ_ω	0.1	3.52	2,187	1,941	-716	7.9	0.63	-0.86	-0.09	-0.15

Note: Log wage variations are multiplied by 100, so they are read as percent variations. Money amounts are in 1982-1984 dollars.

W= Wealth, U=Unemployment, E=Employment

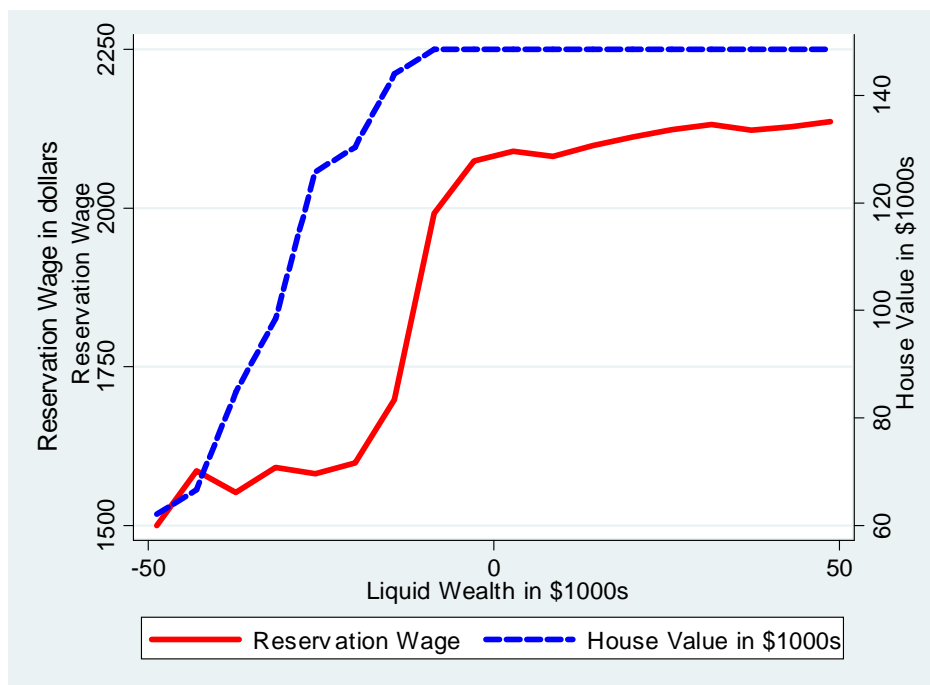


Figure 1. Reservation Wage and Value of House Owned by Liquid Wealth

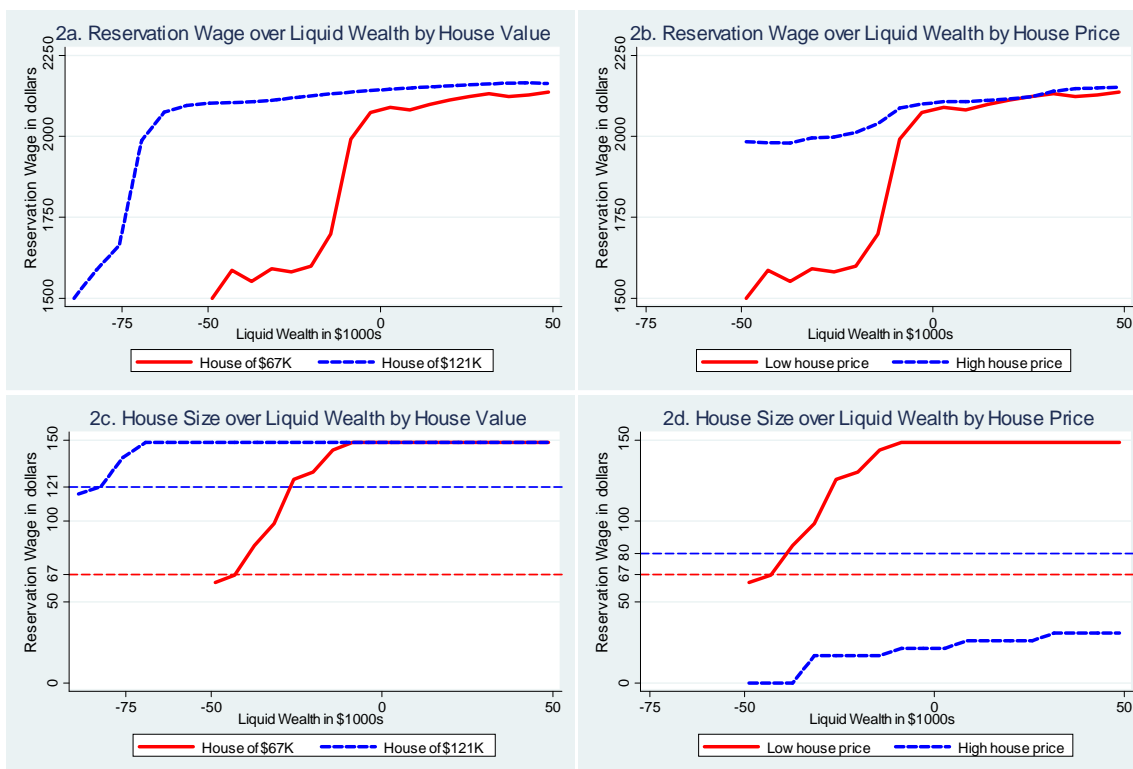


Figure 2: Reservation Wage and House Size by Liquid Wealth, House Value, and House Price

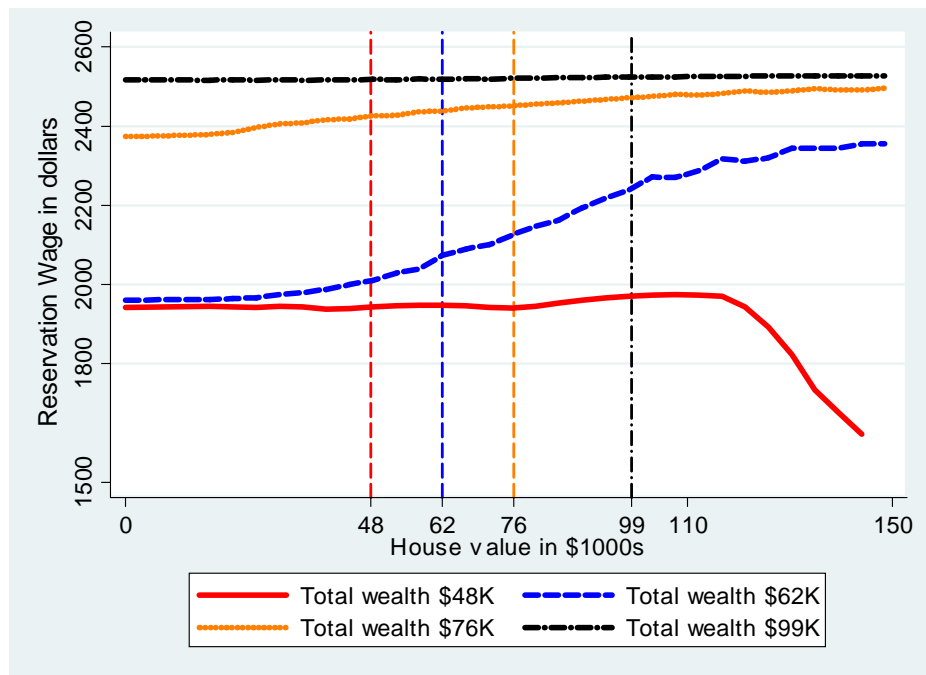


Figure 3. Reservation Wage of Homeowners When House Price Is Low as a Function of House Value, Holding Total Wealth Constant



Figure 4. Reservation Wage of Homeowners When House Price Is High as a Function of House Value, Holding Total Wealth Constant

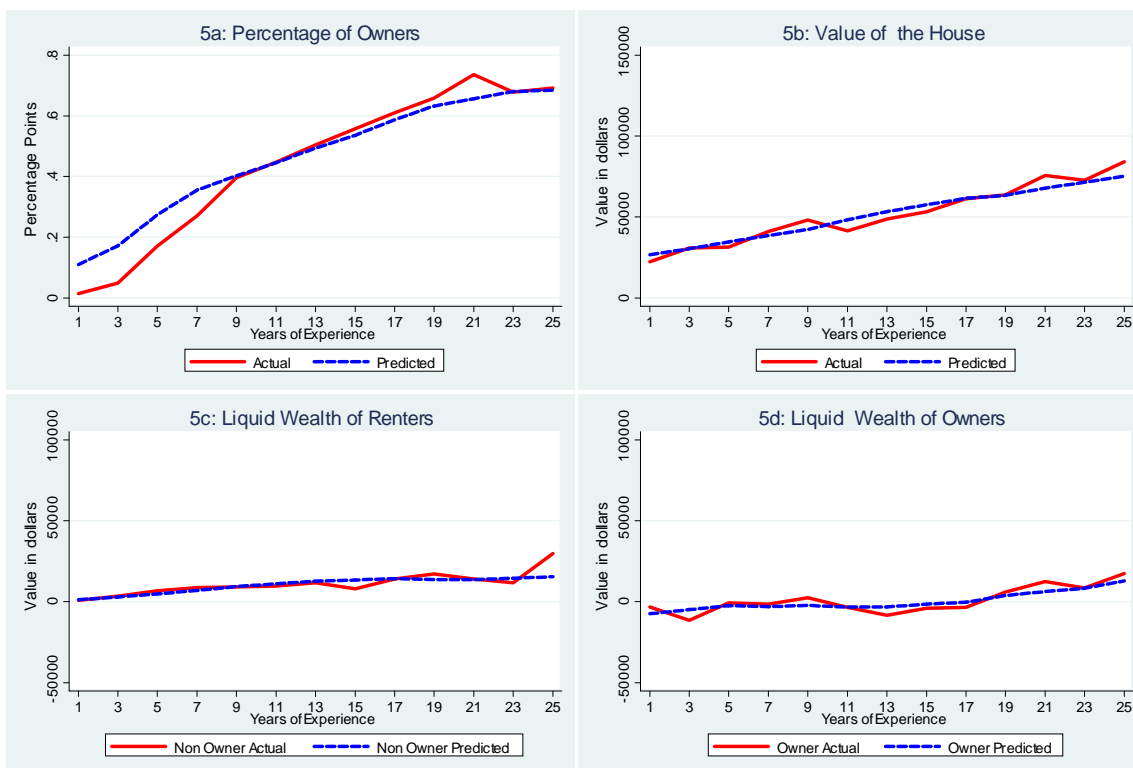


Figure 5: Actual and Predicted Housing Variables

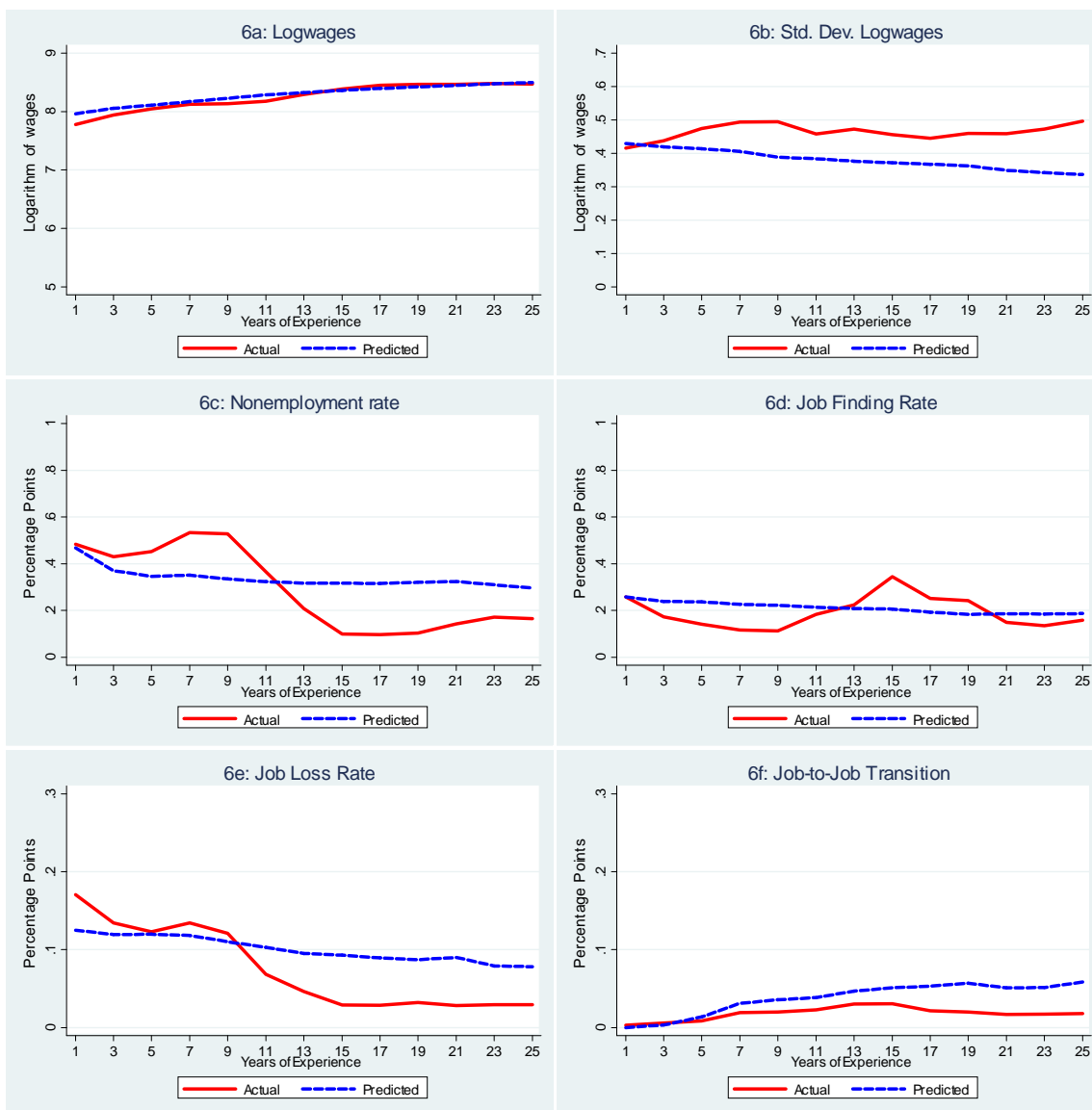


Figure 6: Actual and Predicted Labor Market Variables

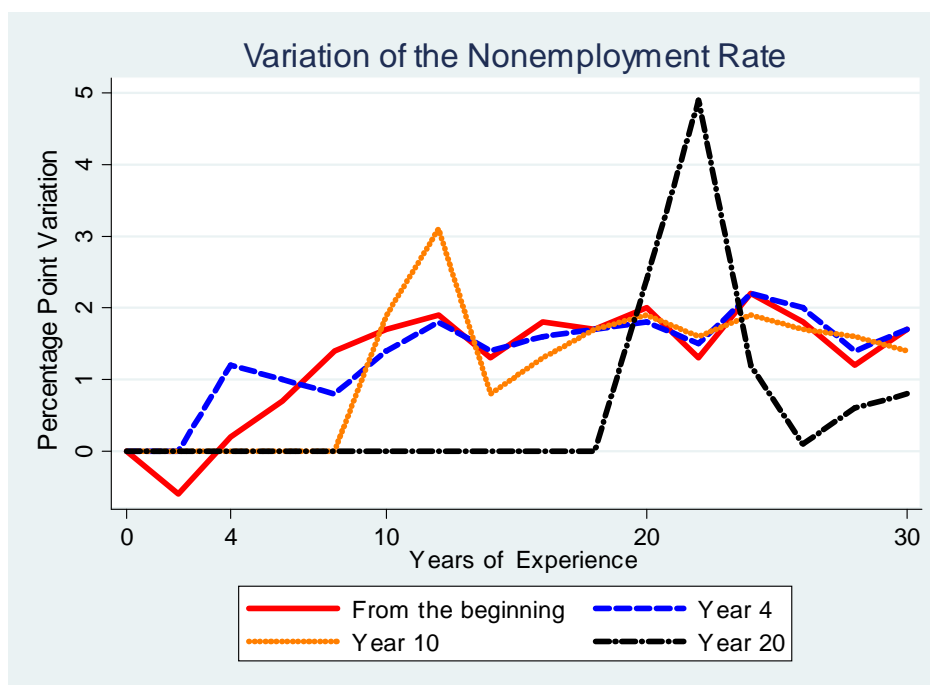


Figure 7: Effect of Housing Market Loosening on Nonemployment by Year of Regime Change

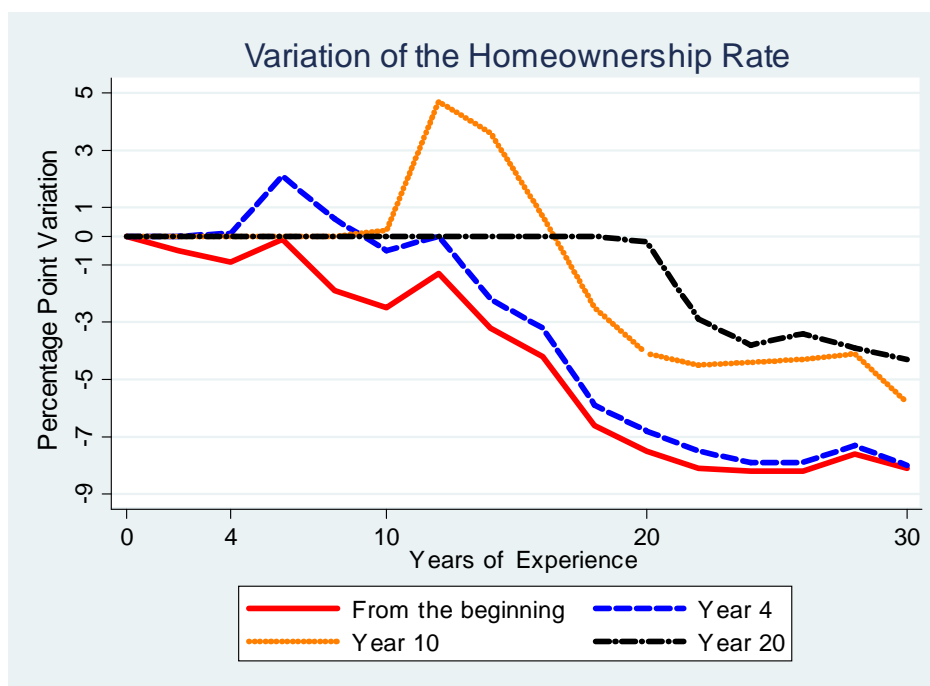


Figure 8: Effect of Labor Market Tightening on Home Ownership by Year of Regime Change