

American Dream Delayed: Shifting Determinants of Homeownership*

– Preliminary and Incomplete –

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Abstract

This paper investigates the delay in homeownership and a subsequent reduction in homeownership rate observed over the past decades. We focus on the delay in giving birth to children and increased labor market participation as contributing factors to homeownership dynamics for prime-age female households. We formulate and estimate a dynamic life-cycle model, in which both single and married households can optimally choose homeownership, the number and timing of children and labor supply. Our theoretical model provides a detailed treatment of the economic costs and benefits associated with housing, fertility decisions and labor supply alternatives faced by the individuals over different stages of the life cycle. The delays in giving birth and buying first home arise endogenously.

KEYWORDS: Housing Demand, Fertility, Labor Supply.

JEL: R21, J13, J22, D14, D91

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1 Introduction

The average age of a first-time home buyer increased from 28 years old in the 1970's, to 30 in the 1990's, and now stands at 32.¹ Thus starting about 1980 the delay in the transition to homeownership resulted in the stagnation and subsequent reduction of homeownership rates for all cohorts of population in working age (Goodman et al., 2015). The delay in first homeownership coincided with postponing marriage and fertility; the average age of mother at first birth rising from 22 forty years ago to 24 two decades ago, and currently stands at about 26. Labor-force participation of females in their fecund period rose dramatically from 48 percent in 1970's, to 74 percent in 1990's, hours worked following a similar pattern. Over this 40 year period real wages increased slightly, the real interest rate declined, while housing prices were mainly on the rise.

There are many studies showing that household decisions about fertility, labor supply and housing are jointly determined. Increased women's labor force participation is tightly linked to the delay in giving birth to children, due to the competing allocation of time between work and raising children (Gayle and Miller, 2006). Childbearing is strongly associated with the transition to homeownership (Öst, 2012). Indeed, according to Fannie Mae's National Housing Survey, homeownership as the best environment in which to raise children was among top reasons people buy a home. Therefore delays in fertility stemming from greater female labor force participation might cause women and their partners to postpone homeownership. But causality also seems to run the other way: recent evidence on the effect of homeownership suggests that homeowners are more likely to be employed and may earn more (Munch et al., 2008), and homeowners may have greater fertility rates compared to renters (Dettling and Kearney, 2014).

Whereas the inseparable nature of labor supply, fertility, and homeownership choices is widely acknowledged, to the best of our knowledge, a dynamic life-cycle model unifying these joint decisions has yet to be estimated. Our analysis seeks to fill this gap by developing and estimating such a model, in order to better understand the joint determinants and timing of these important interrelated life cycle decisions, and hence explain the secular decline in home ownership within the U.S.

We find that, all else being equal, households prefer becoming homeowner earlier in life. Therefore, the delay in homeownership is not a preference, but rather a result of a trade-off between homeownership and other important life-cycle decisions, such as working and family formation. The estimated preference parameters suggest that the transition to homeownership

¹U.S. Bureau of the Census, American Housing Survey, Chicago Title and Trust Co. survey, and authors own calculations based on the Panel Study of Income Dynamics.

homeownership is positively related to labor market participation and the presence of children in a household. This finding implies that whereas an increase in labor market participation can speed up the transition to homeownership, having children later in life and having smaller number of children per family makes homeownership less attractive and may result in reduced homeownership rate. Further, we find that the utility of giving birth to children is larger for more educated cohorts of females, who are typically older when having their first child. We further explore the channel of increased educational attainment for females in a counterfactual policy simulation exercise. Providing an extra year of education indeed shifts fertility for later in life and results in later child birth, however it also enables households to become homeowners earlier due to greater preference for homeownership for more educated cohorts of households.

Our next experiment deals with increasing wage. Estimation of wage equation does not bring a convincing evidence on systematic differences in wage rates between homeowners and renters. However, the counterfactual policy experiment shows that higher wages stimulate larger labor force participation and provide a strong incentive to increase labor supply for those households who already work. An increase in working activities substitutes away child birth and results in having first child later in life and lower number of children per household in total. The reduction in fertility and overall number of children is strong enough to lead to the delay in homeownership and reduction in homeownership rate.

Finally, a less confounding factor to explain the delay and subsequent reduction in homeownership is the increase in housing prices. The channel of higher housing prices works directly through increasing the monetary cost of acquiring a home, and therefore, reducing the incentive to become a homeowner. We also observe some changes in fertility and labor market participation induced by the decline in homeownership through the dynamic feedback from homeownership to giving birth and work, however, these adjustments are only minor.

The paper proceeds as follows. The next section summarizes the data and provides a basic empirical analysis of the relationship between housing and homeownership, fertility decisions and labor supply. We show that since homeowners rarely revert to renting permanent accommodation, the decline in home ownership is largely attributable to the first home purchase. In Section 3 we develop a theoretical model to analyze the economic costs and benefits associated with homeownership, fertility decisions and labor supply alternatives faced by the households over the life cycle. Our model is used to disentangle the effects of fertility decisions and labor supply on housing choices, and to quantify the dynamic feedback that homeownership induces on households' fertility choices and labor supply. This section also explains the estimation strategy, which is based on the conditional choice probabilities of decisions taken by females in our data set, the Panel Study of Income Dynamics (PSID). We estimate the parameters of the model that determine household fixed costs of transition to homeownership, preferences over

housing, working (and leisure) choices, the number and timing of children. Technical details on the estimation are relegated to an Appendix. We report the results of the structural estimation in Section 4, while Section 5 conducts counterfactual exercises with the estimated model to illustrate the effects of permanent changes in the education level, wage rate, interest rate, and housing prices. The last section concludes with a summary of the main empirical results from estimation and the counterfactual exercises.

2 Relating homeownership to fertility and labor supply

This section describes the data and documents complex dynamic relationship between housing, homeownership, fertility decisions and labor supply over the life cycle.

Our analysis is conducted using the Panel Study of Income Dynamics (PSID) for the years starting from 1968 through 1993. This dataset has two key advantages for the purpose of this study. First, it contains broad and comprehensive information on household housing, labor supply, income, and detailed family characteristics for a sample of households representative of the US population. To keep the sample representative, from the original data we exclude the poverty subsample and the Latino subsample added closer to the end of our study period. Second, the PSID dataset has a panel dimension so that we can measure household transition to homeownership, intertemporal labor supply dynamics and changes in family composition due to births of children.

Demographic characteristics include age, education and marital status of the individual, family size of household, number of children and their ages. Labor force participation data include number of hours put into working activities and the associated income from labor. We collect information on household housing arrangements, including number of rooms in a dwelling, indicator for homeownership, value of primary residence for home owners and amount of rent paid by renters. All monetary values, such as house value for homeowners, rent paid by renters and labor income, are adjusted for inflation using Consumer Price Index and converted into 1984 dollars. While homeownership choices are made throughout investor's life, her labor force participation and fertility choices are relevant during investor's prime age and her fecund period. For this reason, our study considers prime age households of females in their fecund stage of life and excludes observations for individuals younger than 22 or older than 45. We use the same data in constructing motivating figures, conducting basic reduced form analysis, and use it in the estimation of a dynamic structural model.

Table 1 presents summary statistics for the data sample used in the analysis. Over the observed time period, the average homeownership rate for the sample of 22-45 years old females constitutes 64%, which matches the homeownership rate reported for other nationally repre-

sentative data over the same time period (e.g., U.S. Bureau of the Census, Housing Vacancy Rate Survey, Smith et al., 1988).² The summary statistics for the data sample suggest that there are no substantial differences in education levels between homeowners and renters in the sample of 22-45 years old females. Demographic profile of homeowners differs from the one of renters along the dimensions of age, marital status and the number of children. Homeowners are an older cohort relative to renters, they are more likely to be married and have more children. Figure 2 illustrates homeownership profile over the life cycle, broken down by marital status and the number of children. We display average life cycle homeownership rates for both married and single households with or without children. Homeownership rates are larger for married households than for single ones, reflecting on a strong effect of marriage on the demand for homeownership. Additionally, demand for homeownership is greater for households with children, both married and single. On average, homeownership rate of families with children is 5-7% higher compared to families with the same marital status but without children.

Fisher and Gervais (2011) show that marriage and homeownership are tightly linked, so that the decline in the incidence of marriage during 1980s and further on results in subsequent reduction of homeownership rates for households aged 25-44 years. The decline in marriage rates was predetermined by women's liberation movement of the late 1960s and 1970s, with the boost in female educational attainment, increase of workforce participation and delayed motherhood.³ These factors changed the dynamics of the relationship between the sexes and resulted in marriage becoming less necessary for women's economic survival. The decline in marriage is being compensated to some extent by the rise of cohabitation, where almost half of cohabiting households have children, however, it also resulted in the rise of single parent households. The shifts in family composition due to the delay in motherhood (and marriage) translated into the changes in the demand for homeownership. Single homeowners are almost equally split between homeowners with and without children, where both groups of single households reveal a growing trend in homeownership. The share of married homeowners without children is relatively stable over time, while the reduction in married homeownership is largely driven by the declining numbers of married homeowners with children. In the light of the reduced homeownership for the young households, documented in Fisher and Gervais (2011), the decline in married homeowners with children becomes even more dramatic. This evidence calls for a further investigation of the effect of fertility decisions of both married and single households on the demand for homeownership.

The delay in fertility may likely have resulted in the reduced homeownership rates, as

²This rate matches the average homeownership rate in the sample that includes males as well.

³Introduction of the birth control pill during those years contributed significantly to gaining control over the timing of fertility, delaying motherhood and enjoying better careers (Miller, 2011).

illustrated by Figure 4. In early 1970s the average age at having first child was somewhat over 22 years old, while it grows up to 27 in the 1990s. Subsequently, the average age at the birth of second child also became delayed with the average timing between two consecutive birth at 2 years, although there is a reduction of the average time between the first and the second child to 1.5 years by 1990s. Figure 4 also shows that the purchase of the first home has the same trend of being delayed over the life cycle along with the delay in fertility. Timing of children seems to be an important determinant of homeownership. Figure 4 shows that the age at first homeownership very closely follows the birth of the second child. In early 1970s first homeownership occurs on average one year after the birth of the second child, while in late 1970s and up to early 1990s the timing of the first homeownership and the birth of the second child seem to nearly coincide. Indeed, two thirds of households already have one or more children at the time of purchase of their first home; half of first time home buyers have only 1 or 2 children, and one third have only one child at the time of home purchase. Most of those first children were born one year or two years before the home purchase. Our observations are consistent with the findings in Öst (2012) on the simultaneity of homeownership and childbearing with an important distinction that homeownership decision is likely to be driven by the presence of children in the household, but also is likely to coincide with childbearing beyond the first child.

The delay in fertility provided an opportunity for women to increase their workforce participation, allowed for stronger careers and lead to a better financial standing. Consequently, the delay in home purchase over the life cycle came with an opportunity to purchase a larger home. Figure 5 illustrates that the delayed homeownership trend is aligned with the growing average home size as a number of rooms per family member (the right hand scale) at the time the first home is purchased. The increase in the residential housing size is observed not only for homeowners, but for renters as well, indicating that consumers in general choose larger houses. This evidence from the PSID agrees with the one from the US Census Bureau, according to which the average size of a single-family house in 1970 was 1600 square feet, whereas it was 2400 square feet in 2010. This trend could be the result of the increase in housing affordability, but possibly also due to a greater preference for larger space over time.

Overall, we have illustrated that the decision to buy a home is tightly linked with the fertility decisions and the timing of birth. It also is related to the growing female labor force participation, which opens up an opportunity for a household to buy larger homes. In turn, housing decisions may have important implications on the fertility and work choices. Dettling and Kearney (2014) show that homeowners respond to growing housing prices with an increase in fertility, which overall can result in greater fertility rates for homeowners in the view of typically growing real estate prices over the period. Greater likelihood of giving birth for homeowners and greater number of children in households-homeowners can be expected to

result in the reduced labor force participation and the reduced number of working hours for females-homeowners. Homeowners are more likely to be married and, therefore, enjoy financial support provided by their working spouses. Consequently, they could more likely be expected to drop out of the labor force, or have reduced hours worked. Table 1 shows that there are the differences in both extensive and intensive margins of labor force participation for home owners and renters. Figure 3 shows that labor supply does not differ much for married homeowners and renters, with renters having a somewhat smaller number of hours worked in general. For single females with children, differences in labor supply for homeowners and renters are substantial up to their late 30s and align afterwards. In the absence of substantial differences in labor force participation and hours worked for married households with children, homeowners receive greater hourly wages, as shown in Figure 7. Wage rates for single females with children do not differ much between homeowners and renters, however, they start growing apart after women's later 30s for single cohort of households. According to Table 1, in general the average difference in labor income between homeowners and renters is substantial, with homeowners earning almost 12% more on average if compared to renters. This finding could be attributed to various factors and calls for further investigation. The difference in earnings could be attributed to a stronger start for homeowners in the beginning of their careers due to the delayed fertility. Alternatively, it could be a result of specific career choices induced by the needs to service greater maintenance costs associated with homeownership. It is also likely that homeownership status signals about stability of the worker. Homeownership may serve as a collateral against unexpected termination of the contract on the worker's side. Greater expected stability could result in larger responsibilities assigned to the worker and more rapid career achievements. Another possible explanation is the elevated productivity of homeowners. The literature finds support for stronger academic achievements and workplace success of children living in owned homes. If home ownership provides a better environment for children, the same effect could also be valid for adults living in owned homes.

3 The Model

The evidence presented above strongly suggests that households jointly determine their fertility, labor supply and housing decisions over the life cycle. This section develops a dynamic model of discrete choice of housing demand, fertility choice and labor supply to explain their decision making process.

3.1 Choices

To focus on the decision of becoming a homeowner we only model accommodation choices for those who have not previously purchased a house and are currently renting. Each period after she purchases her first home, the household makes her current consumption, labor force participation and fertility choices. The birth of a child in period t is a choice variable denoted by the indicator variable $b_t \in \{0, 1\}$, where $b_t = 1$ if a child is born. Female workforce participation in period t is given by the indicator variable $w_t \in \{0, 1\}$, where working is denoted by $w_t = 1$. Renting households have a larger choice set, because in addition to choosing (b_t, w_t) , they also decide whether to continue renting by setting $h_t = 0$ or changing their accommodation status and purchasing their first home, by setting $h_t = 1$.

To model the choice set, let $d_{jt} \in \{0, 1\}$ where $d_{jt} = 1$ for:

$$j \equiv (1 - h_t) b_t (1 - w_t) + 2(1 - h_t) (1 - b_t) w_t + 3(1 - h_t) b_t w_t \\ + 4h_t (1 - b_t) (1 - w_t) + 5h_t b_t (1 - w_t) + 6h_t (1 - b_t) w_t + 7h_t b_t w_t$$

Thus $\sum_{k=0}^7 d_{jt} = 1$ and the base choice $d_{0t} = 1$ involves setting $(h_t, b_t, w_t) = (0, 0, 0)$. Since purchasing the first house is a once-in-a-lifetime decision, if $h_t = 1$ then $h_\tau = 0$ for all $\tau \in \{t + 1, \dots, T\}$, and hence $\sum_{j=0}^3 d_{jt} = 1$. In this way the model restricts homeowners to four choices each period t , while renters can pick any one of the eight. After period T the household only smooths her accumulated wealth: she retires, has no further children, and continues to rent if she is not already a homeowner, setting $d_{0t} = 1$ for all $t \in \{T + 1, T + 2 \dots\}$.

3.2 Household preferences

The household derives utility from consumption, leisure, offspring, renting or owning a house, and housing services. Preferences are characterized by a discounted sum of a time-additively separable, constant absolute risk-aversion utility function.⁴ The utility function is decomposed into utility of consumption of market goods and nonpecuniary factors. The nonpecuniary factors are further decomposed into systematic and nonsystematic components. The systematic component of the nonpecuniary utility is characterized by household-specific indices capturing the influence of household lifetime housing choices and housing characteristics, fertility decisions and family composition, working choices and working history. The nonsystematic component

⁴We adopted the CARA utility function, because we lack reliable information on wealth. During the period of 1968 - 1993, the PSID provides detailed questions on household wealth for only two years, 1984 and 1989, insufficient for modeling of changes in household wealth within a dynamic framework. As explained in Margiotta and Miller (2000), the CARA assumption is useful in this context because it is consistent with consumption smoothing from accumulated wealth and accommodates risk aversion in a parsimonious fashion.

of the flow utility, denoted by ε_{jt} , captures a choice-specific idiosyncratic taste shock for each $j \in \{0, \dots, 7\}$ and $t \in \{1, \dots, T\}$. Thus the household's lifetime utility is modeled as:

$$-\sum_{s=t}^{\infty} \sum_{j=0}^7 \beta^{s-t} d_{js} \exp(u_{js}^h + u_{js}^b + u_{js}^l - \rho c_s - \varepsilon_{js}) \quad (1)$$

where β denotes the subjective discount factor, ρ is the constant absolute risk aversion parameter, $u_{jt}^h \equiv h_t u_t^h$ indexes the utility payoff from buying a house, $u_t^l \equiv w_t u_t^l$ the current utility payoff from leisure time, and $u_t^b \equiv b_t u_t^b$ is the discounted utility stream from births. It immediately follows that if $(h_t, b_t, w_t) = (0, 0, 0)$ then current utility is $\exp(-\rho c_t - \varepsilon_{0t})$. Thus buying the first home, giving birth or working in the labor force raises utility, and as we show in the Appendix the current value function, by a multiplicative scalar.

The indices for housing, leisure and family composition can be further decomposed. We define the home purchase index as:

$$u_t^h \equiv x_t' \theta_0 + x_t' s_t \theta_1 + \theta_{20} s_t^2 + \theta_{21} s_t s_{t-1} + \theta_3 s_t l_t \quad (2)$$

where s_t measures house size in period t , $l_t \in [0, 1]$ is female labor supply in t , and x_t is a set of fixed or time varying attributes that characterize the decision maker (including age, education and marital status) along with previous fertility and labor market outcomes. The rationale for including s_{t-1} in the index is that although we do not explicitly model future housing decisions, we do follow resale and future housing purchases. Thus in our model the purchase of the first house is a commitment to continue living in a house owned by the household that matches the changing demographics of the family, rather than in any particular house. Since we cannot assign the value of owning a home to separate periods, we interpret u_t^h as the discounted lifetime increment from becoming a homeowner.

The indices for fertility and labor supply follow the literature.⁵ The lifetime utility of giving birth and raising one more child is given by

$$u_t^b \equiv x_t' \gamma_0, \quad (3)$$

where the marginal lifetime utility of a second child is affected by the age of the first through x_t . Finally we define:

$$u_t^l \equiv x_t' \delta_0 + \delta_1 x_t' l_t + \delta_{20} l_t^2 + \delta_{21} l_t l_{t-1} \quad (4)$$

where $x_t' \delta_0$ is the fixed cost of working, and lagged labor supply affects the marginal utility of

⁵See for example Hotz and Miller (1988), Eckstein and Wolpin (1989), Altug and Miller (1998), Francesconi (2002) and Gayle and Miller (2006).

current leisure, defined as $1 - l_t$.

3.3 Budget constraint

In our framework home ownership confers upon the household a right to adapt their living quarters to their own lifestyle in ways that a landlord might object.⁶ We model the cost of home ownership as the excess over rents paid to secure those rights; they include but are not limited to the real estate commission paid at the time of sale. In a competitive housing market where some fraction of houses are rented, the price of a house is roughly equal to the discounted sum of its rental stream. Our framework equates rental by tenants for a home of specified characteristics to the implicit rental by homeowners. To simplify the econometric implementation of our model we also assume prices, interest rates and hence aggregate fluctuations are known in advance. Thus fertility and homeownership decisions are not driven by short term financial exigencies in the model but life cycle considerations.

Denote by e_t household financial wealth at the beginning of period t , let c_t denote nonhousing consumption, and denote the period t interest rate by i_t . Income from real wages paid to the female if she works in period t is denoted by Y_t . Rent and implicit rent in period t , denoted by $R(s_t, q_t)$, depend on house size s_t , plus quality and aggregate factors q_t . For future reference we let $s_\tau^{(j,t)}$ and $q_\tau^{(j,t)}$ denote the size and quality of accommodation in period $\tau \in \{t+1, t+2, \dots\}$ subsequent to making discrete choice j at t and always making the base choice afterwards. Thus $R\left(s_\tau^{(j,T)}, q_\tau^{(j,T)}\right)$ denotes rent and implicit rent in periods in period $\tau \in \{T+1, T+2, \dots\}$ after setting $d_{jT} = 1$. The price of a house is the discounted sum of implicit rents plus a transaction cost, denoted by $H(s_t, q_t)$, which the household pays to become a homeowner. When becoming a homeowner, the household balances the transaction cost of purchase and a size inertia inherent to homeownership against the benefits of tailoring their own property to individual tastes and having more geographic stability to cultivate social and economic opportunities within the neighborhood.

Define y_{jt} in periods t preceding T as income net of all current accommodation expenses conditional on making choice j ; define income at period T as net of all current and future accommodation expense obligations. Letting i_t denote the one period interest rate in period t :

$$y_{jt} \equiv \begin{cases} \sum_{j \in \{2,3,6,7\}} d_{jt} Y_t - \sum_{j=4}^7 d_{jt} (\pi + \varphi) H(s_t, q_t) - R(s_t, q_t) & t \in \{1, \dots, T-1\} \\ \sum_{j \in \{2,3,6,7\}} d_{jT} Y_T - \sum_{j=4}^7 d_{jT} (\pi + \varphi) H(s_T, q_T) - R(s_T, q_T) \\ \quad - \sum_{\tau=T+1}^{\infty} \left[\prod_{r=t+1}^{\tau} \frac{1}{1+i_r} \right] R\left(s_\tau^{(j,T)}, q_\tau^{(j,T)}\right) & t = T, \end{cases}$$

⁶In this way we implicitly treat moral hazard issues arising from tenants lack of care for the premises they rent, and other agency issues associated with landlord/tenant relationships.

where π denotes downpayment rate, and φ is the real estate commission rate incurred by household upon completing the home purchase transaction. These definitions imply the law of motion for disposable household wealth is:

$$(1 + i_t)^{-1} e_{t+1} \leq e_t - c_t - y_{jt} \quad (5)$$

The left side of the inequality (5) represents household financial resources in $t + 1$ for different contingencies; the right side is the sum of current wealth and labor income less housing and non-housing consumption, plus a one time payment of becoming a homeowner if the householder chooses to buy (for the first time).

3.4 State variables

The state variables in the model include those which the household controls directly, namely the composition of the household, labor force experience, and whether she owns her own home or not, state variables that individually lifestyle but are determined outside the model, the size and quality of housing accommodation, and aggregate variables, including shifters in housing prices, aggregate wages and interest rates.

The timing and spacing of children affect the benefits they confer upon the household. We track the number and ages of children until they turn 18 years old, when the child becomes a young adult and is assumed to leave the household. We denote by a_{it} the age of the i^{th} child in t for $i \in \{1, \dots, I\}$. Let n_t denote the number of offspring living in the household in period t :

$$n_t = n_{t-1} + b_{t-1} - \sum_{i=1}^I I \{a_{i,t-1} = 17\}$$

Thus $a_t \equiv (a_{1t}, \dots, a_{I,t})$ represents both the number and ages of offspring under 18 belonging to the household in period t .

The household also decides whether to work or not, but we do not model how many hours labor force participants work. Age, education, and hours worked in the previous period affect her current wage rate. Denoting female leisure by $l_t \in [0, 1]$, the last remark implies lagged leisure l_{t-1} is a state variable. House size and quality is not directly determined by the household in our framework, but nevertheless enters as a state variable because of their intertemporal dependence. We assume (s_t, q_t) follows a deterministic process the household knows, and that after purchasing her first home $s_t = s_{t-1}$. Finally, rather than imposing stationarity in the economy, we allow housing prices, aggregate wages and interest rates to fluctuate over time, but assume future prices can be perfectly forecasted.

3.5 Intertemporal choices

At the beginning of each period t the household observes the vector of disturbances to its preferences, $\varepsilon_t \equiv (\varepsilon_{0t}, \dots, \varepsilon_{7t})$, her non-housing assets e_t and other state variables, denoted by z_t , which include family demographics, housing status, and lagged labor supply l_{t-1} . Family demographics include fixed characteristics, such as educational background, and variables such as age and marital status, along with lagged fertility a_t . The variables on housing status include (s_t, q_t) and whether the household previously purchased her own home, formally $h_\tau = 1$ for some $\tau \in \{1, \dots, t-1\}$. Households are expected utility maximizers, sequentially optimizing the expected value of (1) subject to (5) by choosing (b_t, w_t) , and also h_t if $a_\tau = 0$ for all $\tau \in \{0, 1, \dots, t-1\}$. Let $p_{jt}(z_t)$ denote the probability of choosing j at year t conditional on the value of the household state variable vector z_t (but not e_t), and B_t , the current price of a bond in t that pays one consumption unit each period to eternity.

Denote by ε_{jt}^* the truncated variable that takes on the value of ε_{jt} when $d_{jt} = 1$ and is not defined when $d_{jt} = 0$. Adapting Gayle et al. (2015) to our framework, let $A_{T+1}(z_{T+1}) \equiv 1$, and recursively define an index of household capital for a household at year t as:

$$A_t(z_t) \equiv \sum_{j=0}^7 p_{jt}(z_t) \exp\left(\frac{u_{jt}^h + u_{jt}^b + u_{jt}^l - \rho y_{jt}}{B_t}\right) E_{jt} \left[\exp\left(\frac{-\varepsilon_{jt}^*}{B_t}\right) \right] A_{t+1}(z_{t+1}^{(j)})^{1-\frac{1}{B_t}} \quad (6)$$

where $z_{t+1}^{(j)}$ is the value of the state vector at $t+1$ following the choice j in period t applied to z_t , the value of the state vector in the t^{th} period, B_t is the current price of a bond paying into perpetuity, ε_{jt}^* is the value ε_{jt} takes when $d_{jt} = 1$, and $E_{jt}[\cdot]$ is the expectations operator conditioning on $d_{jt} = 1$. The index is strictly positive; lower values of $A_t(z_t)$ come from higher current income and lower rent, both incorporated within y_{jt} , as well as less distasteful z_t values, associated with higher values of household capital that show up in current and future values of $u_{jt}^h + u_{jt}^b + u_{jt}^l$. Denote by $d_t^o = (d_{1t}^o, \dots, d_{7t}^o)$ the discrete choices that along with the optimal consumption choices, c_t^o , maximize the expected value of (1) subject to (5). The theorem below shows that all the household dynamics are transmitted through $A_t(z_t)$.

Theorem 1. *For each $t \in \{1, 2, \dots, T\}$ the optimal choices d_t^o maximize:*

$$\sum_{j=0}^7 d_{jt} \left[\rho y_{jt} - u_{jt}^h - u_{jt}^b - u_{jt}^l - (B_t - 1) \ln A_{t+1}(z_{t+1}^{(j)}) + \varepsilon_{jt} \right] \quad (7)$$

Intuitively, the household maximizes a weighted sum of net current income, the three components of current utility, which in the case of births and new home ownership also impound the future benefits of making a durable choice, plus adjustments to the household capital that

potentially affect the magnitude of costs and benefits from future decisions.

3.6 Identification and estimation

The model is identified from (7) up to a probability distribution for $\varepsilon_t \equiv (\varepsilon_{0t}, \dots, \varepsilon_{7t})$ and normalizing constants for each state.⁷ We assume ε_{jt} is independently and identically distributed as a Type I extreme value with location and scale parameters $(0, 1)$. Let $p_{jt}(z_t) \equiv E_t [d_{jt}^o | z_t]$ denote the conditional choice probability (CCP) of optimally making the j^{th} choice. Noting $u_{0t}^h = u_{0t}^b = u_{0t}^l = 0$, it is well known that under this parameterization of the disturbances:

$$\ln \left[\frac{p_{0t}(z_t)}{p_{jt}(z_t)} \right] = u_{jt}^h + u_{jt}^b + u_{jt}^l + \rho(y_{0t} - y_{jt}) + (B_t - 1) \ln \left[\frac{A_{t+1}(z_{t+1}^{(j)})}{A_{t+1}(z_{t+1}^{(0)})} \right]$$

Let $z_\tau^{(j)}$ define the value of the state vector in any period $\tau \in \{t+1, \dots, T\}$ when choice j made at t is followed by choice zero for all successive periods. Estimation is based on successively telescoping $\ln \left[A_{t+1}(z_{t+1}^{(j)}) / A_{t+1}(z_{t+1}^{(0)}) \right]$ into the future through to the end of the discrete choice phase at T . The following theorem provides the basis for the CCP estimator used in our application.

Theorem 2. *For each $j \in \{1, \dots, 7\}$ and $t \in \{1, \dots, T\}$:*

$$\begin{aligned} \ln \left[\frac{p_{jt}(z_t)}{p_{0t}(z_t)} \right] &= \rho(y_{jt} - y_{0t}) - u_{jt}^h - u_{jt}^b - u_{jt}^l + \sum_{\tau=t+1}^T \prod_{r=t+1}^{\tau} \left(\frac{1}{1+i_r} \right) \ln \left[\frac{p_{0\tau}(z_\tau^{(0)})}{p_{0\tau}(z_\tau^{(j)})} \right] \\ &\quad - \sum_{\tau=t+1}^{\infty} \prod_{r=t+1}^{\tau} \left(\frac{1}{1+i_r} \right) \rho [R(s_\tau^{(j,t)}, q_\tau^{(j,t)}) - R(s_\tau^{(0,t)}, q_\tau^{(0,t)})] \end{aligned} \quad (8)$$

This theorem shows that the log odds of the conditional choice probability in period t for buying a house and working but not giving birth (setting $d_{6t} = 1$), versus the base choice of not working, not giving birth and continuing to rent (setting $d_{0t} = 1$), depends on four factors. First is the difference in net income this period $y_{jt} - y_{0t}$ is scaled by the coefficient of absolute risk aversion ρ . Recalling that our normalization sets $u_{0t}^h = u_{0t}^b = u_{0t}^l = 0$, the second factor are the differences in utility this period $u_{jt}^h - u_{jt}^b - u_{jt}^l$. Third is the difference in the discounted streams of rental payments from period $t+1$ onwards, where both streams are generated by making the base choice, but one stream begins with the household owning a home

⁷See Hotz and Miller (1993), Magnac and Thesmar (2002) and Arcidiacono and Miller (2016). In fact this model is overidentified because the coefficients on preferences are not separately indexed by calendar time and state.

and the other pertains to a household who never becoming a home owner; the terms involving $R\left(s_{\tau}^{(j,t)}, q_{\tau}^{(j,t)}\right) - R\left(s_{\tau}^{(0,t)}, q_{\tau}^{(0,t)}\right)$ on the second line of (8) comprise this factor. The remaining terms in (8), a discounted sum of future CCPs, are correction factors to account for the fact that always choosing the base action in future periods is not optimal.⁸

The estimation of the primitives in equation (8) follows a two-step strategy. The first step nonparametrically estimates the CCPs as nuisance parameters using a kernel estimator. The CCP estimates are substituted into equation (8), and the parameters of the utility function are estimated off the empirical counterpart to the resulting moment conditions. Further details about the estimation procedure can be found in the Appendix.

4 Results

This section describes the empirical findings. We estimate parameters of the utility payoff presented in equation (1), that incorporates the parameters of the utility of consumption and parameters associated with non-consumption utility from housing services (2), raising children (3), and disutility from working (4). Table 2 reports the estimated utility parameters grouped by utility components. We also estimate wage equation for working females that controls for homeownership status, and report the results in Table 3.

4.1 Utility parameters

Column (1) of Table 2 reports the estimated parameters of the fixed utility of buying a home, while column (2) shows the estimates of the utility of home size.

We find that utility of homeownership is decreasing with age, indicating on the strong desire to become homeowner earlier in life. This finding suggests that the delay in homeownership is not a preference, but rather a result of the competing trade off between homeownership and other life cycle decisions, such as working and family formation. We find that utility of homeownership is increasing with education, suggesting that more educated households attach a greater value to homeownership. This finding agrees with the statistical records indicating that homeownership rate is larger for more educated cohorts of population. Utility of homeownership is smaller for single households and non-white households, reflecting on lower homeownership rates for these cohorts of population.

Utility of homeownership is increasing and concave in children, and is lower for households with older children. This finding indicates that homeownership is more attractive to households when there are only few children in a family and the children are still quite young. In the same

⁸See Proposition 1 of Hotz and Miller (1993).

time, homeownership gives a positive feedback to the household's fertility decisions. Positive coefficient on homeownership in the utility of giving birth to children, shown in column (3) of Table 2, provides evidence that giving birth is more desirable if a household is a homeowner. However, this finding largely applies for married households, as we also find a sizable negative effect of being a single homeowner on the fertility decision. In general, our findings are consistent with empirical evidence that homeownership is beneficial for families with children (Green and White, 1997; Haurin et al., 2002), and is highly correlated with the fertility decisions (Öst, 2012).

Past working history is positively associated with the utility of homeownership, and this positive association survives after controlling for the process of family formation and the rich set of demographic characteristics. That is, we find that labor force participation helps to speed up the transition to homeownership. This finding suggest that the observed increase in labor force participation documented in Figure 1 should indeed be associated with higher homeownership rates and sooner transition to homeownership. We further find that both married and single homeowners have a higher disutility of working, as revealed by the negative coefficient on homeownership in the utility of working in column (4) of Table 2, but homeowners choose longer hours of work, as the positive coefficients on homeownership for both married and single households in the (dis)utility of working hours in column (5) of Table 2 suggest. That is, whereas homeowners might have a lower labor force participation, our results indicate that, if they work, they choose longer working hours.

Column (2) in Table 2 shows the estimates of the utility of housing size. Utility of housing size is increasing and concave. We find that new homeowners choose larger homes relative to the previously rented homes, which is consistent with the statistical facts that rental-occupied housing is typically smaller than owner-occupied housing. Next, we find that the utility of home size is increasing with age. These finding is consistent with what Figure 5 documents, and with the trends in other representative data sources, where the average residential housing size generally is on a growing trajectory. Our results indicate that, as households transition to homeownership later over the life cycle, they also choose larger homes, captured by the preference for bigger home size over the age. Further, we find the positive coefficient in the utility of housing size for single households, which can be indicative of the economies of scale exploited by married households. Our findings also suggest that the utility of housing size is decreasing with education and is larger for non-white households.

Utility of housing size is decreasing and convex in children, and is decreasing with the age of the youngest child in the family. This findings suggest that there could be no big need in larger home size if there are few children in a family. However, as the number of children increases, so is the demand for larger home. The demand for housing size starts decreasing again as children

grow older, and, if a household with older children considers buying home, it may anticipate older children leaving home soon, and opt for smaller home size.

We find that utility of home size is negatively related to the number of hours put into work. This finding can be related to smaller number of leisure hours effectively spent at home for more intensely working households. These households are likely to spend less time at home, and therefore, may have reduced requirement for housing space. On the contrary, households who work fewer hours or do not work at all, care to live in more spacious homes.

At last we briefly describe our other findings on the utility of giving birth to a child and the disutility of working and work hours, presented in columns (3)-(5) of Table 2. Utility of giving birth to a child is expectedly decreasing with age and smaller for single households. It is larger for more educated households, which may capture the higher fertility of more educated older households, whereas the fertility of less educated households is mostly realized at their younger age. The utility of giving birth is larger if a family already has some children additionally to a newly born child, and is decreasing with the timing difference between the newly born and second youngest child in the family, which reflects that households typically do not wait too long with the subsequent births, but try to bunch them to reduce the age difference between siblings.

The utility of work is decreasing with age, higher for more educated and single households, and lower for non-white households. The utility of working is decreasing with children and is higher for households with older children. Households are more likely to work if they worked in the previous periods. The utility of supply of working hours is increasing and concave. It is increasing with age, is lower for more educated and single households, and higher for non-white households. The utility from working hours is decreasing with the number of children in a family and with the age of younger child.

4.2 Wage equation

Summary statistics in Table 1 show a difference in labor force participation, average hours worked, and income from labor between homeowners and renters. We estimate the wage equation in order to explore what factors can help explain the difference in earnings between homeowners and renters. The results of the estimation of the wage equation for working females are reported in Table 3. In addition to basic demographic characteristics, such as age, education, and marital status, we also control for working history in previous periods and lagged input of working hours (see Miller and Sanders, 1997; Altug and Miller, 1998; Gayle and Miller, 2006, for a similar wage equation specification). The important difference of the current estimation of the wage equation from the one estimated in previous literature is that we also control for

homeownership status.

The results from Table 3 suggest that working extra hour increases wage rate. The effect of working hours is diminishing with time, reflecting on greater importance of most recent working experience relative to the more distant one. We find that marital status magnifies the effect of past hours worked on the current wage rate. Our findings resonate with similar conclusion reached by Killewald and Gough (2014), who find that marriage is associated with significant wage gains for women as compared to being never-married and living singly. The nonlinearity in working experience is captured by past participation variables. Individual productivity reduces with age, captured by the negative quadratic effect of age on wage rate. Additional year of education affects wage rate positively.

Column (2) of Table 3 reports the estimated coefficients on demographic and labor input variables interacted with the homeownership dummy. The coefficients on variables related to labor supply history interacted with the homeownership dummy are mostly insignificant, indicating that, if there is any wage premium for the homeowners, it may not be explained by differences in labor supply. We find, however, that wage rate is larger for more educated homeowners, which can explain part of the wage gap between homeowners and renters in Figure 7. We also find that the effect of quadratic age is stronger for homeowners.

5 Counterfactual simulations

This section discusses counterfactual simulations aimed at determining the strength of various factors on shifting labor force participation profile, homeownership rate, and childbirth pattern. We simulate the benchmark model to show how the estimated model fits the relevant patterns observed in the data.

The details of simulation setting are provided in Appendix B. Simulation results for a benchmark model are presented in Table 4. This table compares homeownership rate, home size, labor force participation rate, labor supply for those who work, and total number of children generated by the model to the analogous data characteristics computed from the PSID sample. The model provides a good fit to both homeownership rate and home size over the life cycle. It matches very well the overall level of labor force participation and hours input for those who work. Finally, it provides a close description of the average number of children born to the households over the life cycle, reaching the peak for average number of children in a household at about age 35, followed by a decline.

We compute additional statistics from the model that are useful in our analysis. Table 5 reports the average age at first child for a female household and the average age at first homeownership generated by the model. For the benchmark model the average age at first

child is 23.8 years. The average age at first homeownership in the model is 28 years. These statistics are remarkably close to the data patterns documented in Figure 1. According to the National Vital Statistical System, the average age of mother at first birth in the U.S. grew from 21.4 in 1970s to 24.2 in 1990s (Mathews and Hamilton, 2002). While nationally representative records on the average age at first homeownership are scarce, computations based on the PSID show that the average age at first homeownership for 1970-1990 is around 29.⁹

In what follows we investigate how homeownership, labor market participation and giving birth respond to various factors. In particular, we explore the effect of an increase in wages, the effect of higher education, interest rates reduction and an increase in housing prices. The model in its complexity provides multiple channels of influencing the outcome variables. The first and most direct channel is through affecting the preferences for buying home, giving birth and working. The counterfactual simulation of higher education works primarily through this channel. Second channel is to alter the payoffs through utility of consumption, such as increasing wage rate or raising housing prices. The third channel allows to modify the strength of the dynamic feedback from the future possibility set on the current choice by affecting the discounting. We explore this channel by altering the interest rate. Although these channels are dominant for particular counterfactual simulations, note that it is difficult to isolate cleanly the effect of each channel, as they are tightly interconnected both contemporaneously and through dynamic feedback on future choices.

5.1 Wages (incomplete)

The first policy experiment constitutes an overall and permanent increase in wages by 5%. This policy immediately affects the choice of hours worked. Under higher labor market compensation working females may increase hours worked, which in turn, further positively affect their total labor market compensation. Also, under higher wages more females who value their leisure time find it beneficial to be engaged into labor market activities. Greater wage affects the choice of hours worked, resulting in larger labor supply. Larger labor market compensation creates a strong incentive to work, as a result we observe a substantial increase in labor force participation.

Since wage channel creates a strong incentive to work, further substitution of choices is likely, in particular, away from choices that are related to childbirth.

The effect of higher wages on housing demand is complex. Everything else equal, larger labor market compensation reduces financial burden of home purchase and makes homeownership more affordable. Larger labor market participation positively affects home purchase decision,

⁹Similar numbers are reached by Zillow Group Inc., also using the PSID. See Zillow analysis press release at <http://zillow.mediaroom.com>.

whereas reduced number of children in a household reduces the incentive for homeownership. Similar forces counteract the utility from housing size. Reduced leisure time decreases utility of housing whereas smaller number of children increases it.

5.2 Education (incomplete)

To disentangle the complex dynamic relationship of education on labor supply, homeownership and childbirth, we conduct a policy experiment, which constitutes in providing cohorts of households with education level of high school or less with one extra year of education. The expected effect from this policy experiment could be similar to the one of the increase in wages, because higher education positively affects wages (see Table 3). However, education also strongly affects the utility shifter for housing, work and child birth. Our estimation results in Table 2 suggest that education is positively linked to the labor force participation, homeownership, and giving birth to children. In the same time, the estimation of preference parameters indicates that more educated households have a greater preference for leisure, which can adversely affect the incidence of work. The preference parameters suggest that more educated households prefer smaller homes, which could reduce the overall utility of becoming homeowner and result in postponing of homeownership. In addition, the effect of education goes beyond just preference parameters by affecting labor market compensation.

Overall, years of education is a strong predictor of labor force participation. Despite that the incidence of work can be mitigated by the higher preference for leisure for households with higher level of education, we observe an immediate and strong increase in the labor force participation. Complementarity between past and current leisure choices and between past and current labor force participation further reinforces the increase in work and reduction in work hours throughout households life cycle.

Households with higher levels of education have a greater preference to be a homeowner, which translates into an earlier age at first homeownership. Although the increase in education could result in smaller average home size, determined by a negative coefficient of education on home size, instead we observe an increase in the average home size. Apparently, an immediate increase in leisure time, which is positively related to the chosen home size, counteracts the immediate negative effect of education to the extent that larger homes are now chosen. The further dynamics of homeownership is reinforced by larger labor force participation, positively linked to homeownership through the fixed utility of buying home.

5.3 House prices (incomplete)

An increase in house prices by 10% directly affects the monetary cost associated with a purchase of home, making it more costly. Therefore it is not surprising to observe a delay in homeownership over the life cycle, and the overall reduction of the homeownership rate. A reduction on homeownership is negatively related to the incentive to work but positively related to the hours of work through the utility.

5.4 Interest rate (incomplete)

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Appendices

A Appendix

Proof of Theorem 1. Define the date zero price of a bond that pays a consumption unit each period from date t onwards as:

$$\tilde{B}_t \equiv \sum_{s=t}^{\infty} \left(\frac{1}{1+i^{(s)}} \right) = \tilde{B}_{t+1} + \frac{1}{1+i^{(t)}}$$

where $i^{(t)} \equiv \prod_{s=0}^t (1+i_s) - 1$ is the compound interest rate over the first t periods. Let:

$$\tilde{Q}_t \equiv \sum_{s=t}^{\infty} \frac{\ln [\beta^s (1+i^{(s)})]}{(1+i^{(s)})} = \tilde{Q}_{t+1} + \frac{\ln [\beta^t (1+i^{(t)})]}{(1+i^{(t)})}$$

For convenience we also define:

$$\alpha_{jt} \equiv \exp (u_{jt}^h + u_{jt}^b + u_{jt}^l) \quad (9)$$

and note that $\alpha_{0t} = 1$ for all t .

After making all its discrete choices before period T , the household chooses its remaining lifetime consumption profile $\{c_t\}_{t=T+1}^{\infty}$ to maximize:

$$- \sum_{t=T+1}^{\infty} \beta^t \exp (-\rho c_t) \quad (10)$$

subject to a sequence of budget constraints:

$$(1+i_t)^{-1} e_{t+1} \leq e_t - c_t$$

The indirect utility function for this Lagrangian problem is:

$$V_{T+1}(e_{T+1}) = -\tilde{B}_{T+1} \exp \left(\frac{\tilde{Q}_{T+1}}{\tilde{B}_{T+1}} - \frac{\rho e_{T+1}}{(1+i^{(T+1)}) \tilde{B}_{T+1}} \right)$$

Suppose a household with state variables z_T makes choice j at age T for one period and then retires. Let y_{jT} denote net income for the last period in which the household makes discrete choices; it includes wage income for the last period and the discounted sum of all future rents:

$$y_{jT} = (1-l_{jT}) w_T - [1+i^{(T)}] \sum_{t=T+1}^{\infty} \frac{R(s_t^{(j)}, q_t^{(j)})}{(1+i^{(t)})}$$

Note that future rents payable depend on the final housing choice. After selecting choice j , and receiving income y_{jT} , she chooses consumption and next period's endowment (c_T, e_{T+1})

optimally to maximize:

$$-\beta^T \alpha_{jT} \exp(-\varepsilon_{jT}) \exp(-\rho c_T) - \tilde{B}_{T+1} \exp\left(\frac{\tilde{Q}_{T+1}}{\tilde{B}_{T+1}} - \frac{\rho e_{T+1}}{(1+i^{(T+1)})\tilde{B}_{T+1}}\right) \quad (11)$$

subject of her budget constraint:

$$\frac{e_T}{1+i^{(T)}} + \frac{y_{jT}}{1+i^{(T)}} = \frac{e_{T+1}}{1+i^{(T+1)}} + \frac{c_T}{1+i^{(T)}}$$

Denoting by $V_{jT}(e_T)$ the discounted sum of expected utility for a householder of age T onwards with wealth e_T who chooses j and makes optimal consumption choices thereafter, we can apply Lagrangian methods to show:

$$\begin{aligned} V_{jT}(e_T) &= -\tilde{B}_T \alpha_{jT}^{1/\tilde{B}_T(1+i^{(T)})} \exp\left\{\frac{\tilde{Q}_T}{\tilde{B}_T} - \frac{\varepsilon_{jT}}{\tilde{B}_T[1+i^{(T)}]} - \frac{\rho(e_T + y_{jT})}{\tilde{B}_T[1+i^{(T)}]}\right\} \\ &= \frac{-B_T}{(1+i^{(T)})} \alpha_{jT}^{\frac{1}{\tilde{B}_T}} \exp\left[\frac{Q_T}{B_T} - \frac{\varepsilon_{jT}}{B_T} - \frac{\rho(e_T + y_{jT})}{B_T}\right] \end{aligned} \quad (12)$$

where the second line exploits the relationships $B_T = \tilde{B}_T(1+i^{(T)})$ and $Q_T = \tilde{Q}_T(1+i^{(T)})$.

Appealing to the definition of $A_t(z_t)$ given in the text, we can now prove by an induction argument that, conditional on choosing j , the value function at t discounted back to date zero is:

$$V_{jt}(e_t, z_t, \varepsilon_{jt}) = \frac{-B_t}{(1+i^{(t)})} \alpha_{jt}^{\frac{1}{\tilde{B}_t}} \exp\left[\frac{Q_t}{B_t} - \frac{\varepsilon_{jt}}{B_t} - \frac{\rho(e_t + y_{jt})}{B_t}\right] A_{t+1}\left(z_{t+1}^{(j)}\right)^{1-\frac{1}{\tilde{B}_t}} \quad (13)$$

At time t the household chooses j to maximize $V_{jt}(e_t, z_t, \varepsilon_{jt})$. Since maximizing an objective function is equivalent to minimizing the logarithm of its negative, the maximum can be found by minimizing:

$$\ln \frac{B_t}{(1+i^{(t)})} + \frac{\ln \alpha_{jt}}{B_t} + \frac{Q_t}{B_t} - \rho \frac{e_t + y_{jt}}{B_t} - \frac{\varepsilon_{jt}}{B_t} + \left(1 - \frac{1}{\tilde{B}_t}\right) \ln A_{t+1}\left(z_{t+1}^{(j)}\right)$$

The proof is completed by multiplying the expression above by B_t , subtracting terms that do not depend on j , appealing to (9) and rearranging. \square

Proof of Theorem 2. It is helpful to define the date zero price of a bond which pays a consumption unit each from date t onwards as:

$$\tilde{B}_t \equiv \sum_{s=t}^{\infty} \left(\frac{1}{1+i^{(s)}}\right) = \tilde{B}_{t+1} + \frac{1}{1+i^{(t)}} \quad (14)$$

where $i^{(t)} \equiv \prod_{s=0}^t (1+i_s) - 1$ is the compound interest rate over the first t periods, and that:

$$\frac{\tilde{B}_{t+1}}{\tilde{B}_t} = 1 - \frac{1}{\tilde{B}_t[1+i^{(t)}]} = 1 - \frac{1}{B_t} \quad (15)$$

It is well known and note that if ε_{jt} is independently and identically distributed as a Type I extreme value with location and scale parameters $(0, 1)$ then from Theorem 1:

$$\begin{aligned} \ln \left[\frac{p_{0t}(z_t)}{p_{jt}(z_t)} \right] &= \rho y_{0t} - (B_t - 1) \ln A_{t+1} \left(z_{t+1}^{(0)} \right) - \left[\rho y_{jt} - \ln(\alpha_{jt}) - (B_t - 1) \ln A_{t+1} \left(z_{t+1}^{(j)} \right) \right] \\ &= \rho (y_{0t} - y_{jt}) + \ln(\alpha_{jt}) + (B_t - 1) \ln \left[\frac{A_{t+1} \left(z_{t+1}^{(j)} \right)}{A_{t+1} \left(z_{t+1}^{(0)} \right)} \right] \end{aligned}$$

Exponentiating the result and raising to the power $1/B_t$, we obtain:

$$\left[\frac{p_{0t}(z_t)}{p_{jt}(z_t)} \right]^{\frac{1}{B_t}} = \alpha_{jt}^{\frac{1}{B_t}} \exp \left[-\frac{\rho (y_{jt} - y_{0t})}{B_t} \right] \left[\frac{A_{t+1} \left(z_{t+1}^{(j)} \right)}{A_{t+1} \left(z_{t+1}^{(0)} \right)} \right]^{1 - \frac{1}{B_t}} \quad (16)$$

Rearranging equation (16) we obtain:

$$\alpha_{jt}^{\frac{1}{B_t}} \exp \left(-\frac{\rho y_{jt}}{B_t} \right) A_{t+1} \left(z_{t+1}^{(j)} \right)^{1 - \frac{1}{B_t}} = \left[\frac{p_{0t}(z_t)}{p_{jt}(z_t)} \right]^{\frac{1}{B_t}} A_{t+1} \left(z_{t+1}^{(0)} \right)^{1 - \frac{1}{B_t}} \exp \left(-\frac{\rho y_{0t}}{B_t} \right)$$

From the definition of $A_t(z_t)$:

$$A_t(z_t) = \sum_{j=0}^J p_{jt}(z_t) \alpha_{jt}^{\frac{1}{B_t}} E \left[\exp \left(-\frac{\varepsilon_{jt}^*}{B_t} \right) \right] \exp \left(-\frac{\rho y_{jt}}{B_t} \right) A_{t+1} \left(z_{t+1}^{(j)} \right)^{1 - \frac{1}{B_t}} \quad (17)$$

Substituting the left hand side into the recursion for A_t given in Equation (17) yields:

$$A_t(z_t) = \sum_{j=0}^J p_{jt}(z_t) E \left[\exp \left(-\frac{\varepsilon_{jt}^*}{B_t} \right) \right] \exp \left(-\frac{\rho y_{0t}}{B_t} \right) \left[\frac{p_{0t}(z_t)}{p_{jt}(z_t)} \right]^{\frac{1}{B_t}} A_{t+1} \left(z_{t+1}^{(0)} \right)^{1 - \frac{1}{B_t}}$$

But from the online appendix of Gayle et al. (2015):

$$E \left[\exp \left(-\frac{\varepsilon_{jt}^*}{B_t} \right) \right] = p_{jt}(z_t)^{\frac{1}{B_t}} \Gamma \left(\frac{B_t + 1}{B_t} \right)$$

where $\Gamma(\cdot)$ is the complete gamma function. Substituting for the left hand in the expression derived for $A_t(z_t)$ above it thus yields:

$$\begin{aligned} A_t(z_t) &= p_{0t}(z_t)^{\frac{1}{B_t}} \Gamma \left(\frac{B_t + 1}{B_t} \right) \sum_{j=0}^J p_{jt}(z_t) \exp \left(-\frac{\rho y_{0t}}{B_t} \right) A_{t+1} \left(z_{t+1}^{(0)} \right)^{1 - \frac{1}{B_t}} \\ &= \Gamma \left(\frac{B_t + 1}{B_t} \right) p_{0t}(z_t)^{\frac{1}{B_t}} \exp \left(-\frac{\rho y_{0t}}{B_t} \right) A_{t+1} \left(z_{t+1}^{(0)} \right)^{1 - \frac{1}{B_t}} \end{aligned}$$

or:

$$\ln A_t(z_t) = \ln \Gamma\left(\frac{B_t + 1}{B_t}\right) + \frac{1}{B_t} \ln p_{0t}(z_t) - \frac{\rho y_{0t}}{B_t} + \left(1 - \frac{1}{B_t}\right) \ln A_{t+1}(z_{t+1}^{(0)})$$

Using this expression to difference $\log A_{t+1}(z_{t+1}^{(j)})$ with $\log A_{t+1}(z_{t+1}^{(0)})$ gives:

$$\begin{aligned} \ln \left[\frac{A_{t+1}(z_{t+1}^{(j)})}{A_{t+1}(z_{t+1}^{(0)})} \right] &= \frac{1}{B_{t+1}} \left\{ \ln \left[\frac{p_{0,t+1}(z_{t+1}^{(j)})}{p_{0,t+1}(z_{t+1}^{(0)})} \right] - \rho(y_{t+1}^{(j,t)} - y_{t+1}^{(0,t)}) \right\} + \left(1 - \frac{1}{B_{t+1}}\right) \ln \left[\frac{A_{t+2}(z_{t+2}^{(j)})}{A_{t+2}(z_{t+2}^{(0)})} \right] \\ &= \frac{1}{B_{t+1}} \left\{ \ln \left[\frac{p_{0,t+1}(z_{t+1}^{(j)})}{p_{0,t+1}(z_{t+1}^{(0)})} \right] - \rho(y_{t+1}^{(j,t)} - y_{t+1}^{(0,t)}) \right\} + \frac{\tilde{B}_{t+2}}{\tilde{B}_{t+1}} \ln \left[\frac{A_{t+2}(z_{t+2}^{(j)})}{A_{t+2}(z_{t+2}^{(0)})} \right] \end{aligned}$$

where the second line follows from (15). Telescoping to period T and appealing to the fact that $A_{T+1}(z_{T+1}^{(j)}) = 1$ yields:

$$\begin{aligned} \ln \left[\frac{A_{t+1}(z_{t+1}^{(j)})}{A_{t+1}(z_{t+1}^{(0)})} \right] &= \sum_{s=t+1}^T \frac{1}{B_s} \prod_{r=t+1}^{s-1} \frac{\tilde{B}_{r+1}}{\tilde{B}_r} \left\{ \ln \left[\frac{p_{0s}(z_s^{(j)})}{p_{0s}(z_s^{(0)})} \right] - \rho(y_s^{(j,t)} - y_s^{(0,t)}) \right\} \\ &= \frac{1}{\tilde{B}_{t+1}} \sum_{s=t+1}^T \frac{\tilde{B}_s}{B_s} \left\{ \ln \left[\frac{p_{0s}(z_s^{(j)})}{p_{0s}(z_s^{(0)})} \right] - \rho(y_s^{(j,t)} - y_s^{(0,t)}) \right\} \\ &= \frac{1}{\tilde{B}_{t+1}} \sum_{s=t+1}^T \frac{1}{1+i^{(s)}} \left\{ \ln \left[\frac{p_{0s}(z_s^{(j)})}{p_{0s}(z_s^{(0)})} \right] - \rho(y_s^{(j,t)} - y_s^{(0,t)}) \right\} \quad (18) \end{aligned}$$

Taking the logarithm of (16), multiplying by $-B_t$ and substituting the expression for $A_{t+1}(z_{t+1}^{(j)})/A_{t+1}(z_{t+1}^{(0)})$, obtained in (18), yields:

$$\begin{aligned} \ln \left[\frac{p_{jt}(z_t)}{p_{0t}(z_t)} \right] &= \rho(y_{jt} - y_{0t}) - \ln(\alpha_{jt}) + (1 - B_t) \ln \left[\frac{A_{t+1}(z_{t+1}^{(j)})}{A_{t+1}(z_{t+1}^{(0)})} \right] \\ &= \rho(y_{jt} - y_{0t}) - \ln(\alpha_{jt}) + \frac{(1 - B_t)}{\tilde{B}_{t+1}} \sum_{s=t+1}^T \frac{1}{1+i^{(s)}} \left\{ \ln \left[\frac{p_{0s}(z_s^{(j)})}{p_{0s}(z_s^{(0)})} \right] - \rho(y_s^{(j,t)} - y_s^{(0,t)}) \right\} \end{aligned}$$

But from (15):

$$\tilde{B}_{t+1} = \tilde{B}_t - \frac{\tilde{B}_t}{B_t} = \frac{\tilde{B}_t(B_t - 1)}{B_t}$$

implying:

$$\frac{(1 - B_t)}{\tilde{B}_{t+1}} = (1 - B_t) \frac{B_t}{\tilde{B}_t(B_t - 1)} = -\frac{B_t}{\tilde{B}_t} = -[1 + i^{(t)}]$$

Therefore:

$$\begin{aligned} \ln \left[\frac{p_{jt}(z_t)}{p_{0t}(z_t)} \right] &= \rho(y_{jt} - y_{0t}) - \ln(\alpha_{jt}) - \sum_{s=t+1}^T \frac{1+i^{(t)}}{1+i^{(s)}} \left\{ \ln \left[\frac{p_{0s}(z_s^{(j)})}{p_{0s}(z_s^{(0)})} \right] - \rho(y_s^{(j,t)} - y_s^{(0,t)}) \right\} \\ &= \rho(y_{jt} - y_{0t}) - \ln(\alpha_{jt}) + \sum_{s=t+1}^T \prod_{r=t+1}^s \frac{1}{1+i_r} \left\{ \rho(y_s^{(j,t)} - y_s^{(0,t)}) + \ln \left[\frac{p_{0s}(z_s^{(0)})}{p_{0s}(z_s^{(j)})} \right] \right\} \end{aligned}$$

Appealing to (9) and definition of $y_s^{(j,t)}$ the theorem is proved. \square

B Simulation details

Let t denote the age of a female. Let z_t denote state vector, such that $z_t = (z_t^f, z_t^v)$. Components of z^f include state variables fixed for a given female. These characteristics include education, race, marital status and bond price regime. Education is divided into 4 categories, which correspond to “less than high school”, “high school”, “some college”, and “college degree”. Race includes two categories: white and non-white. Marital status includes married and single households. Bond price regime for the benchmark simulation correspond to the average interest rate of 8% over the period 1972 - 1993. Variable components of state vector, z^v include householder’s age, number of children in household at time $t - 1$, age of the youngest child at time $t - 1$, leisure choice at $t - 1$, home size at $t - 1$ and home-ownership status at $t - 1$.

A female decides on giving birth to a child or not, on new allocation of hours to leisure, and, if a renter, whether to become a homeowner or not. The decision to work is then determined by a non-unity leisure choice. We discretize possible continuous outcomes of leisure time, and housing characteristics on a fine grid, which increases the number of choices beyond eight choices considered in the model estimation up to J , where J depends on the fineness of the grid.

The participation ratios $p_{j,t}$, $j = 0, \dots, J - 1$ are computed by solving the model backwards, starting from the termination condition. Termination condition is set to occur at age 65 after which a household terminates. A household may enjoy a payoff $v_{j,65}$, however no future decisions are possible, which results in the ratio of conditional choice probabilities being set to one: $p_{0,65}(z_{j,64}^{(1)})/p_{0,65}(z_{0,64}^{(1)}) = 1$, so that we have:

$$\ln \frac{p_{j,64}}{p_{0,64}} = -\ln \alpha_{j,64} - (b_\tau - 1) (\ln E_{64}(v_{j,65})). \quad (19)$$

Equation (19) allows us to evaluate $p_{j,64}$, $j = 0, \dots, J - 1$, which are then being fed into an equation for age 63:

$$\ln \frac{p_{j,63}}{p_{063}} = -\ln \alpha_{j,63} - (b_\tau - 1) \left(\ln E_{63}(v_{j,64}) + \frac{1}{b_{\tau+1}} \ln \frac{p_{0,64}(z_{j,63}^{(1)})}{p_{0,64}(z_{0,63}^{(1)})} \right).$$

The procedure is continued recursively until the age 22:

$$\ln \frac{p_{j22}}{p_{022}} = -\ln \alpha_{j22} - (b_\tau - 1) \left(\ln E_{22}(v_{j23}) + \sum_{s=1}^{17} \frac{1}{b_{\tau+s}} \prod_{r=1}^{s-1} \left[1 - \frac{1}{b_{\tau+r}} \right] \ln \frac{p_{0,22+s}(z_{j,22}^{(s)})}{p_{0,22+s}(z_{0,22}^{(s)})} \right) \quad (20)$$

From equation (20) one can notice that the planning horizon cannot exceed 17 years. This horizon length is the longest from possible planning horizons. The planning horizons for three decisions, which we consider in this paper, do not have to coincide. For decision to work, we can rely on finite dependence (shown in Altug and Miller (1998), and further formalized in Arcidiacono and Miller (2011)), which occurs in two periods in our model specification. The decision to buy a house may involve a planning horizon based on household expectations about the length of the tenure in a chosen home. According to the 2009 American Community Survey, the median length of tenure in the same house for homeowners is 10 years. Finally, if a female gives birth to a child, she expects to care for this child until the child turns 18, when, according to our assumption, the child leaves the parent family and forms her own household. Once the youngest child reaches age of 18 and leaves a household, no more children are born to the household as the probability of such cases is very small.

American Dream Delayed:
Shifting Determinants of Homeownership
– Figures –

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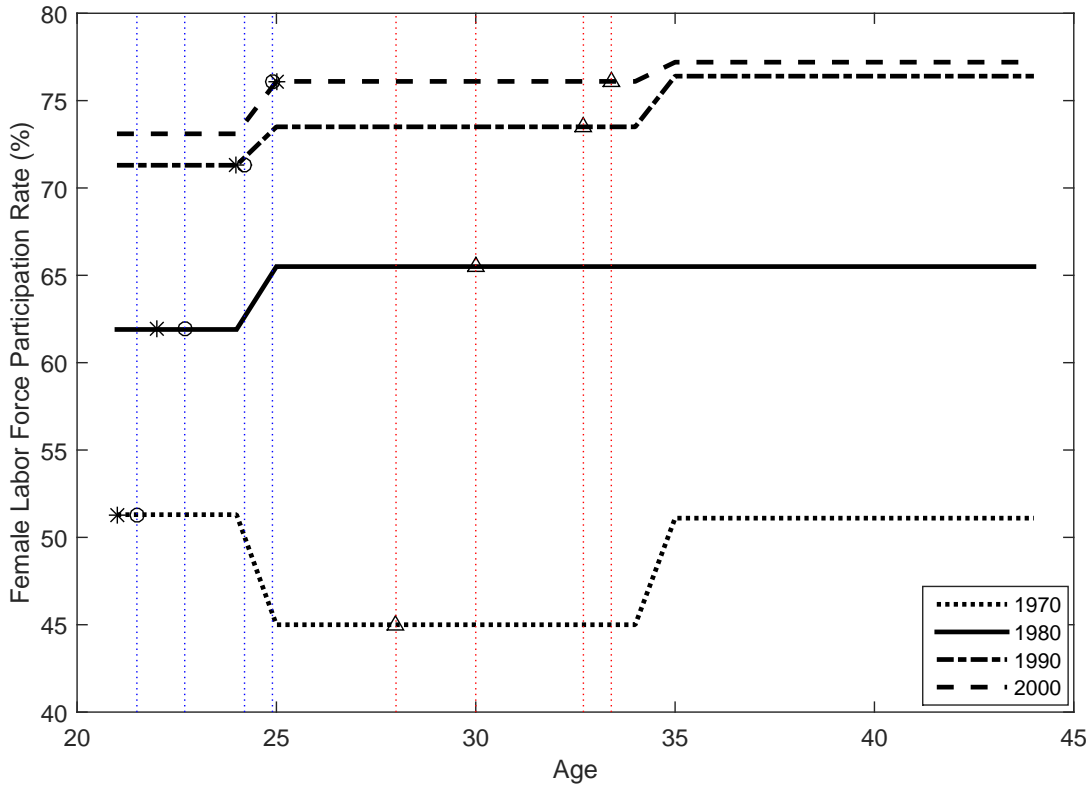


Figure 1: Labor force participation rate by age for 1970 - 2000. “Star” denotes median age at first marriage, “circle” denotes average age at first birth, “triangle” denotes average age at first homeownership. Age at first marriage is taken from the U.S. Census Bureau, age at first birth is taken from the National Vital Statistical Reports (Mathews and Hamilton, 2002), age at first homeownership is computed from the PSID, whereas labor force participation rates are taken from publications of the U.S. Bureau of Labor Statistics (Toossi 2002, 2012).

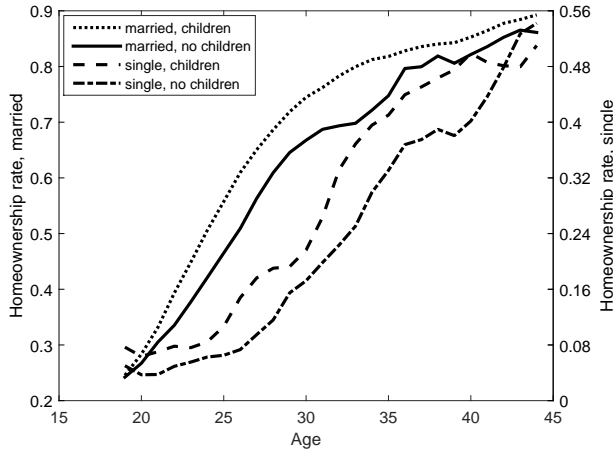


Figure 2: Average homeownership rate.



Figure 3: Average hours worked for females with children.

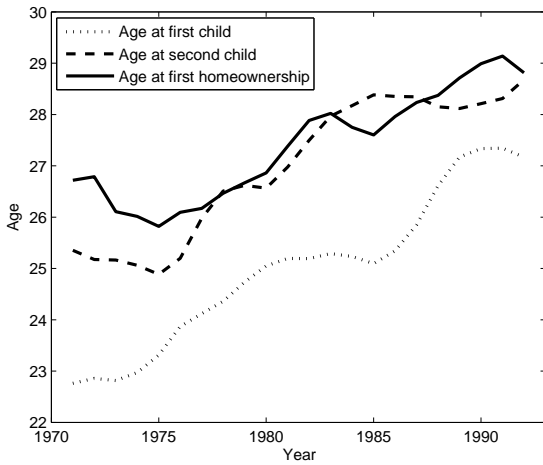


Figure 4: Timing of children and first homeownership.

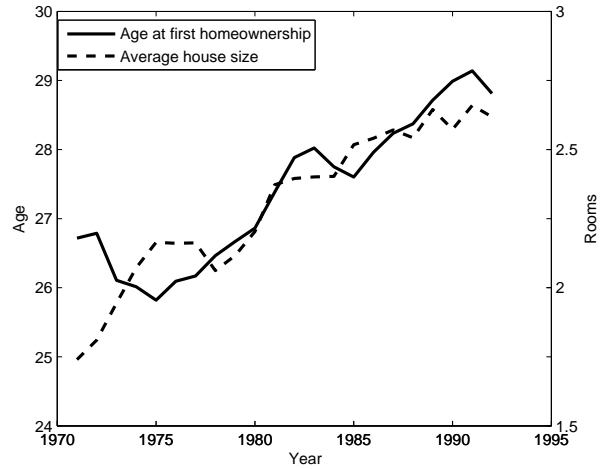


Figure 5: First homeownership and average home size.

Table 1: Summary statistics

	Full sample	Owners	Renters
Age	32.4 (6.6)	33.9 (6.3)	29.7 (6.1)
Education	13.0 (2.2)	13.0 (2.1)	12.9 (2.3)
Married	0.82 (0.38)	0.92 (0.26)	0.64 (0.48)
White	0.89 (0.31)	0.93 (0.26)	0.82 (0.38)
Number of children	1.53 (1.30)	1.67 (1.24)	1.28 (1.36)
Home ownership rate	0.64 (0.47)		
House value for home owners		66,381 (42,859)	
Annual rent for renters			2,956 (2,102)
Move to owned house	0.087 (0.282)		
own-to-own**		0.062 (0.241)	
rent-to-own***		0.064 (0.244)	
Move to rental house	0.126 (0.331)		
rent-to-rent***			0.329 (0.470)
own-to-rent***			0.041 (0.198)
Number of rooms in dwelling	5.8 (1.7)	6.4 (1.5)	4.7 (1.5)
Labor force participation	0.753 (0.430)	0.736 (0.440)	0.783 (0.411)
Hours worked*	1,497 (742)	1,479 (741)	1,527 (743)
Labor income*	11,070 (8,850)	11,504 (9,374)	10,341 (7,842)
Number of observations	43,504	27,871	15,633

Sample averages for females between 22 and 45 years old, standard deviations are in parenthesis; data covers 1968 through 1993.

*Conditional on working.

**Including observations on households who spend one or two years of renting between two consecutive home ownerships.

***Excluding observations on households who spend one or two years of renting between two consecutive home ownerships.

Table 2: Period-Specific Utility

$$\begin{aligned}
u_t^h &= d_t^p(x_t'\theta_0 + x_t's_t\theta_1 + \theta_{20}s_t^2 + \theta_{21}s_t s_{t-1} + \theta_3 s_t l_t) \\
u_t^l &= d_t^w x_t'\delta_0 + \delta_1 x_t' l_t + \delta_{20} l_t^2 + \delta_{21} l_t l_{t-1} \\
u_t^k &= d_t^k x_t'\gamma_0
\end{aligned}$$

	Utility from:				
	Home Purchase	Home size	Offspring	Work	Work hours
	(1)	(2)	(3)	(4)	(5)
	$d_t^p \times$	$s_t \times$	$d_t^k \times$	$d_t^w \times$	$l_t \times$
Constant	1.124 (0.469)	0.623 (0.082)	2.137 (0.194)	-0.298 (0.168)	6.233 (0.916)
Work	0.333 (0.495)		-4.343 (0.251)		
Birth	-3.221 (0.491)				
Work*Birth	-23.027 (0.515)				
Demographic characteristics (x_t)					
Female age	-0.196 (0.014)	0.038 (0.002)	-0.415 (0.005)	-0.040 (0.005)	0.109 (0.025)
Female education	0.436 (0.029)	-0.067 (0.005)	0.142 (0.011)	0.117 (0.009)	-0.419 (0.050)
Husbands age	0.085 (0.012)	-0.013 (0.002)	-0.020 (0.005)	-0.010 (0.004)	0.052 (0.022)
Husbands education	-0.517 (0.026)	0.082 (0.004)	0.138 (0.010)	-0.074 (0.008)	0.258 (0.044)
Single	-10.429 (0.544)	0.439 (0.090)	-5.783 (0.215)	1.793 (0.201)	-12.261 (1.024)
Non-White	-8.804 (0.203)	0.459 (0.035)	-0.576 (0.080)	-1.307 (0.075)	9.424 (0.398)
Single*Non-White	-24.063 (0.505)	2.465 (0.091)	5.260 (0.165)	-1.145 (0.154)	13.634 (0.764)
Children at $t - 1$	3.769 (0.135)	-0.159 (0.021)	4.281 (0.050)	-0.652 (0.042)	-3.396 (0.242)
Children sq. at $t - 1$	-2.882 (0.043)	0.139 (0.007)	-2.464 (0.015)	0.066 (0.010)	-0.368 (0.063)
Age of last child	-0.352 (0.020)	-0.056 (0.003)	-1.482 (0.006)	0.120 (0.006)	-0.390 (0.030)
Homeowner at $t - 1$			2.643 (0.055)	-0.651 (0.041)	5.180 (0.213)
Single*Homeowner at $t - 1$			-16.352 (0.148)	-1.054 (0.165)	8.570 (0.735)
Current home size (s_t)		-0.048 (0.004)	0.015 (0.012)	-0.003 (0.006)	
Prior home size (s_{t-1})		0.009 (0.001)			
Employed at $t - 1$ (d_{t-1}^w)	0.171 (0.037)			1.281 (0.029)	
Employed at $t - 2$ (d_{t-2}^w)	0.087 (0.036)			0.594 (0.027)	
Work time (l_t)		-2.104 (0.025)			-128.566 (0.857)
Work time at $t - 1$ (l_{t-1})		-0.295 (0.032)			99.939 (0.650)
Work time at $t - 2$ (l_{t-2})		-0.055 (0.028)			-10.004 (0.597)

Table 3: Wage equation

$$\ln(\text{wage}_{it}) = B_1 X_{it} + B_2(O_{it} X_{it}) + \mu_t + \eta_i + \epsilon_{it},$$

where O_{it} is a dummy for homeowner

X_t	B_1 (1)	B_2 (2)
Δ Hours worked at $t - 1$	0.130 (0.007)	0.003 (0.006)
Δ Hours worked at $t - 2$	0.050 (0.007)	-0.005 (0.006)
Δ Work at $t - 1$	-0.061 (0.011)	0.018 (0.013)
Δ Work at $t - 2$	-0.027 (0.011)	-0.001 (0.013)
Δ (Age \times Education)	0.516 (0.126)	0.138 (0.072)
Δ Age ²	-0.284 (0.049)	-0.072 (0.025)
Δ Marital*Hours worked at $t - 1$	0.038 (0.008)	
Δ Marital*Hours worked at $t - 2$	0.008 (0.008)	

Table 4: Simulation results

	21-25	26-30	31-35	36-40	41-45
Homeownership rate					
Data	0.37	0.57	0.72	0.77	0.81
Model	0.39	0.58	0.72	0.78	0.83
Home size					
Data	4.70	5.44	6.04	6.35	6.32
Model	4.70	5.43	6.09	6.44	6.41
Labor force participation					
Data	0.79	0.75	0.75	0.77	0.75
Model	0.82	0.78	0.75	0.76	0.80
Hours worked					
Data	1455	1496	1482	1528	1556
Model	1506	1532	1501	1500	1544
Children					
Data	0.86	1.34	1.84	1.77	1.25
Model	0.91	1.35	1.86	1.91	1.40

Table 5: Counterfactual simulation results

	Average age at		LFP (%)	
	first child	first homeownership	before age 30	after age 30
Benchmark	23.8	28.0	80	77
Extra year of education (to HS or less)				
Increase wage by 5%				
Reduce interest rate by 1%				
Increase house prices by 10%				

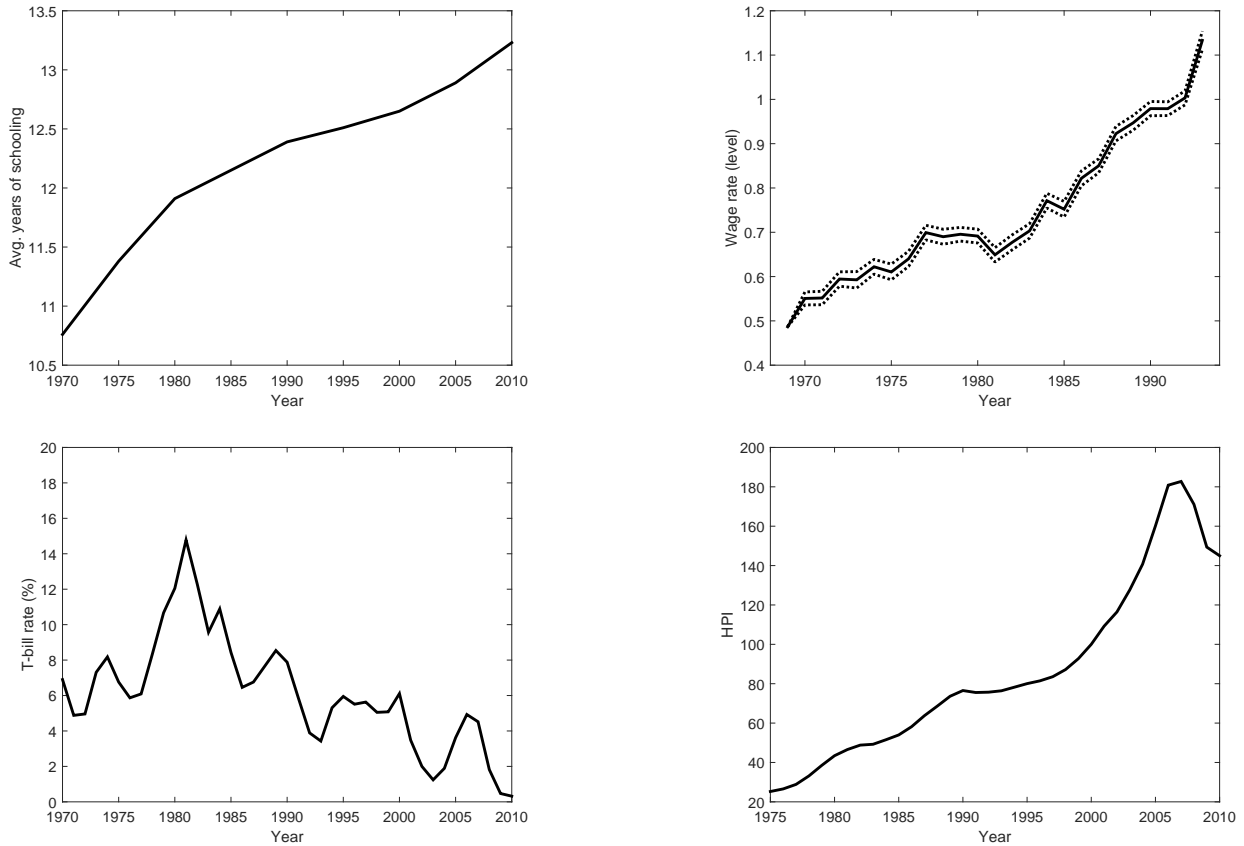


Figure 6: Educational attainment for female population 15 years old and over measured as the average years of total schooling, constructed based on data from Barro and Lee (2013). Women’s earnings as a percentage of men’s earnings. Wage rate is computed by the authors based on the PSID data sample. One-year Treasury constant maturity rate (GS1) and Case-Shiller U.S. National Home Price Index are retrieved from FRED, Federal Reserve Bank of St. Louis.



Figure 7: Average hourly wages conditional on working for females with children.

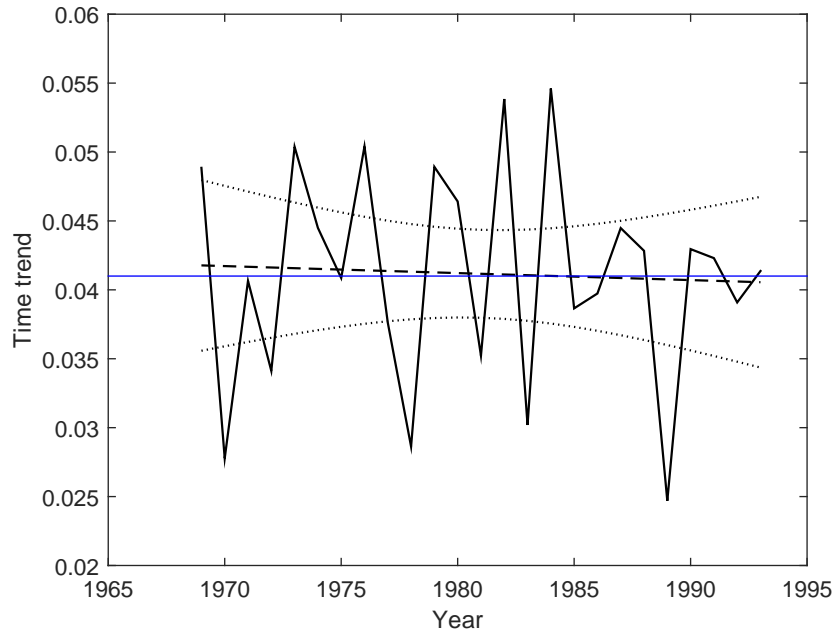


Figure 8: Transition from homeownership to renting